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The distinctive flavour of New Zealand Sauvignon blanc: Sensory characterisation by wine professionals

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Abstract

The distinctive New Zealand wine style "Marlborough Sauvignon blanc" was investigated by sensory characterisation, by judgments of typicality, and by chemical analysis of selected aroma compounds. Typicality was defined in terms of perceived representativeness where good examples of the concept were considered more typical. Wine professionals undertook three sorting tasks and a descriptive rating task involving 15 Sauvignon blanc wines from New Zealand and France. Ortho-nasal and global (retronasal and taste) data were each considered. Wines were sorted into experimenter-provided categories of "green" or "not green", "ripe" or "not ripe", and "good varietal definition" or "not good varietal definition". To elucidate the critical components of representativeness, typicality ratings for each wine were considered in relation to descriptive ratings of specific flavours, to the sensory data from the three sorting tasks, and in relation to the concentrations of two aroma compounds, namely 3-isobutyl-2-methoxypyrazine (IBMP) and 3-isopropyl-2-methoxypyrazine (IPMP). Results demonstrated that wines considered to have good varietal definition were also rated higher on typicality with respect to Marlborough Sauvignon blanc than wines that were judged to be lower in varietal characteristics. The data also showed that the higher-order flavour concepts of Green and Ripe were mutually exclusive but each was essential to the concept of a typical Marlborough Sauvignon blanc. Specific flavour characteristics (e.g., green capsicum; boxwood) were predictive of high typicality ratings for a wine, whilst others (e.g., mineral) were predictive of low typicality ratings. The chemical concentrations of IBMP and IPMP correlated positively with perceived green flavours, and inversely with perceived ripe and fruity flavours. The data are interpreted within a cognitive model of conceptual structure [Rosch, E., & Mervis, C. (1975). Family resemblances: Studies in the internal structure of categories. *Cognitive Psychology, 7*, 573–605] that considers not only the ideal or prototypical Marlborough Sauvignon blanc but also the limits to the variability in flavour profile that can be tolerated by experienced wine professionals for a wine to be perceived as typical of its style.

Keywords: Wine; Sauvignon blanc; Sensory; Wine professionals; Typicality

The *Vitis Vinifera* grapevine appears capable of expressing distinctive flavour characteristics as a function of its physical and cultural environment. Geographical indication with respect to wine is a relatively new concept in New Zealand but has a longer history in Europe, where it is a central part of agricultural policy (Barker, 2006). Inherent in the notion of geographical indication is presence in the wine of unique characteristics, or combination of characteristics, that can be attributed to the product's source. The source is usually defined in terms of a delimited geographical area, often referred to as "terroir" (Jackson & Lombard, 1993). The unique characteristics of a product from a delimited geographical area, chemical and sensory, give the product *typicité*, meaning that the product is representative of its terroir. We employ the term "typicality" as the best, albeit imperfect, translation of the French notion of typicité (see Sauvageot, 1994, for elaboration).

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Sauvignon blanc grapes produced in several regions of New Zealand, in particular the delimited geographical area known as Marlborough (see Rae & Tozer, 1990), do appear capable of producing wines with highly distinctive sensory characteristics. The notion that a concept of Marlborough Sauvignon blanc exists as a distinctive entity in the minds of wine professionals and wine consumers is exemplified in national and international wine writing (e.g., New Zealand Winegrower, Spring, 2004, p. 27). The concept is often expressed in a way that assumes readers know what flavour profile to expect of the wine. The sensory characters reported by wine writers are fruit and vegetable flavours such as passionfruit and green capsicum that, balanced with racy acidity, are central to descriptions of the wine style. In other words, the dominant style of Sauvignon blanc wine currently made in New Zealand emphasises the grape's identity (i.e., varietal characters), rather than oenological manipulations such as oak treatment.

Over the last decade, researchers have reported data concerning existence of a concept for a particular wine variety in specific geographical locations. Arguably the most extensive work to date has involved Burgundy Chardonnay, which has been investigated from both a chemical (e.g., Moio, Schlich, & Etievant, 1994) and sensory (e.g., Ballester, Dacremont, Le Fur, & Etievant, 2005; Moio, Schlich, Issanchou, Etievant, & Feuillat, 1993) perspective. Ballester et al. reported ortho-nasal and global (retronasal and taste) data, demonstrating a reasonable consensus among French wine professionals concerning a shared Chardonnay wine concept. Moio et al. (1994) reported typicality judgments to Burgundy Chardonnay wines as a function of appellation. Other reported work includes investigation of grape composition and wine quality of Californian Chardonnay wines (e.g., Arrhenius, McCloskey, & Sylvan, 1996), South African Sauvignon blanc (Marais, Hunter, & Haasbroek, 1999) and German Riesling wines (Fischer, Roth, & Christmann, 1999) in relation to specific geographical regions.

The overall aim of the present study was to provide empirical evidence to support anecdotal reports concerning existence of a Marlborough Sauvignon blanc wine concept. More specifically, we investigated whether there is an agreed ideal or typical variant amongst wine professionals, and the specific flavours that are essential for a wine to have typicality; that is, to be seen as a good example of the concept. Flavour in the current study refers to attributes perceived via ortho-nasal olfaction, retronasal olfaction, taste, and tactile stimulation.

Three previous studies in our laboratory, where wine professionals generated their own descriptors to New Zealand Sauvignon blanc wines, provided data that demonstrated the salience of both higher-order (e.g., "green") and more specific (e.g., "grassy") perceived flavours to the Sauvignon blanc wines. Some of the reported flavour characters were associated to a statistically significant degree with wines rated as good examples of Marlborough Sauvignon blanc (Parr, Frost, White, & Marfell, 2004; Parr, Green, & White, 2005), and with wines judged as being of high quality in a simulated wine judging show (Parr, Green, & White, 2006). Several of the reported sensory characters such as passionfruit, boxwood, and green capsicum have established relations with chemical compounds of interest to Sauvignon blanc researchers. For example, Tominaga and colleagues (e.g., Tominaga, Baltenweck-Guyot, Peyrot des Gachons, & Dubourdieu, 2000) have reported data implicating several volatile thiol compounds as underlying the distinctive aroma of Sauvignon blanc wines, whilst Allen, Lacey, Harris, and Brown (1991) have focused on methoxypyrazine compounds.

Methodology and theory from cognitive psychology were drawn on to extend our previous published work. The present study involved four sensory tasks. The overall methodology had some similarities to the two-stage methodology reported in a recent study that investigated berry flavour in wine (Piombino, Nicklaus, Le Fur, Moio, & Le Quere, 2004). The two stages employed by Piombino et al. involved a sorting task followed by descriptive analysis of a subset of the sorted wines. The four tasks employed in the current study were a sorting task, a typicality-rating task, a descriptive rating task, and a hedonic (liking) task. Together, these tasks permitted us to gather several types of data in terms of the underlying cognitive processing assumed involved in wine evaluation by wine professionals. We considered it prudent to obtain data via several different methods for validity purposes as Saint-Eve, Paci-Kora, and Martin (2004) reported that profiling specific descriptors did not reveal the same information concerning sensory interactions as did methods tapping global judgments such as sorting.

The sorting and concept rating tasks allowed us to consider responses to wine at the conceptual level of individuals (i.e., global judgments about a wine that can include top-down cognitive processes such as knowledge about winemaking). Top-down cognitive processes include our mental representations of a wine variety (e.g., Sauvignon blanc) and its variants, based on prior experience (Hughson & Boakes, 2002), as well as our expectations, desires, and ideas (see Parr, White, & Heatherbell, 2003). Wine professionals would be expected to bring substantial top-down information to their judgments (Ballester et al., 2005). The sorting tasks and a global concept rating of each wine therefore could be assumed valid with respect to both construct validity and ecological validity.

