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Perceived complexity in Sauvignon Blanc wines: influence of domain-specific expertise

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Abstract

Background and Aims: Complexity is a multidimensional and poorly defined term that is frequently employed to characterise wine sensorially. The present study aimed to investigate the sensorial nature of perceived complexity in wine as a function of domain-specific expertise.

Methods and Results: Eighty-seven French participants (16 wine professionals, 30 connoisseurs and 41 wine consumers) evaluated 13 Sauvignon Blanc wines. The wines were produced in New Zealand as part of a project aimed at increasing perceived complexity in Sauvignon wines. Participants evaluated the wines by free sorting and by judging complexity via a questionnaire. Sorting behaviour across groups was similar qualitatively, but significant differences were observed in variability between wine professionals and consumers. Complexity questionnaire data showed differences in ratings as a function of both participant expertise and wine.

Conclusions: The results are more in keeping with theories that perceived complexity is associated with aspects of harmony and wine balance, rather than with perceptual separability of wine components.

Significance of the Study: The current work reports innovative methodology and new information that furthers the field of sensory science, and specifically investigation of complexity in wine.

Keywords: *complexity, expertise, Sauvignon Blanc, wine*

Introduction

The term complex is frequently employed to describe the sensory properties of wine (e.g. Cooper 2008). Despite this, perceived complexity in wine remains a vague and ambiguous concept (Aron 1999). From a physico-chemical perspective, wine is a complex food stimulus consisting of hundreds of volatile and non-volatile substances (Thorngate 1997). Such objective complexity, however, does not necessarily translate into perceived complexity; that is, despite their chemical complexity not all wines are described sensorially as complex, with terms such as 'simple' employed to oppose complexity. The aim of the present study was to investigate the sensory nature of perceived complexity in white wine, specifically in the white wine cultivar Sauvignon Blanc.

Little published research has directly investigated perceived complexity in wine. Several reported findings, however, provide indirect evidence concerning the nature of perceived complexity. One variable regularly reported as positively associated with perceived complexity is wine quality; wines considered as complex are likely to be judged high in quality (Singleton and Ough 1962, Charters and Pettigrew 2007), and in turn to afford higher prices than those of less-complex wines. The positive association reported by others between perceived complexity and perceived quality received further support from a study demonstrating that complexity is considered a positive attribute of wine by both wine professionals and wine consumers (Parr et al. 2011). A second variable that has been shown to associate positively with perceived quality and perceived complexity in wine is the perceived ageing ability of wine (Langlois et al. 2010, Parr et al. 2011, Saenz-Navajas et al. 2013).

As distinct from objective complexity, that is complexity defined in terms of chemical composition, inherent in the notion of perceived complexity is the inclusion of a perceiver. That is any analysis of perceived complexity in wine requires consideration of the nature of human sensory experience of wine, a cognitively sophisticated (Parr 2008) and multisensory process. In terms of perception, wine is a complex stimulus from several perspectives. First, it is complex in that odorants, tastants and trigeminal stimuli all offer various components to experience at the same time (Auvray and Spence 2008). Second, wine is complex in that it can be difficult to put chemosensory percepts into words, this factor interacting with domain-specific expertise (Melcher and Schooler 1996). Several studies have provided data in support of the notion that the ability of a perceiver to assess or analyse the objectively complex sensory stimulus that is wine is influenced by their relative degree of experience (type, quantity) with respect to wine (Melcher and Schooler 1996, Parr et al. 2002, Langlois et al. 2011, Urdapilleta

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et al. 2011, Saenz-Navajas et al. 2013). In the present study, we considered the nature of perceived complexity in Sauvignon wines in relation to three categories of domain-specific expertise of the perceiver: wine professional/oenologist, wine connoisseur and wine consumer.

Factors associated with perceived complexity

In terms of factors that may be important to perception of complexity in wine, the fundamental literature on odour complexity (see Lawless 1997) provides some indication. Odour complexity is associated with two factors in particular, one pertaining to the participant or perceiver, namely familiarity and domain-specific expertise, and the second pertaining to the stimulus itself, specifically the number of distinct components in the mixture. With respect to expertise, experience with wine has been associated with enhanced discrimination ability (e.g. Gibson and Gibson 1955, Hughson and Boakes 2002, Parr et al. 2002), as well as with higher-order cognitive components of wine evaluation such as semantic memory (Solomon 1990, Zucco et al. 2011). When a wider range of food and beverage products is considered, domain-specific expertise has been shown to influence both hedonics (i.e. liking) (Distel et al. 1999) and intensity judgments (Dalton 2000).

Hence, it is conceivable that perceived complexity in wine could be influenced by participant expertise. A study reported by Parr et al. (2011) provides indirect evidence to suggest that perception of the complexity of a wine could be influenced by domain-specific expertise. The study investigated complexity in wine in terms of how the concept is mentally represented. Employing interview technique methodology rather than wine sampling, the authors investigated perceived complexity in wine as a function of wine expertise (wine professionals, wine consumers). Results showed that although both experienced wine professionals and less-experienced wine consumers considered complexity in wine to be a multidimensional construct, the groups differed markedly in terms of the components of their mental constructs. Wine consumers related complexity in wine to subjective experience, in particular the pleasure (e.g. enjoyment) related to drinking a wine, and to their notions of wine quality, brand and image. Wine professionals in contrast linked wine complexity primarily to factors other than intrinsic factors associated with actual experience of the wine. These included both vineyard factors, for example vine type, soil and vineyard location, and oenological processing operations, for example use of oak and lees stirring, and decision making such as fruit ripeness at harvest.

The literature is less clear with respect to the second aspect, namely number of distinct components and degree of blendedness of the stimulus. Although complexity in wine appears to be mentally represented by wine consumers and wine professionals as a multicomponent concept (Parr et al. 2011), the sensory property 'complex' may be perceived as a single or blended percept, at least in some contexts (Auvray and Spence 2008). Singleton and Ough (1962) commented that perceived complexity in products such as perfumes and foods may be the result of a product being made up of 'many ingredients in amounts small enough to influence flavour or odour without being individually obvious' (p. 189). More recently, a review by Auvray and Spence (2008) extends the ideas of Gibson (1966) to argue that multisensory interactions as occur when sampling wine can be combined to form a single percept (synthetic perception) or can be perceived in terms of their individual qualities (analytic perception) depending on the approach taken by the individual taster. This notion conceivably is one reason that the little research to date investigating blendedness or perceptual separability has produced equivocal results. For example, in a study of blended wines and judgments of wine quality, in which the authors assume 'quality' and 'complexity' to be synonymous concepts, Singleton and Ough (1962) reported data suggesting that quality was enhanced in the blended wines as compared with the non-blended wines. In contrast, Lawless (1997) reported a result somewhat at odds with the notion that blendedness or perceived integration enhances perceived complexity. This study, involving olfaction, produced data that Lawless interpreted as indicating that rated complexity of odours reflected perceptual separability, or lack of blendedness of the components of the odorant mixture. That is, a highly blended or integrated mixture may be perceived as lower in complexity than if the individual components stood out.

