WINE EXPERTISE SHAPES OLFACTORY LANGUAGE AND COGNITION

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Wine expertise shapes olfactory language and cognition

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INTRODUCTION

How we talk about our experiences influences how we think about them. Take a hypothetical example, and imagine that as part of an experiment someone is asked to remember a series of pictures of trees. Among them is a picture of a European oak *(Querques robur)*. Some time passes as the experiment proceeds, and the experimenter shows the participant a new series of tree pictures and asks if they have seen them before. They are shown two very similar pictures of two different oak trees and are asked which of these pictures they have seen previously. Critically, one of the pictures is a photo of a cork oak *(Quercus suber)*, while the other is a repeat of the European oak (see Figure 1.1)[1]. Would having a distinct name for the kind of tree, i.e., European oak, help the participant remember it? Evidence from research on linguistic relativity suggests this would be the case. Distinct names provide an additional, linguistic cue to remember entities. The stimuli become more distinct perceptually (Ashby & O'Brien, 2005; Winawer et al., 2007) because language provides distinct categories for the participant to organize and remember entities ('cork oak' versus 'European oak'). If the participant had only identified the tree by looking at the acorns, and identified it as an oak, the two stimuli would be harder to discriminate, resulting in decreased accuracy.

[1] One may legitimately ask the question whether an example of different trees is appropriate in a dissertation focusing on wine expertise. However, both types of oak have an important role in wine making. Quercus robur is used to make oak barrels in France and Slovenia, which are used to mature wine in. The bark of Quercus suber is used make cork stoppers, the primary method to seal bottles of wine.

Figure 1.1 Close-up of *Quercus robur* (European oak) on the right, and *Quercus suber* (cork oak) on the left. *Quercus suber* can be identified by its thick bark, somewhat rounded leaves and 'bearded' acorns, whereas *Quercus robur* has lobed leafs and smoother acorn cupule.

The linguistic relativity hypothesis proposes that language affects how people think. Benjamin Whorf proposed that behavior and habitual thought is shaped by the languages people speak (Whorf, 1956). Language captures and categorizes continuous human experience into discrete linguistic units (Malt & Majid, 2013; Malt & Wolff, 2010). For example, upon seeing a strawberry, there is a wide array of light frequencies that hit the retina, yet, when describing what a strawberry looks like most people would simply say it is red. At the same time, there is wide variation in what information languages do and do not convey. Some languages have merely three basic color categories, for example the language spoken by the Umpila of Cape York, Australia, has only red, black and white (Hill, 2011), while in most languages, including English and Dutch, there are around a dozen terms for color that most people use frequently (Malt & Majid, 2013).

If human thought is influenced by language, the way languages categorize the continuous stream of experience will affect how people think about it. Since the early conceptions of linguistic relativity (Majid, in press), research investigating the notion has proliferated (for reviews see: Casasanto, 2016; Lucy, 1997; Wolff & Holmes, 2011). Many studies suggest language influences the units of thought or conceptual representations. For example, Roberson and Davidoff (2000) investigated whether colors are remembered by using their linguistic codes. In English, there is a categorical difference between blue and green. The hypothesis in their study was that when language makes color stimuli more distinct, i.e., colors from two different color categories (i.e., from the *blue* and *green* category) should be more distinct than two color stimuli from the same category (e.g., two different kinds of *blue*), memory for the former is expected to be better than for the latter. And this should be the case when controlling for the perceptual distance between the stimuli used, i.e., the blue and green stimuli should be *perceptually* equally distinct as the two blue stimuli. The results from this study showed memory for stimuli from two different categories was indeed better than for the stimuli from the same category (Roberson & Davidoff, 2000). As a stricter test for their hypothesis, verbal interference was used to prevent linguistic encoding of the different color stimuli, by letting participants read words out loud when they had to remember the stimuli. In this condition, the categorical effect, i.e., the difference in memory accuracy for the two blue stimuli and the green and blue stimuli, disappeared. This provides evidence that language is causally involved when people think about color (Roberson & Davidoff, 2000).

Language can also shape sound perception. The use of space-pitch metaphors varies across languages. In English and Dutch, a tone can be "high" *(hoog)* or "low" *(laag)*. In Farsi, however, low-pitched tones are "thick" *(koloft)* and high pitched tones are "thin" *(na-zok)*. Dolscheid and colleagues (Dolscheid, Shayan, Majid, & Casasanto, 2013) asked speakers of these languages to reproduce tones while watching lines varying in width. Interestingly, speakers of the different languages differed in how accurately they reproduced the tones: when Farsi speakers watched a thick line, the pitch of the tone they reproduced was lower than the actual tone, while there was no such effect for Dutch participants. Conversely, when Dutch participants watched a line presented relatively high on the screen, the pitch of the tone they reproduced was higher than the actual tone, while Farsi speakers were not influenced by the visual display in this condition. This suggests that the non-linguistic representations of pitch are influenced by the language people speak. Interestingly, when Dutch participants were trained to use the Farsi metaphors, i.e., describe low pitch tones as *thick* and high pitch tones as *thin*, their performance was influenced by the visual displays in the same way as Farsi participants. This suggests the effects of language are malleable and can, at least in the short term, be learned relatively easily.

The way people talk about events also affects their memory for those events. Speakers of English phrase events in terms of an agent doing something, even in the case of accidents (e.g., *she broke the vase*). In contrast, Spanish speakers use more so-called *non-agentive* phrasing in case of accidents (e.g., *se rompió el florer*o, i.e., "the vase broke"). Fausey and Boroditsky (2011) asked monolingual participants speaking these languages to describe and remember scenes either involving intentional actions (e.g., a person who willingly breaks a pencil in half), or unintentional actions (i.e., accidents, e.g., a person who breaks a pencil while writing). Both groups remembered the person in the scene equally well in the case of intentional actions, but when the scene involved an accident, English speakers had better memory for the person involved in the action than Spanish speakers. This can be explained by the fact that the respective languages shape the way people remember events (Boroditsky, 2011; Fausey & Boroditsky, 2011). These studies are just three examples of how language may shape thought. Various studies have investigated which mechanisms are at play when it comes to cases of linguistic relativity (see Casasanto, 2016 and Wolff & Holmes, 2011).

Wolff and Holmes (2011) outline several ways language can affect thought, ranging from strong linguistic determinism, which states that thought is composed of language, to weaker versions of the relativity view that propose linguistic codes affect thought. A proposal that is of the latter type is the *thinking-for-speaking* hypothesis (Slobin, 1996). This hypothesis proposes that when language is used online, for example when preparing to describe a scene, this use of language guides how the scene is perceived. When languages differ in how scenes are described, the events are perceived differently, affecting how the scene is encoded and remembered. However, according to this hypothesis, linguistic effects are not present when participants do not use language online, for example when they just look at particular scenes (Papafragou, Hulbert, & Trueswell, 2008; Slobin, 1996). Other proposals of linguistic relativity suggest than when people engage in cognitive tasks, linguistic codes are activated alongside non-linguistic codes. When the linguistic code in a language matches a nonlinguistic (e.g., perceptual) code, thinking is facilitated, but when the perceptual code does not mesh well with the linguistic code, language interferes with thinking, compromising speed and accuracy. Similar to the thinking-for-speaking hypothesis, this thinking-with-language proposal predicts an online effect of language (Wolff & Holmes, 2011; Winawer et al., 2007). Finally, language could act as an augmenter, directing attention in specific ways to real-world experiences, highlighting particular aspects of the world that are particularly salient in a given language (Evans, 2010; Lucy, 1997). In this proposal, as language affects learning about the world, it can affect thought even when there are no linguistic processes recruited online, i.e., in an offline fashion. Language may act as a spotlight, by highlighting certain differences between objects in the world because these differences are also reflected as particularly salient categorical differences in a given language (Evans, 2010; Wolff & Holmes, 2011).