On the other hand, the descriptive rating task was assumed weighted toward bottom-up sensory responses to individual flavour characteristics (Dalton, 2000). This is because instruction to make intensity ratings to individual flavour descriptors directs an individual's focus toward one flavour note, rather than toward the wine sample as a whole. Bottom-up processes emphasise properties of the stimulus (i.e., wine sample) such as intensity of salient characteristics, intensity being the psychological correlate of chemical concentration.

Finally, the liking task was included in the study because wine professionals are trained to differentiate between judgments of typicality on the one hand, and judgments concerning their own preferences and liking of a wine on the other. It was conceivable that some judges would give low liking ratings to wines they perceived to be high in typicality with respect to the wine style under consideration, namely Marlborough Sauvignon blanc wine.

The fundamental theoretical base for the present study lies in models concerning how humans categorise and make sense of their worlds (e.g., Rosch & Mervis, 1975), including their chemosensory worlds. An assumption that follows from recent categorisation theory, irrespective of the particular probabilistic model employed, is that those experienced with Marlborough Sauvignon blanc will have developed internalised standards (i.e., a concept) about the wine that will have a central tendency (an ideal or typical example) and boundaries (i.e., limits in terms of variation from the ideal example that can be tolerated before a wine is deemed outside the concept). We investigated wine professionals' conceptual structure in terms of central tendency and boundaries. The descriptive profiling task with 10 experimenter-provided descriptors for flavour intensity ratings served as an indirect method to investigate central tendency or prototypicality. We also took a more direct approach to investigation of prototypicality where participants sorted the fifteen wines into superordinate categories (Green, Ripe, and Good Varietal Definition) and provided three or four self-generated descriptors to each category (e.g., to the category Green). A full ortho-nasal replication of the sorting tasks was conducted. Sorting tasks are notorious for between-subject and within-subject variability in the data (Ishii, Kemp, Gilbert, & O'Mahony, 1997), although Cartier et al. (2006) recently reported relative consistency in sorting task data.

Concept boundaries were investigated by including examples from outside the category of interest. We employed two wine types that were external to our chosen dominant category, namely Marlborough 2004 Sauvignon blanc wine. Maturity was one variable employed to elucidate the boundaries to the concept. We included a small number of wines from a prior vintage in the study. Maturity was considered particularly relevant since anecdotal evidence and received wisdom suggest that New Zealand Sauvignon blanc wines should be consumed in their youth, and that inherent in the wine style's typicality are youthfulness and freshness. The second variable we considered was regionality. We employed French wines that are made from one hundred percent Sauvignon blanc juice (i.e., we did not include those where Sauvignon blanc is typically blended with another variety such as Sémillon) and which anecdotal evidence suggested would differ markedly from young Marlborough Sauvignon blanc. The 2004 French wines were from Saint Bris in Burgundy and from Pouilly sur Loire near the border between Burgundy and the Loire. These wines are similar in style to wines from the Sancerre region, Sancerre being geographically close to Pouilly sur Loire and perhaps more well known to wine consumers outside France than the Sauvignon blanc wines from Burgundy.

In keeping with the argument that only those experienced with the product of interest, including in terms of its diversity, can truly judge typicality (Sauvageot, 1994), we employed Marlborough wine professionals as participants. Over the course of their wine industry experience, such experience involving repeated exposure to relevant stimuli both within and outside of a wine category, wine professionals could be assumed to have gathered experientially-gained cognitive constructs (memories; classification systems) that should allow their perceptual systems to make effective use of subtle variations in the wine style of interest (Hughson & Boakes, 2002; Solomon, 1997). As expertise develops with a product, internal references are assumed to take shape, with new additions to the category resulting in constant adjustment to categorical structure (Ishii & O'Mahony, 1987). For example, we may know what is meant by a "large mouse" because we have seen mice at home with some regularity. A person who has seen one mouse only would have more difficulty knowing the boundary regarding how large a mouse might get to be called large. Habitual exposure to a product is assumed to refine judgments of central tendency (the 'ideal' or 'typical' example), as well as adjust concept boundaries (Brochet & Dubourdieu, 2001). This is assumed to result in improved precision and clarity when reporting flavour characters, both qualitatively (e.g., is it "woody" or "smoky"?) and quantitatively (e.g., when is grassy "grassy"?) (Ishii & O'Mahony, 1987). Further, wine professionals working with similar products would be assumed, over the course of time, to develop conceptual alignment (O'Mahony, 1991) and similar linguistic structures concerning the specific product so as to facilitate within-group communication. Such conceptual alignment would be expected to reduce between-participant differences. It is also conceivable that conceptual alignment may form the basis, at least in part, of the notion of 'house' or 'winery' palate. House palate is a well-known concept in the wine industry where it refers to a tendency to judge favourably wines in keeping with one's predominant experience, rather than to embrace novelty. To our knowledge, house palate has received little scientific exploration to date, and further elaboration of the notion is outside the scope of the present study.

The sorting task and its replication were undertaken by ortho-nasal aroma assessment to minimise possibility of palate fatigue, and because New Zealand Sauvignon blanc wines are renowned for their volatile components. The flavour descriptor-rating task involved ortho-nasal evaluation followed by a global evaluation (full tasting) in a second session. This is a valid option in wine evaluation studies involving wine experts because in the course of their responsibilities, most expert tasters start out by sniffing all the samples, and then taste them only to confirm their ortho-nasal assessments. For example, Sauvageot (1999,

p. 63) has argued that a particularly good method for wine sensory analysis with oenologists is to evaluate a wine by olfaction first, and then by mouth.

We formulated three specific predictions. First, we predicted that for young Marlborough Sauvignon blanc wines, "good varietal definition" would be synonymous with "good example of Marlborough Sauvignon blanc". In other words, we hypothesised that a strong positive relationship would be found between typicality ratings to wines and judgments of "good varietal definition". Second, we predicted that "green" and "ripe" perceived characters were both essential to prototypical members of the concept and to judgments of "good varietal definition", but that neither "green" nor "ripe" was highly predictive on its own. Finally, we predicted that there would be boundaries to the concept "Marlborough Sauvignon blanc", as demonstrated by low concept ratings to the older wines and to those from outside the geographical region of Marlborough.

1. Materials and methods

1.1. Participants

Participants were 18 Marlborough wine industry professionals who were selected on the basis of having extensive experience with the product of interest, namely Sauvignon blanc wines. The 6 female and 12 male participants had a mean age of 35.8 years (range = 27–45). There were 17 non-smokers and 1 smoker. Mean number of years of experience in the wine industry was 10.7 years (range = 4–24). Fourteen of the 18 participants reported winemaker to be their major occupation, and 8 participants had formal wine-judging experience.

1.2. Experimental wines

The wines were 15 commercial Sauvignon blanc wines (see Table 1). Ten wines were from the Marlborough 2004 vintage (the dominant category), 3 were from the Marlborough 2003 vintage (older category), and two wines were French (regional category). French wines from the Pouilly-sur-Loire region and from Saint Bris in Burgundy were from the 2004 northern hemisphere vintage and were selected as being representative of their wine variants (judged as such by either their French winemakers and/or our wine importers). The Marlborough 2004 wines were selected to provide a distribution of quality as judged by peer evaluation at the 2004 Air New Zealand Wine Awards (ANZWA), arguably New Zealand's most prestigious wine competition. In the dominant category, the 10 wines comprised one gold medal winner, three silver medal winners, three bronze medal winners, and three wines that had received no award. The Marlborough 2003 wines had each received a bronze medal. The French wines were not subjected to ANZWA quality judgments, but the Pouilly Fumé wine was awarded 90/100 in Wine Spectator in 2005. Wines ranged in alcohol concentration between 12.5% v/v and 14.5% v/v. The New Zealand wines were sealed with screw-cap closures whilst the two French wines were sealed with cork closures.