The assumed underlying cognitive processes are often referred to as 'configural' (e.g. Jinks and Laing 2001, Le Berre et al. 2010) and contrast with perceiving the separate qualities or elements in a mixture as distinct characteristics. There are several lines of olfactory research that support this notion. For example, in their many studies concerning human ability to discriminate and recognise components in multicomponent mixtures, Laing and colleagues (Livermore and Laing 1996, Jinks and Laing 2001, Marshall et al. 2006) have argued on the basis of both physiological and psychological evidence that integration of aromas in a multicomponent mixture (i.e. a wine or a perfume) may, via a configurational process, give rise to a single percept described by the single word 'complex'. Similarly, Lawless (1997) has suggested that multiple odours may be recognised as a whole pattern, with the individual features not being accessible to consciousness. For this reason, our complexity questionnaire methodology included quantitative judgments of wine familiarity, number of perceived distinct components, degree of harmony or integration, and ease of identifying the distinct components in each wine. Participants were also asked to make a global evaluation of each wine by providing an overall complexity rating, this judgment potentially being independent of ability to recognise and identify any individual components of the wine sample.

Methodologies employed

Two sensory methods were employed in the present study to draw on a range of sensory and cognitive processing by the study participants. The methods comprised a rating task involving a recently developed questionnaire for investigation of perceived wine complexity (Medel Maraboli 2011) and a free sorting task. The complexity questionnaire, developed in French, has subsequently been translated and used in Spanish and English (Parr et al. 2012). This questionnaire was used (Meillon et al. 2010) to understand the sensory impact of reducing alcohol content in wines. The complexity questionnaire comprises an overall quantitative judgment or rating of complexity for each wine, and ratings to seven assumed subcomponents of perceived complexity. The eight continuous scales are anchored with pictures (Figure 1), which aim at clarifying the concept under evaluation. The seven assumed attributes of perceived complexity in wine include wine familiarity, number of perceptible flavours, ease of identification of the separate flavours, harmony, balance, persistence of wine in mouth (length) and concentration (strength of flavour). Of particular importance, the questionnaire contains items that investigate perceived blendedness (e.g. evaluation of harmony) or lack of blendedness (e.g. ease of identifying the different flavours/components).

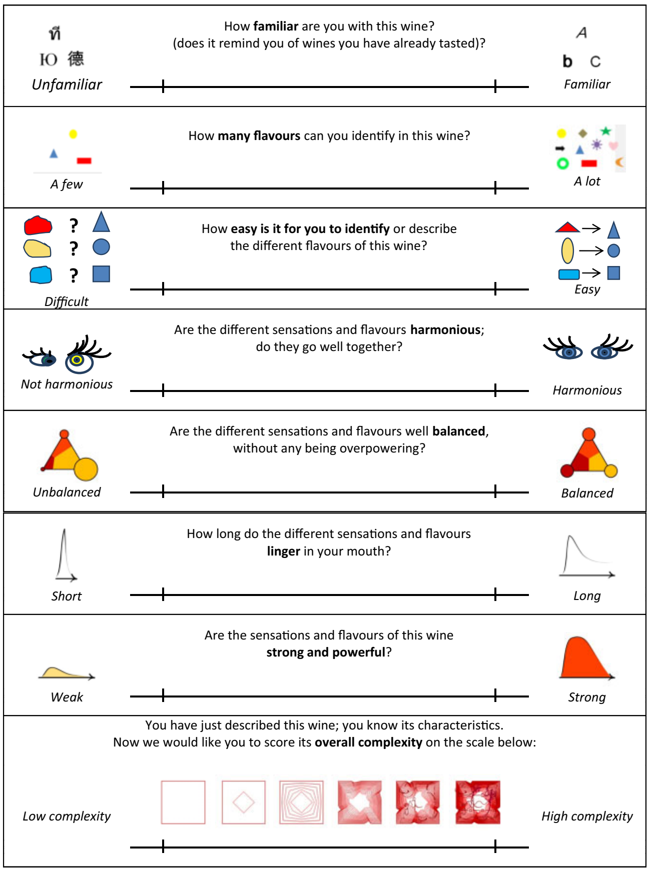

Figure 1. The Institut National de la Recherche Agronomique complexity questionnaire.

Sorting tasks require participants to group or classify objects into classes. The task is assumed to require holistic or global wine assessment (Green et al. 2011), drawing on both sensory and top-down cognitive skills (Dalton 2000) of participants. Sorting task methodology was employed to assist in highlighting any differences in domain-specific expertise among the participant groups. To make a classification in a sorting task, participants need to favour some criteria (i.e. characteristics of the wines) and neglect others (Manetta et al. 2011). Such discrimination behaviour is likely to be influenced by qualitative (type) and quantitative (amount) relevant expertise or familiarity with the products to be sorted, making the sorting task an effective methodology to employ when investigating wine sensory evaluation involving participants of variable expertise level. In a recent study, however, reported by Chollet et al. (2011), that involved sorting beers, non-trained participants performed similarly to trained participants in terms of sorting task behaviour, although there was greater within-group agreement among those with domain-specific expertise (the trained participants) than those without (non-trained participants). This study is of further interest in that the authors (Chollet et al. 2011) reported data to demonstrate the robustness of the sorting task with respect to reliability (replicate data), especially for participants with expertise (i.e. prior training).

The final methodological point to elaborate upon concerns the nature of the wines employed in the experiment. Thirteen Sauvignon Blanc (*Vitis vinifera* L.) wines, produced in Marlborough, New Zealand, were the chosen stimuli for the current study. The wines were considered to be relatively novel stimuli for the French participants in the current study, irrespective of their general level of wine expertise (oenologist, connoisseur or consumer). The wines were produced by a large wine producer, in commercial quantities, specifically with the aim of investigating perceived complexity in Sauvignon Blanc wine by producing wines that varied, either viticulturally or oenologically, from the standard production technique (see Table 1). These same wines had been evaluated by New Zealand wine professionals via non-directed sorting and descriptive rating 2 months prior to the current French experiment. The data from the New Zealand study suggested that a major point of difference among the 13 wines was the influence of the type of harvesting of the fruit that produced the wine (hand or machine harvesting) (Parr et al. 2013).

To summarise, the major aim of the present study was to investigate differences in perception of the complexity of Sauvignon Blanc wine among participants as a function of general wine expertise. We formed two hypotheses. First, we predicted that domain-specific expertise would influence sorting behaviour and judgments of perceived complexity, with the ratings of wine professionals demonstrating less within-group variability and greater discrimination among wines than those of less-experienced participants. Second, it was expected that judgments of overall complexity in a wine would associate differentially with the assumed subcomponents of perceived complexity, in particular with perceived blendedness (harmonious nature) or lack of blendedness (ease of identifying different flavours; poor balance) of a wine. This hypothesis was non-directional, given the equivocal nature of prior literature.

