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Wine Experts' Recognition of Wine Odors Is Not Verbally Mediated

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Experts have better memory for items within their domain of expertise. Critically, this does not depend on more efficient use of language. However, this conclusion is based mainly on findings from experts in visual and auditory domains. Olfactory experts constitute an interesting potential counterexample since language has been implicated to be critically involved in odor memory in previous studies. We examined the role language plays in odor recognition memory for wine experts, who typically display better wine odor memory than novices and who are also able to name odors better than lay people. This suggests wine experts' superior recognition memory for odors may be verbally mediated. In 2 experiments, recognition memory for wine odors, wine-related odors, and common odors was tested in wine experts and novices. The use of language was manipulated in Experiment 1 with an overt naming versus no-naming condition, and in Experiment 2, with a verbal interference task inhibiting covert verbalization. Across the two experiments the results showed wine experts have better recognition memory for wines, but not for wine-related or common odors, indicating their memory advantage is expertise specific. Critically, this effect was not verbally mediated, as there was no relationship between experts' ability to name wines and their memory for them. Likewise, directly inhibiting online use of verbalization did not affect memory for wine odors in experts. In sum, once expertise has been acquired, language does not play a causal role in recognition memory for odors.

Keywords: olfaction, expertise, memory, language, wine

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It is well known that expert populations across domains provide a window into how dedicated training and deliberate practice can dramatically affect cognition, including language and memory (Ericsson & Charness, 1994; Ericsson, Prietula, & Cokely, 2007). This is especially true for memory functions. For example, musicians have enhanced memory for musical pieces (Williamson, Baddeley, & Hitch, 2010), interpreters have increased memory for words (Christoffels, de Groot, & Kroll, 2006), and servers for customers (Bennett, 1983; Ericsson & Polson, 1988). Research with chess grandmasters has been especially instrumental in understanding the mechanisms underlying expert memory effects (Chase & Simon, 1973; de Groot, Gobet, & Jongman, 1996; Gobet, 1998; Vicente & de Groot, 1990). Critically, studies have shown that chess experts' memory for chess positions is independent of online language use (Saariluoma, 1992), and that taxi drivers (i.e., route experts) store street names in a spatial, not semantic format (Kalakoski & Saariluoma, 2001).

This is in stark contrast to memory functions in novices where language is critical for the online processing of episodic memories

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(Schrauf, 2002; Schrauf, Pavlenko, & Dewaele, 2003). Thus domain-specific memory in expert populations seems to draw on mechanisms that do not involve language. However, there are good reasons to think that odor memory in olfactory experts may depend more on language functions than expert memory in other domains. There is a duality and malleability in the relationship between olfaction and language that is unique. For example, while the link between odors and their names is extremely weak in Westerners (Olofsson & Gottfried, 2015; Yeshurun & Sobel, 2010), other communities can name odors with relative ease (Majid & Burenhult, 2014; Majid & Kruspe, 2018; Majid et al., 2018; O'Meara & Majid, 2016; Wnuk & Majid, 2014). In particular, people who practice hunting-gathering as their main mode of subsistence seem to be particularly adept in talking about smells (Majid & Kruspe, 2018; Majid et al., 2018). Similarly, while lay people struggle to name odors, even sommelier students have no problem doing so (Poupon, Fernandez, & Frasnelli, 2019). Moreover, it seems that the sense of smell may be exceptionally malleable (Damm et al., 2014; Hummel et al., 2009; Majid, Speed, Croijmans, & Arshamian, 2017; Mouly & Sullivan, 2010) and particularly susceptible to linguistic context (Herz, 2003; Speed & Majid, 2019a). Given these unique characteristics, odor experts are an ideal candidate group to challenge the notion that expert memory does not depend on online language functions. Before presenting new empirical evidence to address this issue, we first outline evidence for and against the possibility that olfactory memory in experts relies on odor naming.

Evidence That Odor Naming Enhances Odor Memory Functions

Language is known to enhance odor recognition memory in novices. For example, many studies demonstrate that when novices describe an odor accurately, they also have better recognition memory for that odor across short as well as long retention intervals (Cessna & Frank, 2013; Cornell Kärnekull, Jönsson, Willander, Sikström, & Larsson, 2015; Jehl, Royet, & Holley, 1997; Larsson, 1997; Olsson, Lundgren, Soares, & Johansson, 2009; Russell & Boakes, 2011). Likewise, several studies show that when participants label odors, they remember them better compared to when the odors are not labeled or when the label is incorrect (Cessna & Frank, 2013; R. A. Frank, Brearton, Rybalsky, Cessna, & Howe, 2011; Jehl et al., 1997; Lehrner, Glück, & Laska, 1999; Olsson et al., 2009; Russell & Boakes, 2011). Other evidence for a role for language in olfactory memory comes from verbal interference studies. Walk and Johns (1984) found recognition memory for odors was reduced when participants named an additional, unrelated odor during the encoding phase. In line with this, two later studies (Annett, Cook, & Leslie, 1995; Perkins & Cook, 1990) found an unrelated verbal interference task during odor encoding task led to poorer odor recognition (but see Annett & Leslie, 1996).

Evidence That Odor Naming Does Not Enhances Odor Memory Functions

At the same time, there is evidence that odor naming does not enhance memory. When lay people are asked to recognize an odor that was encoded using only the name of the odor compared to an actual odorant, memory performance drops (Cleary, Konkel, Nomi, & McCabe, 2010). Similarly, Poupon et al. (2019) found that within 2 months of training, student sommeliers had improved odor naming abilities, but showed no corresponding improvement in odor memory, suggesting these two expert skills are unrelated. Evidence suggests that mental simulation of odor—automatically activating olfactory representations during language comprehension—is difficult (Speed & Majid, 2018; Speed & Majid, 2019b). Evidence also indicates that conscious odor images—that is, an active odor representation without the presence of the actual odor—are particularly difficult to evoke from language (Stevenson & Case, 2005; Stevenson, Case, & Mahmut, 2007; Stevenson & Mahmut, 2013), possibly more difficult than imagery in other modalities (cf., Arshamian & Larsson, 2014; Arshamian, Olofsson, Jönsson, & Larsson, 2008). For example, while the vividness of mental imagery for vision and audition increases during development, odor imagery remains poor throughout (Arshamian, Manko, & Majid, 2020). This indicates that changes in language development, such as increased vocabulary, do not directly enhance odor imagery. This view is reinforced by brain imagining studies with olfactory experts (such as perfumers)—who are objectively better at odor imagery than novices. Such studies reveal that changes in odor imagery are not driven by changes in semantic processing, but perceptual processing instead (Delon-Martin, Plailly, Fonlupt, Veyrac, & Royet, 2013; Plailly, Delon-Martin, & Royet, 2012). These examples suggest that odor memory is, first and foremost, perceptually driven and that relying on an odor label will not be sufficient to efficiently encode or retrieve an episodic odor memory.

Wine Experts' Memory May Rely More on Language Than Memory in Other Experts

While the above summary presents a mixed view on the relationship between language and odor memory, evidence suggests that specific expert subgroups may rely more strongly on a verbal code in episodic odor memory than novices do. Wine experts constitute a subculture as they have their own rituals, practices, and language use (Silverstein, 2004, 2006). For this group olfaction plays an important role. For example, they rely heavily on their sense of smell in order to distinguish and categorize wines (Herdenstam, Hammarén, Ahlström, & Wiktorsson, 2009; Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013). Smell is important both in orthonasal olfaction (i.e., sniffing wine in a glass) and retronasal olfaction (i.e., where odors pass to the olfactory epithelium via the mouth). Indeed, wine experts report higher odor awareness than novices (Croijmans & Majid, 2016), suggesting they are more preoccupied with their sense of smell. Importantly, there is also evidence that wine experts describe wine odors more consistently than novices (Croijmans & Majid, 2016), and use more precise and specific terms in their descriptions (Chollet & Valentin, 2000; Lawless, 1984; Lehrer, 2009; Melcher & Schooler, 1996; Sezille, Fournel, Rouby, Rinck, & Bensafi, 2014; Solomon, 1990, 1997; Zucco, Carassai, Baroni, & Stevenson, 2011). In fact, their descriptions of wine are informative enough to predict attributes of the wine itself (e.g., color, grape variety, country of origin) from wine reviews (i.e., text) alone (Croijmans, Hendrickx, Lefever, Majid, & Van den Bosch, 2019; Hendrickx, Lefever, Croijmans, Majid, & Van den Bosch, 2016; Hu, 2018).

