

Measuring the multisensory imagery of wine:
The Vividness of Wine Imagery Questionnaire (VWIQ)

Ilja Croijmans^{1,2*}, Laura J. Speed^{2*}, Artin Arshamian^{2,3,4,5}, & Asifa Majid^{2,5,6,7}

¹Faculty of Social and Behavioral Sciences, Utrecht University, Utrecht, NL

²Centre for Language Studies, Radboud University, Nijmegen, NL

³Department of Clinical Neuroscience, Karolinska Institutet, 17177, Stockholm, Sweden

⁴Department of Psychology, Stockholm University, 10691, Stockholm, Sweden

⁵Donders Institute for Brain, Cognition, and Behaviour, Radboud University, Nijmegen, NL

⁶Max Planck Institute for Psycholinguistics, Nijmegen, NL

⁷University of York, Heslington, York, UK

*Joint first authorship

Corresponding author

Asifa Majid

Radboud University

Erasmusplein 1

Nijmegen 6500HD, Netherlands

Asifa.majid@let.ru.nl

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Abstract

When we imagine objects or events, we often engage in multisensory mental imagery. Yet, investigations of mental imagery have typically focused on only one sensory modality—vision. One reason for this is that the most common tool for the measurement of imagery, the questionnaire, has been restricted to unimodal ratings of the object. We present a new mental imagery questionnaire that measures multisensory imagery. Specifically, the newly developed Vividness of Wine Imagery Questionnaire (VWIQ) measures mental imagery of wine in the visual, olfactory, and taste modalities. Wine is an ideal domain to explore multisensory imagery because wine drinking is a multisensory experience, it involves the neglected chemical senses (olfaction and taste), and provides the opportunity to explore the effect of experience and expertise on imagery (from wine novices to experts). The VWIQ questionnaire showed high internal consistency and reliability, and correlated with other validated measures of imagery. Overall, the VWIQ serves as a useful tool to explore mental imagery, for researchers, as well as individuals in the wine industry during sommelier training and evaluation of wine professionals.

Keywords: Multisensory imagery; wine; vision; olfaction; taste; cognition; experience

Introduction

Mental imagery is the ability to create an inner “image” in any sensory modality, in the absence of a physical stimulus (Freeman, 1981; Pylyshyn, 1973). Imagery can be thought of as reconstructions of sensory experiences from the past, to anticipate experiences to come (Thomas, 2006). In this capacity, it can help in everyday activities, such as planning for the future and reflecting on past events (Gregg, Hall, & Nederhof, 2005; Kosslyn, Thompson, & Ganis, 2006), and it has been linked to several aspects of cognition, such as memory and spatial reasoning (Kosslyn, Behrmann, & Jeannerod, 1995; Marschark & Cornoldi, 1991).

The private experiential character of imagery makes its investigation a difficult endeavor. Many studies rely on self-report. Self-report questionnaires have been developed to measure mental imagery in distinct sensory modalities, including vision (e.g., Marks, 1973), audition (e.g., Halpern, 2015; Willander & Baraldi, 2010), olfaction (e.g., Gilbert, Crouch, & Kemp, 1998), and movement (Isaac, Marks, & Russell, 1986). Other investigations have used neuroimaging methods to localize visual (e.g., Kosslyn, Thompson, & Alpert, 1997), auditory (e.g., Halpern & Zatorre, 1999), and olfactory (Bensafi, Sobel, & Khan, 2007) imagery in the brain. These investigations suggest there is overlap with regions involved in perception. Behavioral experiments have been used as well, based on the idea that imagery can prime or interfere with associated stimuli (e.g., Craver-Lemley & Arterberry, 2001; Tomiczek & Stevenson, 2009). Importantly, self-report responses have been shown to be related to or predict scores on behavioral tasks (e.g., Arshamian, Willander, & Larsson., 2011; Djordjevic, 2004; Halpern, 2015), and neuroimaging measures (e.g., Flohr et al., 2014; Cui, Jeter, Yang, Montague, & Eagleman, 2007; Djordjevic, Zatorre, Petrides, Boyle, & Jones-Gotman, 2005).

