Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Food Quality and Preference 15 (2004) 411–420
Food Quality and Preference
www.elsevier.com/locate/foodqual

Exploring the nature of wine expertise: what underlies wine experts' olfactory recognition memory advantage?

Wendy V. Parr [a,*], K. Geoffrey White [b], David A. Heatherbell [a]

[a] Centre for Viticulture and Oenology, Lincoln University, P.O. Box 84, Lincoln University, Canterbury, New Zealand
[b] Department of Psychology, University of Otago, Dunedin, New Zealand

Abstract

To source the locus of the recognition memory advantage demonstrated by wine experts in a previous study [Chem. Senses 27 (2002) 747], we investigated recognition of wine-relevant odours as a function of wine expertise and type of encoding of the to-be-remembered odorants. Fourteen wine experts and 14 wine novices participated in tasks measuring olfactory threshold, odour recognition, and odour identification. Odour recognition memory was investigated as a function of type of encoding task, namely whether participants were required to identify an odorant or to judge an odorant in terms of its pleasantness. Wine-relevant odorants were sampled orthonasally by each participant in the semantic (identification), hedonic (pleasantness rating), and episodic (recognition) memory tasks. Results showed superior olfactory recognition by expert wine judges, despite their olfactory sensitivity, bias measures, and odour-identification ability being similar to those of novices. Contrary to a prediction that wine experts' recognition memory would not be influenced by type of odorant-encoding task, while novices' recognition memory would be inhibited by forced naming of odorants, both groups' olfactory recognition was facilitated by identifying odorants relative to judging odorants in terms of pleasantness. Ability to recognise odours and ability to name odours were not positively correlated, although novices' data showed a trend in this direction. The results imply that the source of superior odour recognition memory in wine experts was not due to enhanced semantic memory and linguistic capabilities for wine-relevant odours, but perceptual skill (e.g., olfactory imaging).

Keywords: Wine; Expertise; Odour memory

1. Introduction

What are the objective ways in which wine experts are better than novices when evaluating wines? Several recent studies, employing methodologies from experimental psychology (e.g., Morrot, Brochet, & Dubourdieu, 2001), including comparison of expert and novice behaviour (Hughson & Boakes, 2002; Parr, Heatherbell, & White, 2002; Solomon, 1991), are beginning to provide data aimed at elucidating the cognitive processes implicated in wine expertise.

In a previous experiment, wine experts demonstrated superior explicit recognition memory for wine-relevant odorants, despite their sensitivity, bias, and odorant-naming abilities being similar to those of wine novices (Parr et al., 2002). This result was unexpected, given previous demonstrations of a positive relation between identification and recognition of odorants in the general population (e.g., Lehrner, Gluck, & Laska, 1999). Parr et al.'s results were interpreted as demonstrating the importance of perceptual skill, namely sensory memory for the odorant, rather than semantic memory ability, in wine-relevant olfactory expertise. It was suggested that veridical odorant-naming ability did not underlie ability to recognise wine-relevant odours. Further, the data suggested that novices were compromised in their recognition memory performance by the semantic memory task inherent in the requirement to identify and overtly name each odorant. In other words, when perceptual olfactory skill in a specific domain was relatively undeveloped but naming ability adequate, remembering the actual smells of the odorants was interfered with by the cognitive requirements involved when forced to name each odorant.

The present study was designed to further investigate odour recognition memory in expert and novice wine

* Corresponding author. Tel.: +64-3-325-3803x8135; fax: +64-3-325-3851.
E-mail address: parrw1@lincoln.ac.nz (W.V. Parr).

0950-3293/$ - see front matter © 2003 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodqual.2003.07.002

judges. There were two main aims. First, the experiment examined the source of the superior olfactory recognition memory demonstrated by wine experts in Parr et al. (2002). Parr et al. argued that, depending on one's domain-specific expertise, forced naming of an odorant could interfere with memory for the actual odorant itself. Several authors have theorized that information processing of complex stimuli such as odours and tastes can be compromised under some circumstances by forced verbalization (Lorig, 1999; Melcher & Schooler, 1996).

The current experiment investigated whether verbalization per se (i.e., employing speech to comment on an odorant), or the specific type of verbalisation involved in *naming* an odorant (e.g., semantic memory), influenced recognition accuracy. This was achieved by experimentally separating verbalization per se from verbalization that involved forced naming of the odorants. Verbalization without forced naming involved an affective judgment concerning each odorant where participants were asked to comment as to whether the odorant they were smelling was pleasant, neutral, or unpleasant. The human olfactory system is considered one of the most primitive systems of the human body and the primary response to odour is one of liking or disliking (Ehrlichman & Halpern, 1988). Therefore, making a pleasantness judgment could reasonably be conceived as a less cognitively demanding task than odorant naming. Further, it was important to employ a task that would not serve as a confounding factor in terms of its influence on recognition. As reported by Sulmont, Issanchou, and Koster (2002), whereas a positive relationship between odour familiarity and recognition performance has been demonstrated in many studies, Lawless and Cain (1975) failed to find a relationship between the pleasantness of an odour and odour recognition.