Materials and methods

Participants

Participants were 16 French wine professionals, 30 French wine connoisseurs and 41 French wine consumers. The 16 wine professionals were oenologists, employed in wine production in Burgundy, France, and were recruited on the basis of their known employment and in keeping with criteria specified by Parr et al. (2002). They reported that they tasted wines almost every day. The participants who were not wine professionals were recruited in Burgundy by invitations to participate in research wine tasting at the Centre des Sciences du Goût et de l'Alimentation (CSGA).

The participants who were not wine professionals were allocated to either the consumer or connoisseur group on the basis of two measures, wine experience and wine general knowledge. First, the wine experience of each person was assessed. Wine experience was determined by measuring two behavioural parameters: (i) frequency and place(s) of wine consumption with particular interest in noting regular attendance at formal wine tasting events; and (ii) number of wine bottles in their wine cellar, the latter assumed to reflect wine purchase frequency. These data were employed to allocate participants to either the wine consumer or wine connoisseur category. In terms of frequency of consumption, the selection criterion for wine consumers was a minimum consumption of white wine once per month. Participants were designated connoisseurs and allocated to that group on the basis that they reported regular participation in a wine-tasting club involving technical tastings at least once a month. The second measure obtained involved participants providing information about their general wine knowledge (as separate from their reported experience) via a

Table 1. Viticultural details and composition of the Sauvignon Blanc wines from Marlborough, New Zealand, from the 2009 vintage.

Wines	Description	Wine type†	Ethanol (%) v/v	TA (g/L)	pH	RS (g/L)	Dry extract (g/L)
WF3yob	Uninoculated ferment in 3-year old, 228-L Vicard barrel; Awatere Valley fruit; hand-harvested	Expe/Oeno	13.7	9.56	3.16	5.5	24.5
X5Yst	Yeast X5; hand-harvested	Expe/Oeno	14.8	8.48	3.18	4	19.8
LgWoodFe	Large wooden ferment: Vicard cuve; hand-harvested	Expe/Oeno	14	10.29	3.13	2.3	20.1
StainLSt	Stainless steel tank; hand-harvested	Expe/Oeno	14.3	9.71	3.12	3.5	20.1
PichiYst	*Pichia kluyveri* yeast; hand-harvested	Expe/Oeno	14.6	8.24	3.16	5.8	20.3
MES	4.5% in French oak for 150 days; machine-harvested	Expe/Oeno	13.9	7.43	3.3	3.1	17.2
AwatereF	Awatere Valley fruit; hand-harvested	Expe/Viti	14.1	7.89	3.19	1.5	15.7
Oldvines	Old vines (planted 1982); hand-harvested	Expe/Viti	12.3	10.63	3.07	5.5	23.5
ShadEWV	Shaded-side fruit of east-west vine; hand-harvested	Expe/Viti	14.7	8.38	3.19	2.7	18.3
EWVCoqP	All fruit east-west vines; hand-harvested; Coquard press	Expe/Viti	14.5	9.81	3.07	3.3	20.1
MVS	Standard wine production; machine-harvested	Standard	12.8	7.1	3.39	4.2	18.3
MRS	Standard wine production; machine-harvested	Standard	13.6	6.97	3.35	2.8	18.3
STS	Standard wine production; machine-harvested	Standard	13.2	7.32	3.36	3.4	16.7

†Wine type categories: Standard production, Experimental/Viticultural (Expe/Viti), Experimental/Oenological (Expe/Oeno). TA, total acidity expressed as g/L tartaric acid equivalent; RS, residual sugars.

questionnaire that they completed in their second session. The multiple-choice questionnaire, designed specifically for the present study, comprised 25 items about wine. Example questions include: 'What colour are Merlot grapes?' (there were three response categories for this question: red; white; I don't know); 'What colour are Sémillon grapes?'; 'Can red grapes be used to make white wine?'; 'What are the principal grape varieties grown in Burgundy?'. Results from this wine knowledge questionnaire (connoisseurs and consumers on average scored 78 and 58% correct items, respectively; $P < 0.0001$ by t-test) served to validate that participants were accurately classified as consumer or connoisseur. This resulted in 30 wine connoisseurs (15 male, 15 female) and 41 wine consumers (20 male, 21 female). Participants also provided basic demographic details via the questionnaire. The proportion of connoisseur participants within the following age ranges was: 25–39 = 4; 40–49 = 10; 50–64 = 43; >65 = 43. The proportion of consumer participants within these age ranges was: 25–39 = 20; 40–49 = 22; 50–64 = 46; >65 = 12.

Wines

Thirteen 100% Sauvignon Blanc wines from the 2009 New Zealand vintage were evaluated in the experiment. All wines were produced in commercial quantities by the same large, commercial wine producer and spanned a range in terms of price points and wine styles. The wines comprised three wines made employing standard wine practices for production of Sauvignon Blanc wine in Marlborough, New Zealand (see Parr et al. 2013), and ten wines that were produced innovatively with the aim of increasing Sauvignon wine complexity via various grapegrowing and winemaking practices. The standard technique in Marlborough involves the production of fruit-driven wines by machine harvesting fruit, reductive processing and use of inert vessels such as large stainless steel tanks; that is, the wines are relatively free of winemaker influence (see Parr et al. 2013). The ten non-standard or innovation wines were classified in terms of the dominant factor (viticultural or oenological) that distinguished the particular wine. Factors such as vineyard site or viticultural management were dominant in four of the innovation wines, with these wines being termed 'Experimental/Viti'. Six of the ten innovation wines involved oenological manipulations, for example type of pressing, older oak maturation and indigenous yeast fermentation, and these wines were categorised as 'Experimental/Oeno'. The specific details regarding each of the 13 wines and how they were classified into three wine-type categories (Standard production, Expe/Viti, Expe/Oeno) can be seen in Table 1. Four of the wines were produced from fruit harvested by machine (three Standard, one Expe/Oeno), and the remaining nine wines were produced from grapes that were predominantly hand-harvested. The New Zealand wines were freighted to France for the empirical component of the study.

Procedure

The study was conducted at the sensory facilities of the ChemoSens Platform, CSGA, Dijon, France. Two sessions were held for each participant, separated by an interval of 1 week. Each session lasted approximately 1 h and involved one task only, either sorting or complexity rating. Sessions took place with a maximum of 16 participants at any one time and were held at common wine-consumption times, namely either before lunch (12 noon) or in the evening (1800 h), depending on the availability of participants. Participants were seated in separate booths, with the environment controlled as advised for sensory experimentation (ASTM International 1986).

In each session, the wines were served at ambient temperature and were first checked for faults by at least one experienced wine professional. Samples (40 mL) were then poured into standardised tasting glasses (International Organization for Standardization 1977) that were opaque (black) to eliminate visual cues as sources of information. The glasses were coded with three-digit numbers and were covered with plastic Petri dishes. In order to limit carry-over effects and memory biases, all wine samples were presented in a different order specific to each participant according to a Williams Latin square arrangement generated by FIZZ software (Biosystèmes, Courtenon, France). Evian water was available throughout each session and participants were invited to have a break whenever they wanted and to rinse their mouths with water.

