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Iranian Herbalists, But Not Cooks, Are Better at Naming Odors Than Laypeople

Marisa Casillas,[a,b] Afrooz Rafiee,[b] Asifa Majid[a,b,c,d]

[a]*Language and Cognition Department, Max Planck Institute for Psycholinguistics*
[b]*Centre for Language Studies, Radboud University*
[c]*Donders Institute for Brain, Cognition and Behaviour, Radboud University*
[d]*Department of Psychology, University of York*

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Abstract

Odor naming is enhanced in communities where communication about odors is a central part of daily life (e.g., wine experts, flavorists, and some hunter-gatherer groups). In this study, we investigated how expert knowledge and daily experience affect the ability to name odors in a group of experts that has not previously been investigated in this context—Iranian herbalists; also called attars—as well as cooks and laypeople. We assessed naming accuracy and consistency for 16 herb and spice odors, collected judgments of odor perception, and evaluated participants' odor meta-awareness. Participants' responses were overall more consistent and accurate for more frequent and familiar odors. Moreover, attars were more accurate than both cooks and laypeople at naming odors, although cooks did not perform significantly better than laypeople. Attars' perceptual ratings of odors and their overall odor meta-awareness suggest they are also more attuned to odors than the other two groups. To conclude, Iranian attars—but not cooks—are better odor namers than laypeople. They also have greater meta-awareness and differential perceptual responses to odors. These findings further highlight the critical role that expertise and type of experience have on olfactory functions.

Keywords: Chemosensory; Olfaction; Odor naming; Cross-cultural; Expertise; Individual differences

1. Introduction

Odors are omnipresent in our daily life, from the smell of the coffee we drink every morning to the toiletries we use each day. Humans have an excellent sense of smell:

Correspondence should be sent to Asifa Majid, Department of Psychology, University of York, York YO10 5DD, UK. E-mail: asifa.majid@york.ac.uk

They can discriminate trillions of odors (Bushdid et al., 2014), and they can detect some odors as well as dogs (Laska, 2011; Shepherd, 2004). But when it comes to *naming* odors, people perform inaccurately with even the most familiar smells (Cain, 1979; Engen, 1987; De Wijk, Schab, & Cain, 1995; Yeshurun & Sobel, 2010). For example, Engen (1987) found that participants only named 32% of a set of “very familiar” odors correctly, including mint, banana, lemon, and onion. In a recent study comparing people from 20 diverse cultures for their ability to talk about smells in comparison to other perceptual modalities, Majid et al. (2018) found odor naming was generally the poorest across communities. This difficulty in odor naming has been attributed, in part, to a lack of dedicated olfactory vocabulary (Lawless & Engen, 1977; cf. Huisman & Majid, 2018), such that odors—even those with which people have frequent experience—are said to be “ineffable” (Levinson & Majid, 2014). Not only is there a relative paucity of words for smells in comparison to other sensory modalities, but mention of odors of any sort is extremely infrequent across genres and over historical time (Winter, Perlman, & Majid, 2018).

This apparent failure in our expressive capacity is of central interest to the cognitive sciences since differential expressibility provides insight into the architecture of cognition. When it comes to olfaction—aside from a lack of lexicon—various explanations have been proposed for why odors are ineffable. According to one account, the core function of the olfactory system is to detect novelty and change, so odors are represented as singular episodes intertwined with the situations in which they are first perceived. Since language relies on abstraction, it is said to be incompatible with this episodic representation (Köster, Møller, & Mojet, 2014). Similarly, Young (2019) suggests the issue resides in representational format, but according to him the problem is due to an incompatibility in compositional formats for odors versus language. Other explanations appeal to neuroanatomy. For example, Lorig (1999) argues that the cortical resources required to process odors and language interfere with each other. Still others have proposed that the ineffability of odors is a result of the ways in which olfactory areas of the brain are connected to language areas: either these links are too weak (e.g., Engen, 1987) or too direct (Olofsson & Gottfried, 2015).

These explanations typically overlook the fact that while odor naming is difficult, it is not impossible. As has been shown in a variety of other arenas (e.g., Bailenson, Shum, Atran, Medin, & Coley, 2002; Medin, Lynch, Coley, & Atran, 1997; Ross, Medin, Coley, & Atran, 2003; Wolff, Medin, & Pankratz, 1999; for review see ojalehto & Medin, 2015), culture shapes olfactory cognition (Majid, 2015). Systems of categorization are, in fact, maintained at multiple levels: individual experience, cultural convention, and institutionally formalized convention (Glushko, Maglio, Matlock, & Barsalou, 2008). Systems at the level of shared cultural experience show effortless acquisition via daily experience and (flexible) stability in inter-generational transmission, while systems of formal expertise are marked by the fact that learning occurs through explicit instruction in adulthood and is typically limited to a few experts in a particular domain (cf. Glushko et al., 2008). We return to this distinction between experience and expertise below.

The relevance of cultural convention in the domain of olfaction has been illustrated by studies showing that some languages have rich odor vocabularies; odor naming is not hard for everyone (e.g., Floyd, San Roque, & Majid, 2018; Majid & Burenhult, 2014; O'Meara, Kung, & Majid, 2019; O'Meara & Majid, 2016; Wnuk & Majid, 2014). For example, Majid and Burenhult (2014) showed that the Jahai, who live in the Malay Peninsula, can name odors as easily as they name colors. The Jahai even outperformed English speakers in naming odors that were common for the English speakers. In fact, odor is highly codable for the Jahai: When asked to name odors, they use basic odor terms, give short responses, name odors quickly, and show higher agreement across speakers (Majid, Burenhult, Stensmyr, De Valk, & Hansson, 2018).

The Jahai are a community preoccupied with odors in their everyday life, and it seems that this is related to their hunter-gatherer lifestyle and associated cultural practices (Majid & Kruspe, 2018). For instance, in blood-throwing ceremonies they mix their own blood with water and throw it into the air hoping that its odor will please their thunder god (Burenhult & Majid, 2011). The Jahai have an odor lexicon that includes around a dozen terms, all of which are commonly used across different contexts. When Majid and Burenhult (2014) asked Jahai participants to name odors, they typically replied with terms from this odor lexicon, the same terms they use in their everyday communication. The Jahai's performance on odor naming might therefore stem from two sources: their oft-used odor lexicon and their preoccupation with odors in their daily cultural practices.

An interest in odors can also be observed among wine and coffee experts, perfumers, flavorists, and cooks, where institutional structures underpin learning. These professionals have extensive experience with odors from their domain of expertise. They often take part in explicit odor-related training, and they frequently communicate about odors in their work. For example, wine experts undergo years of training in olfactory and linguistic practices around wine, and spend much of their time reading and talking about the olfactory properties of wines in tasting and professional reviews (e.g., Hendrickx, Lefever, Croijmans, Majid, & Bosch, 2016; Hughson & Boakes, 2001). Because these professionals have more frequently encountered odors in their daily business (their experience), and because they have acquired formal knowledge about those odors and their sources (their expertise), we might expect that, like the Jahai, these experts would show improved performance in naming odors.