The senses work together to interpret the world around us. Yet despite this, mental imagery is typically only investigated for distinct sensory modalities, neglecting the multisensory quality of imagery. For example, although the widely used versions of the

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Betts' questionnaire (e.g., Betts, 1909; Sheehan, 1967) or the more recent Plymouth Sensory Imagery Questionnaire (Andrade, May, Deepröse, Baugh, & Ganis, 2014) explores mental imagery across seven modalities, the vividness of imagery in each modality is assessed by imagining separate situations, rather than one situation involving multiple modalities. This could mean that estimates of vividness of imagery are inaccurate and not comparable across sensory modalities. For example, differences in ratings across vision, audition, touch, taste, and odor (e.g., visual imagery being most vivid; Arshamian & Larsson, 2014; Andrade et al., 2014) could reflect differences between the situations depicted, and not necessarily differences specific to each sensory modality. To overcome this limitation, we present a new mental imagery questionnaire that assesses imagery in multiple sensory modalities simultaneously using wine as our domain of imagery: the Vividness of Wine Imagery Questionnaire (VWIQ).

We chose wine because it is an ideal topic for the study of multisensory mental imagery for several reasons. First, wine is an inherently multisensory experience: we typically visually assess the color of a wine, sniff the wine, listen to the sound of the wine being poured, and then taste the wine, followed by the wine's after-taste. Thus, it enables the assessment of mental imagery from multiple senses while keeping the situation constant. Next, in the wine drinking experience, the often-neglected chemical senses of olfaction and taste are of comparable significance to the more dominant visual modality (cf. Speed & Majid, 2017). The questionnaire can therefore tap the propensity for mental imagery in olfaction and taste, which otherwise can be difficult to assess. Finally, people differ in their experience with wine—from novices to professional sommeliers, for example—and so an instrument which measures imagery of wine provides the perfect opportunity to test theories of expert cognition. The new questionnaire is therefore a useful tool to track the development of expertise and changes in mental imagery in general. Moreover, as an applied resource it

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will be valuable during the education of sommeliers. For a skilled sommelier, it is necessary to draw on imagery abilities across all senses when evaluating, comparing and recommending wines. Thus, evaluating imagery would give direct feedback for students, and can also function as an evaluative tool in wine education.

In this study we present and validate the newly developed VWIQ. We first used principal components analysis to check the underlying structure of the questionnaire. Next, to assess construct validity we compared scores on the VWIQ with established questionnaires of mental imagery: the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973), the Vividness of Olfactory Imagery Questionnaire (VOIQ; Gilbert et al., 1998), and the Plymouth sensory imagery questionnaire (PSI-Q; Andrade et al., 2014). We further validated the questionnaire by comparing scores on the VWIQ with wine-related measures (wine knowledge test, grape type test, average wine consumption). In addition, we compared the wine imagery scores across the different sensory modalities, to see whether the vividness of imagery for wine, with an arguably more important role for the chemical senses, also has vision as the dominant, and thus most vivid sensory modality (e.g., Andrade et al., 2014; Arshamian & Larsson, 2014; Kosslyn et al., 2006).

Method

The VWIQ is based on three separate validations. Below we report the design and validation of the final version of the questionnaire. The questionnaire evolved across validations with the most important outcome being that one out of the four included senses—audition—was removed. We initially focused on four senses: vision, sound, taste, and smell. We focused on those sensory experiences which would be accessible to novices and experts alike, and put aside those components that required specific training or instruction (e.g., mouthfeel, after-taste). Following the first two validation studies, we removed the sound subscale from the

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questionnaire since it showed low factor loadings and low test-retest reliability. Details of the first and second validation can be found in Supplementary Material S1.