Importantly, these improvements are seen not only in odor language, but also in odor memory. For example, wine experts have better recognition for wine flavors than wine intermediates and novices (Melcher & Schooler, 1996), even in a delayed match-to-sample paradigm (Zucco et al., 2011). Wine experts also have better memory for aromas that can be recognized in wine (i.e., wine-related odors), such as vanilla, buttery, and horsey aromas (Parr, Heatherbell, & White, 2002; Parr, White, & Heatherbell, 2004), and there is some evidence that wine experts are better at recognizing common odors than novices (Bende & Nordin, 1997). This latter finding is at odds with the wider literature, since most studies show expert memory is domain specific (cf., Kimball & Holyoak, 2000). For example, expert chess players have better memory for chess positions, but not for randomly placed pieces (i.e., in nonmeaningful positions) on a chess board (Chase & Simon, 1973). Similarly, because wine expertise involves a tightly structured linguistic community (Lehrer, 2009), descriptions for wine are more consistent among wine experts, but not descriptions for coffee or common odors (Croijmans & Majid, 2016). In other words, it could be argued that better odor recognition memory for wine odors by wine experts is mediated by odor naming.

Few studies have tested this possibility, and the ones that have show mixed results. Melcher and Schooler (1996) found that although wine experts have better memory for wines they tasted, giving a verbal description (overt naming) did not improve memory compared to a nonverbal condition. Similarly, Parr and colleagues (2002) did not find direct evidence for a relationship between the ability to name wine-related odors and subsequent memory for those odors. In contrast, Parr et al. (2004) found recognition memory for wine-related odors (e.g., vanilla) was better when participants overtly named odors than when they made pleasantness judgments. This was true for both experts and novices, although experts showed superior recognition for wine-related odors overall. So it remains unclear to what extent language plays a role in expert odor memory.

The Current Research

In this article, we test the role of language in wine experts' odor memory in two experiments. In Experiment 1, we first asked if we could replicate wine experts' better odor recognition memory for wine odors, wine-related odors, and common odors. We did this using a language manipulation task. One group of participants overtly named the odors during encoding (naming condition), while the other group only smelled the odors (no-naming condition). If odor recognition memory depends on naming odors, recognition of odors should be better when odors are explicitly named. We further predicted that wine experts would outperform novices in the odor recognition task, but only for wines and wine-related odors.

In Experiment 2, the causal role of verbalization in odor recognition memory was tested for wines and common odors using a verbal interference paradigm. Specifically, we asked if covert speech—as induced by subvocalization—mediated the odor recognition memory advantage in experts. We also included a visual interference task that let us control for the effects of a dual-task on working memory. We hypothesized that if language is involved in odor memory, then (a) wine experts' recognition memory for wine odors would be correlated with their ability to describe wine odors, and critically (b) their odor recognition memory would be worse under verbal interference than under visual interference. If, on the contrary, wine experts' odor memory is independent of the ability to name odors, we expect (a) no association between odor naming and memory, and (b) no difference between odor recognition memory under verbal interference and visual interference.

Experiment 1

Method

Participants. Twenty-four of the 48 participants were experts (6 women, $M_{age} = 49$, $SD = 9$, age range 29–60), and worked as qualified vinologists, sommeliers or wine producers. The remaining 24 were novices (6 women, $M_{age} = 47$, $SD = 13$, age range 26–71). Expert participants were recruited by active approach in wine shops and vineyards, via social media networks, and via word-of-mouth advertising. Novices were recruited via the university's participant system and social networks. To confirm wine expertise, all participants completed a questionnaire assessing their knowledge of wine (i.e., the Wine Knowledge Test, based on Hughson & Boakes, 2001; Lehrer, 1983; Melcher & Schooler, 1996; and previously used in Croijmans & Majid, 2016). The Wine Knowledge Test has a minimum score of 0 and maximum score of 15, where the maximum score indicates all questions were answered correctly. Because the data was severely skewed, a nonparametric Mann–Whitney U test was used to confirm wine experts had significantly higher wine knowledge ($M = 14.5$, $SD = .59$) than novices ($M = 7.2$, $SD = 2.80$), $U = .00$, $p < .001$, $r = .87$.

All participants were native speakers of Dutch, and were paid with a €15 shopping voucher. All participants were informed about the methods and task, and signed informed-consent forms before they began. The project was approved by the Ethics Assessment Committee of the Centre for Language Studies at Radboud University.

Materials. Forty-eight odors were used. There were 16 wines, eight red and eight white, selected for their distinctiveness based on origin and grape variety. The wines were bought as bag-in-box wines, to be minimize oxidization during the duration of the experiment.[1] In addition, there were 16 wine-related odors from the "*Le nez du vin*" kit (Lenoir, 1995), that is, aromas that can be found in wine, including wine faults. Finally, there were 16 common odors considered to be of relatively high familiarity for Dutch participants. The common odors varied in pleasantness, and were real odor objects, that is, products with a smell. All stimuli, including the wines, were presented in small 30-ml brown screw-top jars. A small tuft of scentless polyester hollow fiber in each jar obscured the object inside so the participant could not see it.

From the total stimulus set of 48 odors, we randomly selected a set of 24 odors so we had eight wine odors (4 white and 4 red wines), eight wine-related odors, and eight common odors at the encoding phase. A different random set of odors was selected for each expert leading to 24 different random order of presentation at encoding; each expert was yoked to a novice who received the

[1] See Tables S1.1, S1.2, and S1.3 in the online supplemental materials for a detailed description of the stimuli used in Experiment 1.

same random order. Participants received the full set of 48 odors at the recognition phase, presented in different random order for each yoked pair of expert and novice.

Procedure. The experiment followed a classic recognition memory paradigm (Figure 1). Participants were first informed they had to memorize a set of odors, without being told the exact number to be smelled. They were told there were three types of odors: wines, wine-related odors, and common odors. Throughout the experiment, the jars containing the odors were placed out of sight of the participant, and lids were removed by the experimenter before presentation. All participants were told they would be tested for their odor memory later.

In the encoding phase participants smelled the 24 odors (i.e., wine odors, wine-related odors, and common odors in random order) from the randomly allocated encoding set. Half the participants were allocated to the naming and half to the no-naming condition. In the no-naming condition, participants only smelled the odors for three seconds during encoding, with an interstimulus interval (ISI) of 30 s. In the naming condition, participants smelled the odors for the same duration of three seconds and then named the odor as quickly and precisely as possible out loud during encoding (ISI also of 30 s). These answers were recorded by means of both a voice recorder and written down by the experimenter, to be later checked and transcribed to Excel. This was followed by a retention phase, that is, a 10-min break, where participants completed the wine knowledge test (see the Participants section) and two other questionnaires.

At the recognition phase, participants smelled the original 24 odors again plus 24 new odors presented in a randomized order. Participants were told that they had previously smelled some of the odors before, while others were new, without specifying how many. They were instructed to indicate whether they had in fact smelled each odor previously; specifically, they were asked, in Dutch, "is this smell new or old?" on encountering each odor. Participants were further instructed to rate odors on pleasantness and familiarity, and to name the odors with the caveat that there were no right or wrong answers. They rated the pleasantness and familiarity on a 7–point scale (ranging from 1 = *very unpleasant/unfamiliar* to 7 = *very pleasant/familiar*, with midpoints anchored at 4 = *neutral*) .[2] Participants indicated both ratings and names for odors verbally. Responses were noted by the experimenter. The total duration of the experiment was between 75 and 90 min.