Majid and colleagues described four concrete mechanisms by which linguistic relativity effects can be observed (Majid, Bowerman, Kita, Haun, & Levinson, 2004). First, experience, including experience with language, can guide attention to features in the environment, where perception can be tuned to be particularly sensitive to these features through habitual attention to these features. Thinking may be influenced by this habitual process through perceptual learning (Gibson & Gibson, 1955; Goldstone, 1998), as features that are easily described receive more attention, and stand out more, compared to features not coded in language (cf. Goldstone, 1998; Lively, Logan, & Pisoni, 1993). Second, recoding of conceptual representations can take place based on linguistic input and experience. Schooling and training, both processes taking place with language as a medium, can reshape and refine early acquired knowledge. In line with this, scholars have described the novice-expert shift (Carey, 1999, 2009; Gobbo & Chi, 1986; Priest & Lindsay, 1992; Solomon, 1997), in which the conceptual structure of a particular domain becomes much more refined. For example, children may initially talk about the broad category of dinosaurs, and perceive species of dinosaurs similarly. When they become more acquainted with the variation of Jurassic animals, by learning the different species in books and other language-based sources, their knowledge of dinosaurs becomes refined. As a result, they also perceive diverse species of dinosaurs differently (Alexander, Johnson, Leibham, & Kelley, 2008; Alexander, Johnson, & Schreiber, 2002). The third proposed mechanism by which linguistic relativity could work (Majid et al., 2004) is through analogical learning, where conceptual structures become linked, a process called 'structure mapping' (Gentner, 1983). Languages can differ in how conceptual representations are learned through analogy, by differing in "what is compared to what" (Majid et al., 2004, p.113), and which words are used in different situations to describe different events or scenes. The learned concepts will subsequently also differ. Last, having various semantic categories for a given concept, for example having many different categories for color, can result in someone having to consider all the different options in a semantic field when selecting the most appropriate category (e.g., red, pink, purple etc.). This subsequently results in differential use of cognitive resources depending on the language spoken (Hunt & Agnoli, 1991). As the mind works to minimize the use of cognitive resources, i.e., computational cost, language could influence how people arrive at decisions and thus influences how people think by providing the categories people use. These mechanisms offer plausible and testable ways in which language could influence thought.

The idea that language can influence thought is nevertheless controversial. One of the problems that has surrounded linguistic relativity is that it can be a challenge to separate cultural practices from linguistic influences (Casasanto, 2016; M. C. Frank, Everett, Fedorenko, & Gibson, 2008; Li & Gleitman, 2002; Zlatev & Blomberg, 2015), as these are often closely intertwined. To illustrate, in Seri, a language spoken in Mexico, there are several verbs that can be used to describe how something smells. For example, the verb root –con can be used to say that someone smells a particular smell quality, such as smoke, cooking food, spoiled beans, onion, or when cooking an immature sea turtle (O'Meara & Majid, 2016). Yet, smell plays an important role in Seri culture too. Seri use fragrant plants such as desert lavender to cure diseases and in protective amulets, or use aromatic flowers as adornment for their houses (Felger & Moser, 1985; O'Meara & Majid, 2016). Finding a difference in thinking about smells in Seri, reflected for example in their memory for particular smells named using different linguistic categories, may have an underlying linguistic cause, but could also be explained by their cultural awareness of odors in everyday life. In turn, their awareness of odors in daily life could also be driven by the fact that odors are talked about in everyday conversation, which would indicate a more subtle effect of language. These mechanisms demonstrate language can potentially shape thinking in different ways.

1.2 OLFACTORY LANGUAGE

Many studies on linguistic relativity have focused on vision, sound, or space. These domains allow easy cross-linguistic comparison. One domain that is somewhat neglected, yet possibly very interesting to study from a linguistic relativity viewpoint, is olfaction. Olfaction is interesting as people seem to differ widely in their ability to describe smells and flavors, which suggests there are people with more elaborated olfactory concepts, and other people for whom olfactory concepts are relatively weak (Herz, 2003; Speed & Majid, 2016). Speed and Majid (2016) suggest that because olfaction is difficult to conceptualize and verbalize for most people, language can have a strong influence on how smells are perceived. This makes olfaction a particularly pertinent domain to look at effects of language on thought, as the influence of language could be particularly large.

In addition, olfaction is incredibly important in our daily lives. The flavor and fragrance industry, with a turnover of over 24 billion euros in 2016 (Leffingwell & Associates, 2016), develops the precise, just-right flavor of food and beverages (e.g., soft drinks, crisps, ready-meals), and also the smell of other non-food consumables (e.g., shampoo, toilet paper). In addition, odors are frequently used in public spaces, stores and marketing settings, and in multimodal virtual reality settings (e.g., Bradford & Desrochers, 2009; Rimkute, Moraes, & Ferreira, 2016). Yet, most people in Western countries do not seem consciously aware of these smells (Köster, Møller, & Mojet, 2014). This unawareness seems to coincide with poor linguistic coding too.

In Western languages, olfactory lexicons are small. Whereas other sensory domains have at least some—and sometimes an abundance of—terms that can be used to describe sensory properties, smell has very few (Levinson & Majid, 2014; Majid, 2015). The words that are used to describe smells in English are words like *musty*, *aromatic*, and *fragrant*, words that do not seem to capture specific qualities of a particular olfactory experience (Majid, 2015; Majid & Burenhult, 2014). Similarly, in Dutch, there are only a few words used specifically for smells, similar to those in English, e.g., *muf* (‘musty’). When asked to name a smell, Dutch or English speakers predominantly use words that refer to sources instead (i.e., source-based terms). Speakers are not very consistent in their descriptions, and often they refer to something other than the actual odor object (i.e., they give an incorrect answer) – they might say "cinnamon" when the odor is *vanilla*, or "candy" when the odor is *banana* (De Wijk & Cain, 1994; Engen, 1987; Majid & Burenhult, 2014; Wilson & Stevenson, 2006). When people are asked to name odors, they will give the correct, i.e., the *veridical* label in only about 50% of instances (Cain, 1979; Cain, de Wijk, Lulejian, Schiet, & See, 1998; Engen, 1987).

Titchener (1915) and Henning (1916) stated that odors cannot be abstracted into language in the same way as color. Odors are thought to be *ineffable*, or not easy to talk about (Levinson & Majid, 2014). In addition, odors can elicit strong emotional reactions (e.g., Royet, Plailly, Delon-Martin, Kareken, & Segebarth, 2003), and bring back powerful autobiographical memories (Chu & Downes, 2002; Willander & Larsson, 2006), which is suggested to interfere with linguistic associations for smells (Lorig, 1999).

The same picture appears when examining flavor. Smell and flavor are related, in that they share an underlying physiology (Shepherd, 2006). Flavor is perceived in the mouth when retronasal smelling[2] is combined with taste (i.e., what the receptors on the tongue register), and other sensations, such as temperature, texture, sound, and trigeminal sensations (Smith, 2012; Spence, 2015b). Given that smell alone already "has more sensations than we can count or name" (Titchener, 1915, p. 49), this makes naming flavors vastly complex (Smith, 2012). Likewise, there are few words that capture flavor. There is some vocabulary for the basic tastes *(sweet, sour, salty, bitter)*, yet people still often confuse these tastes in their descriptions (O'Mahony, Goldenberg, Stedmon, & Alford, 1979; Stevenson, Prescott, & Boakes, 1999). This makes that flavors are also difficult to name.

However, recently, studies suggest smells are not universally ineffable. Small communities of hunter-gatherers on the Malay Peninsula, the Jahai and

[2] Retronasal olfaction literally means "smelling through the back (retro-) of the nose", as opposed to orthonasal olfaction, meaning "smelling using the proper (ortho-) side of the nose"

the Maniq, have an extended vocabulary of words for smells (Burenhult & Majid, 2011; Majid & Burenhult, 2014; Wnuk & Majid, 2014), and smell lexicons can be found in other languages too, such as Thai (De Valk, Wnuk, Huisman, & Majid, 2016), a language spoken by 40 million people. When Jahai are asked to name odors, they use short, abstract words from their smell lexicon (Majid & Burenhult, 2014), suggesting smells are highly expressible in language for them. It could be that the poor ability to describe smells is only apparent in WEIRD *(Western, Educated, Industrialized, Rich, Democratic*; Henrich, Heine, & Norenzayan, 2010) populations, but above all, this shows there is variation in how good people are at describing smells.