At the beginning of each session, participants were presented with their unique order of the 13 wines and advised that they would taste and make judgments about these 13 wines and that all wines were Sauvignon Blanc. They were not given any other information about the wines. The experimental design was a fully within-subject design where every participant evaluated every wine via both the free-sorting task and via the complexity rating scale, employing a full tasting procedure, that is evaluation by orthonasal olfaction, retronasal olfaction and palate stimulation. Half of the participants evaluated each wine via the Institut National de la Recherche Agronomique complexity questionnaire (Figure 1) in their first session and a free-sorting task in session 2. The other half of the participants undertook the tasks in the reverse order. Participants were advised that expectoration of all wine samples was a requirement of participation. For the sorting task, specific instructions to participants were to smell and taste each wine, in the order presented, and then to classify the wines in any way that made sense to them, drawing on similarities and differences among the wines. The task was not directed further. For example, the number of groups or categories that a participant could employ was not specified.

In their second session, all participants who were not designated oenologists/experts completed the knowledge questionnaire at the beginning of the session.

Data analysis

Sorting task data. The sorting task data were analysed globally (87 subjects) and separately for each of the three groups of subjects: 41 consumers, 30 connoisseurs and 16 experts. An ordinal multidimensional scaling was computed for each of the four corresponding co-occurrence matrices (size 13×13) containing the number of subjects having grouped together each pair of wines. A two-dimensional map was retained for each of these four analyses resulting in stress values just lower than 0.20. The maps from the three groups of subjects were compared by the RV coefficient and the normalised RV coefficient, the latter providing an analytical permutation test allowing an assessment of the significance of the similarity of two maps towards noise generated by product permutations within one of them (Schlich 1996).

The Rand index, measuring the level of similarity between two partitions of the same set of products, was computed for each pair of subjects. The mean values of these Rand indexes within groups allowed comparison of group heterogeneity in terms of product perception as measured by the sorting task. The mean values of the Rand indexes over every pair of subjects, a pair comprising one subject from a given group and one subject from another group, allowed comparison of individual perception between these two groups. The expected Rand index, however, under the null hypothesis of no similarity between two individual partitions is larger than 0 because the same wines can be categorised together in both partitions just by chance. To take this into account, it is possible to compute the so-called, adjusted Rand index (Hubert and Arabie 1985) or to conduct a permutation test ($n = 100$) for each Rand index in order to derive significance ($P = 0.05$) of similarity between partitions generated by two subjects. For the first application of the Rand index on sensory data, the reader is referred to Callier and Schlich (1997). The proportion of subject pairs being assessed as having a similar perception was produced within and between groups as a complementary criterion to the mean Rand indexes.

The three groups of subjects were also compared in terms of the average number of categories produced in their sorting task. A one-way analysis of variance (ANOVA) on these individual numbers was used for that purpose.

Analysis of the complexity questionnaire. The following ANOVA model was computed for each of the eight items of the complexity questionnaire:

$$\begin{aligned} &Group + Subject\ (group) + Wine\ Type + Wine\ (Wine\ Type) \\ &+ Group \times Wine\ Type + Group \times Wine\ (Wine\ Type) \end{aligned} \quad (1)$$

The Group effect expresses the extent to which the consumers, the connoisseurs and the experts differ in their mean score of the item. The Subject factor is nested within the Group factor because a subject belongs to a single group; thus, the Group factor is tested against the Subject factor. Similarly, the Wine factor is nested within the Wine Type factor (Standard, Expe/Oeno, Expe/Viti), and thus the Wine Type factor is tested against the Wine factor. It thus considers both subject and wine as two random factors. The four other effects in this model are tested against the residual means square. The Group-by-Wine-Type or by-Wine interactions are of paramount importance because their significance would denote the fact that the wine type or the wine within wine type differences would not be the same for the three groups of subjects. Following the results of this ANOVA, mean scores of groups of subjects were compared using a least significant difference procedure at $P = 0.10$. The same procedure was used for comparing the three types of wines.

In order to achieve a map of the three Wine Types, summarising their complexity differences, a canonical variate analysis (CVA) of the table composed of the 13 wines times the 87 subjects as observations and the eight complexity items as variables was run. The level of significance of the multivariate ANOVA (MANOVA) F ratio of the Wine Type factor allows an assessment of the extent to which the three wine types are perceived with different complexity. This is illustrated by the CVA map and the extent to which the three confidence ellipses are not overlapping on this map. The Hotteling T^2 statistics were computed for each of the three pairs of wine types, providing P-value for each of these three multivariate, pairwise comparisons of wine types. Also a maximum likelihood test indicated whether one or two dimensions were necessary for discriminating the three wine types in the complexity space. For a comparison of MANOVA and CVA to principal component analysis, the usual way of mapping descriptive sensory data, the reader is referred to Peltier et al. (2015).

Although the superimposition of the questionnaire items as arrows on the former CVA map (bi-plot representation of observations and variables in CVA) helps in understanding the correlational structure among the items, it is just an overall picture at population level with no consideration of the subject groups. To investigate deeper the relations between each of the seven subcomponent items and the final, overall complexity item, individual correlation coefficients were computed and assessed for statistical significance at the 5% level. This article reports the numbers of subjects by group with significant positive, non-significant and significant negative correlation coefficients between each item and the overall complexity item.

Results

Sorting task

Figure 2 shows the outcome from the sorting task. The multidimensional scaling (MDS) product map at general population level (Figure 2a) exhibits a neat structure with the four machine-harvested fruit wines (three Standard wines and wine MES) being clustered together at the top left, the wines WF3yob and OldVines isolated at the bottom left and the bottom right, respectively, and the remaining innovation wines grouped together at the top right. This structure is fairly well recovered by the individual groups of experts (Figure 2b), connoisseurs (Figure 2c) and consumers (Figure 2d), as measured by the RV coefficients. These were equal to 0.84, 071 and 0.87, respectively (Table 2), with corresponding normalised RV largely higher than 1.645, thus significantly better than the chance level defined by permutation. It is also quite clear, however, from observing the maps that the wines are clustered more tightly by experts and connoisseurs compared with that by consumers; that is, the experts and connoisseurs were more discriminating of the wine differences.

The Rand indexes within groups of subjects range from 0.747 for experts to 0.713 in connoisseurs and 0.613 in consumers (Table 3), this denoting a decreasing level of similarity between individuals' categorisations as the level of domain-specific expertise decreases. Further, the highest similarity of individual categorisation is obtained between expert and connoisseur categorisations (0.729), whereas consumers' similarity towards connoisseurs and experts results in Rand indexes of 0.652 and 0.662, respectively. The results of the permutation tests exemplified these findings because 42% of the expert pairs were significant, whereas only about 1% of the pairs from consumers or connoisseurs were significant. Across groups, 23.5% of pairs composed of a connoisseur and an expert were significant, whereas there were 14.6 and 18.6%, respectively, when comparing a consumer to a connoisseur or to an expert (Table 4).