The second aim was to extend the research field by employing an incidental, rather than explicit, memory paradigm for the recognition task. In employing an incidental learning situation, we asked whether wine experts are better than novices at recognising recently smelled odorants when they are not expecting their memories of the smells to be tested. An incidental memory task involves a recognition test where the participant is not advised in advance that they are to undergo a memory task. This task was employed for three reasons. The first related to ecological validity. Incidental memory paradigms investigate unintentional learning. It was considered that asking wine experts such as winemakers to name and make affective judgments about odours, without overtly asking them to try and remember the smells, was more in keeping with their everyday activities than the task employed in our previous experiment. Second, a large body of theory (e.g., Schacter, 1987), and empirical work involving implicit memory for odours (e.g., Degel & Koster, 1999) suggests that memory for odorants should be as good, if not better, when participants are not explicitly asked to remember the olfactory stimuli as when they are advised that a memory task will follow. Third, it has been shown in other domains that the memory difference between experts and novices is greater in an incidental context than in an intentional one (e.g., Norman, Brooks, & Allen, 1989).

Finally, the present study extended the research field by employing domain-specific novices who were more in keeping with those typically defined as novices in much of the research literature, rather than "intermediates" as employed in Parr et al. (2002).

Several hypotheses were put forward for testing. On the basis of our previous results, it was hypothesized that olfactory sensitivity and recognition bias would not differ as a function of wine expertise. Superior performance of experts was predicted on odour recognition, despite the task involving unintentional learning. On the other hand, no directional hypothesis was put forward regarding odour identification. This was due in part to the degree of experience of the participants (i.e., true novices were employed). Finally, an hypothesis was put forward that predicted an interaction between expertise and type of learning task. Specifically, it was predicted that for experts, recognition for odorants would be unaffected by the type of unintentional learning manipulation (i.e., naming the odorant versus making an affective judgment). Novices' recognition on the other hand was predicted to be a function of the type of learning task. More specifically, on the basis of the results reported by Parr et al. (2002), novices' olfactory recognition was expected to be compromised when they had been instructed to name the odorants during the learning phase of the recognition task.

2. Methods

2.1. Subjects

Twenty-eight adults, aged between 21 and 57, participated in the study. Participants were classified on the basis of their experience with wine, with the subject pool consisting of 14 wine experts and 14 wine novices. An attempt was made to match the groups for age, gender, dietary and smoking status. Exact matching proved difficult. There were four female novices, ten male novices, seven female experts, and seven male experts. Age range was 21–57 years for novices (mean = 34.29) and 21–55 years (mean = 33.43) for experts. There was no significant difference between the groups in terms of age ($t(26) = -0.22$, $p = 0.83$). There were five participants who smoked amongst the experts and two novices who smoked. The remaining participants were non-smokers.

Experts were defined via the criteria employed in our prior study (Parr et al., 2002). The expert group comprised winemakers, other wine professionals (e.g., wine retail; MW), and wine science students who met the criteria. A person was defined as an expert if they fitted at least one of the following categories:

- Established winemakers;
- Wine-science researchers and teaching staff who were regularly involved in wine-making and/or wine evaluation;
- Wine professionals (e.g., Master of Wine; wine judges; wine writers; wine retailers);
- Graduate students in Viticulture and Oenology who had relevant professional experience (e.g., had participated in *more than one* vintage; had run wine-tasting classes);
- Persons with an extensive (>10 years) history of wine involvement (e.g., family history; extensive wine cellar; regular involvement in formal wine tastings).

Novices were persons who drank wine at least once per month but who had no, or virtually no, formal wine evaluation or winemaking experience. Relative to the prior experiment, where 'intermediates' were employed, the present novices were more in keeping with the definition of novice typically employed in the published literature (e.g., Chollet & Valentin, 2000).

2.2. Materials

The stimuli employed in the olfactory-detection threshold task were prepared as described in Parr et al. (2002). The only point of difference was that a further two dilution steps were included in the current study (see Bende & Nordin, 1997). Beginning with a 4% solution of 1-butanol in distilled water, serial dilution progressed in 12 steps of successive thirds (dilution factor 3). The 13 concentrations, ranging from 4% (dilution step 0) to 0.0000075% (weakest concentration; dilution step 12), were stored in glass bottles with tightly fitting, plastic screw lids. Each contained approximately 7 ml of fluid. Four identical bottles, each containing distilled water, were also prepared.

The 27 stimuli used as odorants in the recognition task were compounds typically found in wine (Bende & Nordin, 1997; Lenoir, 1995). They were identical to those employed in a previous study (Parr et al., 2002) in terms of chemical compound, concentration and dilution medium (see Table 1). Compounds employed were those for which information was available concerning usage of veridical name (ASTM Atlas of Odor Character Profiles, 1985), or general acceptance of veridical name (e.g., as reported on the Flavornet web page). The compounds were selected to provide perceived odour-notes from the categories of wine faults (e.g., excess acetic acid), primary characters (e.g., floral and fruity notes), secondary characters (e.g., buttery; oaky), and maturation notes (e.g., tobacco). They included odour notes that are typically considered pleasant (e.g., vanillin) and those generally considered unpleasant (e.g., rancid/rotting). Analysis of participants' performance in the prior study (Parr et al., 2002) as a function of each specific odorant had shown the following: Correct identification of odorants varied between 23% for cloves and 79% for floral/rose, with a mean of 44%; correct recognition memory varied between 63% for green/herbaceous and 100% for each of anise and nutty/sweet, with a mean of 83%. Of particular importance, no specific odorant stood out as an outlier in terms of either its mean recognition or identification.

A pilot study was undertaken prior to the experiment proper for two reasons, one qualitative and one quantitative. The qualitative reason was to ensure that the experiment employed odorants that were appropriate in terms of character or quality; that is, that a reasonable goodness of fit existed between the veridical name of an odorant and the perception of people in the population from which participants were to be drawn. The quantitative information gathered in the pilot study was to permit development of chemical concentrations that resulted in relatively similar perceived intensities across odorants, thereby avoiding a confounding effect of stimulus intensity in the experiment proper.