Table 1
Sauvignon blanc wines employed in the study

Wine	Vintage
Vidal Estate Marlborough	2003
Morworth Estate S. blanc Marlborough	2004
Morton Estate Stone Creek Marlborough	2004
Chatelain Pouilly Fumé	2004
Giesen Marlborough Single Vineyard Selection	2003
Highfield Estate Marlborough	2004
Foxes Island Marlborough	2004
Grove Mill Marlborough	2003
Vavasour Awatere Valley	2004
Forrest Estate Marlborough	2004
Villa Maria Cellar Selection	2004
Coopers Creek Limited Release Marlborough	2004
Forrest Estate Belmonte Marlborough	2004
Brocard Chablis Sauvignon blanc	2004
Ngatarawa Glazebrook Marlborough	2004

1.3. Sensory procedures

The study was conducted in two one-hour sessions, separated by a 20-min break. The environment of the purpose-built sensory facility was controlled as advised for sensory laboratories (ASTM, 1986) and International Wine Competitions (O.I.V., 1994). There was a uniform source of lighting, absence of noise and distracting stimuli, and ambient temperature was between 19 and 22 °C across the day. Three to six wine professionals participated at any one time. Prior to participation and in keeping with ethical requirements, each person was provided information about the impending study and, after having any questions answered, completed and signed an informed consent form. Participants were then seated in separate booths where their 15 experimental wines, protected by coverslips, were placed in the order designated for the particular participant. A 16th Sauvignon blanc wine was positioned to the left of the flight as a palate conditioner (i.e., as a warm-up wine) and no data were collected on judgments toward this wine. Each participant received the 15 experimental wines in a unique order. The 18 orders were taken from Macfie, Bratchell, Greenhoff, and Vallis (1989) concerning balanced designs for 1st-order carry-over effects (i.e., to control for the effect of wine $N-1$ on wine N). Wines were 50 ml samples at ambient temperature, served in standard, coded, ISO (1977) wine tasting glasses. Fresh water was available. The within-subject design involved each participant evaluating all 15 wines in every task in both sessions.

1.4. Session 1

1.4.1. Sorting tasks

Participants first undertook three ortho-nasal, sorting tasks successively. Each person sorted the 15 wines into

the categories "green" or "not green", "ripe" or "not ripe", and "good varietal definition" or "not good varietal definition". The order of the three sorting tasks was balanced across participants with every possible order being employed. At the end of a sorting task, each participant was asked to provide 3–4 perceived aroma descriptors that had been salient in their decision to allocate the wines into the respective category. These were defined as self-generated category descriptors, and they were produced prior to a participant seeing the 10 experimenter-imposed descriptors employed in the subsequent task.

1.4.2. Descriptive rating task

Each participant's wines were re-ordered into their original order after the sorting tasks had been completed. Participants were asked to rate each wine, via ortho-nasal olfaction, on intensity of 10 experimenter-provided flavour descriptors, a typicality scale, and a liking scale. Participants rated wines by making a vertical mark in pen on the 100 mm visual analogue scales (VAS: see Savic & Berglund, 2000) provided. The 100 mm horizontal line that constituted each VAS scale had 'absent' at the left-hand end and 'extreme' at the right-hand end. Each VAS scale had one descriptor positioned centrally below (e.g., passionfruit). The 10 flavour descriptors were selected on the basis of prior studies (e.g., Parr et al., 2005) and their assumed relation with chemical compounds of interest. Four descriptors were assumed more in keeping with the higher-order category green (grassy; herbaceous; green capsicum; leafy/stalky/vegetal), four with ripe/fruity/tropical (passionfruit; stone-fruit; tropical; grapefruit/citrus), and two "other" (mineral; boxwood). The 10 experimenter-provided descriptors were put in a random order. Half the participants rated each wine on the 10 descriptors in the random order, and the other half rated them in the reverse order.

The typicality rating instructions followed the 10 flavour descriptor scales for each wine. Participants were advised that all wines in the study were Sauvignon blanc and were asked: Please now rate the wine as to how good you think it is as an example of your concept of "Marlborough Sauvignon blanc". The VAS scale for rating typicality was anchored with "poor example" at the left end and "very good example" at the right-hand end. The final VAS scale was a liking scale, with "strongly dislike" at the left end and "strongly like" at the right-hand end. Participants were asked: Rate the wine in terms of how much you like this wine. The typicality and liking scales were evaluated by ortho-nasal olfaction in Session 1.

1.5. Session 2

The three sorting tasks were repeated with task order reversed for each participant. After each sorting, participants again provided 3–4 descriptors to report the salient criteria on which their sorting was based. The wines were re-positioned into their original order and participants commenced the second part of the session. Twelve scales were rated by global evaluation (ortho-nasal; retronasal; taste). The 12 scales were as per Session 1, with each wine evaluated on the 10 specific flavour descriptors, and on the typicality and liking scales. Each participant rated the 10 descriptors in the same order for their ortho-nasal (Session 1) and global (Session 2) conditions to prevent a confounding of descriptor order with sensory modality condition. Expectoration of all wine was a requirement of participation.

2. Data analyses: sensory tasks

The self-generated descriptors to each of the three sorting task categories, namely Green, Ripe, and Good Varietal Definition, were pooled across sessions for each participant. Where appropriate, the descriptors were categorised in keeping with the 10 experimenter-provided flavour descriptors that were employed in the subsequent descriptor-rating task. Those self-generated descriptors that were outside the 10 experimenter-provided categories formed their own categories. Frequencies were tabulated for each category.

Ratings to VAS scales for each experimenter-provided flavour descriptor were quantified in terms of a number between zero and 100, with 0.5 gradations, as a function of condition (ortho-nasal or global) and descriptor quality (e.g., tropical; green capsicum).

Data for each of the 15 wines from the three ortho-nasal sorting tasks were converted into similarity matrices by summing over all participants the number of times each pair of wines was sorted into the same group. This produced six matrices, as a product of two replications of the three tasks. These matrices were analysed with multidimensional scaling (MDS) implemented by the PROXSCAL procedure in SPSS 13.0. MDS was conducted separately for each task using the two matrices corresponding to the replications as input, with a simple Euclidean model applied to ordinal data where ties were not kept tied. The matrices were then submitted to a between-groups linkage hierarchical cluster analysis (HCA) to identify groups, which were then plotted in MDS space. To interpret the MDS dimensions, the associations between MDS dimension scores and VAS descriptor scores were estimated using multilevel models (MIXED procedure in SPSS 13.0). Multilevel models provide an analytic advantage in that they do not require averaging across participants. The Level 1 model was VAS Descriptor = Subject Intercept + MDS Dimension Score (fixed) + Error, with the Level 2 model Subject Intercept = Overall Mean + Subject (random). This model estimates a single slope between MDS Dimension Score and VAS Descriptor, with a separate intercept for each participant. A separate model was estimated for each VAS Descriptor and each MDS Dimension. VAS descriptor scores were Z-standardized to facilitate interpretation and comparison. The relationship between hedonic liking and typicality was also assessed

with a multilevel model. The Level 1 model was VAS Liking = Subject Intercept + VAS typicality (fixed) + Error, with the Level 2 model Subject Intercept = Overall Mean + Subject (random), with Concept scores centred around Subject means ([1]Singer, 1998).