In these communities, where smell has a dedicated vocabulary, people not only talk more consistently about smells, but smells are also pertinent to the corresponding cultures. Briefly, in Thailand, odors and flavors are important in a wide-spread folk medicinal theory (Wnuk, de Valk, Huisman, & Majid, 2017); and similarly, in Maniq, odors have medicinal associations (Wnuk et al., 2017). For both the Maniq and Jahai, odors are closely monitored during preparation of food and tools, during hunting, and play an important role in religious practices (Burenhult & Majid, 2011; Wnuk & Majid, 2014). Likewise, as illustrated previously, smells can be talked about using specific verb roots in Seri, coinciding with cultural practices around olfaction (O'Meara & Majid, 2016). These practices suggest olfaction is not only talked about more, but also part of everyday cultural practices. That is, the ability to describe smells seems to coincide with more conscious appreciation of smells, and with more conscious smell experience. This opens up the possibility that experience can affect peoples' ability to talk and think about olfaction.

In Western countries, olfaction experts also differ from novices in their awareness for smells: novices are relatively unaware of their sense of smell in their daily lives, but flavor experts, such as wine and coffee experts, are much more aware of the *smellscape* that surrounds them (see Chapter 3, p. 63). Olfactory awareness is related to several aspects of olfactory cognition, for example odor memory and identification (Arshamian, Willander, & Larsson, 2011). Because olfactory concepts seem less stable in the minds of Western novices (cf. Herz, 2003; Speed & Majid, 2016), olfactory expertise offers an interesting comparison.

Wine expertise is a particularly compelling area to study olfactory language and thought. Communicating about smells and flavors is one of the core tasks of wine experts (cf. Herdenstam et al, 2009). In order to buy and sell wine, wine experts have to engage in conversations to get a sense of the smell and flavor of wines, without tasting every single bottle. Similarly, the relationship between price and quality for wine is not one-to-one (R. Goldstein et al., 2008; Horowitz & Lockshin, 2002; Lebois, Wilson-Mendenhall, & Barsalou, 2015). For this reason, consumers have to rely on descriptions by wine experts in stores and online, among other sources of information, to decide on a good bottle of wine.

Some studies indeed suggest differences between novices and wine experts regarding conceptual representations. Sorting tasks can be used to infer conceptual categories in which people think about the world (Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Solomon (1997) asked experts and novices to sort 10 different wines into four groups based on their similarity, without knowing what kind of wine it was. The results showed wine experts sorted wines along grape type and region of origin, whereas novices sorted wines based on perceptual features like bitterness and sweetness. In later studies, replicating the work of Solomon, wine experts were found to sort wines with high agreement, whereas novices sort with no agreement in their solutions, suggesting wine experts share cognitive constructs for wine (Ballester, Patris, Symoneaux, & Valentin, 2008; Urdapilleta, Parr, Dacremont, & Green, 2011). So, wine experts and novices differ in the way their knowledge of wine is cognitively structured.

In summary, wine experts have years of perceptual training and knowledge of wines, and thus pose a unique opportunity to study the effect of expertise on olfactory language and cognition. In addition, it provides the opportunity to study the interplay of language with other cognitive functions, such as memory. Furthermore, the relationship between language and thought in wine experts is also relatively unexplored. These are the main topics of this dissertation.

1.3 WINE EXPERT LANGUAGE

The absence of a specific smell and flavor vocabulary in most Western languages makes it difficult to consistently describe olfactory experiences (cf. Majid & Burenhult, 2014), and this is also reflected in wine vocabulary (Lehrer, 2007). Similar to novices, wine experts use many concrete source-based words (e.g., Gawel, 1997; Lehrer, 1975; Solomon, 1990). In addition, wine experts make use of metaphors (Caballero, 2007; Caballero & Suárez-Toste, 2008; Suarez-Toste, 2007). It has also been suggested that wine experts' descriptions are highly idiosyncratic (Cain, 1979; H. T. Lawless, 1984), and perhaps even non-informative (Quandt, 2007; Shesgreen, 2003).

Part of the difficulty in studying the language of wine may stem from the highly complex nature of the stimulus, which leads to complex descriptions, and no clear right or wrong answers. In a classic study, Brown and Lenneberg (1954) investigated how language can affect thought, and coined *codability* as how easy it is to express a concept in language (cf. Levinson & Majid, 2014). Codability is an influential concept in linguistic relativity research, and has been successfully used to study various domains (e.g., R. W. Brown & Lenneberg, 1954; Lachman, Shaffer, & Hennrikus, 1974), including taste (O'Mahony & Ishii, 1986) and smell (Chrea, Ferdenzi, Valentin, & Abdi, 2007; Majid & Burenhult, 2014). Codability is operationalized using three criteria (based on R.W. Brown and Lenneberg, 1954): when something is codable, it is (1) described in a succinct way, (2) has dedicated vocabulary, and is named (3a) more consistently and (3b) more accurately. These criteria are used to address the first question of this dissertation, i.e., are smells and flavors found in wines more codable for wine experts?

Whether wine experts meet these criteria for codability is investigated in different chapters. In Chapter 2, I explored whether there is a distinct vocabulary for wines used by experts. Scholars have criticized how informative wine reviews are (Quandt, 2007; Shesgreen, 2003), perhaps because wine experts frequently use metaphors and creative prose. The truth or validity of the claim—that wine reviews are uninformative or *bullshit* (cf. Quandt, 2007)—was put to the test in Chapter 2, using computational models to predict different objective properties of wines from descriptions written by experts. If a computer algorithm can predict different wine properties from reviews alone this would indicate wine experts vary their reviews along predictable dimensions, and thus resulting in informative reviews.

Still, when writing wine reviews, wine experts have access to other sources of information, such as the information on the bottle, which gives them additional cues above and beyond the smell and flavor of the wine. In addition, as all reviews were written by experts, this study did not directly address the question of whether wine experts are better at describing wines than the average person, i.e., a novice.

This question was addressed in Chapter 3, where I compared wine experts to novices on the consistency and length of their smell and flavor descriptions. Additionally, wine experts were compared to a different group of flavor experts i.e., coffee experts. While wine and coffee experts both have extensive practical experience with smells and flavors, and olfaction plays a major role in their profession, wine descriptions are more embedded in wine subculture as compared to coffee descriptions in coffee subculture. Wine, as a beverage, has been consumed for a much longer period of time as compared to coffee. It has a cultural history estimated to date back 7,000 years (McGovern, Fleming, & Katz, 2005). In contrast, coffee as a beverage is first mentioned in Ethiopian written sources from the 11th century (B. Weinberg & Bealer, 2001), and was introduced on a large scale in Western cultures halfway through the

18th century (Ukers, 1922). In addition, today, written descriptions of wines have a more prominent place in restaurants, bars and shops than those of coffee. This makes for an interesting contrast between these two expert groups, as wine experts have more opportunities to practice describing smells and flavors than coffee experts.

In addition, Chapter 5 explored two other aspects of wine experts' descriptions, i.e., how consistent they are over time with themselves, and the accuracy of their descriptions, both for wine odors and common odors. Together, these chapters used different methods and measures to address the question of whether smells and flavors of wines, and other smells, are more codable for wine experts than novices.

1.4 WINE EXPERT COGNITION

Since De Groot's (1946, 1978) pioneering work on chess experts, the study of expertise has greatly informed the understanding of human cognition. Studying expertise provides a window into the effect many years of training, deliberate practice, and knowledge in a specific domain have on cognition (Caley et al., 2014; Ericsson, Charness, Feltovich, & Hoffman, 2006; Weinstein, 1993). Expertise effects have been shown in many different areas of cognition, for example how musicians remember musical pieces (Williamson, Baddeley, & Hitch, 2010), or how professional actors remember scripts (Noice & Noice, 2006). Two other pertinent aspects of cognition, in addition to language, are investigated in this dissertation. These are the ability to imagine wine odors and common odors (i.e., *imagery*), and the ability to remember wine odors and common odors (*memory*).