However, studies investigating the effect of expertise on odor language in these groups have yielded mixed results. Some studies suggest that odor naming is no better among experts than laypeople (e.g., Lawless, 1984; Parr, Heatherbell, & White, 2002), a claim which is bolstered by the substantial variation between experts when producing free odor descriptions (e.g., Sauvageot, Urdapilleta, & Peyron, 2006). Other studies have shown that experts can have higher agreement among themselves in how they name odors (e.g., Croijmans & Majid, 2016; Urdapilleta, Parr, Dacremont, & Green, 2011; Zucco, Carassai, Baroni, & Stevenson, 2011). In one study, Sezille, Fournel, Rouby, Rinck, and Bensafi (2014) compared free descriptions of pleasant and unpleasant chemical compounds by flavorists and perfumers (both with formal odor training), trainee cooks (with extensive odor exposure), and laypeople (with no training or extensive exposure). Flavorists and perfumers used more source terms (e.g., *flower*) and made more reference to chemical terms (e.g., *beta ionone*) than trainee cooks, and trainee cooks produced more source terms than laypeople. The authors conclude that both formal training and exposure improve free odor description.

A closer examination of the positive evidence of expertise on odor description and odor naming indicates any expert advantage may, in fact, be quite limited. For example, Croijmans and Majid (2016) compared wine and coffee experts' and laypeoples' descriptions of wine and coffee smells and flavors, everyday smells, and basic tastes. They found that wine experts agreed with each other more in how they described wine smells and flavors, but they were no different than coffee experts or laypeople in their descriptions of the other stimuli. On the other hand, coffee experts did not show any advantage in describing the smells or flavors of coffee. Croijmans and Majid (2016) attribute this difference to communicative practices associated with wine versus coffee cultures in that there are many more opportunities for wine experts to practice their "wine talk" than there are for coffee experts to practice their "coffee talk." Additionally, neither group showed an advantage over laypeople when asked to name everyday odors and tastes.

As suggested earlier, individual experiences can differ even among non-experts, such that attention to olfactory activities and long-term exposure to odors may affect laypeople's odor perception (e.g., Plially, Delon-Martin, & Royet, 2012; Royet, Delon-Martin, & Plailly, 2013; see also Knaapila et al., 2017; Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013). For example, Knaapila et al. (2017) found that non-experts who are regularly exposed to herbs and spices in their home cuisine gave higher ratings of pleasantness and familiarity to dried herb and spice stimuli, as compared to those who were not regularly exposed. The same participants were also more accurate in selecting correct odor labels for herb and spice stimuli when given a closed set of options. The authors speculate that regular food preparation with herbs and spices increases attention to and, thereby, learning of herb and spice olfactory properties, resulting in the increased odor identification accuracy and pleasantness ratings in their data (Knaapila et al., 2008, 2017; Prescott, Kim, & Kim, 2008; Schloss, Goldberger, Palmer, & Levitan, 2015). Pleasantness ratings may have been affected because increased exposure to an unfamiliar or neutrally valenced stimulus can increase positive attitudes toward it (Delplanque, Coppin, Bloesch, Cayeux, & Sander, 2015; Zajonc, 1968). Positive ratings of a stimulus may increase with experience because cognitive access to that concept becomes entrenched, making future retrievals more fluent (e.g., Topolinski & Strack, 2009). In any case, we do not know whether the participants' odor *naming* ability in Knaapila et al.'s (2017) study was also affected by exposure to herbs and spices because participants were given a closed set of options for identification and because the stimuli were not visually masked.

Taken together, prior evidence supports an account in which people who are preoccupied with odors in their daily life—particularly those who use a culturally shared, early-acquired odor lexicon and, to some extent, those who work formally with odors as part of their profession—show an improved ability to name and describe those odors. It is unclear, however, which aspects of odor preoccupation lead to this improvement. Is the difference one of everyday odor experience, communicative practices, encyclopedic expertise about odors, or some combination of these? In this study, we investigate how two of these sources of knowledge—experience (regular use and/or exposure) and expertise (acquired formal knowledge)—affect the ability to name odors. We tested odor naming in participants from two expert sub-cultures in Iran that interact with herbs and spices in their everyday life: herbalists (hereafter referred to as "attars") and cooks.

There is a long tradition of trading and using herbs and spices in the Middle East that goes back at least to the time of the Silk Road. Situated between the eastern and western endpoints of major trade routes, Iranians have dealt in spices, silk, jewels, and aromatics for more than a thousand years. Since that time, herbs and spices have been a central part of Iranian life, finding their way into ideological texts and scientific and medicinal practices (e.g., Adhami, Mesgarpour, & Farsam, 2007). In modern-day Iran, one can find shops in a bazaar that exclusively sell herbs and spices. The freshness and the quality of herbs and spices are highly valued because they are extensively used for everyday culinary (Koçtürk, 2004), medicinal (e.g., Sharafzadeh & Alizadeh, 2012), and ritual purposes (e.g., Tehrani & Duffy, 2015). For instance, Iranians use damask rose to flavor their food, eat licorice to cure stomachaches, and may welcome their guests by burning esfand, an aromatic seed. The central importance of herbs and spices in Iranian life ensures a vital and prestigious role for professionals who work with herbs. We focus here on two such occupations—cooks and attars.

Iranian cooks have extensive experience with a wide range of culinary herbs and spices. Cooking practices are transmitted orally and by "watching and doing" from mother to daughter as part of the daughter's preparation for marriage. Once a woman has married, she refines her cooking techniques through everyday practice but has limited need for further discussion about the details. Although written recipes exist for traditional dishes (Jurafsky, 2014), an experienced Iranian cook typically does not follow these and must instead develop a sense for what, and how much, to combine for every dish. Cooks either dry and prepare their own herbs or buy herbs and spices in bulk for storage in their personal containers. A cook might use up to 15 different herbs and spices in a single dish. For instance, *kalampolo*, a typical Iranian dish, requires up to 10 different herbs and spices: dried basil, dried tarragon, dried dill, dried chives, dried lime, unripe grape powder, turmeric, red pepper, saffron, and damask rose. Thus, while cooks may ultimately be most concerned with the gustatory outcome of their practice, they have frequent experience with the olfactory practices required to effectively purchase, prepare, and use, herbs and spices (see also Shepherd, 2006).

Attars talk about herbs and spices in their daily communication with their customers and have encyclopedic knowledge about the uses of each herb and spice they sell. The word attar (*ætta:r*) is derived from the Arabic noun *ætr* "scent" and is used by Iranians to refer to vendors of herbs and spices. Like cooks, attars are exposed to herbs and spices on an everyday basis but, unlike cooks, attars also have a professional responsibility to maintain extensive knowledge about herbs and spices. For example, attars prescribe and explain herbal remedies to their customers (Adhami et al., 2007). To learn about the use and function of different herbs and spices, attars get information from both direct (more experienced attars) and indirect (herb and spice literature) sources. Extensive communication about herbs and spices is central to an attar's profession and, aside from reading, includes talking to colleagues, instructing apprentices, and explaining herb uses to customers. Demonstrated expertise and skillful communication about herbs and spices leads to a successful business for an attar.

In sum, while both attars and cooks have extensive experience with herbs and spices, attars communicate with a wider range of people about them and have more extensive knowledge about their workings. Does this difference in expertise give attars an advantage over cooks in naming herbs and spices? And how do the two groups compare to ordinary Iranians without extensive experience or expertise? We compared odor naming accuracy and consistency across these three groups—attars, cooks, and laypeople—and hypothesized that attars would produce more correct responses and be more consistent than cooks in naming odors, and that cooks, in turn, would produce more correct and consistent responses than laypeople.