Similarity between the product configurations produced by the three MDS analyses was assessed with the RV-coefficient (Robert & Escoffier, 1976). The RV-coefficient is a multivariate generalisation of the correlation coefficient, and ranges between 0 and 1, with values closer to 1 indicating higher degrees of similarity. Good agreement has been reported with values from 0.68 (Tang & Heymann, 2002) upward.

A final product configuration was created by principal components analysis (PCA) with SPSS 14.0 FACTOR. PCA was initially performed on product means averaged across participants separately for ortho-nasal and global data, but similar descriptor loadings and product configurations suggested that descriptors could be pooled across modalities. Ortho-nasal and global product means were correlated for all descriptors ($r(15)$ $s > 0.59$), except for mineral/smoky/flinty ($r(15) = 0.04$, ns). Therefore, ortho-nasal and global product means were collapsed across modality except for mineral/smoky/flinty for the final PCA. The product configuration from this PCA was very similar to the separate ortho-nasal PCA (RV = 0.93) and global PCA (RV = 0.90). In all cases, two component configurations adequately described the data. This product map was compared with the MDS configurations again using the RV coefficient. Additionally, the first dimension for each MDS solution was correlated against the two PCA components to produce a vector. Similar vectors were also created for typicality, hedonic liking, and concentrations of IBMP and IPMP.

2.1. Data analyses: chemical

2.1.1. Methoxypyrazine analysis

The 3-isobutyl-2-methoxypyrazine and 3-isopropyl-2-methoxypyrazine concentrations in each of the wines were determined using a novel automated HS-SPME (Head Space Solid-Phase Micro-Extraction) technique using a synthetic deuterated internal standard, 3-isobutyl-2 (D_3)-methoxypyrazine (D_3-IBMP). The deuterated standard was prepared in a 5-step synthesis using L-leucine as the starting material according to the methods of Brenner and Huber (1953) and Murray and Whitfield (1975). As well as this D_3-IBMP, non-deuterated 3-isobutyl-2-methoxypyrazine (IBMP) and 3-isopropyl-2-methoxypyrazine (IPMP) needed to generate standard curves for quantitative analysis were obtained from a commercial supplier (Sigma–Aldrich).

[1] Singer provides a clear introduction to multilevel models providing SAS commands for examples. Data files (and SPSS commands) for her examples are also available (UCLA Academic Technical Services, 2004).

Sample preparation involved pipetting 1.8 ml of wine and 5.12 ml of de-ionised water (i.e., a 5-fold dilution) into 20 ml SPME sample vials, followed by 80 μl of D_3-IBMP internal standard solution (final conc. ~20 ng l^{-1}) and 3.0 g of crystalline sodium chloride. Immediately after that, 2 ml of 4 mol l^{-1} sodium hydroxide (NaOH) was added and the tube was quickly capped. Samples were incubated for 30 min at 50 °C with their enclosed headspace exposed to a 1 cm long DVB/CAR/PDMS combination SPME fibre. During this exposure period the headspace volatiles, including the methoxypyrazines, were absorbed onto the fibre. Desorption of these volatiles occurred when the fibre was inserted into the heated (250 °C) injection port of a Shimadzu GCMS-QP2010 gas chromatograph–mass spectrometer equipped with a 30 m × i.d. 0.25 mm Restek RTX5MS column operated at 90 °C with helium carrier gas at a linear flow of 28.3 cm s^{-1}. The IPMP eluted at 12.9 min and both IBMPs at around 18.7 min. During the elution of the methoxypyrazines the GC–MS was switched to single ion monitoring (SIM) mode and tuned to measure m/z values of 137 and 152 for IPMP, 127 and 154 for D_3-IBMP and 124 and 151 for IBMP, respectively. The m/z ratios of 137/127 and 124/127 were used to quantify the IPMP and IBMP wine concentrations, respectively.

Chemical concentrations were related to VAS Descriptor scores using a multilevel model for each methoxypyrazine and each descriptor. The Level 1 model was VAS Descriptor = Subject Intercept + Concentration (fixed) + Error, with the Level 2 model Subject Intercept = Overall Mean + Subject (random). Both chemical concentration and descriptor scores were Z-standardized.

3. Results

3.1. Sensory analyses: sorting tasks

Stress values for two-dimension MDS configurations were acceptably low (Good Varietal Definition = 0.041, Ripe = 0.057, Green = 0.051), with little reduction in stress or improvement in interpretability gained by adding a third dimension.

3.1.1. Concept of good varietal definition

Fig. 1 plots wines in MDS space for Good Varietal Definition. The marked arrow indicates a line from the wine that was least frequently sorted into Good Varietal Definition ($M = 0.17$) to the wine most frequently sorted into Good Varietal Definition ($M = 0.86$), suggesting that Dimension 1 is primary in distinguishing good varietal definition. Further reinforcing this, the lowest scoring wine was, by definition, not Marlborough Sauvignon blanc, but French, and the highest scoring had been awarded a gold medal at a prestigious, national wine competition. Cluster analysis distinguished two clear groups demarcated on the same axis as good varietal definition. Toward the right is a cluster that contains the two French wines (plus

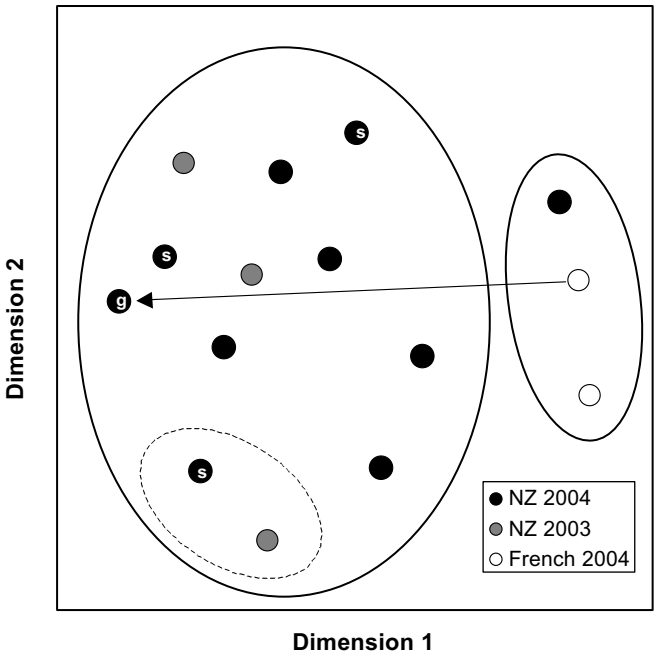

Fig. 1. Wines represented in multidimensional space for the Good Varietal Definition sorting task. The arrow represents a line from wine judged the least varietal to the most varietal. Wines contained in an ellipse were grouped together by cluster analysis: G, gold medal winning wine; S, silver-medal winning wines.

Wine 13), and indicates wines with poor fit to varietal definition.