The ability to bring something to consciousness without that something being physically present—i.e., *imagery*—has been linked to other cognitive functions such as creativity, but more importantly for the focus of this dissertation, to language and memory (Kosslyn, Behrmann, & Jeannerod, 1995; Kosslyn, Thompson, & Ganis, 2006). It has previously been shown that expertise can affect imagery (e.g., Hatta & Miyazaki, 1989; Stevenson & Case, 2005). When linguistic representations are more refined through expertise, this could allow more vivid recollections of wines experienced in the past. Another possibility is that if language guides attention to specific aspects of the environment, wine experts may be more attuned towards those aspects of wine, because their linguistic skill directs their attention to these properties in wine (cf. Goldstone, 1998). Through perceptual learning, representations of particular aspects of the environment, or in the case of wine experts, of a wine, may become more elaborated and more vivid in imagery.

Imagery has been an important area in cognitive psychology (Thomas, 2006). While there is little controversy of whether people can engage in visual or auditory imagery (Farah, 1988; Kosslyn et al., 2006; Kraemer, Macrae, Green, & Kelley, 2005), there is debate concerning the nature of olfactory imagery, and how these modalities compare to each other (Arshamian & Larsson, 2014). Olfactory imagery is difficult (Gamble, 1909, as cited in H. T. Lawless & Cain, 1975), and people vary widely in their reported ability to imagine smells (Arshamian & Larsson, 2014; Stevenson & Case, 2005). Interestingly, people in different cultures also differ in their reported ability to imagine the senses, including olfaction and gustation (Marsella & Quijano, 1974). Similarly, perfumers have been found to consciously engage in olfactory imagery with relative ease, whereas perfume students report that imagining odors is very difficult (Delon-Martin, Plailly, Fonlupt, Veyrac, & Royet, 2013; Royet, Delon-Martin, & Plailly, 2013). Stevenson and Case (2005, p. 261) have suggested experts may be able to bypass the limitations of olfactory language, possibly making olfactory imagery as good as imagery in other modalities. If true, this would mean particular experiences can change the ability to consciously re-experience odors, i.e., imagine odors.

In Chapter 4, the role of wine expertise on imagery was investigated. A new questionnaire, measuring multisensory imagery, i.e., the appearance, smell and flavor, of wine was introduced. In a follow-up study, wine experts and novices were compared for their multisensory imagery of wines, and also on their general olfactory imagery, using an existing questionnaire (Gilbert, Crouch, & Kemp, 1998). Comparing wine experts and novices on these two questionnaires revealed the effect expertise has on olfactory imagery in general, but also on wine imagery in particular.

Memory is another aspect of cognition investigated in this dissertation. Across many other domains of expertise, experts are found to have a better memory for the stimuli salient to their domain of expertise. There is evidence wine expertise can affect memory processes too. In a four-alternative forced choice paradigms task, wine experts were found to be better than novices in selecting wines they experienced before (Melcher & Schooler, 1996; Zucco, Carassai, Baroni, & Stevenson, 2011). Apart from these few studies, the effect of wine expertise on recognition memory for wines remains largely unknown. Therefore, in Chapter 5, two experiments investigated the effect of expertise on memory for wine odors and other odors. These two studies, using similar paradigms, tested whether wine experts can remember wine odors, wine related odors, and common odors, better than novices.

1.5 THE RELATIONSHIP BETWEEN LANGUAGE AND THOUGHT IN WINE EXPERTS

In Chapters 2 and 3 of this dissertation, I looked at how wine expertise affects the ability to describe smells and flavors, and I investigated how wine expertise affects cognition, i.e., imagery and memory, in the subsequent chapters. The fact that wine expertise shapes both naming of wines and episodic memory for wines raises another question: What is the relationship between language and wine expert memory?

There is evidence language can affect how people remember odors and flavors. Herz and Engen (1996) concluded “the jury was still out” (Herz & Engen, 1996, p. 303) on whether odor memory is verbally mediated. However, since their review many studies have found language can improve memory for odors and flavors. In Chapter 5, I briefly review this research, and conclude there is evidence language can play a role in how odors are remembered by novices.

Linguistic relativity offers several mechanisms by which online language use can influence memory (Majid et al., 2004). First, what can be named can simply be rehearsed more easily (Darley & Glass, 1975; Maki & Schuler, 1980). A benefit that novices might have from naming is that they can rehearse the names of the odors they have smelled before, thus remembering the label better. In a similar vein, the dual coding theory (Paivio, 1986) predicts people use two routes to encode stimuli—a perceptual route that contains the perceptual representation or image of the stimulus, and a verbal route that contains a verbal code or label. As wine experts are better at describing wine, their improved memory might simply be because of their verbal skills. Odor perception could still be the same in experts and novices. The difference between experts and novices should then be directly mediated by language; if an expert can name a particular wine informatively, using concrete words, it is encoded through the verbal route in addition to the perceptual route, resulting in a better memory trace (e.g., Brunyé, Taylor, & Rapp, 2008). A novice may not be able to name the wine informatively, and may only encode the stimulus through the perceptual route. This dual coding account of memory predicts an online effect of language on memory.

On the other hand, previous studies have found perceptual learning and working memory processes play an important role in expert memory (Biederman & Shiffrar, 1987; Gobet, 1998; Kellman & Garrigan, 2009). The perceptual learning theory of expertise (see Kellman & Massey, 2013, for a review) hypothesizes that after frequent encounters of a particular type of stimulus, the ability to extract information from that stimulus becomes more effective and more efficient. This theory leaves room for an offline role for language in expert odor memory. As students become experts, language can guide their attention to particular aspects of wine: such as grape type and region of origin, and this may lead them to pay attention to particular odors and flavors, driving perceptual learning. This mechanism resembles the *language as a spotlight* hypothesis in linguistic relativity theory (cf. Wolff & Holmes, 2011), or a perceptual tuning through language (cf. Majid et al., 2004). Another way in which language can be involved in expert wine memory is by shaping conceptual structures (Carey, 2009). Linguistic input, encountered during the process of becoming a wine expert, can direct the novice-expert shift, and shape how experts remember odors and flavors particular to wine (e.g., Ballester et al., 2008; Solomon, 1997).

In Chapter 5, I test whether wine expert memory is mediated by language through an online role of language. In the first study, during encoding, experts and novices were asked to name the odors of wines, or to be silent. These two different conditions were compared as a test of the influence of overt naming on memory for wines and smells. Using this paradigm, the effect of online language use can be tested. If experts use language in the way suggested by thinking-for-speaking (Slobin, 1996), experts would have better memory when they name wines overtly, but not in the silent condition. In a second study, experts and novices performed a secondary task as they memorized, i.e., encoded, the wine odors and common odors. This task, a verbal interference task, is thought to selectively interfere with linguistic encoding of the to-be-encoded stimulus (M. C. Frank, Fedorenko, Lai, Saxe, & Gibson, 2012; Winawer et al., 2007). This condition was compared to an active control condition, i.e., a visual-spatial interference task, and passive control condition, i.e., just encoding the stimuli. Combining these two studies enabled a comparison of the effect of online naming on odor memory.

1.6 DOMAIN-SPECIFICITY OF WINE EXPERTISE

In expert cognition, a recurrent theme is that expertise is domain- and perhaps even task-specific (Kimball & Holyoak, 2000). However, transfer is a basic learning process, as acquired skills and knowledge are applied to new experiences and problems (A. L. Brown & Kane, 1988; Kimball & Holyoak, 2000). Thus, transfer of certain abilities to other situations must occur during the acquisition of expertise. The question then is to what extent wine expert cognition is transferable. This raises another question considered in this dissertation: Is wine expertise domain-specific, or can aspects of wine expert cognition transfer to other smells and flavors? Expertise, for example in chess, has been shown to have profound effects on cognition (Charness, 1992) and possibly also on language (De Groot, 1978), but most of these effects are limited to the domain of expertise (Kimball & Holyoak, 2000).

For wine expertise, the question is where the boundary of expertise can be drawn. Because smells are so important for wine experts in their daily life, their attention to odors may not be restricted to wine odors, but could be reflected in how they deal with any type of odor. If attention makes all odors in the expert environment more salient, this would predict wine experts would also be better at describing common smells, and may imagine and remember any type of smell better than novices. On the other hand, the expert literature in other domains suggests deliberate practice with the topic of expertise is necessary to improve cognition, and that an increased awareness for a broad sensory domain is not enough to overcome the domain-specificity of expertise.