The Vividness of Wine Imagery Questionnaire

We designed scenarios phrased in analogy with the VVIQ (Marks, 1973) and VOIQ (Gilbert et al., 1998), with sentences that focused specifically on the color, odor, and taste of wine. Each scenario started with a scene-setting description followed by statements related to the color, odor, and taste of the wine in each scenario (see Table 1 for example; full questionnaire can be found in the Appendix). Six different scenarios were constructed, set in various locations, including: a vineyard, restaurant, bistro, a relaxing night at home, and two wine tastings. Within all six scenarios three statements were used to assess imagery in each modality (vision, olfaction, and taste), resulting in a total of 18 statements. Statements occurred in the fixed order—color, odor, taste—iconically reflecting a wine tasting episode.

Table 1. Example item from the VWIQ

Sentence function	Description
Scene setting	<i>Imagine you are going to a short wine tasting where you will try different wines. The tasting starts with a French white wine, a Sauvignon Blanc.</i>
Vision	<i>The color of the wine as the sun is reflected in your glass</i>
Odor	<i>The smell of the wine as you place your nose in the glass</i>
Taste	<i>The taste of the wine when you have your first sip</i>

Following the VVIQ and VOIQ, we used a five-point scale ranging from “1 – no image at all, just knowing that I’m thinking about the object” to “5 – perfectly clear and as

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vivid as the real situation"¹. Therefore, each sensory modality had a minimum score of 6 (low vividness) and a maximum score of 30 (high vividness). The overall questionnaire has a minimum total score of 18, and a maximum total score of 90.

The Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973)

The VVIQ contains 16 statements describing visual scenes (e.g., *The sun is rising above the horizon into a hazy sky*). Participants are instructed to imagine each scene and rate how vivid their mental images are using the same five-point scale as the VWIQ. Participants are instructed to complete the questionnaire twice; once with their eyes open and once with their eyes closed. The total score is averaged across the two occasions. The minimum score on the VVIQ is 16 (high vividness) and the maximum score is 80 (low vividness).

The Vividness of Olfactory Imagery Questionnaire (VOIQ; Gilbert et al., 1998)

The VOIQ contains 16 statements describing olfactory scenes (e.g., *The smell of your shirt or blouse when you remove it*). Participants are instructed to imagine each scene and rate how vivid their mental images are using the same five-point scale as the VWIQ. The minimum score on the VOIQ is 16 (high vividness) and the maximum score is 80 (low vividness).

The Plymouth Sensory Imagery Questionnaire (PSI-Q; Andrade et al., 2014).

The PSI-Q measures vividness of imagery in 7 sensory domains: vision, sound, touch, taste, smell, bodily sensations and feelings. Each sensory domain has five items such as "*Imagine the appearance of a bonfire*". Participants are instructed to rate their mental image on an eleven-point scale from 0 (*no image at all*) to 10 (*as vivid as real life*). Each sensory domain therefore had a minimum score of 0 and a maximum score of 50.

¹In the VOIQ and VVIQ, the scale is reversed: "*1 – perfectly clear and as vivid as the real situation*" to "*5 – no image at all, just knowing that I'm thinking about the object*".

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Wine measures

We also administered the Wine Knowledge Test (WKT) which is based on similar questionnaires by Hughson and Boakes (2001), Melcher and Schooler (1996), and Lehrer (1983). This questionnaire contains 10 items asking about the typical color of grape types, 7 items assessing wine knowledge (e.g., *Which wine is made with Flor yeast?*) and 2 items about wine experience (*How often do you drink wine? How much have you read about wine?*).

Participants

In total, across all three validation trials, 300 participants were recruited through Amazon's Mechanical Turk (see Supplementary Material S1). In the final validation, 100 participants were recruited. Seven of these were excluded after outlier analysis ($M \pm 2SD$). Two simple test questions were included in the questionnaire to ensure that participants were reading and responding to questions accurately. One question asked participants to click on the response "clear and reasonably vivid", and the other asked "what is the color of red wine?". Ten participants were excluded from analyses after failing these test questions. This left 83 participants ($M_{age} = 40.8$, $SD = 12.8$, 45 female). Participants were paid \$1.50 for completion of the survey, and were informed that it was possible to take part in a follow-up study for which they could earn a bonus of \$1. Fifty participants completed this follow-up.