Twenty-eight odorants that had been employed in the prior experiment were each rated on a 100 mm visual analogue scale (VAS) (Savic & Berglund, 2000) with respect to quality and intensity of the particular odour note. Eight adults, who were classified as 'intermediates' in terms of wine expertise, participated in the pilot study. One compound, ethyl anthranilate, that exemplified the descriptor "grape-like", received a mean rating on the VAS lower than 20 mm ($M = 13.18$) and was excluded from further use. All compounds that received mean ratings lower than 33 or higher than 67 on the 100 mm scale were re-prepared for the present study.

The 27 odorants to be employed were randomly assigned to one of three groups, labeled A, B, and C, and each containing nine odorants. Group C stimuli served as distractors in the recognition task. The remaining stimuli served as odorants to-be-remembered. Odorants were contained in 10 ml, amber glass bottles with polypropylene screw lids. They were numbered with three-digit code numbers. Odorants were kept in a cool, dry cupboard (<10 °C) when not in use and taken out to warm up to ambient room temperature (20 °C) before an experimental session began. The entire testing was completed within a three-week period.

2.3. Procedure

Participants were tested individually in a single session that lasted approximately 60 min. For 21 of the 28 participants, testing took place in a purpose-built

Table 1
Details of odorants employed as materials

Veridical name(s)	Chemical name	Dilution	Source
Rancid/manure/rotting	Butyric acid	10% v/v in 12% ethanol	L.U. Stores
Earthy/musty/mouldy	2-Ethyl fenchol	Neat[a]	Bedoukian 818
Cinnamon	Cinnamaldehyde 97%	Neat	Ajax Chemicals D3247
Pine/woody/resinous	Alpha-pinene	Neat	Aldrich P4570-2
Aniseed/liquorice	Anethole	Neat	BDH Chemicals
Coconut	Gamma nonalactone	Neat	Bedoukian 452
Fatty/oily	2,4-nonadien-1-al	Neat	Bedoukian 363
Pineapple-like	Ethyl 3(2-furyl) propanoate	10% v/v in 12% ethanol	Bedoukian 852
Banana-like	Amyl acetate 95%	400 ppm in 12% ethanol in pilot study; 200 ppm in experiment	BDH Chemicals 27211
Buttery/malolactic	Diacetyl	10% v/v in 12% ethanol	Sigma D3634
Caramel/maple	5-ethyl-4-methyl-3-hydroxy furanone	10% v/v in 12% ethanol	Bedoukian 875
Pear (Bartlett)	Ethyl 2,4-decadienoate	10% v/v in 12% ethanol	Bedoukian 433
Cloves	Oil of clove	10% v/v in 12% ethanol in pilot study; 5% v/v in experiment	BDH Chemicals 36063
Ripe or rotting fruit	Ethanol 99.5%	100 ppm in distilled water in pilot study; 400 ppm in experiment	BDH Chemicals 270034L
Coriander wood/citrus	Linalool 95–97%	10% v/v in 12% ethanol	Sigma L-5255
Floral/rose/sweet	Rose oxide	Neat	Bedoukian 480
Green/herbal/leafy	Trans-2-hexenal	200 ppm in 12% ethanol	Bedoukian 350
Mint/peppermint	R-carvone	Neat	Sigma
Nutty/sweet	3-acetyl-2,5-dimethyl furan	10% v/v in 12% ethanol	Bedoukian 858
Mushroom	1-octen-3-ol	Neat	Sigma
Smoky/leather/tobacco	Ethyl-3-hydroxy hexanoate	Neat	Bedoukian 434
Soapy/sour	Capric acid	0.13 g in 5 ml of 12% ethanol	Bedoukian 882
Herbaceous/tobacco	Gamma-hexalactone	Neat	Bedoukian 449
Citrus/floral	Nerol BRI	Neat	Bedoukian 449
Vanilla/oak	Ethylvanillin prop. glycol acetate	Neat	Bedoukian 831
Vinegar/sour/acetic	Acetic acid 100%	5% v/v in distilled water	L.U. Stores
Melon	Cis-5-octen-1-ol	Neat	Bedoukian 168

[a] Neat refers to 0.5 ml solution in the 10 ml glass bottle.

sensory laboratory that was designed according to the guidelines of the American Society for Testing and Materials (ASTM, 1986). Ambient temperature of the room was maintained at 20±2 °C. For the remaining participants (four experts and three novices), testing took place off-campus. In each case, the testing situation simulated the conditions of the sensory laboratory (e.g., testing occurred in the wine-tasting area of the participant's winery).

Participants were advised that the study involved making judgements about wine-relevant smells. The olfactory threshold task preceded the odour-recognition conditions. Each participant was evaluated for odour detection threshold using solutions of *n*-butyl alcohol in distilled water in an ascending staircase, two-alternative, forced-choice procedure (Bende & Nordin, 1997; Lehrner et al., 1999). Starting at the lowest concentration, an odorant bottle was presented to the participant in the booth, accompanied by an identical bottle that contained distilled water only. Participants were encouraged to sniff each bottle bi-rhinally. An inter-trial interval of 30 s occurred between trials. The distilled-water-only bottle was presented as the left or the right sample equally often. When a correct choice was made, the same concentration of odorant was presented to the participant until four consecutive correct responses were given. This concentration was taken as an estimate of the participant's detection threshold. A different bottle of distilled water was presented alongside each of the four consecutive presentations of the same concentration of odorant.