Data analysis. We analyzed our data in a signal detection theory framework using d-prime (d')—an unbiased measure of sensitivity—as our index of episodic memory recognition performance (Macmillan & Creelman, 2005), as well as the decision criterion, c. The decision criterion indicates the degree of strength that has to be exceeded for an item to be accepted as previously experienced and is a measure of response bias. To calculate these, we first coded hits (Hs) and false alarms (FAs) from recognition responses for each odor type. An H was coded when a participant correctly recognized a stimulus from the encoding set, and an FA was coded when a participant mistakenly recognized a new stimulus as coming from the encoding set. From these values d' was calculated by taking the standardized ratio, that is, the Z score, of corrected Hs and FAs for the different stimulus types for each participant (Macmillan & Creelman, 2005; Parr et al., 2004), using the following formula:

$$d' = z\left(\frac{\text{Hits} + 0.5}{N_{\text{targets}} + 1}\right) - z\left(\frac{\text{FA} + 0.5}{N_{\text{distracters}} + 1}\right)$$

The sensitivity measure d' ranges from -3 to 3, with a larger, positive d' indicating better discrimination between old and new odors, while a d' of zero indicates performance at chance level.

Criterion was calculated using the formula (Macmillan & Creelman, 2005):

$$c = -\frac{1}{2}[z(\text{Hits}) + Z(\text{FA})]$$

Negative values on c indicate a liberal response bias with a tendency to respond "old", positive values indicate a conservative response bias with a tendency to respond "new", and zero indicates an unbiased and optimal response criterion (Macmillan & Creelman, 2005).

Odor labels provided by participants were coded by blinding responses, so as to remove information about group and condition. An answer was considered correct (i.e., accurate) if participants gave the same answer as the predetermined "veridical" label.[3] For example, for the cedar odor, "cedar" and "woody" were correct responses. For wines, a response was considered correct if participants gave the correct color, grape type, or production country. Coding was completed by the experimenter and a second researcher independently with an interrater agreement of κ = .89, indicating almost perfect agreement (McHugh, 2012). Cases on which raters disagreed were resolved through discussion. Data for both experiments is accessible via Open Science Framework (https://osf.io/c9ymj; Croijmans, Speed, Arshamian, & Majid, 2019).

We began by testing the overall effect of naming condition on memory ((d') and c) by means of an analysis of variance (ANOVA) to establish whether overt naming improved odor memory. As hypothesized in the introduction, if wine experts' odor naming is related to odor recognition memory, then experts should have better odor recognition memory for wine odors in the naming condition than the no-naming condition. Thereafter, the relationship between naming and memory was investigated with simple correlation analyses between recognition memory and naming to test whether accuracy of naming was related to accuracy of odor recognition memory (following Parr et al., 2002).

Results

Odor recognition memory. We ran a three-way mixed ANOVA, with expertise (wine expert vs. novice) and naming condition (naming vs. no-naming) as between- participant factors and odor type (wine odor, wine-related odor, and common odor) as a within- participant factor on d' values to test whether odor recognition memory differed. The data was inspected for normality, outliers, and other violations of the assumptions for ANOVA. No anomalies were found. The results revealed a main effect of odor type, $F(2, 43) = 30.61$, $p < .001$, $\eta_p^2 = .587$. Bonferroni corrected pairwise comparisons showed that overall wine odors ($M = -.83$, $SD = .67$) were recognized less accurately than

[2] See Table S1.4 in the online supplemental materials for an overview of the mean pleasantness, intensity and familiarity ratings for the three stimulus types.

[3] See - Tables S1.1–S1.3 in the online supplemental materials for a detailed description of what constitute a veridical answer for each stimulus.

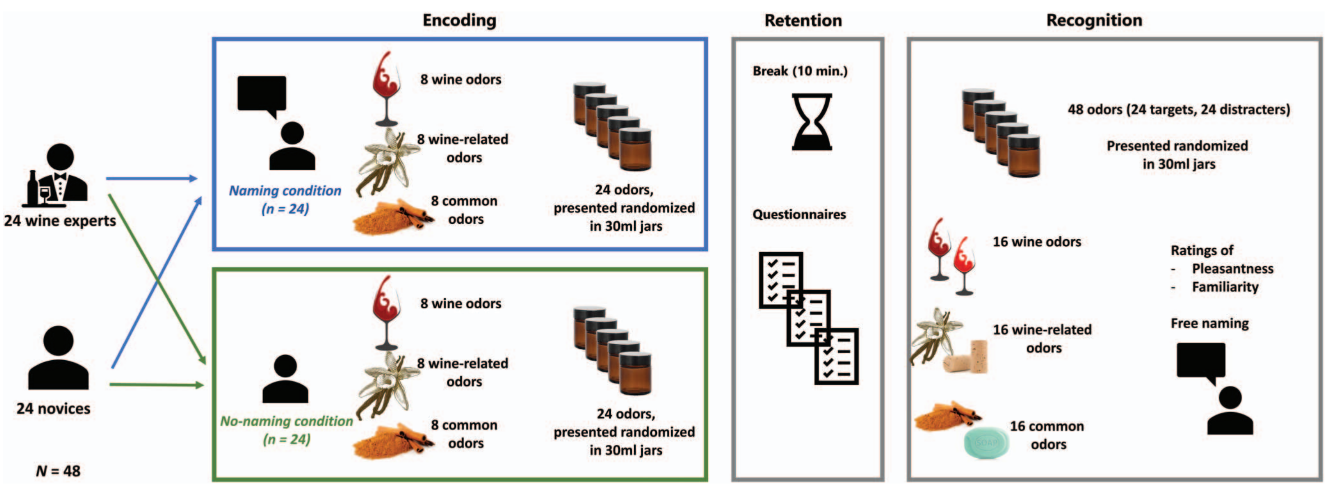

Figure 1. Design and procedure for Experiment 1. See the online article for the color version of this figure.

wine-related odors (M = .47, SD = .84), $p < .001$, and common odors (M = .36, SD = .91), $p < .001$, and there was no difference between wine-related odors and common odors, $p > .200$. There was no significant interaction between expertise and naming condition, $F(1, 44) = .86$, $p = .244$, $\eta_p^2 = .031$, no significant interaction between expertise and odor type, $F(2, 43) = 2.35$, $p = .108$, $\eta_p^2 = .098$, and no significant interaction between naming condition and odor type, $F(2, 43) = .88$, $p = .875$, $\eta_p^2 = .006$. The main effects of expertise, $F(1, 44) = .64$, $p = .427$, $\eta_p^2 = .014$, and naming condition, $F(1, 44) = .46$, $p = .503$, $\eta_p^2 = .010$, were also not statistically significant.

To test our specific prediction that overt odor naming affects wine experts' odor recognition memory, we examined the effect of overt naming for each odor type separately (Figure 2). This is because the study is underpowered to detect a three-way interaction as tested above, but is sufficiently powered to test the specific hypothesis posited at the outset; that is, wine experts have better odor recognition memory for wine odors when overtly named. A two-way ANOVA with expertise and naming condition as between participant factors on d' for wine odors revealed a main effect of expertise, $F(1, 44) = 4.70$, $p = .036$, $\eta_p^2 = .096$. Wine experts (M = .23, SD = .56) had better odor recognition memory than novices (M = −.13, SD = .57). Critically, there was no effect of naming condition, $F(1, 44) = .71$, $p = .406$, $\eta_p^2 = .016$, and no interaction between expertise and naming condition, $F(1, 44) = .000$, $p = .984$, $\eta_p^2 = .00$.