Procedure

Questionnaires were conducted using a Qualtrics survey (Qualtrics, UT, USA). Participants gave their informed consent by clicking "accept" to a standardized text. Participants completed the questionnaires in the following order: VWIQ, VVIQ, VOIQ, PSI-Q, WKT.

Analysis

Participant ratings on the VWIQ were averaged for each sensory modality, and also overall. To investigate whether the structure of imagery ratings reflected the three sensory modalities

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the VWIQ was designed to measure (vision, olfaction, and taste), a Principal Component analysis was conducted on all data from the first session using SPSS Version 23. Oblique rotation (Oblimin, with $\delta = 0$) was used to maximize the difference between components.

To assess internal consistency (whether items for each modality led to similar ratings) omega was calculated separately for items within each modality (for more information see Dunn, Baguley, & Brunnsden, 2014; Peters, 2014). The closer the value of omega to 1, the greater internal consistency a scale has. Omega was calculated in R (R Core Team, 2013) using the package *userfriendlyscience* (Peters, 2015) was used.

To assess test-retest reliability, only data from participants that completed the VWIQ twice was analyzed. Test-retest reliability was operationalized using typical error (the difference between two test occasions), the change from mean (whether a significant difference exists between the two test occasions), and the correlation between two test occasions (test-retest correlation).

In order to compare the VWIQ to the established mental imagery questionnaires, correlations were conducted between the VWIQ subscales and the respective scales on the other questionnaires. We also performed correlations between the VWIQ subscales and ratings on the three aspects of the WKT, to assess to what extent the VWIQ is related to experience with wine. Finally, we conducted an ANOVA to compare the scores of different sensory modalities of the VWIQ.

Results

Principal components analysis. The sampling adequacy indicated relatively good sample size ($KMO = .818$), with anti-image correlations ranging .640 – .909. The principal component analysis (PCA) suggested three components, indicated by the component loadings ($> .40$ for the first three components) and interpretation of the scree plot. A fourth component had an eigenvalue of just over 1.0 (1.025) but was not supported by the scree plot. The first

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three components explained 68.8% of the variance. Component 1 explained 48.5% of the variance, with high loadings from smell and taste items. Component 2 explained an additional 13.3% of the variance, with loadings from vision items. Component 3 explained a further 7.1% of the variance, with negative loadings from smell items. Component loadings for the three-factor solution are displayed in Table 2.

Table 2. Component loadings ordered by modality and question, with Oblique (Oblimin) rotation applied; component loadings < .4 are suppressed.

	Component		
	1	2	3
Color Q1		.719	
Color Q2		.617	.531
Color Q3		.828	
Color Q4		.725	
Color Q5		.725	
Color Q6		.661	
Odor Q1			-.586
Odor Q2	.585		
Odor Q3	.553		-.496
Odor Q4	.460		-.504
Odor Q5	.511		-.420
Odor Q6	.552		-.411
Taste Q1	.863		
Taste Q2	.935		
Taste Q3	.879		
Taste Q4	.821		
Taste Q5	.885		
Taste Q6	.921		

Internal consistency and reliability. Internal consistency and re-test reliability were high (Table 3), with omega values ranging from .88 (VWIQ-color) to .96 (VWIQ-taste). None of the test-retest values significantly differed between the two test occasions, and the test-

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retest correlations were high to very high for the total score and each of the subscales, indicating very good test-retest reliability.

Table 3. Internal consistency (omega), test-retest reliability (typical error), change from mean and retest correlations.