The olfactory recognition task followed the threshold task. Each participant was provided with instructions concerning the two learning conditions of the cognitive task, although at no stage were they advised that they should remember the smells or that a memory task was involved. This is in keeping with an unintentional learning paradigm. Participants were told that they would be presented with a series of odorants. They were advised that on some occasions they would be asked to name the particular odour, taking account of the wine context. On other occasions they would be asked to give the odour a pleasantness rating. Participants were provided with the pleasantness scale and were familiarised with its use. The scale consisted of a 100 mm black horizontal line on white paper. The line was numbered 1–5 at equal intervals. Directly below the digit 1 was the word "unpleasant", below the 3 was the word "neutral" and below the 5 was the word "pleasant". Participants were advised that the task was as straightforward as answering the question "Do you like this smell". They were advised that they could employ half-marks when reporting their pleasantness rating (e.g., could report a score of $3\frac{1}{2}$). Participants were advised that they were to report their score orally to the experimenter, rather than to mark the paper. Finally, they were reminded of the wine context for all odorants.

Each participant smelled in succession the 18 odorants from groups A and B. The 18 odorants were randomly ordered for each participant. For alternate participants in each group (expert or novice), the nine odorants comprising sample set A served as stimuli to be named, whilst odorants in sample set B served as stimuli to which an affective judgment was to be made. The reverse occurred for the remaining participants. That is, set B odorants were to be named, whilst odorants in sample set A served as stimuli to which an affective judgment was made. The random ordering of the 18 stimuli for each participant meant that the presentation of each odorant was accompanied by verbal instruction from the experimenter as to the specific task for that odorant (i.e., whether to name the odorant or to rate it for pleasantness). During testing, odorants other than the one being sniffed were kept tightly sealed and an extraction fan minimised diffusion of odours into the testing room. A stimulus presentation rate of 45 s was employed to control for possible adaptation effects.

A retention interval of 10 min followed, during which time the participant was invited to chat about their wine-relevant experience. Twenty-seven odorants were then presented in random order. They comprised the 18 previously presented odorants (old) and the nine group-C odorants (new). Participants judged whether each odorant was old or new, and then gave a confidence rating for their recognition judgment. The confidence rating scale comprised a horizontal line scale, numbered 1–5, with the words "extremely confident" positioned below the 5, and "not at all confident" below the 1.

3. Results

All hypothesis testing involved two-tailed tests, and a probability of less than 0.05 before the null hypothesis was rejected.

3.1. Sensitivity

The score obtained for each participant's odour-detection threshold comprised the dilution number corresponding to the 1-butanol concentration correctly chosen over distilled water in four consecutive trials. A high number represents a low threshold. Consistent with previous results, detection thresholds for *n*-butyl alcohol did not differ between groups, $t(26) = 0.57$, $p = 0.57$ (experts: $M = 9.57$, $SD = 2.50$; novices: $M = 9.07$, $SD = 2.09$) (Fig. 1). Correlation coefficients were calculated between threshold scores and the cognitive tasks (Table 3). There were no significant relations between experts' thresholds and odour recognition ($r = 0.15$) or odour identification ($r = 0.06$). Similarly, the correlations between novices' sensitivity to 1-butanol and their odour recognition ($r = 0.04$) and identification ($r = 0.25$) were low. Superior sensitivity in experts could not be argued as the source of any enhanced olfactory memory performance. That is, enhanced sensitivity could not be considered a major factor in ability to recognise or identify wine-relevant odorants.

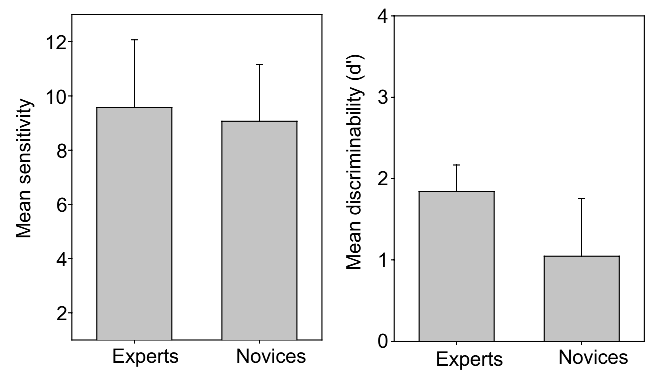

Fig. 1. Mean sensitivity to 1-butanol (in dilution steps, where a higher number represents a lower threshold) and mean recognition (d') as a function of expertise.

3.2. Olfactory recognition

Based on the theory of signal detection (TSD), hit rates, false-alarm rates, and measures of discriminability and bias were calculated for each participant (Macmillan & Creelman, 1991). A hit was defined as a "yes" response to an old (previously-presented) odorant, and a false alarm (FA) was defined as a "yes" to a new odorant. The measure of discriminability calculated was the recognition index d' and the measure of bias was the criterion measure, C. There were twice as many target items (18) as distractors (9). Further, performance on the same nine distractors was used to compute hit and FA rates in the two experimental conditions so that any differences in d' or C concerning these conditions reflect differences in hit rates. A correction procedure was implemented as measures of d' (Eq. (1)) and bias (Eq. (2)) are undefined for hit rates of 1.0 and false-alarm rates of zero (see Snodgrass & Corwin, 1988, p. 35). This involved adding 0.5 to each frequency of hits and FAs and dividing by $N + 1$, where N is the number of old or new stimuli.

$$d' = z_{FA} - z_{hit} \quad (1)$$

$$C = 0.5(z_{FA} + z_{hit}) \quad (2)$$

A two-way mixed ANOVA, with expertise as a between-subject variable and encoding condition (naming versus affective judgment) a within-subject variable, was conducted on the data. Results showed a main effect of expertise, $F(1,26) = 12.05$, $p < 0.05$. Experts showed superior recognition of olfactory stimuli ($M = 1.84$, $SD = 0.33$) when compared with novices ($M = 1.05$, $SD = 0.71$). Further, experts demonstrated less within-group variability as reflected in the standard deviation measures. Fig. 1 and Table 2 show *n*-butyl alcohol detection thresholds and olfactory recognition memory results.