The same analysis conducted on wine-related odors revealed no main effect of Expertise, $F(1, 44) = .74$, $p = .39$, $\eta_p^2 = .016$, naming condition, $F(1, 44) = .28$, $p = .60$, $\eta_p^2 = .006$, and no interaction between expertise and naming condition, $F(1, 44) =$

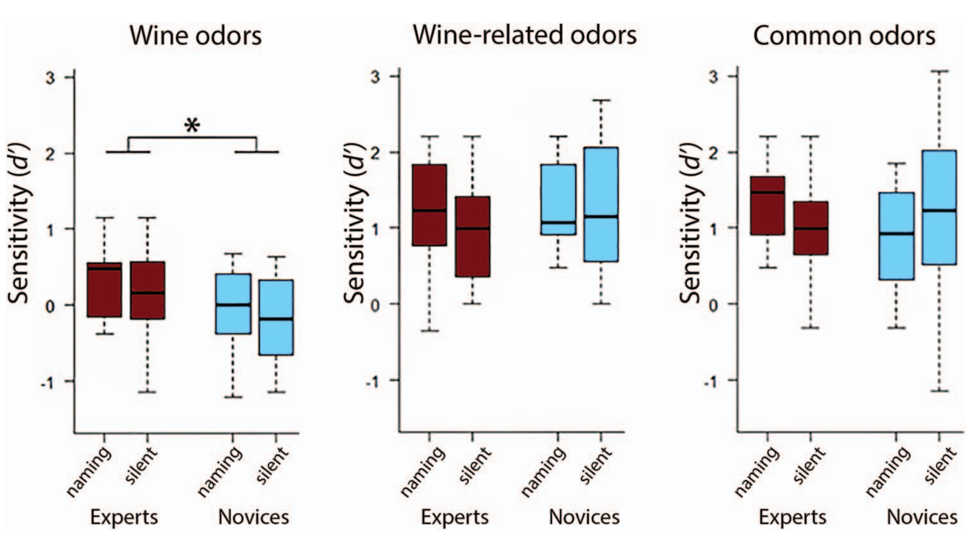

Figure 2. Sensitivity (d') by naming condition for experts and novices per odor type: wine odors, wine-related odors, and common odors. Box-and-whisker plots display median, first, and third quartiles ranges; and whiskers indicate range of the data. Asterisks indicate statistical significance at $p < .05$. See the online article for the color version of this figure.

.20, $p = .66$, $\eta_p^2 = .004$. This was also true for common odors where there was no main effect of expertise, $F(1, 44) = .37$, $p = .98$, $\eta_p^2 = .008$, naming condition, $F(1, 44) = .003$, $p = .96$, $\eta_p^2 = .00$, nor any interaction between the two, $F(1, 44) = 2.48$, $p = .12$, $\eta_p^2 = .053$.

Overall, these analyses show that overt naming of odors during encoding does not boost recognition memory for odors. Critically, even in the case where experts performed better than novices—that is, recognition memory for wine odors—explicit verbalization had no additional benefit (see Figure 2). Taken together, this suggests experts' memory advantage is for wine odors only, and is not verbally mediated. We come back to this lack of an effect of overt naming later.

Response bias. A three-way interaction with expertise and naming condition as between-participant conditions and odor type as within-participant factor of *c* values revealed a significant effect of odor type, $F(2, 43) = 13.93$, $p < .001$, $\eta_p^2 = .39$. The effects of expertise, $F(2, 43) = 2.28$, $p = .138$, $\eta_p^2 = .049$, and naming condition $F(2, 43) = 1.42$, $p = .240$, $\eta_p^2 = .031$, and the interaction effects were not significant, $ps > .200$. The analyses per odor type also showed no differences in bias across Expertise or Naming condition (Figure 3). For wine odors, there was no effect of expertise, $F(1, 44) = 1.09$, $p = .30$, $\eta_p^2 = .024$, naming condition, $F(1, 44) = .81$, $p = .37$, $\eta_p^2 = .018$, nor an interaction between expertise and naming condition, $F(1, 44) = .000$, $p = .984$, $\eta_p^2 = .00$. Similarly, for wine-related odors, there was no main effect of expertise, $F(1, 44) = 1.16$, $p = .29$, $\eta_p^2 = .026$, naming condition, $F(1, 44) = 1.76$, $p = .19$, $\eta_p^2 = .038$, and no interaction between the two, $F(1, 44) = 1.30$, $p = .26$, $\eta_p^2 = .029$. The same pattern holds for common odors, with no effect of expertise, $F(1, 44) = 1.61$, $p = .21$, $\eta_p^2 = .035$, naming condition, $F(1, 44) = .26$, $p = .61$, $\eta_p^2 = .006$, and no interaction, $F(1, 44) = .53$, $p = .47$, $\eta_p^2 = .012$. Overall, these analyses did not show any evidence of differences in response bias by expertise or experimental condition.[4]

Relationship between odor naming and odor recognition memory. We next examined how odor naming accuracy was related to odor recognition memory by calculating correlations between odor naming and d' for experts and novices separately for each odor type (cf., Parr et al., 2004). If language plays a role in wine experts' recognition memory for wines, then there should be a significant positive correlation between odor naming and recognition memory (d').

We first examined the relationship between odor naming accuracy and odor recognition memory for wine experts.[5] For wine odors, there was no evidence of an association between odor naming accuracy and odor recognition memory, $r(22) = -.15$, $p = .241$. For wine-related odors, however, there was a modest but significant positive correlation between odor naming accuracy and odor recognition memory, $r(22) = .46$, $p = .011$. For common odors, there was also a positive association between odor naming accuracy and odor recognition memory, $r(22) = .31$, $p = .071$, but this was not significant.

Turning to novices, there was no relationship between odor naming accuracy and odor recognition memory, $r(22) = -.04$, $p = .433$. However, for wine-related odors, there was a significant positive association between odor naming accuracy and odor recognition memory, $r(22) = .52$, $p = .004$. This was also the case for common odors, where odor naming accuracy and odor recognition memory correlated positively, $r(22) = .52$, $p = .005$, replicating previous analyses (e.g., Cessna & Frank, 2013). Taken together, these results show that while language may play some role in odor recognition memory for common odors in novices, and perhaps experts, odor recognition memory for wine odors in experts does not appear to be verbally mediated.

Summary. To summarize, overtly naming wine odors during encoding did not improve wine experts' odor recognition memory. Moreover, while there was a relationship between odor naming accuracy and odor recognition memory for common and wine-related odors, this did not hold for wine odors. Although consistent with the idea that naming odors does not play a critical role in recognizing wine odors, the current results are open to another interpretation. Participants may have named the odors covertly in the silent condition—by subvocalization—even though they were not instructed to do so. In particular, because experts have experience giving descriptions to wine odors (cf., Herdenstam et al., 2009), they may have generated a silent verbal code automatically in the no-naming condition too. The results from Experiment 1 cannot rule out this possibility. To test for the direct causal role of odor naming during encoding odors, in Experiment 2 we used a verbal interference paradigm with visual interference as an active control condition.

Experiment 2

Method

Participants. A total of 146 new participants took part in this experiment. Sixty-six participants (20 women, $M_{age} = 49$, age range 21–71) were experts in the field of wine and either worked professionally with wine (e.g., as vinologist, sommelier, or wine maker) or possessed a more than average interest in wine with a proven track record (e.g., had an extensive wine collection; gave wine courses on a nonprofessional basis). These experts were recruited by actively approaching experts in stores and through e-mail and phone, as well as via word-of-mouth. In addition, a few experts responded to a call placed in a magazine. Sixty-six participants were novices (20 women, $M_{age} = 49$, age range 24–70), and were matched to the wine experts in age (±5 years), and gender. The remaining 14 participants were excluded from the analyses since they did not meet the expert criteria outlined above, but could not be considered wine novices either ($n = 3$); or since experts and novices were recruited and tested in parallel, the novices could not be matched to a wine expert based on age or gender ($n = 11$). To confirm the difference in wine expertise between the two groups, all participants completed the Wine Knowledge Test (see Experiment 1). A Mann–Whitney *U* test confirmed experts had significantly higher wine knowledge scores ($M = 13.6$, $SD = 1.2$) than novices ($M = 7.9$, $SD = 2.2$), $U = 33.0$, $p < .001$, $r = .85$. Participants were randomly allocated to one of three conditions: (a) control baseline condition, (b) verbal interference condition, or (c) visual interference condition.

Materials. In Experiment 1, experts and novices only differed in their recognition memory for wine odors, but not wine-related or

[4] -Additional analyses, comparing sensitivity (*d*) bias (*c*) against baseline (0), are presented in S2 in the online supplemental materials.

[5] See S2.2 in the online supplemental materials for additional analyses regarding naming accuracy.