We also asked whether these differences in experience and expertise influence participants' perception and meta-awareness of odors. To test whether experience influenced pleasantness judgments (cf., Yeshurun & Sobel, 2010), we asked participants to rate the pleasantness of all odors, predicting that, because of their increased experience with these odors, attars would find them more pleasant overall (cf. Delplanque et al., 2015; Knaapila et al., 2017; Sezille et al., 2014; Zajonc, 1968). To test whether participants could detect differences between odors that are primarily associated with cooking or primarily associated with herbal remedies, we asked participants to rate the odors as to how edible and medicinal they were. We also asked participants to rate each odor's intensity to measure how well each odor gave off a detectable scent. In addition to this, we estimated participants' experience with odors by asking them to rate each one for its familiarity and frequency. Finally, in order to assess people's meta-awareness of odors, we used an adapted version of the Short Odor Awareness Scale from Smeets, Schifferstein, Boelema, and Lensvelt-Mulders (2008), following Croijmans and Majid (2016). This questionnaire asks people about their awareness of both positive and negative odors. As with odor naming, we hypothesized that attars would report the highest ratings of odor meta-awareness, followed by the cooks, and then laypeople.

2. Method

2.1. Participants

Forty-four adults participated in the experiment, including 10 attars (M_{age} 36 ± 9.80 years; 25–54 years; 1 female), 11 cooks (M_{age} 50 ± 16.10 years; range 19–76 years; all 11 female), and 23 participants with no expertise in herb trading or cooking ("laypeople"; M_{age} 34 ± 12.54 years; range 18–65 years; 10 female). Data collection was conducted by the second author during a 2-month visit to Iran (Shiraz, Fars province). Participants were recruited via personal contacts and were then individually screened for classification into the three participant groups. The participant sample was therefore limited by the availability of local, verified attars, cooks, and laypeople willing to take part in the experiment during that 2-month period. Our attar and cook samples follow traditional demographic lines: Most attars in Iran are men and most cooks are (older) women. Therefore, when recruiting participants for the laypeople group, we took care to ensure that it included both men (M_{age} 39 ± 13.86 years) and women (M_{age} 26 ± 4.15 years) of comparable age to the men and women in our two expert groups. We excluded one additional participant who was initially recruited as an attar but later reported that his primary work was not herb trading. All participants were paid for their participation.

All participants were native speakers of Farsi who had lived most or all of their life in Iran. A demographic questionnaire confirmed that attars, cooks, and laypeople differed substantially in their herb expertise and cooking experience. All 10 attars traded herbs as their primary occupation, with experience ranging between 1 and 39 years in the business (M = 11.05). The attars were primarily self- (8 out of 10) and family- (9 out of 10) taught, and typically supplemented their training by reading texts about herbs. Five of the attars also prepared food on a regular basis (two cook daily, three cook weekly) and reported using herbs when cooking.

None of the cooks or laypeople traded herbs. All eleven cooks prepared food as part of their daily tasks and reported using herbs in their everyday cooking; seven of the cooks prepared food every day and four of them prepared food on four or more days of the week. Twelve of the 23 laypeople prepared food on occasion, one prepared an egg daily, two prepared food once or twice a week, and the rest prepared food irregularly or not at all. Eleven of the twelve laypeople who prepared food on occasion reported using herbs in their cooking. In sum, attars had expert training, experience with herbs, and occasionally prepared food, cooks had more substantial cooking experience compared to the other two groups but no expert training in herbs, and laypeople lacked both expert training in herbs and cooking skill.

2.2. Materials

We conducted naming and rating tasks for each of the 16 herbs and spices. The odor stimuli included 8 “culinary” and 8 “medicinal” dried herbs and spices, as defined by their predominant use. Though nearly all of these herbs and spices have both culinary and medicinal features, the culinary ones are frequently used for cooking while the medicinal ones seldom are. Culinary herbs and spices included the following: dried mint, turmeric, cinnamon, saffron, caraway, dried orange blossom, thyme, and dried lime powder. Medicinal herbs and spices included the following: lavender, clove, lemon verbena, licorice, chamomile, eucalyptus, fennel, and rosemary. The stimuli were prepared in powder form for a stronger scent. Each stimulus was presented in a dark brown glass jar in which the herb or spice was covered with a thin layer of white poly-fiber to keep participants from seeing it.

2.3. Procedure

The experiment took place in Iran and was conducted in Farsi. The stimuli were presented in two different fixed random orders in the first and second naming tasks (first task: naming only; second task: odor ratings and naming). During the first naming task, participants smelled each odor, one at a time, with a break of at least 30 s between odors. The participant was asked to name the odor that he or she smelled by answering the question *what is this the smell of?* (Farsi: *In buye chi hast?* / *in buye chiye?*). After naming all 16 stimuli, the participant was given a Short Odor Awareness Questionnaire (adapted from Smeets et al., 2008), which also served as a break before smelling the odors again.

Participants then rated each odor on a 7-point scale for six properties: familiarity (*how familiar is the odor?*), odor frequency (*how often do you experience this odor?*), edibility (*how edible would an object with this odor be?*), medicinalness (*how medicinal would an object with this odor be?*), intensity (*how strong does the odor smell?*), and pleasantness (*how pleasant is the odor?*), and named the odors again. Finally, participants answered some demographic questions about their experience with herbs and spices (see the group summaries above).

2.4. Coding

On each naming trial, we noted participants' source-term responses and whether their response was correct or not. Sometimes participants responded to the prompt with a non-source-term response (e.g., "nice"). We consider non-source-term responses as non-answers in this odor-naming task, and so we did not record them when they occurred. Pronunciation variants were collapsed, as was any modification of the name (e.g., *abshan* and *avshan* are variants on the same word for thyme; *shirin bayan* and *rishmak* are variants for licorice). When participants gave more than one response for a stimulus, the final response that the participant settled on was coded as the answer; for example, if a speaker said "*this is fennel; no no sorry this is chamomile*," then "chamomile" was coded as the answer.

2.5. Statistical models

For all analyses, we used linear mixed-effects regression with the lme4 package (Bates, Maechler, Bolker, & Walker, 2015) using R (R Core Team, 2014). All plots were generated with the R ggplot2 package (Wickham, 2016). In each model we included participant group (attar/cook/layperson) as a fixed effect and participant and odor stimulus as random effects with random slopes when justified and possible (Barr, Levy, Scheepers, & Tily, 2013). We additionally included other participant-based predictors (smoker status, age), item-based predictors (odor type, ratings of odor familiarity, frequency, intensity, etc.), and interactions between these predictors when a likelihood ratio test suggested that each added predictor contributed to a significantly better model fit. All model outcomes reported in the tables below use attars as the reference level for participant group; this means that, by default, our models evaluate the differences between attars and cooks and between attars and laypeople, but not between cooks and laypeople. To fully report pairwise effects of participant group, we also ran a second model for each analysis, identical to the default one, only this time with cooks as the reference level for participant group. The re-leveled models allow us to estimate the third pairwise difference (i.e., cooks vs. laypeople), which we always report in the results text. For simplicity, we only report significant effects in the results text, with the exception of the pairwise outcomes for participant group—non-significant results can be evaluated in the tables displaying full model outcomes (Tables 1–3).