The final sorting task result to report concerns the number of categories formed in the sorting task as a function of expertise. Consumers were less discriminating in that their categorisation was less complex in terms of the number of categories formed than was the categorising of experts or of connoisseurs. Indeed, the consumers formed on average 3.83 categories (SE = 0.16), whereas the experts and the connoisseurs formed 5.25 (SE = 0.17) and 5.00 (SE = 0.36) categories, respectively. This difference between consumers and experts and connoisseurs is significant according to a t-test at $P = 0.05$, while the difference between experts and connoisseurs is not.

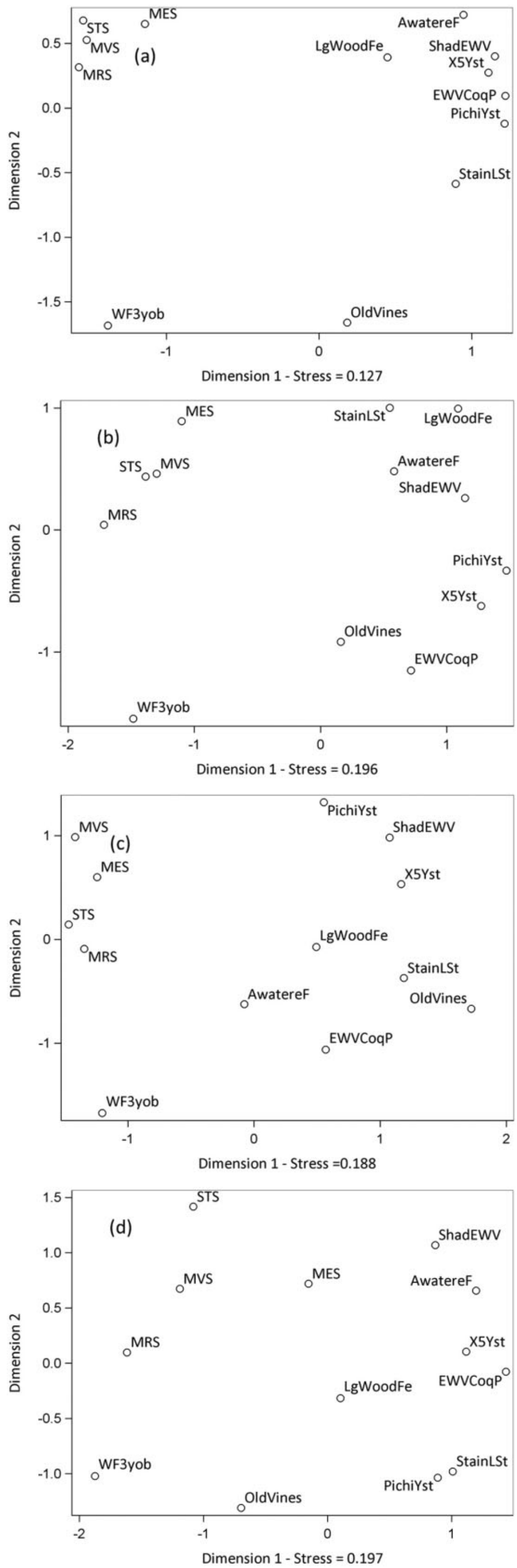

Figure 2. Non-metric ordinal multidimensional scaling of numbers of wine co-occurrences in individual categories from a free-sorting task: (a) based on all 87 subjects; (b) based on 16 experts; (c) based on 30 connoisseurs; and (d) based on 41 consumers.

Again, the current data show greater similarity between performance of wine professionals and designated connoisseurs than between consumers and either of the other expertise-level groups.

Table 2. Index of similiarity (RV) and normalised RV (in parenthesis) coefficients between wine configurations obtained from the sorting task in the three groups of participants.

	Consumer	Connoisseur	Expert	All
Consumer ($n = 41$)	1	–	–	–
Connoisseur ($n = 30$)	0.50 (3.5)	1	–	–
Expert ($n = 16$)	0.67 (5.1)	0.66 (5.0)	1	–
All ($n = 87$)	0.87 (7.2)	0.71 (5.5)	0.84 (6.9)	1

RV is an index of similarity between two multidimensional configurations. Its values can be between 0 and 1 and the closer to 1, the more similar the two configurations. The normalised RV is the standardised deviation of the observed RV to its expected value under permutations. Under a normality assumption, if the normalised RV is higher than 1.645, then the two configurations are significantly ($P = 0.05$) similar.

Table 3. Mean of Rand indexes within (diagonal) and between (off-diagonal) groups of subjects from the sorting task.

	Mean		
	Consumer	Connoisseur	Expert
Consumer	0.613	–	–
Connoisseur	0.652	0.713	–
Expert	0.662	0.729	0.747

The Rand index is the proportion of object pairs being grouped accordingly (either grouped or split) in two different partitions of a set of objects.

Table 4. Proportion of significant Rand indexes within and between groups of subjects.

	Proportion (%)		
	Consumer	Connoisseur	Expert
Consumer	15.6	–	–
Connoisseur	14.6	14.9	–
Expert	18.6	23.5	41.7

Significance ($P = 0.05$) was tested by a permutation (n = 100) test for each pair of subjects.

Complexity questionnaire

Table 5 gives the *P*-values of the ANOVA model described in the Data analysis section. First, the two interactions between Group (i.e. participant expertise) and Wine Type, or Wine nested within Wine Type, are both virtually never significant. This simplifies considerably the subsequent interpretation, which can thus be conducted separately between groups of subjects, and then between types of wines. Indeed, these two factors exhibit significant *P*-values in Table 5 for several items. The lack of interaction between participant group and the wines, whether the latter were classified in terms of wine type or not, shows that all participant groups found the same qualitative differences among the wines when making their complexity ratings; that is there were no qualitative differences in rating the eight complexity items as a function of domain-specific expertise. In contrast, there were quantitative differences as described below.

Table 6 shows Group effects. The first result of interest is that all groups scored familiarity of the wines similarly, validating our notion that the New Zealand wines would serve as novel stimuli for all participants, irrespective of participant differences in general wine expertise. Second, experts gave significantly lower scores on average over the 13 wines to overall complexity, balance and, to a lesser extent, harmony and lingering (palate length), but higher scores to the item 'easy to identify the flavours' than the other two participant groups. These results suggest that the experts, compared with the other participants, found the set of wines less complex but were more able to deconstruct the wines in terms of ease of identifying the various flavour components.

The Wine Type effects are shown in Table 7. The first result of interest is that perceived intensity was the only judgment that was similar across participant groups. Table 7 demonstrates that the Standard wines were perceived as having a larger number of flavours and that the flavours were easier to identify than those of the two other types. The Standard wines were also reported as being more harmonious and, to a lesser extent, more familiar and balanced than the two types of innovation wines. In contrast, the Expe/Oeno wines were perceived as similar in complexity to the Standard wines, and more complex and more lingering than the Expe/Viti wines, the latter generally scoring lower on all attributes. The CVA bi-plot (Figure 3) illustrates these data geometrically. The size of the 90% confidence ellipses shows that the differentiation between the three types of wines is not large and lies on a single dimension (horizontal axis) as confirmed by the likelihood ratio test. This result is further confirmed in that Hotelling's T2 tests significantly split the Standard wines from Expe/Viti wines ($P = 0.005$) and from the Expe/Oeno wines ($P = 0.069$) in the complexity space, whereas the Expe/Viti and Expe/Oeno wines were not split ($P = 0.162$).