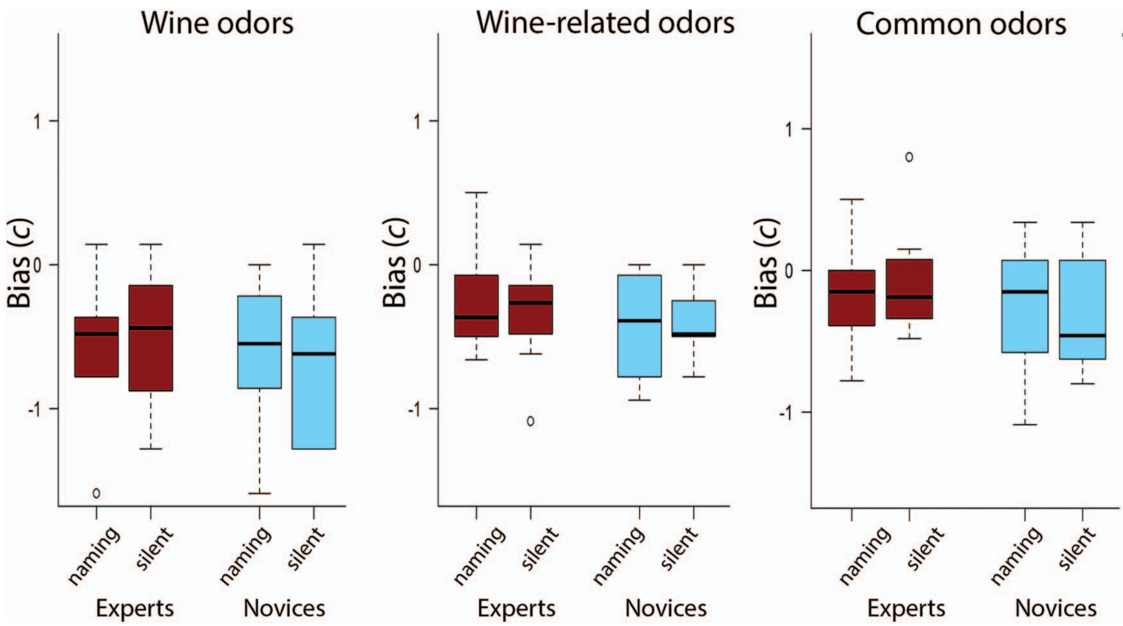

Figure 3. Bias (*c*) by naming condition for experts and novices per odor type: wine odors, wine-related odors, and common odors. Criterion did not differ across expertise or conditions. Box-and-whisker plots display median, first, and third quartiles ranges; whiskers indicate the range of the data without outliers; and dots represent observations outside 1.5 times the interquartile range. See the online article for the color version of this figure.

common odors. To reduce the number of odors participants had to smell we therefore focused only on wine odors and common odors in Experiment 2. In addition, to make the difference between odor types more salient, the odors were presented in separate blocks.

Twenty wines were selected by consultation of a vinologist (who did not take part in the study), including red, white, and rosé, as well as a dessert and sherry wine. Wines were bought in bottles, and poured into small, 60 ml bottles without headspace to minimize oxidation of the wine between tests. These smaller bottles were either used over the course of 2 weeks or discarded. Black opaque Tritan copolyester (Happyglass, Goes, the Netherlands) plastic wine glasses were used to present the wines so as to obscure the color of the wine to the participant. The glasses had a volume of 510 ml with the opening being smaller than the biggest circumference of the glass; 60 ml of each wine was poured into a glass. The common odors were presented once again in 30 ml dark brown glass jars. As in Experiment 1, a small tuft of hollow fiber wool obscured visual cues as to the object in the jar. Half the wine odors and half the common odors served as targets, and the other half were distractors in the recognition phase of the experiment.[6]

Procedure. Before the experiment began, participants were informed about the methods and signed a consent form. Participants were informed that the experiment was about odor memory. Participants were allocated to one of three conditions (Figure 4). First, there was a baseline control condition where participants just smelled the odors. Second, there was a verbal interference condition where participants had to keep a series of digits in working memory while smelling the odors. This task should selectively interfere with verbal encoding of odors. Finally, there was a visual interference condition where participants had to keep a visual/spatial pattern in working memory while smelling. Because visual working memory is not hypothesized to influence the relationship between language and odor recognition memory, this condition served as an active control.

Since people differ in their working memory capacity (Baddeley, 1994; Miller, 1956), the effect of verbal interference (and, similarly, visual interference) has to be equated across participants (see e.g., the discussion in M. C. Frank, Fedorenko, Lai, Saxe, & Gibson, 2012, p. 85). We did this by adjusting the difficulty level of interference tasks for each individual: each participant's threshold for their verbal or visual memory was established prior to the experimental manipulation. This also ensured that the visual and verbal interference tasks were comparable in difficulty.

To establish verbal threshold, participants were presented with a sequence of digits for 2 s. After a 3.5-s interval, they saw two digit sequences and had to indicate which had been presented previously. The task increased in difficulty level, starting with a sequence of four digits and increasing to 11 digits. Each level contained 11 trials. When a participant reached 80% correct on a given difficulty level, they continued to the next level. If their accuracy was less than 80%, they stayed on that level. The task ended when accuracy was less than 80% on two series of trials within the same level. The last difficulty level for which accuracy was 80% or more was then assigned as the participant's difficulty level.

[6] See Tables S3.1 and S3.2 in the online supplemental materials for a detailed overview of the stimuli used in Experiment 2.

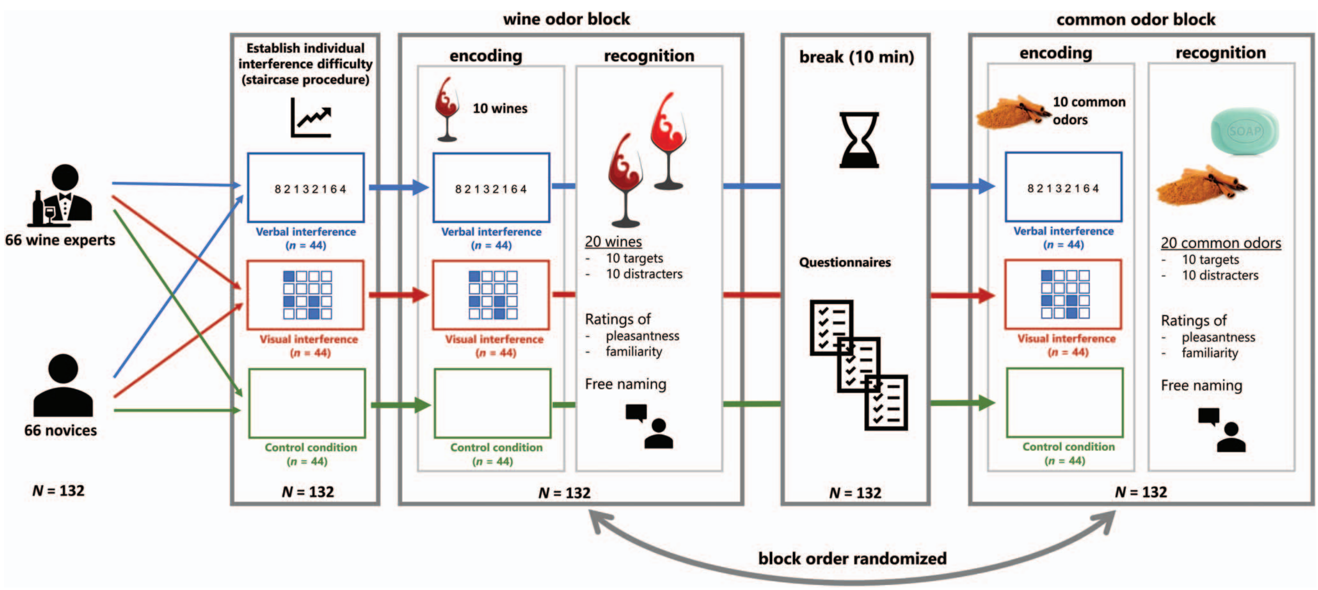

Figure 4. Design and procedure of Experiment 2. See the online article for the color version of this figure.

The visual interference threshold task followed the same structure as the verbal interference task. Participants were first presented with images of black and white blocks in random patterns (based on Winawer et al., 2007), for 2 s. The difficulty levels for this task ranged from a three-by-three grid with four black squares to a 5 × 5 grid with 12 black squares. Participants' maximum difficulty level was established in the same way as the verbal interference task.