	Omega [n = 83]	Typical error <i>M</i> and <i>SD</i> [n = 50]	Change from mean <i>t</i> (<i>p</i>) [n = 50]	Retest correlations <i>r</i> (<i>p</i>) [n = 50]
VWIQ-total	.95	.38 (6.0)	.06 (.955)	.865 (<.001)
VWIQ- color	.88	.02 (2.5)	.22 (.828)	.785 (<.001)
VWIQ-odor	.95	.10 (3.2)	.62 (.538)	.805 (<.001)
VWIQ-taste	.96	.26 (3.0)	.45 (.654)	.831 (<.001)

Correlations. In order to assess construct validity of the VWIQ subscales, we conducted correlations between the subscales of the VWIQ and the established mental imagery questionnaires, and between the subscales of the VWIQ and the measures of wine knowledge. The VWIQ subscales correlated highly with other questionnaires and their relevant subscales (Table 4). Wine knowledge was significantly related to the VWIQ total score, as well as the odor subscale (Table 5). Taken together, the VWIQ with three subscales (color, odor, and taste) proved to have sufficient construct validity, internal consistency, and reliability.

Table 4. Pearson correlation coefficients between related questionnaire scales.

Questionnaire scales	Correlation
PSI-Q VWIQ-total	.488*
PSI-VISION VWIQ-color	.508*
PSI-SMELL VWIQ-odor	.357*

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PSI-TASTE	VWIQ-taste	.433*
VVIQ	VWIQ-color	-.505*
VOIQ	VWIQ-odor	-.426*

*correlation significant at $p < .001$ (all two-tailed). Note: VVIQ and VOIQ scales were reversely anchored compared to the VWIQ scales, resulting in negative correlations.

Table 5. Pearson correlation coefficients between VWIQ subscales and measures of wine knowledge.

	VWIQ-total	VWIQ-color	VWIQ-odor	VWIQ-taste
WKT	.228*	.170	.226*	.171
Grape score	.210	.167	.200	.159
Wine consumption	.092	.050	.065	.106

Comparing across modalities. A repeated-measures ANOVA on total ratings found a significant difference in ratings across the three modalities, $F(2, 164) = 12.91, p < .001, \eta^2_p = .136$. Within-subject contrasts showed ratings of vividness of imagery were significantly higher for the visual modality compared to olfaction, $F(1, 82) = 23.57, p < .001, \eta^2_p = .223$, and taste, $F(1, 82) = 5.28, p = .024, \eta^2_p = .061$, and higher for taste compared to olfaction, $F(1, 82) = 9.84, p = .002, \eta^2_p = .107$.

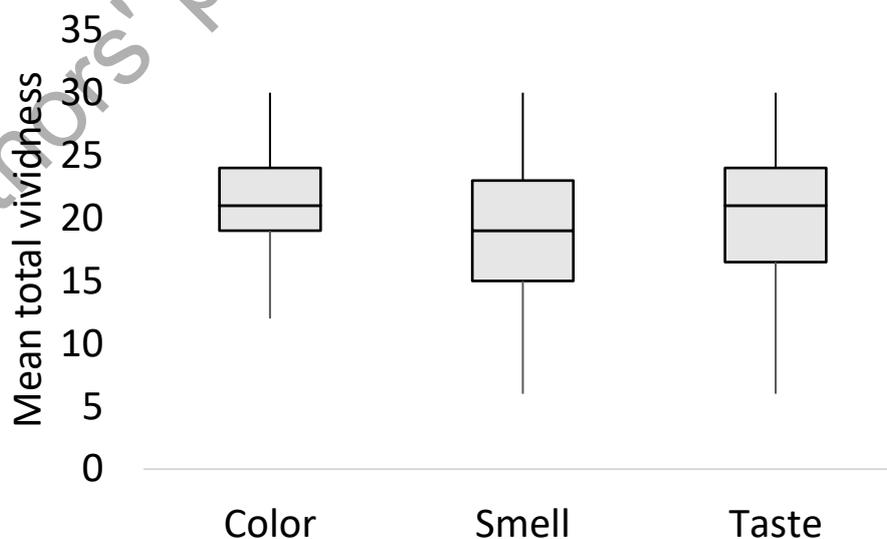


Figure 1. Mean total ratings on the VWIQ for each modality.