The question of whether wine expertise transfers to other smells outside of the expert domain is a recurrent theme in this dissertation. In Chapters 3 and 5, the comparison was made between the ability to describe the smell and flavor of wines versus common smells and tastes. In Chapter 4, imagery for different sensory aspects of wine, i.e., appearance, smell and flavor, was compared to imagery for common smells. In Chapter 5, the domain-specificity of memory was tested in wine experts, by using wine smells, wine-related smells and common smells. Taken together, using stimuli from within and outside the domain of expertise in these different chapters, the domain-specificity of wine expert cognition was put to the test.

1.7 SUMMARY

In this dissertation I investigate what the effect of wine expertise is on language and cognition, and what the relationship is between language and cognition in wine experts. To answer this question, I have introduced four sub-questions:

1. Are smells and flavors more codable for wine experts?
2. What is the influence of wine expertise on olfactory cognition?
3. What is the relationship between language and wine expert memory?
4. Is wine expertise domain-specific, or does it transfer to other smells and flavors?

The following chapters will answer these questions, and in the general discussion (Chapter 6) the questions will be revisited in light of the empirical evidence provided in this dissertation.

2

THE LANGUAGE OF WINE REVIEWS[3]

2.1 ABSTRACT

Wine is a multi-billion dollar industry. People use wine reviews to select wines with a better price-quality ratio, but talking about odors and flavors is difficult for most people speaking Western languages. It has been suggested language is simply poorly equipped for describing wines. On the other hand, there are wine writers and critics who write about their flavor experiences, and do so in entertaining writing prose. This seems to be a contradiction. Indeed, wine experts' descriptions are frequently received with criticism, with accusations that wine talk is "bullshit". Can wine experts give an informative description of a wine, while maintaining their own personal writing style? In this chapter, I examine these claims by predicting wine properties (color, grape type, and origin) from written reviews alone, while taking into account individual writing styles. In addition, the wine vocabulary used in online wine reviews was examined. More specifically, the words wine experts use to describe wine and whether these words were used consistently was examined. Using Termhood analysis, a list of 146 domain-specific words for wine were distilled from a corpus of around 70,000 online-sourced wine reviews written by different authors. This core vocabulary was compared with other wine vocabulary lists, revealing a core list of 45 words that are used both in wine experts' active vocabulary and are documented in established sources of wine vocabulary. In addition, a classification paradigm revealed that even though the authors used their own writing style, color and grape variety could be reliably predicted from the review alone. These studies suggest wine experts are able to give consistent information about wine using domain-specific vocabulary. This suggests wine experts are able to describe wines in an informative way, contrary to previous accounts that smells and flavors cannot be put into words.

2.2 INTRODUCTION

Everyone begins as a novice, but through training and practice, one can obtain comprehensive and authoritative knowledge (i.e., epistemic expertise), and become more skilled in performing certain acts (i.e., performative expertise) in a given domain, and as

[3] This chapter is based on Croijmans, Hendrickx, Lefever, Van den Bosch & Majid (in preparation): Are wine reviews bullshit? Predicting wine properties from the descriptions alone.

such, become an expert (Caley et al., 2014; Weinstein, 1993). Studies of expertise range from classic work on chess masters (De Groot, 1946) and chicken sexers (Biederman & Shiffrar, 1987), to studies of expert players of the Chinese board game GO (Silver et al., 2016), musicians (e.g. Mitchell & MacDonald, 2011), sailors (Pluijms, Cañal-Bruland, Tiest, Mulder, & Savelsbergh, 2015), and Japanese incense masters (Fujii et al., 2007).

Chess expertise, in particular, has been studied extensively, and has come to serve as a model for how expertise is acquired more generally (De Groot, 1946, 1978; De Groot, Gobet, & Jongman, 1996). For this reason, research on chess expertise has influenced the cognitive sciences in general—illuminating, for example, the workings of episodic memory (Chase & Simon, 1973; Gobet, 1998), working memory (Frey & Adesman, 1976; Robbins et al., 1996), problem solving, and artificial intelligence (Berliner & Ebeling, 1989; Campbell, Hoane, & Hsu, 2002). In other domains, experts have also been found to perform better on various cognitive tasks. For example, expert radiologists are better at detecting low-contrast features in x-ray images (Ericsson, Prietula, & Cokely, 2007; Snowden & Roling, 2000). Likewise, expert musicians are able to identify relationships between tones, i.e., relative pitch (Levitin & Rogers, 2005), to imagine musical pieces from musical notations (Brodsky, Henik, Rubinstein, & Zorman, 2003), and recall musical pieces more consistently than novices (Halpern & Bower, 1982).

Similar effects have been shown with respect to linguistic skills too. When computer experts and novices are asked to describe pictures of complex visual scenes containing computer or other electronic equipment, experts' descriptions contain more references to salient details about computer equipment. This linguistic elaboration is related to their improved memory of the scene too (Humphrey & Underwood, 2011). In line with this, when bird and dog experts are asked to list features for birds and dogs, they list more specific features for stimuli in their domain of expertise (Tanaka & Taylor, 1991), suggesting more detailed conceptual representations.

Another line of research on the effects of expertise on language and cognition comes from verbal overshadowing. Verbal overshadowing is the purported phenomenon where describing a non-verbal stimulus, for example a smell or face, interferes with subsequent recognition memory (Fiore & Schooler, 2002; Schooler & Engstler-Schooler, 1990). It is hypothesized that the underlying memory representation is "overshadowed" by the less detailed linguistic representation, which affects subsequent recognition of the stimuli (Schooler, Ohlsson, & Brooks, 1993). Intriguingly, people with more detailed domain knowledge, i.e., experts, seem to be less susceptible to verbal overshadowing (Melcher & Schooler, 1996; Ryan & Schooler, 1998). This suggests experts' conceptual structure is reshaped by experience and expertise (Johnson & Mervis, 1997, 1998).

The few studies investigating expertise effects on language have primarily done so using stimuli from the auditory or visual domain, but rarely investigated smells. Smell is not very elaborated in language (Levinson & Majid, 2014), and studies suggest odors are difficult to name (Cain, 1979; Cain et al., 1998; Engen, 1987; for reviews see Olofsson & Gottfried, 2015; Yeshurun & Sobel, 2010). However, recent studies question the universality of this, showing some populations are more eloquent when it comes to smells (Burenhult & Majid, 2011; Levinson & Majid, 2014; Majid & Burenhult, 2014; O'Meara & Majid, 2016; Wnuk & Majid, 2014; and see Chapter 3). This research suggests both across cultures, and within sub-cultures, experience is important for how smells are talked about.

Wine experts—such as vinologists, sommeliers and wine journalists—are an interesting group to study in this regard. Wine experts work with wines on a daily basis, and communicate about the smell and flavor of wine in conversations amongst themselves—as well as with consumers—during wine tastings, and when writing tasting notes (Herdenstam, Hammarén, Ahlström, & Wiktorsson, 2009). Wines are often described following the same format: experts first describe appearance, followed by smell, flavor, and then mouthfeel of wines. Flavor is defined as the combination of taste, smell, trigeminal activation and tactile sensation in the mouth (Auvray & Spence, 2008; Smith, 2012; Spence, 2015b), with olfaction playing the major role in the experience of flavor (Spence, 2015a). Taken together, this shows olfaction is critical in wine expertise (Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013).

Even though language features heavily in their expertise, wine experts lack specific words that apply to their domain of expertise. In the words of wine journalist Malcolm Gluck:

> *"We wine writers are the worst qualified of critical experts. This is largely, though not exclusively, because we are the most poorly equipped. The most important tool at our disposal is inadequate for the job. That tool is the English language" (Gluck, 2003, p. 107).*

Moreover, scholars have suggested wine reviews are useless for informing readers about the flavor of wines, suggesting these reviews are uninformative prose. For example, Quandt (2007, p. 135) claims: "the wine trade is intrinsically bullshit-prone and therefore attracts bullshit artists". Similarly, Shesgreen (2003, p. 1) states wines reviews are: "mystifying babble used by writers whose prose is deeply disconnected from the beverage they pretend to describe" (Shesgreen, 2003). Finally, Silverstein (2006) suggested that just as much as *wine-talk* describes a wine, wine-talk says just as much about the speaker, namely it displays how much the expert knows about wine. In line with this critique, in an experimental study conducted by Lawless (1984), descriptions written by wine experts were found to be highly idiosyncratic, with the majority of terms used only once by one expert (Lawless, 1984, p. 122). This raises the question of what the effect of expertise is on describing smells and flavors. Do wine experts use the language at their disposal in an informative way? Do they use words in a conventionalized manner?