The analysis also showed a main effect of task, $F(1,26) = 13.30$, $p < 0.05$. Our hypothesis predicting an interaction between expertise and type of encoding task failed to gain support from the present data, $F(1,26) = 0.20$, $p > 0.05$. Recognition for odorants that were overtly named during the unintentional learning manipulation was higher for both experts and novices (Expert $M = 1.95$, $SD = 0.39$; Novice $M = 1.26$, $SD = 0.76$) than was recognition for odorants to which an affective judgment was made (Expert $M = 1.65$, $SD = 0.42$; Novice $M = 0.87$, $SD = 0.77$). When odours had to be identified, experts' recognition was superior to that of novices, and when odour stimuli were accorded a pleasantness rating, experts' recognition was again superior (see Table 2). As reported previously, increased within-group variability is apparent in the novice group.

There was no difference between groups in the overall bias measure, $t(26) = 0.72$, $p = 0.24$. This demonstrates that the difference between the groups reflected a true difference in recognition ability and not a difference in tendency to report having experienced the odorant before.

The results replicate the major effects reported in Parr et al. (2002), namely that experts have superior recognition ability for wine-relevant odours, despite their sensitivity and bias measures being similar to those of novices. The present study extends these effects to an unintentional remembering situation, and to a comparison involving true wine novices, rather than intermediates.

3.3. Memory operating characteristic curves

In the context of TSD, confidence judgements in the recognition task can be interpreted as the person making graded responses that reflect their degree of experience with each odorant. Memory operating characteristic (MOC) curves were constructed for the groups under each condition as described in Parr et al. (2002). Fig. 2 shows that recognition ability is overall higher for experts than novices, and overall higher in both groups when the odorants were identified, rather than rated for pleasantness.

In summary, contrary to our hypothesis, experts' recognition was superior to that of novices, irrespective of encoding task.

3.4. Identification

The data concerning identification of odorants comprised the overt naming responses that were requested in the learning phase of the recognition task. They were scored as described in previous literature (Cain & Potts, 1996; Parr et al., 2002), with 2 for an accurate name (e.g., "cloves" for cloves), 1 for a near miss (e.g., "cinnamon" for cloves) and 0 for a far miss (e.g., "citrus" for earthy/mouldy). It was interesting to note that a reasonable number of incorrect responses involved associative memory. For example, 'bread' or 'crackers' was given to the buttery note (diacetyl). Associative responses were scored as zero unless they were perceptually similar to the odorant (e.g., 'cheesy' for buttery), in which case they were scored as a near miss.

There was no significant difference in accuracy of odorant naming as a function of expertise (Expert

Table 2
Olfactory performance as a function of expertise

Tasks	Wine experts		Wine novices	
	M	SD	*M*	SD
Overall odour memory (d')	1.84	0.33	1.05	0.71*
Recognition I (d')	1.95	0.39	1.26	0.76*
Recognition P (d')	1.65	0.42	0.87	0.77
Hits	0.81	0.08	0.65	0.11*
False alarms	0.20	0.12	0.30	0.21
Criterion (C)	−0.12	0.38	−0.19	0.41
Identification	0.42	0.14	0.44	0.14
Sensitivity to 1-butanol	9.57	2.50	9.07	2.09

Recognition I: recognition of odorants that were named during the encoding phase of the task; Recognition P: recognition of odorants to which a pleasantness rating was made during the encoding phase of the task. Hits, False alarms, and Identification of odorants are reported as proportions correct. Sensitivity to 1-butanol is reported in dilution steps, where a higher number represents a lower threshold.
* Denotes a significant difference between groups ($p < 0.05$).