Finally, due to the fact that nearly all of the attars in our sample were men and all the cooks were women (reflecting the sociological situation in Iran), we can only test for gender effects in the laypeople sample. Participant gender showed no significant impact in any of these extra analyses (odor naming accuracy, consistency, odor ratings, or odor awareness), which are included in the Supplementary Materials (Tables SM2a,b, SM4a,b, SM6a,b, and SM9).

3. Results

We first present the results of the odor naming tasks, then analyses of the odor ratings, and then finally turn to analyses of participants' odor meta-awareness. Data and scripts are available at https://github.com/marisacasillas/Attars-OdorNaming.

3.1. Odor naming: Accuracy

We modeled participants' responses (correct: 1 or incorrect: 0) on the first odor-naming task. Across all trials and participants, odors were correctly named 50% of the time. However, attars were correct on 75% percent of all trials, while cooks were only correct on 49% of trials, and laypeople on 39% of trials, with a range of 19%–94% correctness across the 44 individuals. Overall performance on individual odor stimuli also varied greatly, from 5% correct for rosemary to 89% correct for cinnamon, with a median correctness of 52% across odors (Fig. 1).

Table 1
Naming accuracy model output (N = 704; log-likelihood = −312)

Predictor	Estimate	*SE*	*z*	*p*
(Intercept)	−3.32	0.84	−3.97	<0.001
Group = *Cook*	−1.71	0.59	−2.89	<0.01
Group = *Layperson*	−2.11	0.55	−3.80	<0.001
Odor familiarity	0.68	0.11	6.24	<0.001
Odor frequency	0.17	0.07	2.30	0.02

Table 2
Response likelihood model output (N = 1,408; log-likelihood = −624)

Predictor	Estimate	*SE*	*z*	*p*
(Intercept)	−1.50	0.63	−2.38	0.02
Group = *Cook*	−0.85	0.60	−1.41	0.16
Group = *Layperson*	−1.05	0.52	−2.01	0.04
Odor familiarity	0.45	0.06	7.37	<.001
Odor frequency	0.24	0.05	4.48	<.001
Task order	−0.15	0.15	−0.99	0.32

Table 3
Naming consistency model output (N = 413; log-likelihood = −119).

Predictor	Estimate	*SE*	*z*	*p*
(Intercept)	1.17	1.28	0.91	0.36
Group = *Cook*	−1.21	1.16	−1.05	0.29
Group = *Layperson*	−2.17	1.01	−2.14	0.03
Odor familiarity	0.48	0.13	3.56	<0.001

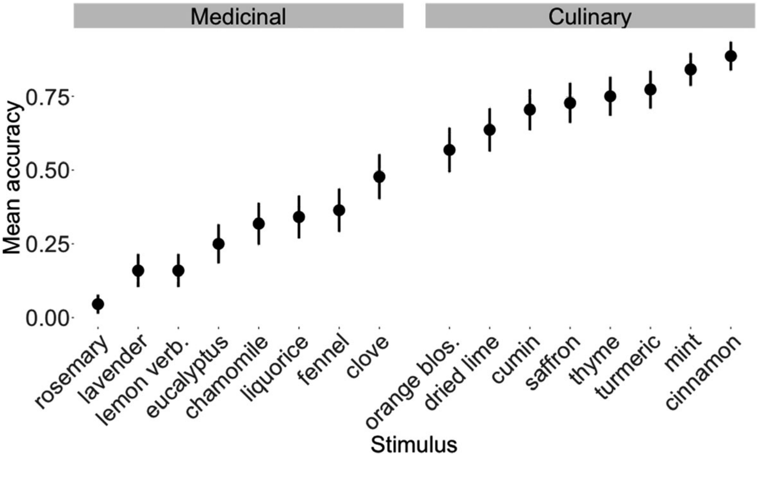

Fig. 1. Mean naming accuracy across all participants for the 16 odor stimuli.

When modeling these data statistically, we used participants' ratings of odor familiarity and frequency instead of an a priori designation of odor type (culinary vs. medicinal). As discussed above, many of the "medicinal" herbs and spices can be used in cooking and vice versa. The odor ratings provide a more direct and continuous estimate of participants' experience with the odors. Parallel models using odor type (medicinal/culinary) instead of odor familiarity and frequency are given in the Supplementary Materials and show broadly similar results (compare Tables 1, 2, and 3 to Tables SM1, SM3, and SM5, respectively).

To test our predictions about the effect of expertise and experience on odor naming, we built a logistic mixed-effects regression of naming correctness. Familiarity and frequency both improved model fit (familiarity: $\chi^2(1) = 85.24$, $p < 0.001$; frequency: $\chi^2(1) = 40.96$, $p < 0.001$), with frequency contributing significant explanatory value beyond familiarity alone ($\chi^2(1) = 5.35$, $p < 0.05$). The final model therefore included participant group (attar/cook/layperson), odor familiarity (numeric), and odor frequency (numeric), with random slopes of participant group for items. Although odor familiarity and odor frequency are correlated, their overlap in explained variance is not attributed to either predictor in a multiple regression in which they are both included; including both predictors yields interpretable coefficients for the explanatory power of each predictor individually (Wurm & Fisicaro, 2014).

The model revealed significant effects of expertise (attar/cook/layperson) and experience (odor familiarity and frequency; Table 1 and Fig. 2). As predicted, attars were significantly more accurate in naming odors than cooks ($B = -1.71$, $SE = 0.59$, $z = -2.89$, $p < 0.01$) and laypeople ($B = -2.11$, $SE = 0.55$, $z = -3.80$, $p < 0.001$), but cooks were not more accurate in naming odors than laypeople ($B = -0.40$, $SE = 0.46$, $z = -0.86$, $p = 0.39$). More familiar and more frequent smells were also named with significantly higher accuracy overall (familiarity: $B = 0.68$, $SE = 0.11$, $z = 6.24$, $p < 0.001$; frequency: $B = 0.17$, $SE = 0.07$, $z = 2.30$, $p < 0.05$).