As reported in the Data analysis section, the relations between each of the seven subcomponent items and the final, overall complexity item were investigated for each group. Individual correlation coefficients were computed and assessed for statistical significance at the 5% level. Table 8 shows the numbers of subjects by group with significant positive, non-significant and significant negative correlation coefficients between each item and the overall complexity item. It is clear from the data that experts related more items to overall complexity than did connoisseurs or consumers. The items associated with complexity by expert participants were number of flavours, harmony, balance, linger and familiarity. The connoisseurs shared with the experts the association of number of flavours and harmony only. Connoisseurs also associated complexity with intensity, something that experts did not do. The consumers also associated

Table 5. *P*-value of the *F* statistics from the ANOVA model: WineType + Wine(WineType) + Group + Subject(Group) + Group × WineType + Group × Wine(WineType).

Item	Wine Type	Wine(Wine Type)	Group	Group × Wine Type	Group × Wine(Wine Type)
EasyIdFl	**0.0088**	0.2688	**0.0227**	0.6386	0.7931
NbFlav	**0.0335**	**0.0567**	0.5317	0.8548	**0.0713**
Complexity	**0.0528**	0.4482	**0.0002**	0.2941	0.5881
Lingering	**0.0615**	0.1809	0.2402	0.4367	0.8702
Harmony	**0.0673**	**0.0004**	0.1270	0.7871	0.6393
Familiarity	0.1150	**0.0057**	0.3625	0.3593	0.3650
Balance	0.1223	**0.0000**	**0.0869**	0.9542	0.3121
Intensity	0.5491	**0.0041**	0.8592	0.6222	0.7417

P-values lower than 0.10 are in bold. ANOVA, analysis of variance; EasyIdFl, easy to identify flavours; NbFlav, number of flavours.

Table 6. Mean scores of complexity items (sorted by significance) by groups of subjects with their multiple comparison.

Item	*P*-value of Group effect	Consumer	Connoisseur	Expert
Complexity	**0.0002**	4.95 a	4.66 a	3.46 b
EasyIdFl	**0.0227**	4.16 b	4.95 ab	5.42 a
Balance	**0.0869**	4.94 a	4.93 a	4.03 b
Harmony	0.1270	5.13 a	4.83 ab	4.17 b
Lingering	0.2402	5.40 ab	5.51 a	4.69 b
Familiarity	0.3625	4.65 a	5.22 a	5.19 a
NbFlav	0.5317	4.33 a	4.32 a	3.83 a
Intensity	0.8592	5.46 a	5.53 a	5.28 a

Two means in the same line with the same letter are not significantly different (least significant difference, $P = 0.10$). *P*-values lower than 0.10 are in bold. EasyIdFl, easy to identify flavours; NbFlav, number of flavours.

Table 7. Mean scores of complexity items (sorted by significance) by Wine Type (Standard; Expe/Oeno; Expe/Viti) with their multiple comparison.

Item	*P*-value WineType	Standard†	Expe/Oeno	Expe/Viti
EasyIdFl	**0.0088**	5.08 a	4.58 b	4.45 b
NbFlav	**0.0335**	4.70 a	4.23 b	3.91 b
Complexity	**0.0528**	4.55 ab	4.69 a	4.42 b
Lingering	**0.0615**	5.40 a	5.46 a	5.00 b
Harmony	**0.0673**	5.42 a	4.85 b	4.43 b
Familiarity	0.1150	5.39 a	4.86 b	4.74 b
Balance	0.1223	5.30 a	4.80 ab	4.34 b
Intensity	0.5491	5.48 a	5.55 a	5.29 a

Two means in the same line with the same letter are not significantly different (least significant difference, $P = 0.10$). *P*-values lower than 0.10 are in bold. †Wine type categories: Standard production, Experimental/Viticultural (Expe/Viti), Experimental/Oenological (Expe/Oeno). EasyIdFl, easy to identify flavours; NbFlav, number of flavours.

intensity with overall complexity and in contrast to the two other groups exhibited a link between complexity and lingering (palate length). The smaller number of clear associations suggests that overall complexity is a concept less consensual in connoisseurs and consumers than in experts.

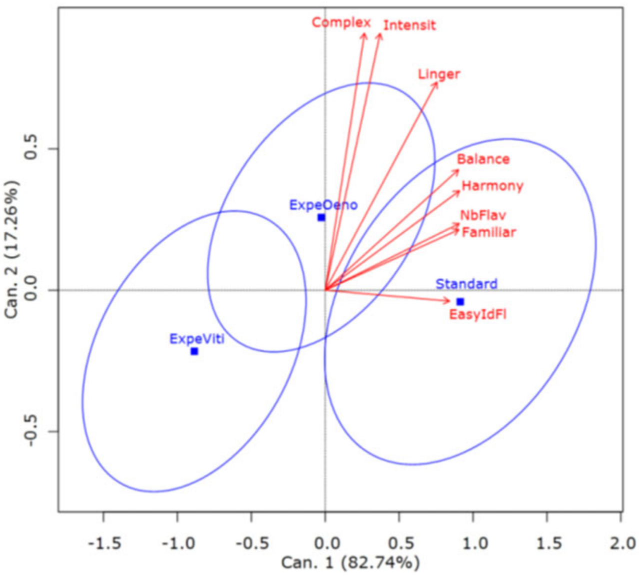

Figure 3. Bi-plot from a canonical variate analysis of the wine type factor.

Discussion

The aim of the present study was to investigate influence of domain-specific expertise on judgments of perceived complexity in white wine, specifically Sauvignon Blanc. The most

Table 8. Number of non-significant, positive significant and negative significant individual correlations between the overall complexity item and each of the other items.

Group	Item	NS	S+	S−
Consumer	**Intensity**	18	22	0
Consumer	**Linger**	20	20	0
Consumer	NbFlav	21	18	2
Consumer	Harmony	22	12	7
Consumer	Familiarity	27	10	4
Consumer	Balance	28	9	4
Consumer	EasyIdFl	29	7	5
Connoisseur	**NbFlav**	8	21	1
Connoisseur	**Harmony**	8	18	4
Connoisseur	**Intensity**	14	16	0
Connoisseur	EasyIdFl	14	13	3
Connoisseur	Balance	16	12	2
Connoisseur	Lingering	18	12	0
Connoisseur	Familiarity	17	9	4
Expert	**NbFlav**	2	14	0
Expert	**Harmony**	3	13	0
Expert	**Balance**	4	12	0
Expert	**Lingering**	5	11	0
Expert	**Familiarity**	8	8	0
Expert	EasyIdFl	11	4	1
Expert	Intensity	11	3	2

Significance is assessed at $P = 0.05$. Items in bold are more often positively correlated than non-correlated with overall complexity. EasyIdFl, easy to identify flavours; NbFlav, number of flavours; NS, non-significant; S+, positive significant; S−, negative significant.

important finding of the experiment is evidence of significant difference in performance, both in sorting and in rating of perceived wine complexity, as a function of wine expertise. In keeping with our first hypothesis, data from both the sorting task and the complexity-rating task showed more consensual behaviour among wine professionals than among wine consumers. Wine connoisseurs at times produced data more in keeping with the experts than with the consumers (sorting), and under other task conditions (complexity rating) performed more similarly to the consumers.