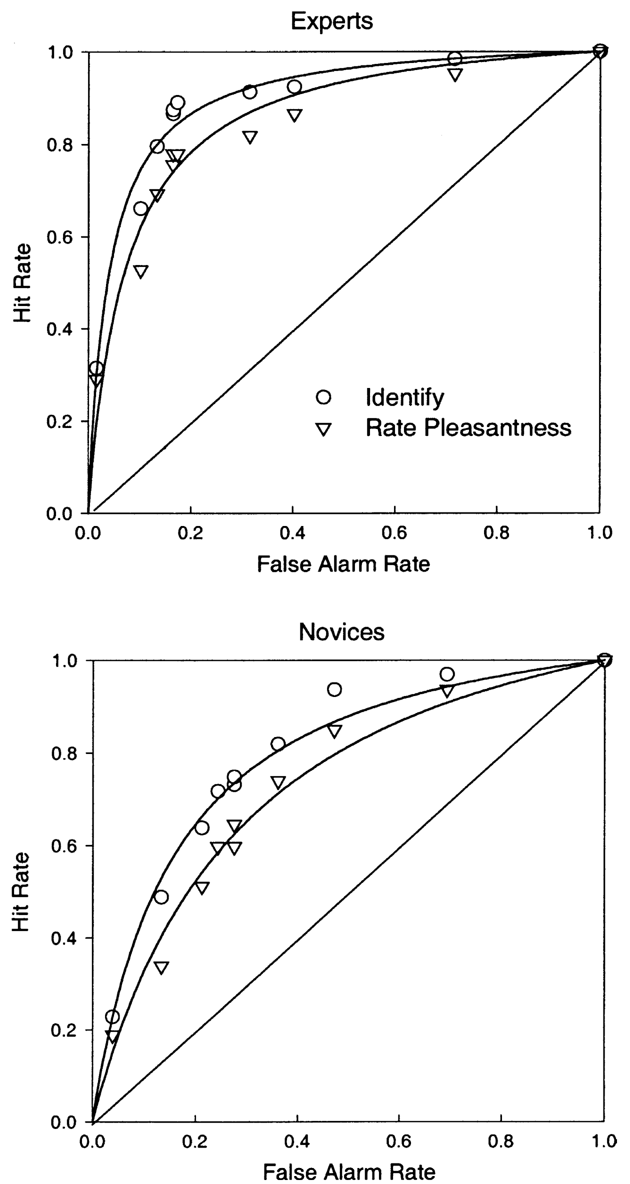

Fig. 2. Group MOC curves for wine experts and novices under each encoding condition (Identify; Rate pleasantness) for the probability of calling an old odour "old" (hit rate) versus probability of calling an old odour "new" (false alarm rate) for each confidence interval.

$M = 0.42$, $SD = 0.14$; Novice $M = 0.44$, $SD = 0.14$). This result replicates that of the previous experiment involving experts and intermediates. The mean scores were in keeping with those typically reported in odour-naming tasks, where it is uncommon for participants to identify more than 50% of the odorants in a recognition task.

3.5. Relation between recognition and identification

To investigate the relation between participant expertise and performance on odour identification and recognition memory, a mixed-model ANOVA was conducted on a subset of data. Data included in the analysis were the identification and recognition results of the odorants that each participant had attempted to identify during the encoding phase of the task. That is, the odorants to which a pleasantness rating had been made during encoding were excluded from this particular analysis. Expertise was a between-group independent variable, while type of task (identification versus recognition memory (recogn I)) was a within-subject factor. Results showed a main effect of expertise, $F(1,26) = 7.01$, $p < 0.05$, a result that must be qualified in light of a significant interaction between expertise and type of task, $F(1,26) = 10.82$, $p < 0.05$. Table 2 shows that experts' recognition memory ($M = 1.95$) was significantly higher than that of novices ($M = 1.26$), while identification scores across groups were similar (Expert $M = 0.42$; Novice $M = 0.44$).

Pearson's correlations were performed within each group (experts; novices) between identification scores and the various recognition memory scores (total odour recognition; recognition of odorants that were named (recogn I); and recognition of odorants to which a pleasantness judgment were made (recogn P)). Table 3 shows that for experts, there was no association between their ability to correctly name odorants and their ability to remember these same odorants ($r = +0.07$) or odorants to which a pleasantness rating was given ($r = +0.005$). For novices, although the correlations between their ability to remember odorants and their ability to correctly name those same odorants failed to reach significance ($r = +0.46$), there was a trend toward a positive association. Similarly, associations between novices' identification and total recognition memory scores ($r = +0.62$) and recognition memory scores for odorants to which they had made pleasantness judgments ($r = +0.69$) were positive, although failed to reach significance. The failure of the hypotheses tests on the novices' data to reach statistical significance presumably reflects, at least in part, the combined effects of the relatively small sample size along with increased variability within the novice group.

In summary, these data replicate and extend the major result reported in Parr et al. (2002). That is, superior recognition of wine-relevant odorants by wine experts did not have its source in enhanced veridical naming of the odorants.

3.6. Pleasantness ratings

The data concerning affective judgments to the odorants were collated and means computed for each odorant. Table 4 demonstrates that the majority of odorants were, on average, neither strongly disliked by participants nor strongly liked. The mean pleasantness ratings given to each odorant were correlated with the mean recognition memory and mean identification scores for each odorant as a function of wine expertise. For experts, there was no relation between an odorant's rated pleasantness and either of the cognitive tasks:

Table 3
Correlations of olfactory threshold, total odour recognition of named odorants (recogn I), odour recognition of odorants to which a pleasantness rating was made (recogn P), and odour identification in expert and novice wine judges

(A) Whole sample (n = 28)						
Variables	1	2	3	4	5	6
(1) Threshold	1.0					
(2) Total odour recogn	0.12	1.0				
(3) Odour recogn I	0.03	0.91*	1.0			
(4) Odour recogn P	0.14	0.95*	0.76*	1.0		
(5) False alarms	0.03	−0.84*	−0.76*	−0.83*	1.0	
(6) Odour identification	0.07	0.27	0.22	0.31	−0.31	1.0
(B) Experts (n = 14)						
Variables	1	2	3	4	5	6
(1) Threshold	1.0					
(2) Total odour recogn	0.15	1.0				
(3) Odour recogn	−0.06	0.70	1.01			
(4) Odour recogn P	0.18	0.86*	0.26	1.0		
(5) False alarms	0.13	−0.67	−0.56	−0.60	1.0	
(6) Odour identification	0.06	0.06	0.07	0.005	−0.09	1.0
(C) Novices (n = 14)						
Variables	1	2	3	4	5	6
(1) Threshold	1.0					
(2) Total odour recogn	0.04	1.0				
(3) Odour recogn I	−0.01	0.92*	1.0			
(4) Odour recogn P	0.05	0.96*	0.78*	1.0		
(5) False alarms	0.03	−0.92*	−0.80*	−0.92*	1.0	
(6) Odour identification	0.25	0.62	0.46	0.69	−0.53	1.0

*Denotes a significant relation between variables ($p < 0.05$).