Fig. 2B illustrates these findings in a raster plot that shows the relationship between familiarity ratings (*x*-axis), frequency ratings (y-axis), and correctness (tile color). Gray-colored tiles indicate correctness (dark gray = 100% correct; light gray = 0% correct), and white tiles indicate frequency-familiarity rating combinations that did not occur in the data. If familiarity were the only factor that determined accuracy, only tiles in the rightmost columns would appear dark gray. If instead frequency ratings were the only factor that determined accuracy, only tiles in the top rows would appear dark gray. If both factors were equally important for naming accuracy, the tiles would form an even gradient from dark gray in the upper-right corner to light gray in the lower-left corner. The two panels of Fig. 2 visualize each of the findings for naming correctness: (a) attars were overall more accurate than cooks and laypeople, but cooks and laypeople performed

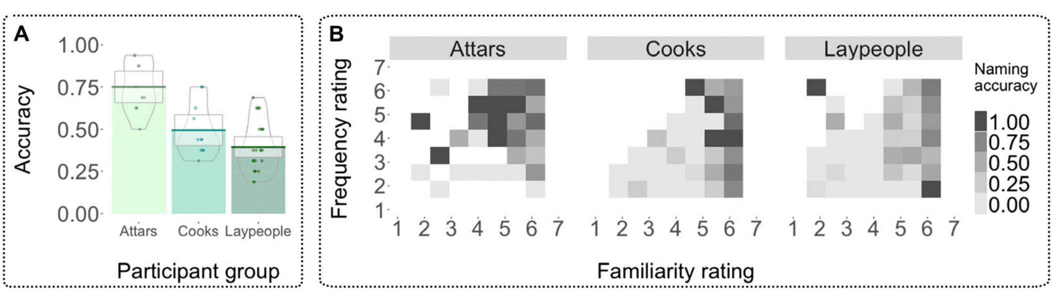

Fig. 2. Average odor naming accuracy (A) by participant group overall and (B) broken down by odor frequency and familiarity ratings (darker = higher accuracy; white = no data available for that rating combination).

similarly, and (b) both familiarity and frequency resulted in higher accuracy, but familiarity was overall a better predictor of naming accuracy than frequency.

3.2. Odor naming: Consistency

To investigate whether naming consistency is affected by expertise and experience, we first excluded cases in which consistency could not be computed; that is, cases when participants did not give a source label at all in either the first or second naming task (or no label in both). Of the remaining responses, a label was only considered consistent when the participants used it on both the first and second odor naming tasks, whether or not they were correct.

3.2.1. Likelihood of response

Participants provided source labels on both naming tasks 59% of the time, but this varied by expertise group and odor; while attars gave labels in both naming tasks in 78% of cases, cooks only did so in 58% of cases, and laypeople in only 50% of cases. To check whether these differences in responsiveness were reliable, we modeled the likelihood that participants gave a response using a logistic mixed-effects regression of whether a response was given (yes: 1 or no: 0). We included task number (first or second) in the base model because participants' likelihood of giving a response may have been influenced by the fact that they performed the naming task two separate times. In addition, familiarity and frequency both improved model fit (familiarity: $\chi^2(1) = 133.74$, $p < 0.001$; frequency: $\chi^2(1) = 95.04$, $p < 0.001$), with frequency contributing significant explanatory value beyond familiarity alone ($\chi^2(1) = 19.81$, $p < 0.001$). The final model therefore included fixed effects of participant group (attar/cook/layperson), odor familiarity (numeric), odor frequency (numeric), and task number (first or second), with random effects of participant and odor, plus random slopes by participant group for odors.

Participants were significantly more likely to give a response for odors rated as more familiar ($B = 0.45$, $SE = 0.06$, $z = 7.37$, $p < 0.001$) and more frequent ($B = 0.24$, $SE = 0.05$, $z = 4.48$, $p < 0.001$; Table 2 and Fig. 3). Attars were also significantly more likely to give a response than laypeople ($B = -1.05$, $SE = 0.52$, $z = -2.01$, $p < 0.05$), but not cooks ($B = -0.85$, $SE = 0.60$, $z = -1.41$, $p = 0.16$), with no difference in the likelihood of giving a response between cooks and laypeople ($B = -0.20$, $SE = 0.47$, $z = -0.43$, $p = 0.67$).

3.2.2. Consistency of response

When participants *did* give odor labels on both naming tasks for a stimulus, they overwhelmingly gave the same label on both trials: 95% of labels were consistent for attars, 91% for cooks and 85% for laypeople, with a range of 50%–100% consistency across individuals ($M = 89\%$), and 60%–97% across odors ($M = 87\%$).

Using the same model-building process, we investigated participants' odor naming consistency (same source label across tasks 1 and 2, scored as consistent: 1 and inconsistent: 0). Odor familiarity improved model fit ($\chi^2(1) = 13.09$, $p < 0.001$). The final model therefore included fixed effects of participant group (attar/cook/layperson) and odor familiarity (numeric), with random effects of participant and odor, plus random slopes by participant group for odors.

Attars' responses were significantly more consistent than laypeoples' ($B = -2.17$, $SE = 1.01$, $z = -2.14$, $p < 0.05$) but not cooks' ($B = -1.21$, $SE = 1.16$, $z = -1.05$, $p = 0.29$), with no difference in cooks' and laypeoples' consistency ($B = -0.95$, $SE = 0.67$, $z = -1.42$, $p = 0.16$). Overall, participants were also significantly more consistent in their responses for familiar odors ($B = 0.48$, $SE = 0.13$, $z = 3.56$, $p < 0.001$; Table 3 and Fig. 4).

Collectively, these findings show that attars are significantly more accurate than both cooks and laypeople in naming herb and spice odors, and they are also more likely to respond and more likely to respond consistently when naming herb and spice odors compared to laypeople. The results also suggest that, for all participant groups, more frequent odors and *especially* more familiar odors result in more naming responses, and responses that are more accurate and consistent. Are these differences in accuracy, responsiveness, and consistency also reflected in the way participants perceived the odors? To test this, we turned next to participants' odor perception ratings.

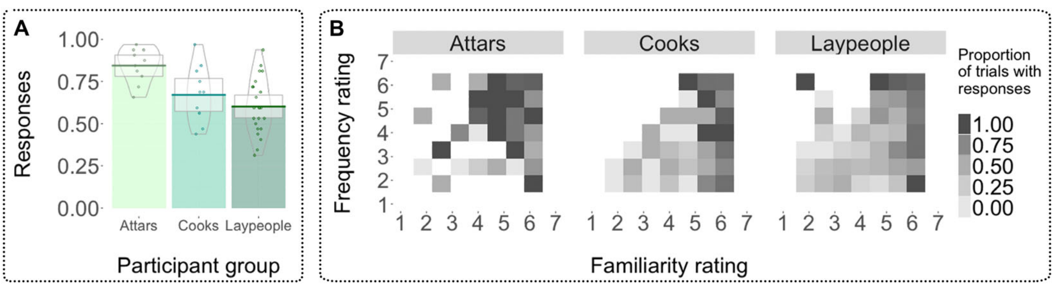

Fig. 3. Average responsiveness (A) by participant group overall and (B) broken down by odor frequency and familiarity ratings (darker = more responses; white = no data available for that rating combination).

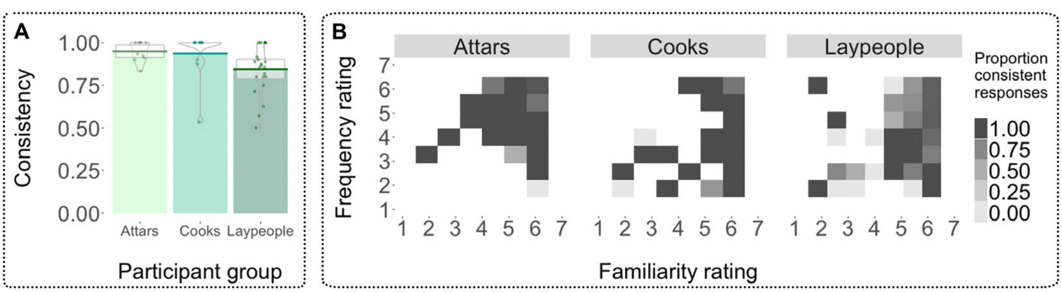

Fig. 4. Average response consistency (A) by participant group overall and (B) broken down by odor frequency and familiarity ratings (darker = more responses; white = no data available for that rating combination).