Once individual thresholds were established, participants took part in the main odor recognition memory experiment. Unlike Experiment 1, Experiment 2 presented wine odors and common odors in separate blocks rather than intermingled. Between the two stimulus type blocks, participants completed the wine knowledge questionnaire and two other questionnaires. For the main study, whether participants started with the wine odor block or common odor block was determined randomly by the computer program in which the procedure was programmed (OpenSesame; Mathôt, Schreij, & Theeuwes, 2012). In both memory blocks (wine odors and common odors), participants smelled 10 target odors for 3 s with a 30-s ISI, in a random order. In the verbal and visual interference conditions, before smelling each target odor, participants saw either a series of digits that they were instructed to silently rehearse, or a visual grid that they had to keep in mind. After smelling the wine, the participant had to choose from two options which of the series of digits or visual grids they had seen before by pressing "z" or "m," representing both options, on the keyboard.

Immediately following the encoding phase, participants continued with the recognition phase of the study, in which they smelled 20 odors, including the 10 target odors, in a randomized order. As before, odors were presented for 3 s with a 30-s ISI. Participants were told that they had smelled some of the odors previously, and that some would be new. For each odor, they had to indicate whether they had, in fact, smelled the odor previously. In addition, participants rated how certain they were about their answer, how familiar the odor was, and how pleasant it was on 7-point Likert scales (the anchors were the same as Experiment 1, but participants answered on the computer, not verbally).[7] They were then asked to name the odor aloud as quickly and precisely as possible. If they were uncertain how to name a wine, participants were told they could, for example, think about the color, grape type, country of origin, or aromas of the wine. In the common odor task, no specific instructions were given about how to name the odors. There was no limit to the length of the naming responses. The naming responses were recorded by means of a voice recorder and later transcribed to Excel by an independent researcher blind to the condition and expertise group. The entire procedure had a duration of approximately 60 min.

Data analysis. The data was processed and analyzed as in Experiment 1. Odor recognition data was analyzed using d' and c. For the naming data, an answer was deemed accurate if it followed a set of predetermined labels.[8] For wine odors, an odor name was deemed accurate if a participant responded with the correct origin, grape type, or gave specific information about the wine (e.g., the brand or house). As in Experiment 1, coding of naming responses was completed blind by the experimenter and independently by another researcher, reaching an interrater agreement of κ = .95, which indicates almost perfect agreement (McHugh, 2012). Cases on which both raters disagreed were resolved through discussion. Data for both experiments is accessible via Open Science Framework (https://osf.io/c9ymj; Croijmans et al., 2019).

[7] See Table S3.3 in the online supplemental materials for mean ratings of pleasantness, intensity, and familiarity of the stimuli used in Experiment 2.

[8] See Tables S3.1 and S3.2 in the online supplemental materials for a description of what constituted a veridical answer in Experiment 2.

Results

If wine experts' recognition memory for wine odors is mediated by language, a significant interaction between expertise and condition should be found for wine odors, such that odor recognition memory is lower with verbal interference than with visual interference in experts, but not novices. It is unclear whether verbal interference will also affect memory for common odors. Results from Experiment 1 are mixed with, on the one hand, no effect of naming condition on memory for common odors, but a correlation between accuracy of naming and memory.

Odor recognition memory. The data was inspected for normality, outliers, and other violations of the assumptions for ANOVA, and no anomalies were found. As in Experiment 1, a three-way ANOVA was first conducted with expertise (wine expert vs. novice) and Interference type (control, verbal, and visual) as between-participant factors, and odor type (wine odors vs. common odors) as a within-participant factor on d' values. There was a main effect of expertise, $F(126, 1) = 6.01$, $p = .016$, $\eta_p^2 = .046$, suggesting wine experts had better recognition memory than novices. There was also a large main effect of odor type, $F(126, 1) = 70.94$, $p < .001$, $\eta_p^2 = .360$, showing common odors were recognized more accurately than wine odors. There was no main effect of interference type, $F(126, 2) = .57$, $p = .569$, $\eta_p^2 = .009$. None of the interactions were significant, $ps > .200$.

To test the specific hypotheses, separate ANOVAs were conducted on the d' values for wine odors and common odors, with expertise (wine expert and novice) and Interference type (control, verbal, and visual) as between-participants factors. For wine odors, we found a significant main effect of eExpertise, $F(1, 126) = 7.82$, $p = .006$, $\eta_p^2 = .058$, replicating Experiment 1: wine experts ($M = .51$, $SD = .60$) had better recognition memory for wine odors than novices ($M = .24$, $SD = .51$). Importantly, the main effect of interference type was not significant, $F(2, 126) = .51$, $p = .603$, $\eta_p^2 = .008$, nor was there an interaction between expertise and interference type, $F(2, 126) = 1.09$, $p = .339$, $\eta_p^2 = .017$ (Figure 5).

For common odors, we also replicated Experiment 1: wine experts did not remember common odors better than novices, $F(1, 126) = .84$, $p = .361$, $\eta_p^2 = .007$. There was no effect of interference type, $F(2, 126) = .24$, $p = .791$, $\eta_p^2 = .004$, nor an interaction between expertise and interference type, $F(2, 126) = .18$, $p = .839$, $\eta_p^2 = .003$.

Response bias. As before, a three-way ANOVA was conducted with expertise (wine expert and novice) and interference type (control, verbal, and visual) as between-participant factors and odor type (wine odors and common odors) as a within-participant factor and c as the dependent variable. The three-way interaction was not significant, $F(2, 126) = 1.67$, $p = .193$, $\eta_p^2 = .026$. There was a significant interaction between odor type and expertise, $F(1, 126) = 5.05$, $p = .026$, $\eta_p^2 = .039$, a significant interaction between odor type and interference condition, $F(1, 126) = 4.09$, $p = .019$, $\eta_p^2 = .061$, but no significant interaction between expertise and interference type, $F(2, 126) = .33$, $p = .719$, $\eta_p^2 = .005$. Turning to main effects in the three-way model, the main effects of interference type, $F(1, 126) = 1.30$, $p = .276$, $\eta_p^2 = .020$, and expertise, $F(1, 126) = 3.26$, $p = .073$, $\eta_p^2 = .025$, were not significant. The effect of odor type, however, was significant, $F(1, 126) = 8.41$, $p = .004$, $\eta_p^2 = .063$, with common odors leading to a less negative bias ($M = -.15$, $SD = .45$) than wine odors ($M = -.24$, $SD = .44$).

To further unpack the effects of Expertise and Interference for each odor type separately, as in Experiment 1, separate ANOVAs