When wine experts talk about wines, they convey the smell and flavor of wine using various strategies. Consider the following review: "Dark and pruny, with molasses, chocolate and beet juice on the nose. Semisweet raspberry and strawberry flavors set up a racy finish that carries live acidity and some serious tannins"[4]. The wine, made from *syrah* grapes harvested in the Maipo Valley in Chile, is described by referring to various fruits, foods, and spices e.g. *"chocolate"* and *"raspberry"*. The review ends with a description of the final impression that the wine leaves, i.e., the finish *"racy finish"*, (after)taste *"acidity"*

[4] This review was retrieved from http://www.winemag.com/ratings/, accessed 14-06-2017

and tannin content *"some serious tannins"*. Chapter 3 in this volume suggests wine experts use more source descriptions e.g. *"red fruit"*, *"vanilla"* for describing smells and tastes than novices, whereas novices use more evaluative terms e.g. *"disgusting"*, *"beautiful"*. Experts were also found to use more specific, concrete words than novices to describe wines (e.g., they would say "blackberry" instead of "sour"; H. T. Lawless, 1984; Solomon, 1990). Other studies suggest experts use more words for particular aspects of wines, such as grape type and terroir, than novices (Parr, Mouret, Blackmore, Pelquest-Hunt, & Urdapilleta, 2011). In addition to frequent use of source terms, wine experts are said to employ metaphors in wine descriptions (Caballero & Suarez-Toste, 2010; Paradis & Eeg-Olofsson, 2013; Suarez-Toste, 2007). The use of metaphors suggests wine experts also aim to write lively prose, and that the words at their disposal are insufficient to capture the full wine experience. Gawel (1997) suggests wine reviews not only contain descriptions of the smell and flavor of a wine, but also how the wine affects the taster subjectively and emotionally.

To help budding wine enthusiasts to learn about wine, tools have been developed that display lists of words deemed helpful to describe wines. These words are often hierarchically ordered by their specificity and category—so-called "wine wheels" (Lehrer, 2009; Noble et al., 1984). These lists structure wine vocabulary, and can be useful for novices beginning to become acquainted with wine (Solomon, 1990). However, it is unknown whether these word lists in fact capture the wine vocabulary employed by wine experts in actual reviews. If this is not the case, learning to become an expert in wine language using these lists would not be effective at all.

Some first computational linguistics work suggests wine experts use informative vocabulary conditional to the wine they describe (Hendrickx, Lefever, Croijmans, Majid, & Van den Bosch, 2016). Hendrickx et al. (2016) used the text of a wine review to predict particular properties, which were captured in the metadata of a wine review, such as the color of the wine and the grape type. If the reviews would not differentiate between wines of different colors, predicting this property would not be possible based on the review alone. In contrast, the results suggested this is possible, suggesting wine reviews are informative for these properties. However, this study has some drawbacks, as the vocabulary used in the wine reviews was not analyzed, leading to the question of whether there is a core vocabulary of wine. Additionally, the corpus contained certain words, such as color-terms, that could have driven the found effects instead of the actual wine descriptions. For example, the classification experiment might have based its judgment on the words *red*, *white* and *rosé* occurring in the reviews, which would yield a trivial result on those reviews. Finally, it did not control for the different authors in the corpus. The corpus used contained reviews from several authors, but not an equal amount of reviews from each author. In fact, the authors who wrote most reviews wrote almost 20 times as many reviews as the authors who wrote the least amount of reviews. This means that when that single author was consistent in their description but not any of the other authors, their reviews may have driven the found effect, leaving the question whether authors are consistent as a group unanswered.

When authors differ in style, their authorship can be predicted from their text. In the text mining literature, authorship attribution of texts has been successfully conducted for a number of years (e.g. Juola, 2006; Kestemont, Daelemans, & Sandra, 2012; Kestemont, Luyckx, Daelemans, & Crombez, 2012; Zheng, Li, Chen, & Huang, 2006). Authors display different rates of function words, word lengths, sentence length, number of syllables, and type to token ratio. These features are relatively immune to conscious control (Holmes, 1994), and are reliable predictors of author style, even in relatively short texts (Luyckx & Daelemans, 2011). In wine reviews, writing style may also differ between authors. Brochet and Dubourdieu (2001) distinguished several different writing styles both in French and English wine experts. Wine experts have been found to differ in their use of lexical and syntactic features, and in their use of technical and hedonic descriptors in their wine descriptions (Parr et al., 2011; Sauvageot, Urdapilleta, & Peyron, 2006). These studies suggest noteworthy differences between authors. Nevertheless, there may be a common vocabulary that can be found across wine descriptions written by different authors. This would suggest wine experts successfully provide informative flavor descriptions of wine, while maintaining individuality of style.

The current study investigates the influence of the expert's personal style in predicting the information content of wine reviews. Three questions are addressed. First, are experts' reviews of wines informative, even though they use creative, personal style in their writings? Second, what domain-specific vocabulary do wine experts use in their reviews, and can this vocabulary be compared to previously assembled wine vocabulary lists, such as the wine wheel (Noble et al., 1984)? And last, are wine experts consistent with each other in their use of this vocabulary?

To test whether reviews are informative (i.e., not *bullshit*; cf. Quandt, 2007), an automatic classifier was trained using reviews of one group of authors, and then used to subsequently predict properties of new wine reviews written by a different author. Previously, Hendrickx and colleagues (2016) successfully predicted wine properties, such as color, grape type and origin, from wine reviews alone. The current study seeks to replicate these results with a more refined and better controlled analysis. In the current analyses, color words were removed from the reviews before the classification analysis was performed. In addition, in contrast to the previous study, author differences were taken into the analysis by using a *13-fold leave-one-author-out* approach.

To answer the second and third questions, a *Termhood* analysis was conducted on the corpus of wine reviews, separately for each of the 13 different authors. Termhood expresses how specialized a term is in a specific corpus compared to standard language use, and has been used successfully to uncover domain-specific language, for example in medicine (Bontas, Schlangen, & Niepage, 2005; Kit & Liu, 2008). In this case, Termhood gives an indication of what words are often used by each author to describe wine, compared to a standard corpus of English. These words were then compared to previously established word lists of wine vocabulary (Lehrer, 2009; Lenoir, 2011; Noble et al., 1984; Parker, 2017), to see differences in what words experts actually use in their reviews, and what these lists portray as wine vocabulary. Additionally, the words ranked on Termhood were analyzed using Principal Component Analysis (PCA). If authors have different vocabularies, and are not consistent in their use of domain-specific language, the PCA would suggest a multidimensional solution. If, on the other hand, experts are consistent and have a shared, domain-specific vocabulary, the PCA solution would display low dimensionality. But first, can wine properties be predicted from wine reviews, and what is the influence of author style?

2.3 PREDICTING WINE PROPERTIES AND AUTHOR DIFFERENCES

2.3.1 METHODS

2.3.1.1 Corpus description

A corpus of wine reviews was collected from the internet[5]. The wine catalogue data contains structured information about each wine, i.e., price, designation, varietal, appellation region, producer, alcohol content, production size, bottle size, category, importer, and when it was reviewed. In addition, each entry also contained an expert rating, with scores (on a scale from 80 to 100), and a review describing the wine (using 40 words on average). We gathered a total of 76,000 wine reviews. As prediction scores are affected by the amount of data used as input, only authors who had reviewed more than 1,000 wines were considered, so as to get reliable prediction scores for all 13 authors. The contributions of these wine experts were still not evenly distributed with some authors producing around 1,000-2,000 reviews, while Author 1 wrote about 19,000 reviews, i.e., 26% of all the reviews in the corpus. Altogether, we compiled a database of 73,329 reviews for these 13 authors.