3.3. Odor ratings

We modeled each of the six odor ratings individually but used identical fixed-effects structures across the models to more easily compare the findings. Each regression included fixed effects of participant group (attar/cook/layperson), odor type (medicinal/culinary), an interaction of participant group and odor type, and participant age (centered numeric), plus random effects of participant and odor, with random slopes by participant group for odor. The only exception to this pattern was the model for edibility, which did not converge with the random slopes of participant group for odor. Smoker status did not significantly contribute to any of the ratings models and so was left out of these analyses. Regressions of the raw rating data resulted in highly skewed residual errors, so all ratings were square-transformed (e.g., intensity^2) in the final models. We give an overview of the results here; the output of each individual model is given in the Supplementary Materials (Table SM7; see Fig. 5).

3.3.1. Odor frequency and familiarity

Attars rated odors as significantly more frequent than both cooks ($B = -13.36$, $SE = 3.92$, $t = -3.40$) and laypeople ($B = -17.86$, $SE = 3.60$, $t = -4.96$), though cooks

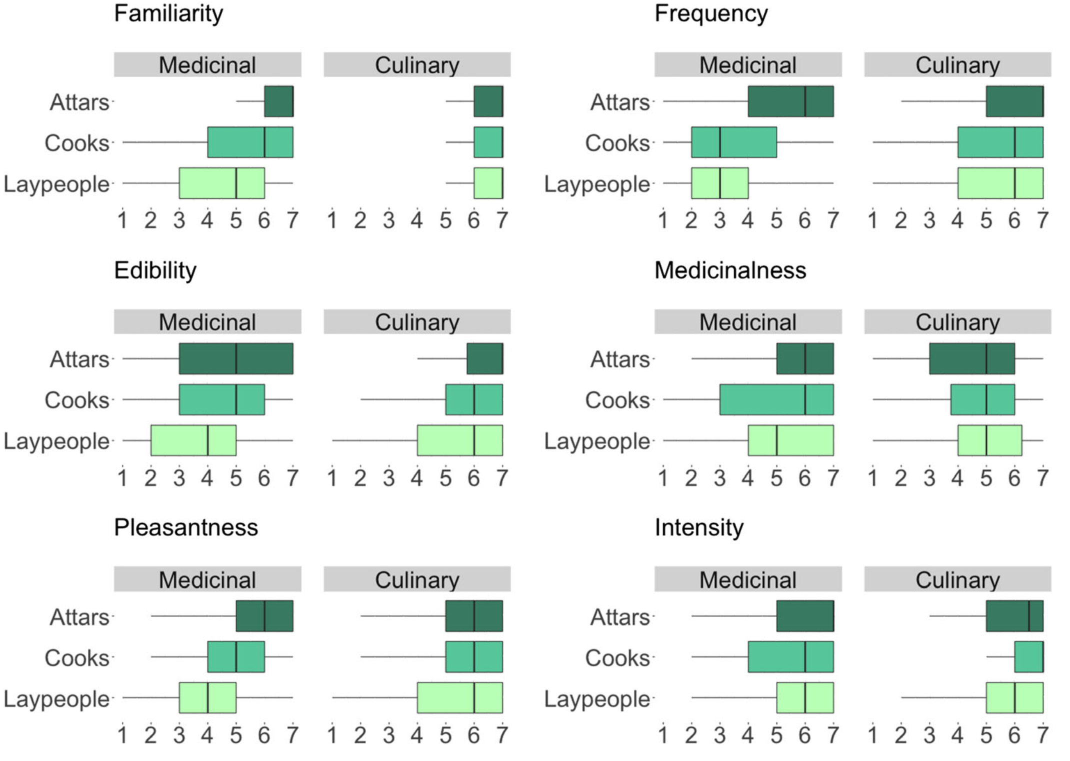

Fig. 5. Boxplots of the ratings (1–7) for the six perceptual judgments grouped by medicinal and culinary herbs and summarized across the three participant groups.

and laypeople showed no difference in odor frequency ratings ($B = -4.50$, $SE = 3.19$, $t = -1.41$). However, when it came to odor familiarity, attars only rated odors as more familiar than laypeople ($B = -13.03$, $SE = 3.78$, $t = -3.45$), but not cooks ($B = -7.21$, $SE = 3.94$, $t = -1.83$), with no difference in familiarity ratings between cooks and laypeople either ($B = -5.82$, $SE = 3.33$, $t = -1.75$). Attars also rated medicinal odors as significantly more frequent and familiar than both cooks (frequency: $B = 9.46$, $SE = 4.08$, $t = 2.32$; familiarity: $B = 9.70$, $SE = 3.92$, $t = 2.48$) and laypeople (frequency: $B = 9.70$, $SE = 4.14$, $t = 2.34$; familiarity: $B = 12.20$, $SE = 4.33$, $t = 2.82$). There were no different effects of odor frequency and familiarity between cooks and laypeople (all $|t|$'s < 0.9).

3.3.2. Odor edibility and medicinalness

Attars rated the whole set of odors as more edible than laypeople ($B = -10.03$, $SE = 3.16$, $t = -3.17$), but not cooks ($B = -4.14$, $SE = 3.87$, $t = -1.07$), and cooks' and laypeoples' edibility ratings were not significantly different ($B = -5.88$, $SE = 3.41$, $t = -1.72$). When it came to medicinalness ratings, none of the three groups significantly differed from each other (attars-vs,-cooks: $B = -8.38$, $SE = 4.64$, $t = -1.81$; attars-vs.-laypeople: $B = -5.68$, $SE = 3.92$, $t = -1.45$; cooks-vs.-laypeople: $B = 2.70$, $SE = 3.96$, $t = 0.68$). Across the board, medicinal odors were rated as significantly less edible ($B = 13.04$, $SE = 2.91$, $t = 4.48$) and more medicinal ($B = -10.97$, $SE = 3.75$, $t = -2.93$) than culinary odors. Attars also rated medicinal odors as significantly more medicinal than culinary odors compared to both cooks ($B = 9.74$, $SE = 3.92$, $t = 2.48$) and laypeople ($B = 9.15$, $SE = 3.63$, $t = 2.52$). However, attars' ratings for the edibility of medicinal odors did not differ from the ratings given by cooks and laypeople ($|t|$'s < 0.4), with cooks and laypeople otherwise giving similar ratings to each other on the edibility and medicinalness of medicinal odors ($|t|$'s < 0.6).

3.3.3. Odor pleasantness and intensity

Attars rated odors as significantly more pleasant overall than cooks and laypeople (cooks: $B = -9.59$, $SE = 3.87$, $t = -2.48$; laypeople: $B = -14.23$, $SE = 3.31$, $t = -4.30$), whereas cooks and laypeople gave similar pleasantness ratings ($B = -4.64$, $SE = 3.10$, $t = -1.49$). Laypeople also rated medicinal odors as significantly less pleasant than culinary odors compared to attars ($B = 10.60$, $SE = 3.57$, $t = 2.97$) with cooks showing a similar, but more attenuated pattern ($B = 7.61$, $SE = 3.93$, $t = 1.94$), and with no difference between cooks and laypeople ($B = 2.99$, $SE = 2.71$, $t = 1.10$). For odor intensity, there was a small but significant decrease in ratings with age ($B = -0.18$, $SE = 0.07$, $t = -2.43$). Cooks also rated culinary odors as being marginally more intense smelling than medicinal odors compared to attars, whose intensity ratings were more similar for culinary and medicinal odors ($B = 8.64$, $SE = 4.40$, $t = 1.96$), with laypeople showing a similar but weaker effect ($B = 6.67$, $SE = 4.67$, $t = 1.43$), and no difference between cooks and laypeople ($B = -1.97$, $SE = 2.19$, $t = -0.90$).