Beta weights from the multilevel model for the relationship between MDS scores and VAS descriptor scores are presented in Table 2. Supporting our first hypothesis, that good varietal definition is synonymous with typicality, there was a very strong association between Dimension 1 and typicality. Supporting our second hypothesis, descriptors that fit with the higher order categories Green and Ripe were also associated with good varietal definition. However, where good varietal definition was highly weighted on typicality, green and ripe MDS dimensions were not as highly weighted. Indeed, not all green characters appear to be positively related to good varietal definition, notably leafy/stalky/vegetal (no association ortho-nasally, and an inverse association globally). Further, while green capsicum, grassy, and herbaceous were positive characters on the nose, they were not associated with Dimension 1 globally. Dimension 1 was also associated with higher liking scores to wines, as well as with the specific character boxwood/broom/sweaty. Finally, mineral/smoky/flinty characters were associated with less fit to varietal definition globally. This interpretation of Dimension 1 is also consonant with participants' self-generated descriptors to good varietal definition given during the sorting task. The most frequently given descriptors are presented in Table 3, and again include a combination of both ripe and green characters, along with sweaty/boxwood notes.

Dimension 2 was not associated with typicality, but lower scores were associated with global liking. The relation between Dimension 2 and the descriptor scores suggests that lower scores on Dimension 2 are associated with more ripe and less green palate notes. As indicated by the dashed circle, the first sub-cluster to form contained Wines 5 and 15, and may be interpreted as a riper subgroup.

3.1.2. Concept of ripe

Fig. 2 presents wines in MDS space for perception of ripeness. The arrow from least to most ripe wine is not clearly associated with either Dimension 1 or 2. This interpretation is supported by the associations of the Dimensions' scores with descriptor ratings in Table 2. Lower scores on Dimension 1 were associated with riper notes, lower liking, and poor global typicality. Higher scores on Dimension 2 were associated with greater typicality, ortho-nasal liking and levels of perceived green notes. Dimension 2 also correlated with Good Varietal Definition MDS Dimension 2 ($r(15) = 0.55$, $p < 0.05$), which was also loaded on green characters. It is interesting that ripeness appears to be defined more in terms of absence of green notes (see Dimension 2 in Table 2) than in terms of an abundance of tropical or fruity notes. This effect is present in both the ortho-nasal and global data. Self-generated descriptors again support this, with Table 3 showing ripe characteristics frequently given, along with reference to not-green characters (e.g., "not stalky").

Two clusters were formed, with the top right cluster containing two unripe wines (9 and 2) at the greener end of Dimension 2, and at the not-ripe end of Dimension 1. The second larger group is slightly more amorphous, but interestingly, the three older wines are represented as more ripe on Dimension 1 than the other wines, and the French wines have very low scores on the greener Dimension 2. Wines 5 and 15, the ripe subgroup identified in Fig. 1, scored as both ripe and not green. Finally, with the exception of Wine 12, the non-awarded or bronze medal wines from the 2004 vintage were all toward the upper right, suggesting 'not ripe' is associated with failure to score well in national wine shows.

3.1.3. Concept of green

Fig. 3 presents the MDS configuration for Green. Higher scores on Dimension 1 were strongly associated with positive green characters (herbaceous, grassy, green capsicum), but less so with leafy/stalky, and a mild negative relationship occurred with tropical characters. Dimension 1 was also weakly related to ortho-nasal typicality. Not surprisingly, given these associations, Dimension 1 was correlated with the Ripe MDS Dimension 2 ($r(15) = 0.74$, $p < 0.01$). Lower scores on Dimension 2 were associated with ripe notes, and less boxwood/sweaty notes, as well as being inversely related to typicality. Green capsicum, herbaceous, and grassy were the self-generated descriptors most frequently reported by participants (Table 3).

Cluster analysis identified Wine 9 as a clear outlier with respect to being perceived as very green. Wine 9 was the

Table 2
Multilevel model slope estimates for MDS dimensions predicting sensory descriptor ratings and judgments of typicality and liking

	Good varietal definition		Ripe		Green	
	Dim 1	Dim 2	Dim 1	Dim 2	Dim 1	Dim 2
Ortho-nasal descriptor						
Passionfruit	**−0.37**	−0.17	**−0.23**	−0.05	**−0.28**	**−0.31**
Tropical	**−0.37**	−0.27	**−0.36**	−0.14	**−0.31**	**−0.40**
Stone-fruit	**−0.21**	−0.16	**−0.26**	−0.15	**−0.31**	−0.01
Grapefruit/citrus	**−0.39**	−0.09	**−0.31**	0.12	−0.03	**−0.30**
Grassy	**−0.37**	0.17	0.12	**0.57**	**0.64**	**0.11**
Green capsicum	**−0.29**	**0.30**	0.01	**0.51**	**0.45**	−0.06
Herbaceous	**−0.24**	**0.27**	**0.11**	**0.66**	**0.65**	−0.15
Leafy/stalky/vegetal	0.06	0.24	0.04	0.18	**0.34**	0.20
Boxwood/broom/ sweaty/cat's pee	**−0.40**	0.22	−0.10	**0.45**	**0.38**	**−0.40**
Mineral/smoky/flinty	0.03	−0.02	0.16	0.04	0.07	−0.01
Typicality	**−0.76**	−0.23	−0.17	**0.39**	**0.28**	**−0.24**
Liking	**−0.67**	−0.24	**−0.17**	**0.34**	0.17	−0.20
Global descriptor						
Passionfruit	**−0.50**	**−0.30**	**−0.23**	−0.08	**−0.22**	−0.14
Tropical	**−0.38**	**−0.36**	**−0.36**	0.20	**−0.36**	−0.21
Stone-fruit	**−0.31**	**−0.40**	**−0.34**	−0.22	**−0.26**	−0.09
Grapefruit/citrus	**−0.24**	0.04	0.00	0.05	0.09	0.06
Grassy	−0.15	**0.42**	0.11	**0.57**	**0.50**	−0.20
Green capsicum	−0.12	**0.53**	0.14	**0.56**	**0.43**	−0.12
Herbaceous	−0.14	**0.43**	0.11	**0.55**	**0.51**	−0.15
Leafy/stalky/vegetal	**0.43**	**0.41**	−0.03	**0.28**	**0.28**	−0.07
Boxwood/broom/ sweaty/cat's pee	**−0.51**	0.08	−0.07	**0.36**	**0.21**	**−0.38**
Mineral/smoky/flinty	**0.20**	**0.31**	0.13	0.04	0.05	−0.02
Typicality	**−0.84**	−0.17	**−0.34**	**0.32**	0.18	**−0.29**
Liking	**−0.65**	**−0.32**	**−0.27**	0.14	0.01	−0.16

Note. Bold values are significant at $p < 0.05$.

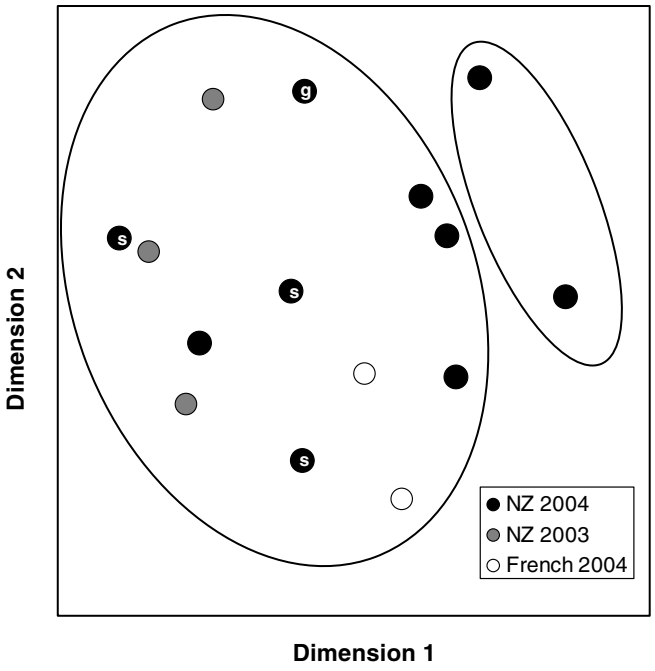

Fig. 2. Wines represented in multidimensional space for the Ripe sorting task. The arrow represents a line from the least ripe to the most ripe wine. Wines contained within an ellipse were grouped together by cluster analysis: G, gold medal winning wine; S, silver-medal winning wines.

sole wine in the sample set that originated from a Marlborough sub-region known as Awatere Valley. It is also interesting to consider that the best exemplars of Marlborough Sauvignon blanc, defined as those 2004 wines that had been awarded silver or gold medals, were found together in the centre of these dimensions. This suggests that green is a necessary character for scoring well in a national wine show, but that it should not dominate.