2.3.1.2 Classification analysis

To create the training and test data for the machine learning experiments, the review texts were first automatically pre-processed by means of the Stanford toolkit (Manning et al., 2014) which added linguistic information to the texts, as described below. This linguistic information was then used to reduce the review to a vector of so called *content words*. The Stanford toolkit performed the following pre-processing steps:

1 Tokenization: splitting the review text into tokens (i.e., words, punctuation marks, numbers, etc.)

[5] The reviews were collected from the website http://www.winemag.com

2 Part-of-Speech tagging: assigning a grammatical category to all tokens (e.g., noun, adjective, verb, adverb, etc.)

3 Lemmatization: providing the lemma (basic form) for all tokens (nouns: singular form, adjectives: masculine singular form, verbs: infinitive form)

As an example, Table 2.1 shows the output of the linguistic pre-processing step for the review sentence *The wine has an easy approach*. The first column contains the token, the second column the lemma, and the third the Part-of-Speech category per token. The vectors used in the experiments contain lemma forms of those terms with the grammatical labels noun, verb, adjective and adverb. For this example sentence the terms 'wine', 'easy' and 'approach' were kept.

input	lemma	grammatical category	kept for classification analysis
The	the	determiner	-
wine	wine	noun	wine
has	have	auxiliary verb	-
an	a	determiner	-
easy	easy	adjective	easy
approach	approach	noun	approach
.	.	.	-

Table 2.1 Example of the output of linguistic pre-processing for the classification analysis

At the same time, we determined a number of categories for each classification experiment were planned to conduct, based on the metadata available for each review. For the category color, three categories were distinguished: red, white and rosé. Wine reviews with the metadata color 'unknown' (n = 5,105) were excluded. The following words were removed from the wine reviews so the classification could not be based on these terms alone: *red, reds, white, whites, rosè, rosé, rose*.

For grape variety, only wines produced from a single grape were considered, and blends were excluded. Different names used for the same grape in the metadata were normalized for the classifier, (but not in the wine reviews), e.g., 'pinot gris' and 'pinot grigio' were normalized into 'pinot gris'. Only those grape labels for which there were at least 200 reviews were included. This resulted in the following 31 categories: *aglianico italian red, albarino, barbera, cabernet franc, cabernet sauvignon, carmenère, chardonnay, chenin blanc, gamay, glera, grenache, gruner veltliner, malbec, merlot, muscat, nebbiolo, nero d'avola italian red, petite sirah, pinot blanc, pinot gris, pinot noir, riesling, sangiovese, sauvignon blanc, syrah, tempranillo, torrontes, traminer, viognier* and *zinfandel*.

The wines in the database originated from 47 different countries and over 1,400 different regions. We investigated the classification of origin using a coarse distinction, namely old versus new world (Banks & Overton, 2010; Remaud & Couderc, 2006). This distinction is based on the difference in tradition that exists in different wine producing countries. Broadly speaking, old world wines (e.g., France, Germany, Spain and Italy) are made according to tradition ("tradition driven"). By keeping to traditional methods and *terroir* standards, producers aim to make a high quality product that can age well, and is valued by experts, connoisseurs and collectors. In contrast, new world wines (e.g., USA, New Zealand and Australia) are made with the latest production methods, and producers aim to make a good product in reasonable volumes that is valued by diverse consumer markets ("consumer driven"). Countries were assigned onto the new world and old world category, and reviews from countries for which the status was ambiguous were excluded. An example of this ambiguity was Eastern European countries. In these countries, innovation and capacity of wine production suffered from communism and/or civil wars, but the countries are not traditionally seen as old world wine countries. Another example is Israel, where wine production has a millennia old tradition, but the contemporary wine industry is relatively small and modern. A list of countries that were included and excluded can be found in Table 2.2.

"New world" class	"Old world" class	Excluded because of unclear status
Argentina, Brazil, Canada, Chile, China, Mexico, New Zealand, Peru, South Afrika, South Korea, USA, Uruguay	Austria, France, Germany, Greece, Italy, Luxembourg, Montenegro, Portugal, Spain, Switzerland	Bosnia Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Egypt, Georgia, Hungary, India, Israel, Japan, Lebanon, Lithuania, Macedonia, Moldova, Morocco, Romania, Serbia, Slovakia, Slovenia, Tunisia, Turkey, Ukraine

Table 2.2 List of countries categorized as "new world", "old world", or that were excluded because of their unclear status.

The machine learning classifier used in this study was Support Vector Machines (SVM) which performs particularly well on text classification tasks (Joachims, 2002). The implementation LIBSVM of SVM was used with an RBF kernel, and the parameter settings were tuned on a small sample of the training set to fit to the data (Chang & Lin, 2011).

To recap, the corpus contained reviews by 13 different wine experts. Per classification task (color, grape variety, origin), we performed 13 leave-one-author-out iterations, meaning that we created a training sample containing all reviews for 12 authors and tested the classifier on the reviews of the remaining author, and repeated this setup 13 times. We report statistics for individual authors, and compute both micro and macro-average accuracy across authors. To calculate macro average, we first computed the average accuracy score per author, then summed these averages and divided by the number of authors. In this calculation, each author was counted equally whether they had written 15,000 reviews or only 1,000. To calculate the micro-average, the accuracy per review was used and divided by the total number of reviews. To establish whether certain class labels were easier or harder to predict, precision, recall and f-score are calculated (Van Rijsbergen, 1979).

Precision was defined as follows:

$$Precision = \frac{\text{Number of correctly predicted labels}}{\text{Total number of predicted labels}}$$

Recall is defined as follows:

$$Recall = \frac{\text{Number of correctly predicted labels}}{\text{Number of gold standard labels}}$$

Finally, f-scores were calculated as follows:

$$F = \frac{2\ (Precision*Recall)}{Precision+Recall}$$

To be able to estimate the predictive value of a classifier, F-score values were compared to baseline values. These baseline values were based on the F-scores of the most frequent category in that task (i.e., color, grape variety, and origin), i.e., the majority baseline. For example, in the color classification task, the category *red* was most frequent, with a frequency of 65.8%, meaning that if the classifier would categorize each review as 'red', it would achieve an F-score of 65.8%. Achieving this or a lower F-score would show the reviews are not informative, as the classifier did not predict the other categories correctly. Similar baselines were used for the other tasks (i.e., grape variety, and origin).

2.3.2 RESULTS

Are wine reviews informative, even though wine experts employ their own personal style when writing reviews? Here, the results of predicting color/grape/origin on average in our 13-fold leave-one-author-out experiments are discussed. Table 2.3 shows the average accuracy over all authors (macro-average) and all reviews (micro-average) for the three different properties, i.e., color, variety and new/old world, compared to their respective baselines.

Property	Number of reviews	Micro average accuracy	Macro averaged accuracy	Baseline
Color	68224	95.5	96.0	65.8
Grape type	48760	57.4	58.8	14.0
Old/New world	72925	62.0	66.3	56.0

Table 2.3. The average accuracy on each of the three different classification analyses predicting wine properties, averaged over the 13 authors.

Predicting the color of the wine solely on the content words of the description turns out to be a task that can be easily learned by the classifier as very high accuracies were achieved. Similar to the previous study by Hendrickx et al. (2016), the leave-one-out experiments revealed the classifier could predict the color of red and white wines very well, even when the training set was composed of reviews by different authors than the test data (see Table 2.4). The results were different for rosé, for which the classifier only predicted class above the baseline F-score (65.8) for one author (Author 8). This could be because the training set was simply too small to sufficiently train the classifier for rosé.

Predicting grape type was a more difficult task, as the classifier has to choose one label from 31 possible candidates. A random classifier would, on average, score not higher than 3% accuracy, and the majority baseline classifier that always predicts the most frequent class label (i.e., chardonnay), which we used as our reference baseline, would not get higher than 14% accuracy. The classifier in fact performed well above this baseline, for all authors (see Table 2.5). The lowest score in this respect is Author 3, which, with an F-score of 35, is still well above the baseline value of 14. This suggests two things: First, the classifier could reliably predict the type of grape from in a specific review, and thus reviews are informative with respect to grape variety. Second, as the prediction was done on reviews of a different author than what the model was trained on, the different authors are consistent when describing wines from the same variety.