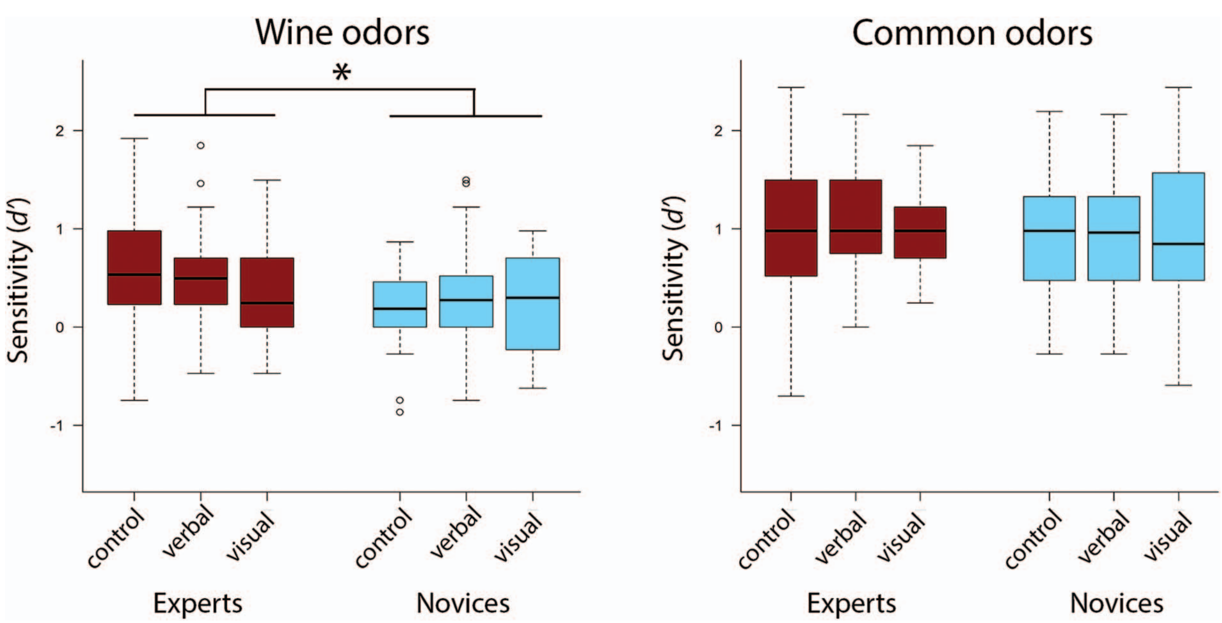

Figure 5. Sensitivity (d') by interference condition for experts and novices per odor type—wine odors and common odors. Box-and-whisker plots display median, first, and third quartiles ranges and whiskers indicate the range of the data without outliers, whereas dots represent observations outside 1.5 times the interquartile range. Asterisks indicate statistical significance at $p < .05$. See the online article for the color version of this figure.

were conducted for the two odor types. For wine odors, there was a significant effect of expertise, $F(1, 126) = 6.93$, $p = .010$, $\eta_p^2 = .052$, but no effect of interference condition, $F(2, 126) = .16$, $p = .857$, $\eta_p^2 = .002$, and no interaction between the two, $F(2, 126) = .22$, $p = .804$, $\eta_p^2 = .003$. For common odors, there was no effect of expertise, $F(1, 126) = .43$, $p = .513$, $\eta_p^2 = .003$, and no interaction between interference condition and expertise, $F(2, 126) = .92$, $p = .403$, $\eta_p^2 = .014$ (Figure 6). However, we did find a significant effect of interference condition, $F(2, 126) = 3.38$, $p = .014$, $\eta_p^2 = .051$. Uncorrected pairwise comparisons showed that, overall, participants' criterion was more neutral in the verbal condition ($M = -.01$, $SD = .45$) compared to the control condition ($M = -.21$, $SD = .42$), $p = .034$, and the visual interference condition ($M = -.23$, $SD = .46$), $p = .020$. There was no difference between the control condition and visual interference condition, $p = .831$.

To better interpret the differences in c observed above, one-sample t tests were conducted separately for each odor type, group, and condition, to test whether c was significantly different from zero.[9] For wine odors, c was not different from 0 for wine experts in any condition—control, $t(21) = -1.5$, $p = .148$; verbal, $t(21) = -1.02$, $p = .318$; or visual, $t(21) = -2.02$, $p = .056$—demonstrating a neutral and optimal response criterion. However novices displayed a lenient c across all conditions (i.e., negative criterion)—control, $t(21) = -3.02$, $p = .007$; verbal, $t(21) = -6.09$; $p < .001$, and visual, $t(21) = -3.71$, $p = .001$.

For common odors, c was significantly lower than 0 for experts in the control condition, $t(21) = -2.64$, $p = .015$, but not in the verbal, $t(21) = -.12$, $p = .908$, or visual condition, $t(21) = -1.83$, $p = .081$. For novices, c was less than 0 in the visual condition, $t(21) = -2.82$, $p = .010$, but not the control condition, $t(21) = -1.97$, $p = .063$, or verbal condition, $t(21) = -.01$, $p = .992$.

Participants' encoding strength of a stimulus class often leads to criterion shifts, with weaker encoding resulting in a more lenient criterion (Stretch & Wixted, 1998). Taken together these results show that wine experts were not biased in their recognition memory for wine odors, however novices were significantly more lenient than chance in all conditions. This implies that for novices wine odors were not strongly encoded. For common odors, responses tended to be more conservative in the verbal condition, suggesting people were less likely to say they had smelled something previously when they could not silently name it. Converging evidence that language may be implicated in memory for common odors comes from correlation analyses between naming accuracy and d'.

Relationship between odor naming and odor recognition memory. For wine odors, odor naming accuracy did not correlate with odor recognition memory in wine experts, $r(66) = .12$, $p = .167$, or novices, $r(66) = -.007$, $p = .477$.[10] However, for common odors wine experts' odor naming accuracy significantly correlated with their odor recognition memory, $r(66) = .50$, $p < .001$, and the same was true for novices, $r(66) = .37$, $p = .001$.

Summary. In sum, there was no effect of interference type on recognition memory for wine odors, suggesting wine odor recognition memory is not mediated by verbal encoding. In particular, wine experts had better recognition memory for wine odors than novices, even when we interfered with their ability to encode those odors linguistically (see Figure 5). Although there was no evidence that odor naming played a causal role in recognizing either wine odors or common odors in measures of d', we did find that bias was reduced for common odors in the verbal interference condition. It appears people are more likely to falsely say they smelled something a common odor previously, when they are able to silently name odors.

Discussion

We find no evidence that wine experts' recognition memory for wine odors is mediated by their use of odor naming. First, in Experiment 1 experts were no better at recognizing wine odors in the naming condition than the no-naming condition. Next, in Experiment 2 verbal interference did not disrupt wine experts' recognition memory for wine odors. Finally, in neither experiment did we find evidence for a correlation between odor naming accuracy and odor recognition memory for wines. Overall, our results suggest wine experts can recognize wines odors without having to rely on odor naming at the time of encoding.

Previous studies show that for novices, the ability to name odors influences odor recognition memory (Cessna & Frank, 2013; R. A. Frank, Rybalsky, Brearton, & Mannea, 2011; Jehl et al., 1997; Lehrner et al., 1999). Similarly, for common odors, we found a positive correlation between odor naming accuracy and odor recognition memory in both experts and novices. Moreover, in Experiment 2 people were less likely to falsely say they had smelled a common odor previously if we interfered with their ability to name odors. Despite this, under verbal interference, recognition memory for common odors (as measured by d') was no more disrupted than when measured under visual interference or no interference at all. This is surprising given that previous studies found verbal interference disrupted odor recognition memory (e.g., Annett et al., 1995; Perkins & Cook, 1990). However, in these studies visual and verbal interference were not equated in difficulty. When Annett and Leslie (1996) equated task difficulty, there was no difference in the disruption to odor memory between verbal and visual interference conditions. So the correlation between odor naming and odor recognition memory may be due to some third factor—perhaps more familiar odors are more memorable and nameable; or conversely, perhaps more robust recognition memory for specific odors helps activation propagate such that an appropriate label is selected.

Across the two experiments, we found that wine experts had better recognition memory for wine odors than novices. Nevertheless, wine experts' recognition memory for wine-related odors and common odors was better than for wine odors. This could be for a number of reasons: first, this could be due to the specific expert group we tested. Perhaps another set of experts (e.g., Master of Wine) would show better memory performance with wine odors compared to common odors. Second, the common odors and wine-related odors used in our studies could have been more distinctive from each other than the wine odors, thereby making

[9] See S4.1 in the online supplemental materials for more details of this analysis, including means and standard deviations.

[10] See S4.2 in the online supplemental materials for additional analyses regarding odor naming accuracy, and see S4.3 for an analysis of the relationship between odor familiarity and odor pleasantness and recognition memory (d'). Data on how certain participants were in their answer was collected, but not further analyzed.