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Summary. The VWIQ questionnaire measuring mental imagery of wine in three modalities was satisfactorily validated. The principal components analysis showed three distinct components distinguishing the three sensory modalities vision, olfaction, and taste. Additionally, the questionnaire demonstrated high reliability and significantly correlated with related imagery constructs, as well as wine knowledge. Ratings of vividness of imagery were highest in the visual modality, followed by taste, and then olfaction.

Discussion

We constructed a new questionnaire to measure multisensory imagery in the specific domain of wine. Initial validations of the questionnaire determined that sound (e.g., the sound of wine being poured into a glass) was unrelated to the multisensory experience of wine. Analysis of ratings on the final version of the VWIQ revealed that the crucial sensory dimensions underlying mental imagery of wine are vision, olfaction, and taste. The questionnaire demonstrated good internal consistency and reliability, and ratings correlated with other validated measures of imagery (VVIQ, VOIQ, PSI-Q).

Scores on the WKT correlated with the overall score on the VWIQ, and with the individual odor sub-scale, supporting the construct validity of the questionnaire. We note however that wine consumption did not correlate with the VWIQ. This is likely because the tested participants did not reflect a wide range of consumption behavior (mean glasses of wine consumed per week was 2.45, $SE = .12$). Testing a wider range of participants differing in their consumption behavior weekly or over the longer-term (i.e., lifetime) could reveal a different pattern.

Using PCA, we found that three components underlie ratings on the VWIQ. Furthermore, we found that vividness ratings significantly differed across the three modalities (vision, olfaction, and taste). This suggests that despite the strong correlation between vision, odor, and taste items, the questionnaire does not tap only one measure of general imagery, but

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also the separate constructs of visual, olfactory and taste imagery. This supports the idea that mental imagery is modality-specific (e.g., Kosslyn, 2005).

Vividness of imagery of wine was strongest in the visual modality, followed by taste, and then olfaction, replicating findings elsewhere for mental imagery (Andrade et al., 2014; Arshamian & Larsson, 2014). This is an intriguing finding given that naïve expectation would hold that taste is the most important component of a wine experience, and arguably, therefore, also the most salient for imagery. However, the results from this study suggest that the noted dominance of vision in mental imagery (e.g., Kosslyn et al. 2006) is also apparent in domains where it could plausibly be thought to be less important. This is also in line with the sensory hierarchy traditionally described in Western philosophy and linguistics (e.g., Levinson & Majid, 2014; Viberg, 1984). In accord with this hierarchy, people are thought to find naming odors more difficult than naming visual objects (e.g., Cain, 1979; see Olofsson & Gottfried, 2015). However, recent findings in hunter-gatherers clearly demonstrate that odor-naming is easy when you have an odor-oriented lifestyle (Majid & Burenhult, 2014; Majid & Kruspe, 2018; Majid et al., in press). Similarly, the ability to name the odor of wines has been shown to be improved in wine experts (Croijmans & Majid, 2016). This suggests that it could be possible that the difference between modalities in wine imagery may not exist in wine experts, since each modality is important in the assessment of wine. This is in line with evidence showing that the sensory order for vividness of imagery can differ depending on culture (Marsella & Quijano, 1974).