3.3.4. Summary

Across the board, participants distinguished culinary and medicinal odors when asked to rate them as edible or medicinal, but attars showed several differences from the other two groups when it came to medicinal odors. Attars consistently rated medicinal odors as significantly more medicinal, familiar, frequent, pleasant, and less intense than the other two groups. Attars were also more likely overall to rate odors as more edible and familiar than laypeople (but not cooks), and more pleasant and more frequent compared to both cooks and laypeople. Finally, we found a small, but significant decrease in odor intensity ratings with age.

3.4. Odor meta-awareness ratings

We then modeled participants' odor meta-awareness responses with a linear mixed-effects regression including fixed effects of participant group (attar/cook/layperson) and age (centered numeric), plus random effects of participant and survey question, and random slopes by participant group for survey questions (see Tables SM8–SM9 and Fig. SM1 for more details).

Attars reported significantly higher overall odor awareness compared to laypeople ($B = -0.51$, $SE = 0.25$, $t = -2.02$) but not cooks ($B = -0.32$, $SE = 0.31$, $t = -1.03$), with no significant difference between cooks' and laypeoples' odor awareness ($B = 0.19$, $SE = 0.27$, $t = 0.70$) and no effect of age ($B = 0.003$, $SE = 0.01$, $t = 0.37$). So attars, but not cooks, showed significantly higher meta-awareness of odors compared to laypeople, with no significant difference between attars' and cooks' ratings.

4. Discussion

Although both attars and cooks could plausibly be better at naming herbs and spices than laypeople, only attars showed a significant advantage in naming odors and, in fact, outperformed both laypeople and cooks. This is in line with evidence from other domains showing that the type of expertise and experience individuals have with stimuli matters for how they categorize them (e.g., Bailenson et al., 2002; Medin et al., 1997). Attars were more likely to produce a name for each odor, and when they produced a label it was more likely to correctly name the source. All participants were tested on their odor naming twice over the course of the experiment. Consistency was high overall and the only between-group differences in odor naming consistency were between attars and laypeople, suggesting that, generally, participants only produced labels on trials when they were confident of the odor's name. When it came to odor meta-awareness ratings and perceptual judgments of the odor stimuli, we also found that attars diverged from cooks and laypeople, reporting higher overall odor awareness than laypeople and shifted perceptual judgments, in particular of medicinal odors, compared to both cooks and laypeople. This raises the question of whether differences in odor perception and meta-awareness might underlie attars' superior odor naming.

Smeets et al. (2008) found that higher overall odor awareness correlated with higher overall olfactory function, as measured by the Sniffin' Sticks test, which includes an odor identification task (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997). Their finding suggests that higher odor awareness might be related to better odor naming. However, a later study specifically examining the relationship between odor awareness and odor identification, where participants had to choose between 90 different odor labels, found no relationship between odor awareness and identification, even though the study had greater power in both participants and items (Demattè et al., 2011). Since Smeets et al.'s (2008) original study combined measures of olfactory detection, discrimination, and identification, it is possible that higher odor awareness is only related to odor detection and discrimination, but not odor-related language use. Therefore, although it is intriguing that the attars report higher odor awareness as well as demonstrating superior odor naming, these may be unrelated effects.

Compared to the other two groups, attars also judged the odors in our task to be more familiar, frequent, and pleasant overall, especially medicinal odors. They also judged the odors to be more edible overall, and the medicinal odors as more medicinal than both cooks and laypeople. Surprisingly, in this context, we did not find any large group-based differences in intensity ratings; attars did not judge odors to be overall more intense than cooks or laypeople. Given that attars' formal knowledge of the medicinal uses of herbs distinguishes them most sharply from the other groups in our study, these differences are noteworthy.

Odor familiarity and frequency are known to correlate with odor naming, as are odor pleasantness and intensity judgments (see, e.g., Cain et al., 1994; Distel et al., 1999; Distel & Hudson, 2001; Knaapila et al., 2017; Lawless, 1978; Lawless & Cain, 1975; Rabin & Cain, 1984; Wijk & Cain, 1994; but see also Delplanque et al., 2015, 2008; Ferdenzi et al., 2013). It is unclear from our data whether attars rated odors as more familiar, frequent, and pleasant because they were able to name them, or whether they could name them because the odors were more familiar, frequent, and pleasant to them (or whether there is some other common cause for all of these effects). There is independent evidence showing that the presence of a label influences perceptual judgments (e.g., Distel & Hudson, 2001; Herz, 2003). For example, people rate odors as more familiar, pleasant, and intense when they are given a label, even when the label is a poor fit to the smell (Distel & Hudson, 2001). Relatedly, different labels for the same odor can change both its pleasantness ratings and corresponding brain activation (e.g., de Araujo, Rolls, Velazco, Margot, & Cayeux, 2005; Herz & Clef, 2001). Taken together, this suggests that attars' advantage in naming odors leads to changes in the perception of the odors, though this proposal would have to be tested directly in future studies.

We found differences in pleasantness judgments between attars and the others, but no differences in intensity judgments. These results stand in stark contrast to the findings of Sezille et al. (2014), who found only weak evidence of expertise on pleasantness judgments, but significant differences on judgments of intensity; that is, perfumers rated odors as more intense than laypeople. In the current study, our odors were at ceiling for intensity ratings (ensuring all participants could detect the odor), whereas those from Sezille and colleagues were not. It could therefore be the case that we simply did not have the variance needed to detect possible differences in intensity judgments. But why did Sezille and colleagues fail to find equivalent differences in pleasantness ratings? There are a number of methodological differences between the two studies that might account for this. We employed natural herbs and spices that were known (though not equally familiar) to all participants, but Sezille and colleagues used chemical compounds that may have only been known to the perfumers and flavorists in their study. We compared attars (i.e., herbalists) to cooks and laypeople, whereas Sezille and colleagues tested perfumers, flavorists, cooks, and laypeople. The studies also differed in precisely how they measured perceptual judgments and odor naming. Any one of these factors could make a critical difference.