In terms of sorting or classification, results demonstrate qualitative similarity among participants in that their sorting produced structurally similar outcomes. Higher discrimination of wine differences by the experts, however, was evident in that they grouped the wines more tightly than the other participants and formed a larger number of categories than the wine consumers. These data, demonstrating increased variability in wine consumers relative to more experienced participants, are in keeping with those reported in Chollet et al. (2011). They are also compatible with results reported in several other recent publications. For example, Urdapilleta et al. (2011) demonstrated greater variability among wine consumers than wine professionals in their use of descriptors considered important to Sauvignon Blanc wine, both when considering the wine from memory (semantic condition) and when actually experiencing the wines (perceptive condition) in a study where participants hierarchically organised 67 descriptors commonly employed to describe Sauvignon Blanc wine. The authors argued that this result likely reflected idiosyncratic knowledge about the Sauvignon wines by wine consumer participants as opposed to stronger homogeneity among wine professionals in terms of how they structured their knowledge about the wine varietal.

Also relevant to the discussion of domain-specific expertise are results reported by Langlois et al. (2011). In the present study, our data show that domain-specific wine expertise may interact with the type of task that a participant undertakes. That is, our data show that wine professionals (experts) and wine connoisseurs performed more similarly under free-sorting task instructions, with consumers performing differently, while under complexity-rating task conditions, consumers and connoisseurs performed more similarly, with the performance of the wine experts differing from that of the other two groups. Langlois et al. (2011), in one of the few studies to consider wine connoisseurs separately from either wine consumers or wine professionals, investigated verbal behaviour (the lexicon and type of discourse) of wine professionals, wine connoisseurs, wine consumers and trained panellists. Their results showed the multidimensional nature of wine expertise, with participants of the various types of expertise performing differently: the wine connoisseurs showed much in keeping with the wine professionals in terms of their discourse about wine, but the lexicon (i.e. words) they employed was more in keeping with that of wine consumers.

In terms of what aspects of the wines drove the structurally similar sorting behaviour demonstrated by the three groups of participants, the present data are in keeping with those reported by Parr et al. (2013). In their study, where the same wines employed in the current study were evaluated by New Zealand wine professionals 2 months prior to the current experiment being conducted, Parr et al. (2013) reported a perceptual map obtained by multidimensional scaling of free sorting data (Parr et al. 2013, Figure 1) that is almost identical to the map produced by the French wine professionals in the current study. Clear separation of the four wines that were produced from machine-harvested fruit (the three Standard wines, plus one Expe/Oeno wine) was considered the result of differences in wine composition. Parr et al. (2013) reported both sensory and chemical data, demonstrating that the thiol compounds considered important to varietal expression of Sauvignon Blanc, namely 3-mercaptohexan-1-ol, 3-mercaptohexyl acetate and 4-mercapto-4-methylpentan-2-one, were significantly higher in concentration in the wines made from machine-harvested fruit than in the those produced from hand-harvested fruit. The influence of grape-processing operations including type of harvesting has been reported by other researchers (Capone and Jeffery 2011).

Several results are of relevance to our second hypothesis concerning the drivers or underlying factors that influence perception of complexity in wine. First, although ease of identifying the separate flavours in the wines was a significant factor in assisting participants to discriminate or separate the wines (Wine Type effect), this factor did not associate with judgments of overall complexity in the wines. In contrast, wine attributes that are associated with perceived integration or blendedness, namely 'harmony' and 'balance', positively associated with judgments of perceived complexity, in particular for wine experts and to a lesser degree for wine connoisseurs. Hence, the present data provide no evidence in support of the notion that perceptual separability enhances perception of complexity. The data do support the notion that perceived blendedness, or harmonious integration of the components of a wine, positively influences perception of complexity in wine, in particular for those participants high in domain-specific expertise. Our data therefore are in agreement with those of Singleton and Ough (1962) who interpreted their data to argue that quality/complexity (the authors used these words synonymously) was enhanced in the blended wines as compared with that of the non-blended wines. With respect to within-group variability in judgments of complexity, complexity scale ratings of wine experts were more in agreement than those of the other two participant groups, again showing differences in within-group variability as a function of domain-specific expertise.

A final point that deserves mention is that the current data show that in general the French participants did not find the wines in this study particularly complex. This should be qualified by noting that the wines typically produced and consumed in Burgundy, France, are Pinot Noir and Chardonnay, rather than Sauvignon Blanc. Conceivably our result could be due, at least in part, to the fact that Sauvignon Blanc is considered a relatively 'simple' white grape cultivar in terms of the number of impact compounds important to its varietal expression (Masneuf-Pomarede et al. 2006). The aim of providing relatively novel stimuli to the participants in the present study in the form of Sauvignon Blanc wines was to investigate perceived complexity in wines as a function of wine expertise in the absence of the confounding factor of differences in familiarity specific to the wine type under consideration. That is, we made the a priori judgment that Marlborough Sauvignon Blanc from New Zealand would present as a relatively novel stimulus to all participants, irrespective of their overall level of general wine expertise.

Conclusion

In contrast to our prior work that employed verbal reports as data (Parr et al. 2011), the present study investigated the multidimensional construct of wine complexity via behavioural methods, that is by actual wine tasting. Results show perceived complexity to associate with several key wine attributes, in particular perceived harmony and balance of a wine, these aspects linked more to blendedness or integration of a wine's parts than to perceptual separability. Although ease of identifying separate components of a wine, in this case the different flavours, was a significant factor in allowing participants to separate the wines, it was not a factor that associated positively with perceived complexity by any of the participant groups. In terms of the influence of domain-specific expertise, our data not only demonstrate behavioural differences in wine assessment as a function of expertise, but also show an interaction between domain-specific expertise and task to be accomplished. More specifically, data from the non-directed sorting task suggest that connoisseurs have more in common with wine professionals than they do with less-serious wine consumers, while connoisseurs had more in common with consumers than they did with oenologists when evaluating perceived complexity. Hence, the present data reinforce the importance of not considering 'wine consumers' as an homogenous group in research investigations.

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References

Aron, L. (1999) From the wine of religion to the religion of wine: evolution of the 'magical' thinking of wine. Journal International des Sciences de la Vigne et du Vin Special Issue Wine Tasting, 43–49.

ASTM International (1986) ASTM STP 913. Physical requirement guidelines for sensory evaluation laboratories (ASTM International: Cobshoshocken, PA, USA).

Auvray, M. and Spence, C. (2008) The multisensory perception of flavour. Consciousness and Cognition **17**, 1016–1031.