Exploring multisensory mental imagery in the domain of wine is useful for the study of imagery more generally, as imagining drinking a wine involves simultaneous mental imagery in multiple sensory modalities. This is the first questionnaire that provides a measure of multisensory imagery within the same experience and object (i.e., the PSI-Q used different scenarios to measure imagery in different modalities). Furthermore, the domain of wine

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provides an ideal testbed to study the effect of the transition from novice to expert on mental imagery. Wine experts have been shown to be better at naming the odor of wines (Croijmans & Majid, 2016), and better at remembering wine odors (Parr, Heatherbell, & White, 2002; Parr, White, & Heatherbell, 2004) compared to novices. It is well established that expertise improves vividness of mental imagery in the sensory modality in focus (e.g., Bensafi, Tillmann, Poncelet, Chase & Simon, 1973; Przybylski, & Rouby, 2013; Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013). It is, therefore, likely that experience with wine can improve wine experts' ability to imagine wines too. This questionnaire provides a means by which to test predictions about the role of experience in multisensory mental imagery of wines. Moreover, the use of mental imagery is pivotal for sommeliers when evaluating wines (e.g., when recalling the memory of the perceptual experience of a specific fruit targeted in a wine). This is also reflected during the training of sommeliers, as the use of mental imagery is a central aspect of the Deductive Tasting Method, for example used in master sommelier training by the Court of Master Sommeliers². However, until now there has not been any explicit methods with which to measure the multimodal imagery experience of wines. Thus the VWIQ is also useful during training and as an evaluative tool in wine education.

In sum, we present a new validated questionnaire that measures vividness of mental imagery of wine simultaneously in the sensory modalities vision, olfaction, and taste. This questionnaire serves as a useful research tool to explore the effects of experience on imagery and possible differences across sensory modalities. The questionnaire also has utility outside of academia, and could be a useful measure of individual wine experience for use in the wine industry.

Acknowledgements

² <http://www.courtofmastersommeliers.org/other/deductive-tasting-grid/>

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Appendix

The Vividness of Wine Imagery Questionnaire (VWIQ)

The following part of the questionnaire contains six sections. In each section, you will be given a description of a scene followed by three statements related to the scenario given. After reading each question, please close your eyes to construct a mental image of the described object or scene. Once your image of this scene has been formed, open your eyes to rate the mental image you constructed. You will do this for each different scenario-based mental image requested. You are then asked to rate how vivid several aspects of the image are, on the following scale:

- 1 No image at all (only “knowing” that you are thinking of the object)
- 2 Vague and dim
- 3 Moderately clear and vivid
- 4 Clear and reasonably vivid
- 5 Perfectly clear and as vivid as the real situation

A. Imagine you are visiting a sunny vineyard and ordered a glass of your favorite sparkling wine on their outdoor terrace.

1. The color of the wine as the sun is reflected in your glass
2. The smell of the wine as you sniff it in your glass
3. The taste of this wine as you have a sip

B. You are in a restaurant and are eating a stew. Imagine you have selected the wine for the table and it is being served.

1. The color of the wine when the waiter spills some on the tablecloth
2. The smell of the wine as you place your nose in the glass
3. The taste of the wine

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C. Imagine you are going to a short wine tasting where you will try several different wines.

The tasting starts with a French white wine (a Sauvignon Blanc).

1. The color of the wine when the hostess pours a little bit in your glass
2. The smell of the wine when you smell it in your glass
3. The taste of the wine when you have a sip of it and swirl it in your mouth

D. You have tasted several wines, and the hostess presents the last wines for the tasting.

1. The color of a white wine, a Chardonnay, that she gives you to try
2. The smell of the next red wine you try, a Pinot Noir
3. The taste of this red wine (Pinot Noir) when you try and taste the wine.

E. You are in a bistro. You are having a light lunch, and you have selected a wine to pair with it.

1. The color of the wine when the waiter pours you some to try
2. The smell of the wine when the waiter asks you to check it
3. The taste of the wine when you have your first sip

F. Imagine you are having a relaxing night at home, and decide to have a casual glass of white wine to unwind, intended to be consumed fresh.

1. The color of the wine when you swirl it round in your glass
2. The smell of the wine when you place your nose in the glass to smell it
3. The taste of the wine when you have a sip and swirl it in your mouth to taste it