Table 4
Mean pleasantness ratings to each odorant as a function of expertise (1 = unpleasant; 3 = neutral; 5 = pleasant)

Odorant descriptor(s)	Expert		Novice	
	M	SD	*M*	SD
Green/leafy/vegetal	2.50	0.91	2.21	0.81
Melon/tropical fruit	3.07	1.02	3.21	1.22
Pears (Bartlett)	3.07	0.84	2.36	0.48
Citrus/coriander wood/muscat	3.57	0.53	3.07	0.79
Citrus/floral	2.93	1.13	3.79	0.70
Pineapple/fruity	2.07	0.79	2.79	0.70
Acetic/ripe or rotting fruit	2.71	0.49	2.86	0.69
Vinegar/acetic acid	1.79	0.49	2.00	0.65
Vanilla	4.00	1.00	4.29	0.86
Rancid/manure/rotting	1.21	0.39	1.79	0.95
Dried herbaceous/tobacco	3.07	0.73	2.93	0.53
Mushroom/fungal	1.93	0.89	2.43	0.98
Smoky/leather/dried	2.93	0.73	2.71	1.04
Earthy/musty/mouldy	2.29	0.70	1.43	0.53
Cinnamon/spicy	3.21	1.29	3.21	1.22
Buttery/malolactic	2.36	1.03	2.43	1.06
Aniseed/liquorice	3.93	0.79	3.79	0.39
Soapy/sour	1.93	0.93	1.71	0.57

correlation coefficients were $r = +0.02$ for recognition and $r = +0.19$ for identification performance. For novices, there was no relation ($r = -0.03$) between pleasantness rating and recognition memory. A moderately low, positive correlation between pleasantness rating and identification performance ($r = +0.30$) suggests that, for novices, pleasant odorants were easier to identify correctly than those rated as less pleasant.

4. Discussion

The present study demonstrated superior olfactory recognition memory for domain-specific aromatic compounds by wine experts, despite their odour-identification skills being similar to those of novices. This result, now replicated, is surprising, given the positive association between ability to name odours and ability to recognise odours that has been reported amongst the general population (e.g., Lehrner et al., 1999).

The study also extends knowledge concerning cognitive aspects of wine expertise in three ways. First, enhanced explicit recognition memory for wine-relevant odorants by wine experts was demonstrated in an unintentional learning paradigm. This paradigm has greater ecological validity than that employed previously as it exemplifies situations that wine professionals are likely to find themselves in such as when making a judgment about an odour note without purposefully trying to remember the specific note. Second, the present study demonstrated that wine novices, as opposed to intermediates (Parr et al., 2002), were as capable as wine experts at giving wine-relevant odorants their veridical name. One possible reason for this result is the fact that many wine-relevant odours are also everyday odours, particularly so for those who enjoy activities such as cooking and gardening.

The third and major contribution to the field results from investigation of the locus of wine experts' superior olfactory recognition memory. Parr et al. (2002) interpreted a similar result in terms of the less-experienced participants being disadvantaged by having to name the to-be-remembered odorants. It was argued that the semantic requirement at time of encoding forced attention away from the smell itself. To provide direct evidence of this, the present experiment compared forced naming of odorants with the requirement to make an affective judgment to each odorant. Contrary to expectation, odour recognition memory was higher in the odour-identification condition than in the pleasantness-rating condition for both experts and novices, demonstrating that semantic memory plays an important role in odour recognition.

However, semantic memory was not the locus of the domain-specific, superior olfactory memory demonstrated by wine experts, unless some aspect of semantic memory other than identifying odorants with their veridical names was involved. It is conceivable that naming an odorant with a name that is meaningful to the participant, irrespective of its objective accuracy, is positively associated with ability to recognise the odour note. This is in keeping with a result reported by Lehrner et al. (1999) where consistency of name use by members of the general population was more strongly associated with olfactory recognition accuracy than was correctness of the name used. There was a suggestion of this in our prior experiment (Parr et al., 2002) where a trend toward a positive correlation between consistency of naming an odorant and ability to recognise the odorant occurred in experts but no such trend occurred in the novices' data.

A theory with relevance to the current data is levels-of-processing theory (Craik & Lockhart, 1972). A levels-of-processing analysis would argue that, for olfactory stimuli, naming an odorant would require a deeper level of cognitive processing than judging an odorant's pleasantness. Rather than negatively affecting later ability to recognise the odours, searching for a name (activation of semantic memory) would be expected to enhance olfactory recognition memory. However, failure to find a positive association between ability to identify an odour and ability to recognise the odour, particularly in wine experts for whom the correlation coefficient was close to zero, tends to argue against such an interpretation.

In the absence of an odour-naming (semantic memory) advantage for wine experts, the locus of their odour recognition memory advantage needs to be sought in other cognitive processes implicated in the type of recognition memory being tested, namely perception, sensory-based memory (i.e., memory for the smell itself) and olfactory imaging. Although olfactory imaging has received little research attention historically, not least because it is difficult to investigate, it could be conceived as a potential candidate for a cognitive process that wine-relevant experience develops. In many wine-judgment situations, such as where a winemaker employs their nose as the major tool with which they systematically monitor their ferments, a small change in concentration of a compound can shift the detected note from acceptable (even "interesting") to the category of an off-note. It follows that being able to match an odour to that which one smelled several hours' ago is at least, if not more, important than being able to label the odour with its correct name.