Callier, P. and Schlich, P. (1997) La cartographie des preferences incompletes. Validation par simulation. Sciences Des Aliments **17**, 155–172.

Capone, D.L. and Jeffery, D.W. (2011) Effects of transporting and processing Sauvignon blanc grapes on 3-mercaptohexan-1-ol precursor concentrations. Journal of Agricultural and Food Chemistry **59**, 4659–4667.

Charters, S. and Pettigrew, S. (2007) The dimensions of wine quality. Food Quality and Preference **18**, 997–1007.

Chollet, S., Lelievre, M., Abdi, H. and Valentin, D. (2011) Sort and beer: everything you wanted to know about the sorting task but did not dare to ask. Food Quality and Preference **22**, 507–520.

Cooper, M. (2008) Wine atlas of New Zealand (Hachette: Auckland, New Zealand).

Dalton, P. (2000) Fragrance perception: from the nose to the brain. Journal of Cosmetic Science **51**, 141–150.

Distel, H., Ayabe-Kanamura, S., Matinez-Gomez, M., Schicker, I., Kobayakawa, T., Saito, S. and Hudson, R. (1999) Perception of everyday odors: correlation between intensity, familiarity and strength of hedonic judgment. Chemical Senses **24**, 191–199.

Gibson, J.J. (1966) The senses considered as perceptual systems (Houghton Mifflin: Boston, MA, USA).

Gibson, J.J. and Gibson, E.J. (1955) Perceptual learning: differentiation or enrichment? Psychological Review **62**, 32–41.

Green, J.A., Parr, W.V., Breitmeyer, J., Valentin, D. and Sherlock, R. (2011) Sensory and chemical characterisation of Sauvignon blanc wine: influence of source of origin. Food Research International **44**, 2788–2797.

Hubert, L. and Arabie, P. (1985) Comparing partitions. Journal of Classification **2**, 193–218.

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

International Organization for Standardization (1977) ISO 3591:1977. Sensory analysis – apparatus – wine-tasting glass (International Organization for Standardization: Geneva, Switzerland).

Jinks, A. and Laing, D. (2001) The analysis of odor mixtures by humans: evidence for a configurational process. Physiology & Behavior **72**, 51–63.

Langlois, J., Ballester, J., Campo, E., Dacremont, C. and Peyron, D. (2010) Combining olfactory and gustatory clues in the judgment of aging potential of red wine by wine professionals. American Journal of Enology and Viticulture **61**, 15–22.

Langlois, J., Dacremont, C., Peyron, D., Valentin, D. and Dubois, D. (2011) Lexicon and types of discourse in wine expertise: the case of vin de garde. Food Quality and Preference **22**, 491–498.

Lawless, H. (1997) Olfactory psychophysics. Beauchamp, G.K. and Bartoshuk, L., eds. Tasting and smelling (Academic Press: San Diego, CA, USA) pp. 125–174.

Le Berre, E., Jarmuzek, E., Beno, N., Etievant, P., Prescott, J. and Thomas-Danguin, T. (2010) Learning influences the perception of odor mixtures. Chemosensory Perception **3**, 156–166.

Livermore, A. and Laing, D. (1996) Influence of training and experience on the perception of multi-component odor mixtures. Journal of Experimental Psychology. Human Perception and Performance **22**, 267–277.

Manetta, C., Sales-Wuillemin, E., Gaillard, A. and Urdapilleta, I. (2011) Verbal representation of fragrances: dependence on specific task. Journal of Applied Social Psychology **41**, 658–681.

Marshall, K., Laing, D.G., Jinks, A.L. and Hutchinson, I. (2006) The capacity of humans to identify components in complex odor-taste mixtures. Chemical Senses **31**, 539–545.

Masneuf-Pomarede, I., Mansour, C., Murat, M.-L., Tominaga, T. and Dubourdieu, D. (2006) Influence of fermentation temperature on volatile thiols concentrations in Sauvignon blanc wines. International Journal of Food Microbiology **108**, 385–390.

Medel Maraboli, M. (2011) Perception de la qualité du vin par les consommateurs. PhD thesis. University of Burgundy, Dijon, France. https://tel.archives-ouvertes.fr/tel-00703094/document [accessed 31/1/15].

Meillon, S., Viala, D., Medel, M., Urbano, C., Guillot, G. and Schlich, P. (2010) Impact of partial alcohol reduction in Syrah wine on perceived complexity and temporality of sensations and link with preference. Food Quality and Preference **21**, 732–740.

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

Parr, W.V. (2008) Application of cognitive psychology to advance understanding of wine sensory evaluation and wine expertise. Kiefer, K.H., ed. Applied psychology research trends (Nova Science Publishers: Happauge, NY, USA) pp. 55–76.

Parr, W.V., Heatherbell, D. and 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.

Parr, W.V., Schlich, P., Theobald, J.C. and Harsch, M.J. (2013) Association of selected viniviticultural factors with sensory and chemical characteristics of New Zealand Sauvignon blanc wines. Food Research International **53**, 464–475.

Parr, W.V., Mouret, M., Blackmore, S., Pelquest-Hunt, T. and Urdapilleta, I. (2011) Representation of complexity in wine: influence of expertise. Food Quality and Preference **22**, 647–660.

Parr, W.V., Mouret, M., Urdapilleta, I., Schlich, P. and Green, A.J. (2012) The nature of perceived complexity in wine. Proceedings of the 8th international cool climate symposium; 31 January–4 February 2012 (Hobart, Tas., Australia). http://winetasmania.com.au/resources/downloads/session_3_Parr.pdf [accessed 31/1/15].

Peltier, C., Visalli, M. and Schlich, P. (2015) Comparison of canonical variate analysis and principal component analysis on 422 descriptive sensory studies. Food Quality and Preference **40** (Part B), 326–333.

Saenz-Navajas, M.-P., Campo, E., Sutan, A., Ballester, J. and Valentin, D. (2013) Perception of wine quality according to extrinsic cues: the case of Burgundy wine consumers. Food Quality and Preference **27**, 44–53.

Schlich, P. (1996) Defining and validating assessor compromises about product distances and attribute correlations. Naes, T. and Risvik, E., eds. Multivariate analysis of data in sensory science (Elsevier Science: Amsterdam, the Netherlands) pp. 259–306.

Singleton, V.L. and Ough, C.S. (1962) Complexity of flavour and blending of wines. Journal of Food Science **27**, 189–196.

Solomon, G. (1990) Psychology of novice and expert wine talk. The American Journal of Psychology **105**, 495–517.

Thorngate, J.H. (1997) The physiology of human sensory response to wine. American Journal of Enology and Viticulture **48**, 271–279.

Urdapilleta, I., Parr, W.V., Dacremont, C. and Green, J. (2011) Semantic and perceptive organisation of Sauvignon blanc wine characteristics: influence of expertise. Food Quality and Preference **22**, 119–128.

Zucco, G.M., Carassai, A., Baroni, M.R. and Stevenson, R.J. (2011) Labeling, identification, and recognition of wine-relevant odorants in expert sommeliers, intermediates, and untrained wine drinkers. Perception **40**, 598–607.

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