It is striking, then, that despite the differences between the studies, cooks do not appear to differ from laypeople in either case. This raises the question about what exactly differentiates cooks from other sorts of odor/flavor experts. In the context of our own study, attars' and cooks' expertise differs in at least two respects: (a) their knowledge about how herbs and spices affect the body, and (b) their communicative practices around herbs and spices. As outlined in the Introduction, attars have to formally communicate about herbs and spices as part of their everyday interactions. The typical Iranian cook, on the other hand, learns her craft informally at home, where frequent communication about ingredients is not a requirement of her being able to produce delicious dishes. Although requesting herbs and spices might happen on occasion—when going to the market, for example—a cook will go through the steps of producing a dish numerous times per day without needing to directly communicate about it. Sezille et al.'s (2014) "trainee cooks" differ in some respects from the Iranian ones, since they were recruited from a cookery institute where they received formal instruction. But, like the Iranian cooks, they did not receive specific linguistic training about odors. On the other hand, Knaapila et al. (2017) find that Finnish non-experts who cook with herbs and spices more regularly are also more accurate in identifying those sources when given a closed set of options. Our cooks and laypeople groups could also be characterized, respectively, as "regular" and "non-regular" herb and spice users (as in Knaapila et al., 2017), but we find no significant difference in naming accuracy between the two groups. So, given the current evidence, it seems that mere exposure to a variety of odors in the context of acquiring a procedural skill is not enough to increase a person's ability to name or identify odors. To be a better odor namer, communicative practice is required. How much practice, and what type is needed to improve odor naming, remain open questions.

Attars also have richer knowledge about herbs and spices than cooks do, including the causal role they play on bodily functions. Having access to more richly structured knowledge may also affect odor naming. There are three separate traditions of medicine in Iran that live side-by-side: humoral, sacred, and modern (Good, 1977). According to the classical humoral model, health is achieved by maintaining balance between hot-cold and wet-dry. Herbs and spices, as well as other food and medicine, are used to keep the body in equilibrium (Foster, 1987); herbs and spices can be imbibed to regulate bodily humors. More recently, however, herbs are also being thought of in psycho-pharmacological terms

(Miraldi, Ferri, & Mostaghimi, 2001). Attars, then, have a well-articulated belief system regarding the function of common herbs and spices on the body, making their concomitant semantic network more entrenched. This elaborated knowledge could provide a richer context for each odor, and thus make odor name retrieval easier. Interestingly, because cooks also typically play a matriarchal role in their families, they are likely to be familiar with common herbal remedies, possibly resulting in a subset of overlapping knowledge with the attars.

We were unable to fully investigate how participant age and gender interact with odor expertise in the current study, but analyses of the laypeople group suggests that neither factor significantly influences odor naming in this sample. A decline in olfactory performance, including odor naming and odor identification, is known to occur in the elderly (Larsson, Finkel, & Pedersen, 2000; Lehrner, Glück, & Laska, 1999); in our study odor intensity ratings did decline significantly with age. However, the effect size was minute (0.18 on a scale of 1–7) and, if anything, would be more likely to cause detriment to the two higher-performing groups (attars and cooks), which included most of the 60+ participants in the overall sample. Prior work has also shown that females often display better performance than males on a variety of olfactory tasks, including both odor naming and odor identification (e.g., Cain, 1982; Cain, Goodspeed, Gent, & Leonard, 1988; Öberg, Larsson, & Bäckman, 2002). However, these effects are small (Sorokowski et al., 2019) and may be due to a number of factors including neural anatomy, gender socialization, hormonal status, other general cognitive differences (e.g., memory consolidation), or an interaction of these factors (Majid, Speed, Croijmans, & Arshamian, 2017). Notably, the bias for female participants to perform better on olfactory tasks runs counter to the pattern of results found in the present study: There was only one female participant in the highest performing group.

The current study addresses a major question for the science of human cognition—why is it so difficult for most people to talk about odors (Majid et al., 2018)? Multiple accounts have been proposed to explain odor ineffability (e.g., Engen, 1987; Köster et al., 2014; Lorig, 1999; Olofsson & Gottfried, 2015; Young 2019). However, a growing number of studies across a variety of communities demonstrates that the ability to talk about odors is strongly influenced by the rich, structured knowledge that accompanies both professional expertise (e.g., Croijmans & Majid, 2016; Knaapila et al., 2008, 2017; Parr et al., 2002; Royet, Delon-Martin, & Plailly, 2013; Sezille et al., 2014; Urdapilleta et al., 2011; Zucco et al., 2011) and entrenched cultural and linguistic practices (e.g., Floyd et al., 2018; Majid & Burenhult, 2014; Majid et al., 2018; O'Meara et al., 2019; Wnuk & Majid, 2014; see Majid, 2015 for a review).

This study aimed to untangle whether everyday odor experience, encyclopedic expertise about odors, or some combination of these two factors influences participants' naming ability and perception of odors, thereby tapping into systems of categorization that may be differently structured, transmitted, and represented across people (cf. Glushko et al., 2008). Compared to groups who acquire and use an odor lexicon as part and parcel of their language socialization (e.g., the Jahai), prior work has shown that those who work formally with odors as part of their profession (e.g., wine and coffee experts, perfumists, and flavorists) display weaker increases in their odor naming ability. Our results, gathered from a novel group of odor experts, contrast with these prior findings in that they show a significant and consistent benefit of expertise on both odor naming and odor perception.

Consistent with prior work (e.g., Knaapila et al., 2017), we also find that, overall, experience does matter for odor naming. However, we find that expertise outweighs experience alone in boosting both odor perception and naming: Despite overall effects of familiarity and frequency, there were few differences in the performance of cooks and laypeople, whose daily experience with herbs and spices differs greatly. Our findings suggest that structure in the world alone is not sufficient to structure cognition (Berlin, 2014); cultural and institutionalized knowledge are critical (e.g., ojalehto & Medin, 2015). In a nutshell, daily experience is no substitute for formal expertise in accurately naming odors.

The current findings suggest a number of interesting and relevant follow-ups. Future studies could better integrate individuals' knowledge and the role it plays in odor naming. This follow-up would be a particularly interesting avenue to explore cross-culturally. Converging cross-cultural evidence from other groups with significant odor expertise and experience would bring new insights to findings from the current study. Training studies may also be a revealing avenue for investigating the extent to which exposure and expertise influence naming while avoiding confounds with age, gender, and self-selection that may arise in naturally occurring expert sub-cultures, as is the case with the attars and cooks in the current study (cf. Morquecho-Campos, Larsson, Boesveldt, & Olofsson, 2019). Finally, future work on odor naming should examine the domain-specificity of experts' superior naming abilities, considering that experts' improved odor descriptions appear to be limited to their own domain of expertise (e.g, Croijmans & Majid, 2016).

To conclude, odor naming is difficult for most people, but some groups appear to get beyond this limitation. The current study sheds further light on the type of expertise and experience that affect olfactory functions. Compared to cooks or laypeople, attars (Iranian herbalists) are better at odor naming, have different perceptual judgments of odors, and are more aware of odors in their everyday lives.

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Notes

1. Correctness $\sim$ Group + Familiarity + Frequency + (1 | Participant) + (1 + Group | Odor).

2. ResponseGiven ~ Group + Familiarity + Frequency + TaskNumber + (1 | Participant) + (1 + Group | Odor).
3. Consistency ~ Group + Familiarity + (1 | Participant) + (1 + Group | Odor).

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Supporting Information

Additional Supporting Information may be found online in the supporting information tab for this article:

Supplementary Materials A: Extra models: Naming accuracy.

Supplementary Materials B: Extra models: Likelihood of response.

Supplementary Materials C: Extra models: Naming consistency.

Supplementary Materials D: Full model outcomes: Odor ratings.

Supplementary Materials E: Extra models: Odor meta-awareness ratings.