Finally, it would seem prudent to consider that several aspects of methodology could be implicated in the present results. First, it is conceivable that participants spent more time with, or gave more attention to, odorants that were to-be-named, than those to which an affective judgment was to be made. Although temporal controls were in place to exclude this possibility, there were limits to which the type of information processing that any participant engaged in during the encoding phase of the task could be constrained. Second, the design of the study, where the within-subject manipulation of encoding condition occurred within a single session, could have influenced participant behaviour, irrespective of the experimenter's specific instructions. It is conceivable that the within-session manipulation could have resulted in participants attempting to name all odorants, despite the absence of a request for an overt naming response. That is, when an affective judgment was asked of the participant, covert naming may also have occurred.

5. Conclusion

Enhanced olfactory recognition memory of wine-relevant odours by wine experts appears a robust finding, although the source of the effect remains elusive. What is clear is that the locus of the advantage does not lie in superior ability to name the odours with what are considered to be the odorants' veridical names. Perceptual skills, such as olfactory imaging, provide one possible source of the experts' demonstrated advantage that requires further research. A second avenue for future research is hinted at by the present study. Whereas there was no relation between experts' identification and recognition memory, or between their affective judgments and their cognitive performance, novices demonstrated moderately positive associations between recognition memory and identification, and between their pleasantness judgments and identification performance. It is conceivable that a component of the advantage that experts demonstrate relates to their ability to recognise smells, whilst being uninfluenced by either the name of the odour or its hedonic nature. From an information-processing perspective, this would suggest that experts could have more attention (e.g., working memory capacity) to direct to the task at hand, unencumbered by the associated semantic and affective input, thereby advantaging them.

Acknowledgements

The work was funded by a Lincoln University Doctoral Scholarship, a Lincoln University Fund for Excellence award, and a Claude McCarthy Fellowship awarded by the New Zealand Vice-Chancellors' Committee (2001) to Wendy Parr. We would like to thank Bedoukian Research Inc. for generously donating many of the odorants, and Dr. Rob Sherlock and Janette Busch for assistance with development of the stimuli.

References

ASTM (1985). Atlas of Odor Character Profiles. Philadelphia: ASTM publications.

ASTM (1986). Physical Requirement Guidelines for Sensory Evaluation Laboratories, ASTM STP 913. Philadelphia: ASTM publications.

Bende, M., & Nordin, S. (1997). Perceptual learning in olfaction: professional wine tasters versus controls. *Physiology and Behavior, 62*, 1065–1070.

Cain, W. S., & Potts, B. C. (1996). Switch and bait: probing the discriminative basis of odor identification via recognition memory. *Chemical Senses, 21*, 35–44.

Chollet, S., & Valentin, D. (2000). Le degré d'expertise a-t-il une influence sur la perception olfactive? Quelques éléments de réponse dans le domaine du vin. *L'Anne psychologique, 100*, 11–36.

Craik, F. I., & Lockhart, R. S. (1972). Levels of processing: a framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11*, 671–684.

Degel, J., & Koster, E. P. (1999). Odors: implicit memory and performance effects. *Chemical Senses, 24*, 317–325.

Ehrlichman, H., & Halpern, J. N. (1988). Affect and memory: effects of pleasant and unpleasant odors on retrieval of happy and unhappy memories. *Journal of Personality and Social Psychology, 55*, 769–779.

Hughson, A., & Boakes, R. A. (2002). The knowing nose: the role of knowledge in wine expertise. *Food Quality and Preference, 13*, 463–472.

Lawless, H. T., & Cain, W. (1975). Recognition memory for odors. *Chemical Senses, 1*, 331–337.

Lehrner, J., Gluck, J., & Laska, M. (1999). Odor identification, consistency of label use, olfactory threshold and their relationships to odor memory over the human lifespan. *Chemical Senses, 24*, 337–346.

Lenoir, J. (1995). *Le nez du vin*. France: Jean Lenoir.

Lorig, T. S. (1999). On the similarity of odor and language perception. *Neuroscience and Biobehavioral Reviews, 23*, 391–398.

Macmillan, N., & Creelman, C. D. (1991). *Detection theory: a user's guide*. Cambridge, UK: Cambridge University Press.

Melcher, J., & Schooler, J. (1996). The misremembrance of wines past: verbal and perceptual expertise differentially mediate verbal overshadowing of taste memory. *Journal of Memory and Language, 35*, 231–245.

Morrot, G., Brochet, F., & Dubourdieu, D. (2001). The color of odors. *Brain and Language, 79*, 309–320.

Norman, G. R., Brooks, L. R., & Allen, S. W. (1989). Recall by expert medical practitioners and novices as a record of processing attention. *Journal of Experimental Psychology: Learning, Memory and Cognition, 15*, 1166–1174.

Parr, W. V., Heatherbell, D., & White, K. G. (2002). Demystifying wine expertise: olfactory threshold, perceptual skill, and semantic memory in expert and novice wine judges. *Chemical Senses, 27*, 747–755.

Savic, I., & Berglund, H. (2000). Right-nostril dominance in discrimination of unfamiliar, but not familiar, odours. *Chemical Senses, 25*, 517–523.

Schacter, D. L. (1987). Implicit memory: history and current status. *Journal of Experimental Psychology, 13*, 501–518.

Snodgrass, J., & Corwin, J. (1988). Pragmatics of measuring recognition memory: applications to dementia and amnesia. *Journal of Experimental Psychology: General, 117*, 34–50.

Solomon, G. (1991). Language and categorization in wine expertise. In H. T. Lawless, & B. P. Klein (Eds.), *Sensory science theory and applications in foods*. New York: Marcel Dekker Inc.

Sulmont, C., Issanchou, S., & Koster, E. P. (2002). Selection of odorants for memory tests on the basis of familiarity, perceived complexity, pleasantness, similarity and identification. *Chemical Senses, 27*, 307–317.