3.2. Typicality ratings

Supporting our third hypothesis, Fig. 4 shows evidence of a boundary to the concept 'Marlborough Sauvignon blanc'. In line with the cluster analysis of the similarity matrices presented in Fig. 1, the two French wines and Wine 13 were clearly rated as poor fits to the typicality concept. Within the boundaries of the typicality concept there

Table 3
Frequency of self-generated descriptors to each sorting category

Good varietal definition		Ripe		Green	
Descriptor	Frequency	Descriptor	Frequency	Descriptor	Frequency
Passionfruit	14	Passionfruit	21	Cut grass/grassy	19
Green capsicum	9	Tropical fruit/tropical	20	Green capsicum	19
Sweaty/armpit	8	Melon	7	Herbaceous/herbal	18
Herbaceous	8	Pineapple	7	Vegetal/vegetative	9
Gooseberry	8	Buttery/oily/olive oil	7	Green beans	8
Citrus/grapefruit	8	Sweat/sweaty	7	Stalky	8
Intensity	6	Stone-fruit	5	Nettles	7
Tropical fruit	6	Fruity/fruit dominant	5	Asparagus	6
Clean/no sulphides	6	Peach	4	Grapefruit/citrus/lemon/lime	6
Nettle	5	Intensity/concentrated/rich	4		
Fresh	5	No stalkiness	4		
		No raw vegetal	4		

Note. Only the upper quartile of descriptors (i.e., most frequently given) is presented.

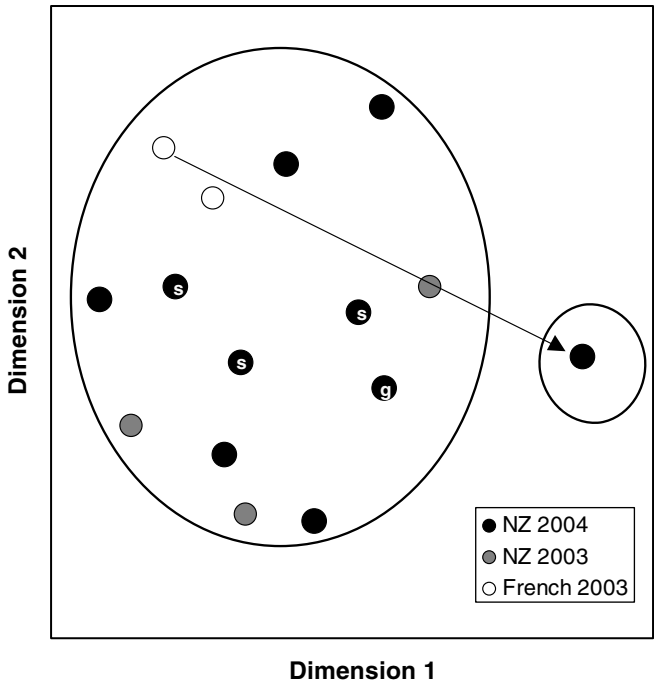

Fig. 3. Wines represented in multidimensional space for the Green sorting task. The arrow represents a line from the least green to the most green wine. Wines contained within an ellipse were grouped together by cluster analysis: G, gold medal winning wine; S, silver-medal winning wines.

is a degree of variation, and again, replicating the cluster analysis results, the 2003 vintage wines do not fall outside the boundary.

3.3. Hedonic ratings

Strong associations were found between participants' assessments of typicality and hedonic liking. Ortho-nasally, each 1 point increment in typicality was associated with a 0.84 increase in liking, $t(251) = 28.30$, $p < 0.001$. Similarly, a 1 point increment in typicality was associated with a 0.80 increase in liking, $t(251) = 23.37$, $p < 0.001$ in the global data. Reductions in the estimates for the residual covariance parameter in the multilevel model suggest that typicality explains 76% and 68% of the variance in liking for ortho-nasal and global ratings, respectively.

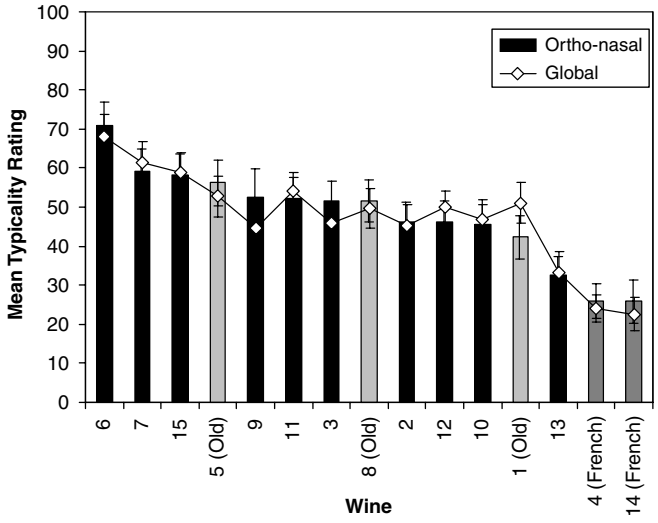

Fig. 4. Mean typicality rating for each wine as a function of category and of modality of flavour perception. Grey bars indicate wines outside the dominant category 2004 Marlborough Sauvignon blanc.

3.4. Chemical analyses and their relation to sensory analyses

The data comprising methoxypyrazine concentrations, expressed in ng/l, were incorporated into several analyses. The aim was to investigate the relation between sensory characterisation of wines and chemical concentrations of compounds assumed to contribute to the distinctive green/vegetative/herbaceous character for which New Zealand Sauvignon blanc is renowned.

Table 4 shows multilevel model slope estimates for methoxypyrazine concentrations predicting sensory descriptor ratings, typicality judgments, and liking judgments. Slope estimates were derived from a Descriptor = Intercept + Concentration + Subject + Error mixed model with Concentration a fixed covariate, Subject a random effect, and Descriptor scores standardised. Concentrations of IBMP and IPMP both show significant positive associations with sensory ratings to all four green descriptors, while inverse relations are demonstrated with fruity/ripe descriptors. More specifically, IPMP is associated with global judgments of leafy/stalky/vegetal characters in conjunction with global judgments of absence of passionfruit, tropical, and stone-fruit characters. IBMP on the other hand is associated with grassy, green capsicum and herbaceous characters as perceived via both ortho-nasal and global modes, and appears less important to the perception of "absence of green".