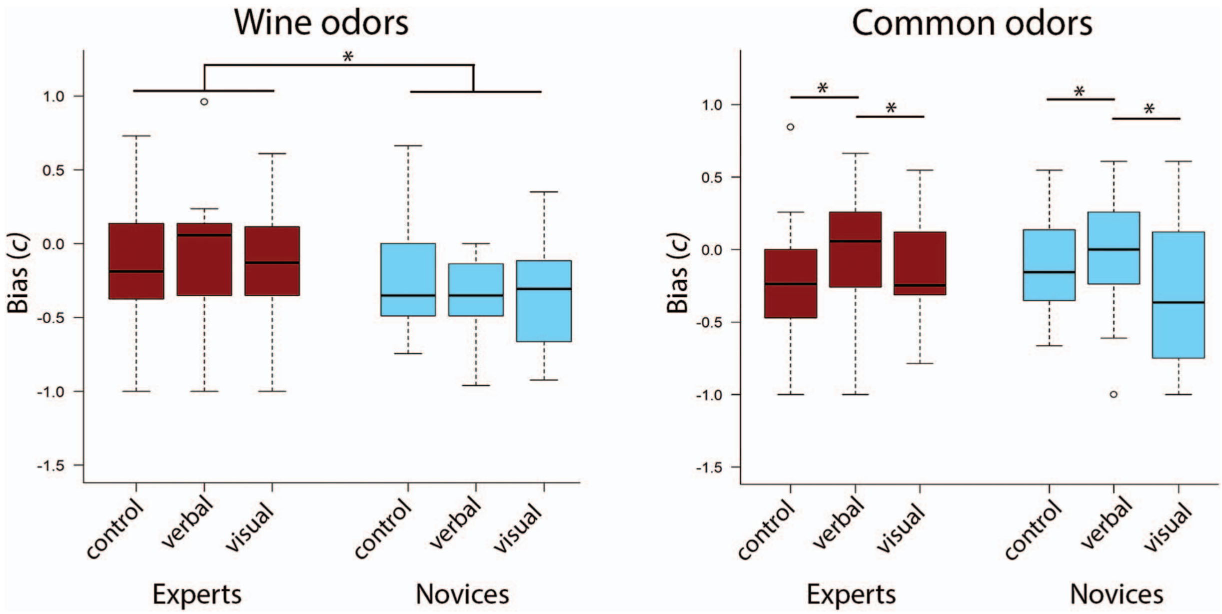

Figure 6. Bias (c) per expertise type and interference condition. Box-and-whisker plots display the median, first, and third quartiles ranges and whiskers indicate the range of the data without outliers, whereas dots represent observations outside 1.5 times the interquartile range. Asterisks mark a significance difference at $p <$ .05. See the online article for the color version of this figure.

the wine odor recognition task harder. It is noteworthy in this respect that when we changed our stimulus set from a more economical set of wines in Experiment 1 to a higher quality set of wines that also sampled a wider range of aromas (i.e., red, white, rosé, dessert, sherry wines), wine experts showed higher recognition. Future studies could more systematically investigate both participant and stimulus characteristics and their role in odor memory.

While our study does not support the idea that odor naming plays a causal role in how wine experts remember wine odors, language could still play a critical role in how wine experts acquire their expertise. For example, language may shape thought by directing attention to particular features of the environment (Majid, Bowerman, Kita, Haun, & Levinson, 2004). So learning that a gewürztraminer is "intensely perfumed, with aromas of rose petals, lychee nuts, and superripe pineapples" (Parker & Rovani, 2002 p. 46) would draw attention to precisely these characteristics, and provide an anchor for what a consumer should look for in the next gewürztraminer they imbibe. Indeed, one study has found that conceptual training with language (including a rudimentary introduction to wine vocabulary) in comparison to mere perceptual training makes novices' memory for wines more robust to interference (LaTour, LaTour, & Feinstein, 2011).

Melcher and Schooler (1996) compared wine flavor recognition between novices, intermediates, and wine experts who either verbalized or did not verbalize the flavor of target wines. Novices and intermediates were defined by their perceptual exposure to wines, either none, moderate, or high. For the nonverbalizers, there was a clear linear improvement in recognition discrimination from novice to expert, consistent with Goldstone's (1998; also see Spence & Wang, 2019 for a recent review) proposed perceptually guided mechanism for remembering wines. Also consistent with our findings, experts showed no particular recognition memory advantage when verbalizing a wine's taste. Their performance was consistent regardless of verbalization. Melcher and Schooler's (1996) original study, like our Experiment 1, does not exclude covert use of verbalization. However, Experiment 2 in the current article shows definitively that verbalization during encoding does not underpin wine experts' wine recognition abilities.

Wine critics state that decomposing a wine into its parts does not do the wine justice. As James (2018) argues: " . . . attempts to create a common tasting vocabulary have in part diminished the holistic appreciation of wine so that we now see fewer references to style, structure and balance in tasting notes" (p. 10). In line with the "holistic appreciation of wine" (James, 2018), when remembering the odors of wines, experts may remember the gestalt, or template (Gobet & Simon, 1996), rather than individual components. An analogy can be made to memory for faces. Humans are excellent at remembering faces, yet perform poorly when having to recall individual features of faces, such as a nose, eye, or mouth (Tanaka & Farah, 1993). Similarly, chess experts are better at remembering the layout of chess plays than novices (Frey & Adesman, 1976; Gobet & Simon, 1996). However, these layouts have to be configurations that are possible during real chess games rather than randomly assembled layouts (Chase & Simon, 1973). This suggests chess experts have learned to remember particular configurations of arrays in a holistic way. Similarly, wine experts may have learned to process particular configurations of odorants that frequently occur together in particular wines, in a holistic manner.

Evidence from perfumers indicates expert odor memory relies primarily on perceptual codes, as indicated by differential brain responses. Plailly et al. (2012) used functional MRI (fMRI) to study brain activity in perfumers compared to novices. They demonstrated that when imagining odors, perfume professionals displayed a different pattern of activation to perfume students, specifically in brain areas underlying olfactory perception (i.e., primary olfactory cortex). Importantly, this effect is moderated by the amount of experience (i.e., number of years as a professional perfumer). In a follow-up study, Delon-Martin et al. (2013) demonstrated that, in addition to functional changes, there was also structural reorganization of primary olfactory brain areas in the same group of perfumers. Similarly, Castriota-Scanderbeg et al. (2005) demonstrated that when sommeliers tasted wine they differentially activated a network in the brain including primary gustatory (insula) and secondary olfactory (orbitofrontal cortex) cortices compared to novices. This network is known to be critical in the integration of flavor perception and indicates that wine experts' advantage in memory for wine odors may rely on changes in chemosensory perception rather than changes in cognitive functions.

In conclusion, with extensive experience, wine experts become better at remembering and naming wines. This improved olfactory recognition memory does not extend to odors beyond their domain of expertise, showing noteworthy similarities with expertise in other domains (e.g., Gobet, 1998; Kimball & Holyoak, 2000). Crucially, wine experts' recognition memory for wine odors does not depend on their ability to accurately name them. This supports the view of odor perception being weakly linked with semantics (Stevenson & Case, 2005), and shows that even in experts, odor is not linguistically well-grounded. Wine experts show superiority in both odor naming and odor recognition memory, but these elements of expertise are distinct.

Context of the Research

This research was motivated by a larger investigation into olfactory language and cognition. There has been a wide consensus in psychology that olfaction is "extremely rudimentary" in humans (Grinker, 1934, p. 313) and that it has "little special value across cultures" (Gardner, 1993, p. 61). Recent cross-cultural investigations by Asifa Majid and colleagues has shown that there are communities where olfaction plays an important role (e.g., Majid & Burenhult, 2014; Majid & Kruspe, 2018; O'Meara, Kung, & Majid, 2019; O'Meara & Majid, 2016; Wnuk & Majid, 2014). These studies typically focus on lesser-studied indigenous communities living a more traditional lifestyle, raising the question of when and where olfaction is relevant for people living in western societies. Wine experts are one such subculture. Previously, Croijmans and Majid (2016) found that wine experts were more consistent in how they talk about wine odors than either novices or coffee experts. This raised the question of whether other aspects of olfactory cognition may also be improved (e.g., odor recognition memory); and, if so, to what extent language plays an online role. Inspired by studies within the linguistic relativity framework (e.g., Majid et al., 2004), we investigated the online role of odor naming in expert odor recognition memory. In Experiment 1, we set out to replicate the finding that wine experts are better at remembering smells than novices (Parr et al., 2002), but since expertise usually shows domain specific effects (Kimball & Holyoak, 2000), we extended this work to include smells both within and outside the domain of expertise. In Experiment 2, we investigated the causal role of online naming in odor recognition memory by using a dual task paradigm with verbal interference. Overall, we found that wine experts do have better odor recognition memory for wine odors, but odor naming at encoding is not required for this.

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