Fig. 5 shows the final PCA undertaken on the sensory descriptor data with vectors for typicality, liking, and concentrations of IBMP and IPMP included on the map. The plot shows the first two principal components of the PCA that together explained 77% of the variance. Component 1 has high loadings on ripe descriptors (passionfruit, tropical, stone-fruit, grapefruit/citrus) and a negative loading for global mineral/smoky/flinty. Component 1 was also negatively associated with leafy/stalky/vegetal. Component 2 described greener notes, with high loadings for green capsicum, herbaceous, and grassy, plus leafy/stalky/vegetal to a lesser extent. Boxwood/sweaty loaded positively on both components, with ortho-nasal mineral/smoky/flinty not loading on either component.

Scores for each wine on the two components are also projected onto Fig. 5, with the two French wines loading negatively on each component. 2003 Marlborough Sauvignon blanc wines were distinguished by lower scores on Component 2. This PCA configuration was also compared with the MDS configurations, showing moderate agreement with Good Varietal Definition (RV = 0.51) and Green (RV = 0.54), but less agreement with Ripe (RV = 0.34). Fig. 5 also shows Dimension 1 for each

Table 4
Multilevel model slope estimates and correlations for chemical concentrations predicting sensory descriptor ratings and judgments of typicality and liking

	IBMP		IPMP	
	Ortho	Global	Ortho	Global
Multilevel				
Passionfruit	**−0.15**	−0.09	**−0.24**	**−0.24**
Tropical	**−0.13**	**−0.14**	**−0.26**	**−0.27**
Stone-fruit	**−0.14**	−0.08	**−0.19**	**−0.23**
Grapefruit/citrus	0.04	0.04	**−0.15**	−0.01
Grassy	**0.35**	**0.28**	**0.24**	**0.24**
Green capsicum	**0.25**	**0.22**	**0.15**	**0.18**
Herbaceous	**0.33**	**0.24**	**0.27**	**0.21**
Leafy/stalky/vegetal	**0.16**	**0.11**	**0.16**	**0.19**
Boxwood/broom/sweaty/cats pee	**0.13**	0.08	0.00	−0.07
Mineral/smoky/flinty	0.04	−0.01	0.03	−0.05
Typicality	**0.17**	**0.13**	−0.05	**−0.13**
Liking	**0.12**	0.06	−0.09	**−0.16**
Correlation				
Passionfruit	−0.41	−0.22	**−0.66**	**−0.57**
Tropical	−0.34	−0.33	−0.34	**−0.65**
Stone-fruit	−0.49	−0.21	−0.64	**−0.63**
Grapefruit/citrus	0.10	0.20	−0.38	−0.09
Grassy	**0.86**	**0.80**	**0.59**	**0.68**
Green capsicum	**0.70**	**0.61**	0.42	0.51
Herbaceous	**0.86**	**0.76**	**0.70**	**0.67**
Leafy/stalky/vegetal	0.46	0.32	0.48	**0.55**
Boxwood/broom/sweaty/cats pee	0.39	0.23	0.39	−0.19
Mineral/smoky/flinty	0.32	−0.05	0.22	0.27
Typicality	0.35	0.26	−0.11	−0.26
Liking	0.26	0.13	−0.19	−0.35

Note. Bold values are significant at $p < 0.05$.

MDS dimension projected as vectors onto the PCA space. Consonant with previous interpretations, Green Dimension 1 projected onto Component 2, whereas Ripe Dimension 1 projected more weakly onto Component 1. Good Varietal Dimension 1 had high loadings on Component 1, with a weaker association with Component 2. Mean typicality and hedonic liking ratings produced vectors close to Good Varietal Definition Dimension 1. With respect to the chemical aroma compounds, high concentrations of IBMP were associated with the main green characters on Dimension 2, namely grassy, herbaceous, and green capsicum. In contrast, IPMP was associated with the green characters leafy/stalky/vegetal and was inversely related to ripe characters. Finally, the two French wines can be seen in the lower left of the plot, associated with minerality but opposing both the fruity and green aspects of the sensory spatial arrangement, and the chemical concentrations of IBMP and IPMP.

4. Discussion

Results described above from the sensory tasks revealed consensual groups of wines considered to have good varietal definition, to be ripe, and to be green. Specific perceived green and ripe characters were positively associated with concepts of good varietal definition and typicality. Two aroma compounds considered important to the distinctive character of Sauvignon blanc wines from New Zealand were also positively associated with perceived green characters, and were inversely associated with perceptions of fruity and ripe characters.

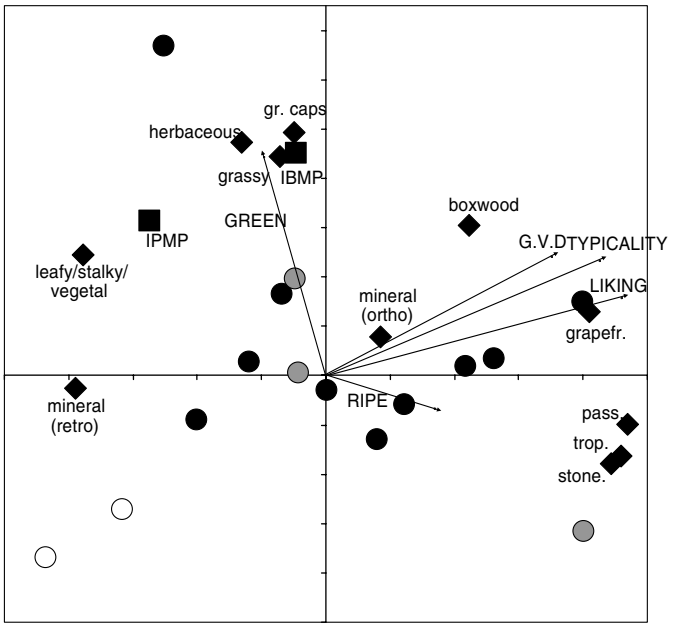

Fig. 5. Principal components analysis descriptor loadings (diamonds) on Component 1 and Component 2 with scores plotted for each wine (black circles = Marlborough Sauvignon blanc 2004; grey circles = Marlborough Sauvignon blanc 2003; white circles = French 2004 wines). Vectors represent correlation with Component 1 and 2 scores with mean typicality, hedonic liking, and MDS Dimension 1 scores for Good Varietal Definition (G.V.D.), Green, and Ripe for each wine. Chemical concentrations of IBMP and IPMP are represented as black squares.

Results from the sensory tasks demonstrated that the concept 'Marlborough Sauvignon blanc wine' has a defined boundary, although contrary to received wisdom, wines with an extra year of bottle age did not fall outside it. Wines from a different geographical region did. We elaborate on these results below.

4.1. Characteristics of wines with high typicality

The first major result of the present study was that, as predicted, wines that were good fits to the concept of Marlborough Sauvignon blanc wine were also judged as having good varietal definition. In other words, when New Zealand wine professionals refer to a Sauvignon blanc wine as representing well the varietal characteristics of the grape, they are also saying the wine has *typicité* (typicality) with respect to the concept Marlborough Sauvignon blanc. In keeping with our second hypothesis, wines with typicality were judged as having specific green *and* ripe characteris-

tics. Conversely, neither green nor ripe classification on its own predicted high typicality ratings for a wine.

Elaboration of the concepts Marlborough Sauvignon blanc and good varietal definition was provided by the sorting task data and the specific descriptor ratings, giving an indication as to the flavour profiles important to each concept. The sorting task data gave an indication as to the specific flavours subsumed within the higher-order categorical descriptors Green, Ripe, and Good Varietal Definition. Further, the flavour profiles of Sauvignon blanc wines with typicality and those judged as having good varietal definition were relatively similar, both when wine professionals generated their own flavour descriptors to the wines (sorting task), and when the same participants rated intensities of 10 experimenter-provided descriptors. The self-generated descriptors did however highlight the importance of descriptors related to wine structure (e.g., intensity and complexity) to wine professionals when evaluating Sauvignon blanc wines, even though these judgements were made by ortho-nasal olfaction alone. The "nose" of Marlborough Sauvignon blanc wine is frequently reported by wine writers to be of major importance to the particular style of wine made in New Zealand, some writers suggesting the perceived olfactory component to provide 80–90% of the wine's flavour.

To be considered a wine with good varietal definition, a Sauvignon blanc appears to require a combination of specific fruity and green notes. These include passionfruit, citrus, tropical, and stone-fruit with respect to fruity notes, while grassy, green capsicum and herbaceous were important green notes. The character variously referred to as boxwood, cat's pee, and/or sweaty was also an important predictor of typicality. On the other hand, presence of a mineral/flinty note in Sauvignon blanc was inversely related to the concept of good varietal definition to a significant degree when the wines were evaluated by full tasting.

Although fruity notes were important to the higher-order category Ripe, the ripe category was defined primarily by an absence of specific green notes. The importance of perception of "absence of green" was further supported by chemical analyses that demonstrated an inverse relation between concentrations of two methoxypyrazine compounds and intensity ratings to fruity/ripe characters. In particular, the aroma compound IPMP that was positively associated with vegetative green characters on the palate, was also significantly related to perceptions of absence of passionfruit, tropical, and stone-fruit characters. This result demonstrates the significance of "green" notes to the mind-sets of New Zealand wine professionals regarding typicality of Marlborough Sauvignon blanc wine. With respect to modality of perception, not all green notes carried equal weight. Whereas grassy, herbaceous, and green capsicum notes were important to both nose and palate judgments the leafy/stalky/vegetal notes appeared more relevant to palate judgments. Finally, typicality rating was a strong predictor of hedonic liking. Given that the majority of the participants in the study are involved with making, judging, and marketing Marlborough Sauvignon blanc wines, the relation between typicality and the concept of 'winery palate' is worthy of investigation.

4.2. Structure of the typicality concept

The second major result from the study concerns structure of the concept of a typical Marlborough Sauvignon blanc wine. The positive association between typicality ratings and wine quality, the latter operationalised in terms of wine show judgments (medal awards) at a prestigious national wine competition, suggests that New Zealand wine professionals do indeed have a prototypical or ideal Sauvignon blanc wine in mind, and that this prototype closely matches what wine professionals consider when they use the term "good varietal definition". Wines that were judged as prototypical members of the concept were not the greenest, nor the ripest wines, but reflected a degree of moderation with respect to these necessary flavour attributes.

The data also show that there are boundaries to the concept, with the two wines outside the geographical region of Marlborough clustering together and separating out from the Marlborough wines in both the sensory and chemical analyses. One Marlborough 2004 wine, Wine 13, clustered together with the French wines in the sorting tasks for Good Varietal Definition and Ripe. Post hoc discussions with the winemaker of Wine 13 provided anecdotal evidence that Wine 13 was subjected to several viticultural and winemaking processes not typically associated with preserving the fresh, primary characters generally associated with New Zealand Sauvignon blanc wines. These included the following: *Botrytis cinerea* affected the fruit around veraison, the fungi subsequently drying out before harvest; grapes were harvested at a higher °Brix (24) than is typical for the wine style; yeast fermentation attained relatively high temperatures (18–20 °C); 20% of the must involved yeast fermentation using "wild" yeast (i.e., non-cultured yeast) which produced some sulphide/cooked cabbage flavour notes. On the other hand, there was no evidence that vintage differences were important to typicality judgments in that wines from the 2003 vintage spanned the distribution of concept ratings given to the ten 2004 Sauvignon blanc wines. It is conceivable that a temporal gap of one year was inadequate to test the importance of wine maturation to typicality judgments of Marlborough Sauvignon blanc wine.

5. Methodological aspects and limitations

The study produced two interesting results from a methodological perspective. First, as already reported, the self-generated flavour descriptors provided by the wine professionals were in keeping both qualitatively and quantitatively with the ratings given to experimenter-provided

flavour descriptors. This provides a degree of validity with respect to choice of experimenter-provided descriptors for the intensity ratings of salient flavours. The self-generated descriptors to the higher-order categories demonstrate however that there were some interesting omissions from the experimenter-provided descriptor list. In particular, the importance of descriptors concerning aspects of a wine other than flavour was apparent with self-generated references to a wine's structure and balance occurring with relative frequency. The self-generated descriptors also provided evidence that 'green + ripe' does not equal 'good varietal definition'; several flavour characters that were not subsumed within green and ripe, notably citrus, boxwood, and the term "intense", were also judged as important.

Second there were marked similarities between the data sets comprising descriptive ratings from the ortho-nasal evaluation and the full tasting condition. In this sense, the conditions serve as replicate conditions. This comment must be qualified as there were also some differences. In particular, the data suggest that the leafy/stalky/vegetal note and the mineral/smoky/flinty note were more important to global (retronasal and taste) judgments than to ortho-nasal judgments. As well, Dimension 2 of Good Varietal Definition appears to be tapping a global aspect while Dimension 2 of Green appears to be an olfactory dimension. These potential modality differences must be treated with caution in light of lack of a full replication for the ortho-nasal and global descriptor-rating tasks in the present study. We intend to follow up these data in future research where methodology permits clearer interpretation of any modality differences, and the degree to which aroma alone accounts for the Marlborough Sauvignon blanc concept.

Two limitations of the present work deserve mention. First, the study cannot separate the contribution of grape versus vinification influences on the distinctive characteristics that contributed to the Marlborough Sauvignon blanc concept, and nor was it designed to. None-the-less, the relationships between chemical data, namely concentrations of IBMP and IPMP, and green characters such as green capsicum, herbaceous, grassy and leafy/vegetal, suggest that these two aroma compounds that enter the wine as constituents of Sauvignon blanc grapevine berries play an important role in expression of green flavours in Sauvignon blanc wines, as well as "absence of ripeness". However, we cannot discount the possibility that some third factor, not investigated here, causes both increased levels of IBMP and IPMP and perceived "absence of ripeness".

A second limitation of the present study is that we did not attempt to investigate wine consumer behaviour and the results cannot be generalised to wine consumers. None-the-less it is important to note that in New Zealand, anecdotal evidence suggests that wine professionals' assessments of wines, both in wine competitions and in written media (e.g., wine columns in local newspapers; wine and food magazines) have a major influence on wine consumers' purchasing decisions.

6. Conclusion

Anecdotal evidence of Marlborough as a distinct geographic region for Sauvignon blanc wines has been supported by sensory data and by chemical analyses of selected chemical compounds. The importance of perceived specific characteristics such as passionfruit, boxwood, and green capsicum to judgments of typicality received support. Marlborough wine professionals appear to have developed techniques for grape-growing and vinification that produced wines from the 2003 and 2004 vintages that are distinguishable sensorially from the 2004 French Sauvignon blanc wines employed in the study. The designation "Marlborough Sauvignon blanc" is therefore meaningful in that it is a concept that evokes a specific flavour profile, at least in the minds of wine professionals. The results must however be qualified by noting that the current study included a small number of wines only, and that the wines outside the formal category of Marlborough Sauvingon blanc, namely French wines, were expected to be distinctive due to known differences in viticultural and oenological practices. There are plans to extend these results via a more stringent test of Marlborough Sauvignon blanc's distinctiveness that includes comparison with wines from a wider range of regions, and from sub-regions in New Zealand.

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