	Class: red		Class: white		Class: rosé		
Author	Number of reviews	F-scores	Number of reviews	F-scores	Number of reviews	F-scores	Average F-score
Author 1	13050	98.1	5364	96.9	302	44.0	97.1
Author 2	5569	92.3	4108	90.7	455	26.1	90.0
Author 3	6882	97.9	2261	94.8	231	33.9	96.0
Author 4	5287	97.2	2098	94.8	157	53.3	95.7
Author 5	4127	97.1	1648	93.9	61	46.6	95.7
Author 6	2831	96.6	2403	97.0	189	41.3	95.5
Author 7	2578	98.3	1011	95.9	39	39.3	97.2
Author 8	1147	99.5	476	99.3	14	78.6	99.3
Author 9	1042	98.3	400	97.8	44	60.6	97.3
Author10	828	97.1	395	95.7	23	35.7	96.0
Author11	345	94.8	754	98.5	42	50.0	96.1
Author12	621	97.5	412	96.8	33	58.3	96.3
Author13	572	97.0	353	98.5	72	63.0	95.7
Total	**44879**	**97.0**	**21683**	**95.2**	**1662**	**41.4**	**96.0**

Table 2.4 **The number of reviews and F-scores for each author for the different color classes and their weighted average. This average is weighed by the number of reviews for each author.**

Finally turning to the old/new world classifier, the results were compared to a majority baseline that would predict the most frequent label, i.e., *new world*, in 56% of the cases (i.e., an F-score of 56.0). The results showed a micro average accuracy of 62% which is just 6% above the majority baseline (Table 2.6). When interpreting this low accuracy it is important to look at the different authors. The results revealed a strong specialization by many authors for wines from a particular part of the world. For example, author 4 and 8 only reviewed wines in the old world class, while author 9 only reviewed wines in the new world class. When taking these differences into account, some authors distinguished the wines in their reviews better regarding their origin than others. Still, the overall low prediction accuracy relative to baseline (i.e., F-score = 56.0%) is surprising, and suggests authors do not describe new world wines distinctly from old world wines.

Author	Number of reviews	F-score
Author 1	16268	69.1
Author 2	4796	42.0
Author 3	6457	35.0
Author 4	4547	45.6
Author 5	4661	60.3
Author 6	4015	64.8
Author 7	3010	53.9
Author 8	759	49.1
Author 9	1193	77.0
Author10	896	56.4
Author11	986	79.0
Author12	618	70.6
Author13	554	61.2
total	**48760**	**57.4**

Table 2.5 The number of reviews and results for each author for the grape variety review classification experiment. Grape variety classes (n = 31) are averaged to obtain these F-scores

Overall, these results show it is possible to predict the different color and grape type of wine from the review alone, even when the classifier is trained using data written by different authors than what is used as test data. This suggests experts describe wines with different colors and made from different grape types in a predictable manner, and thus are consistent with other experts. In addition, it suggests reviews are informative with respect to color and grape type. The different writing styles observed in reviews written by wine experts do not seem to negatively influence how informative and consistent these reviews are written. Next, we turn to the vocabulary wine experts use to describe wines. In addition, this vocabulary is compared to lists of words previously composed by wine experts to aid in describing wine, e.g., the wine-wheel (Noble et al., 1984).

	New world class		*Old world* class			
Author	Number of reviews	F-scores	Number of reviews	F-scores	Number of reviews	Baseline F-score
Author 1	19266	86.7	90	2.0	76.6	
Author 2	65	1.3	11879	31.0	18.8	
Author 3	5428	69.2	4408	44.3	60.3	
Author 4	0	0.0	8622	77.9	63.8	
Author 5	5877	88.8	87	6.7	79.9	
Author 6	3075	71.4	2695	47.1	62.9	
Author 7	2306	77.8	1456	60.9	71.7	
Author 8	0	0.0	1770	90.1	81.9	
Author 9	1548	89.7	0	0.0	81.3	
Author10	1190	85.8	87	21.9	76.0	
Author11	844	72.1	301	41.0	62.1	
Author12	794	73.1	260	43.7	63.6	
Author13	450	64.1	427	62.5	63.3	
Total	**40843**	**69.8**	**32082**	**48.7**	**62.0**	**56.0**

Table 2.6 Results per author for the new/old world class prediction. The average is weighted by the number of reviews The baseline was the same for all authors, as this was based on the most frequent category in the entire corpus.

2.4 THE VOCABULARY OF WINE EXPERTS

2.4.1 METHODS

To answer the questions posed above, Termhood was calculated using *TExSIS* (Terminology Extraction for Semantic Interoperability and Standardization; Macken, Lefever, &

Hoste, 2013). TExSIS is a hybrid terminology extraction pipeline that combines linguistic and statistical information to extract domain-specific terms, i.e., n-grams, from a text corpus. As explained earlier, "Termhood" expresses how much more frequent a word or n-gram is in a domain-specific corpus compared to a corpus of general English. The higher the Termhood value of a specific word is, the more specialized it is in comparison to its use in standard language. This analysis was conducted on the reviews from each individual author, on the corpus of wine reviews introduced in Study 2.3. In the first step of the analysis, a list of candidate terms was generated from the corpus of wine reviews by using part-of-speech pattern selection (i.e., noun-noun, adjective-noun, or verbs were included; other words were excluded). Second, this list of candidate terms was pruned by means of statistical filters. In the statistical filter applied here, the frequency of the candidate term was equated to the frequency of that term in a background corpus: the Web 1T 5-gram v1 corpus. This corpus, contributed by Google Inc., contains approximately one trillion word tokens from publicly accessible web pages (Brants, Thorsten, & Alex Franz, 2006).

The 1,000 n-grams ranked highest by Termhood values for each author were compiled into one list of 13,000 words, and Termhood values were added for each author, resulting in a 13,000 term by 13 author matrix. As using 1,000 words for each author gives greater opportunity for the lists of most frequent domain-specific terms to overlap, this might inflate the rate of agreement. To overcome this issue, the same analysis was also performed with the first 100 n-grams ranked by Termhood values for each author, resulting in a list of 1,300 terms. Most n-grams in this list were single words, but some bigrams also occurred (e.g. *green apple, dried fruit*). In the remainder of this chapter, *terms* can be read meaning n-gram or single word. This author by term matrix was subsequently used as input for Principal Components Analysis (PCA). PCA was carried out using R (R Core Team, 2016) packages FactoMineR (Lê, Josse, & Husson, 2008) and factoextra (Kassambara & Mundt, 2017). If authors are inconsistent in their descriptions of wines, the different Termhood lists would be different per author, and the PCA would produce a highly dimensional solution. But if authors are consistent with their expert peers, Termhood values are expected to be similar, resulting in a low dimensional solution.

2.4.2 RESULTS

2.4.2.1 Domain-specific wine vocabulary

Duplicates were removed from the list of 13,000 words, leaving 7,853 unique terms. This means a total of 5,147 terms were present in at least two top 1,000 words ranked by Termhood across all authors. Only 2,706 terms occurred in reviews from a single author. This means there was approximately 79.2% overlap (i.e., occurred in lists from at least 2 authors) in the terms used much more frequently in this corpus than in the reference corpus, i.e., are domain-specific for wine. For each author, Termhood values for each of these 7,853 terms were added to a matrix.

A scaled dual factor PCA (i.e., over authors and terms) showed the data could be explained adequately with two factors. The scree plot supported retaining a two factor solution, but the eigenvalues suggested the first factor was sufficient (eigenvalues: factor 1 = 6.51; factor 2 = 0.91; factor 3 = 0.80). To ease interpretation, the first two factors were retained. The first dimension explained 48.5% of the variance, and the second dimension 7.0%. All authors loaded positively on the first dimension (see Figure 2.1). Looking at the term loadings, the first dimension may be interpreted as distinguishing more general terms (e.g., *flavors, aroma, palate*), from more specific terms (e.g. *spice, vanilla, plum, lemon*). Authors seemed to be distinguished on the second dimension; with Author 8 and Author 5 being most distinct (see Figure 2.1). The second dimension also differentiated aroma terms from flavor terms; e.g., terms like *plum*, and *spice* loaded positively towards aromas, whereas words like *acidity* and *tannic* loaded negatively towards flavors.

The solution was highly unidimensional, and all authors loaded positively on the first dimension. This finding suggests high consistency between authors in their use of the different terms. The authors nevertheless differed somewhat on the second dimension, suggesting some differences in the use of aroma versus flavor terms.

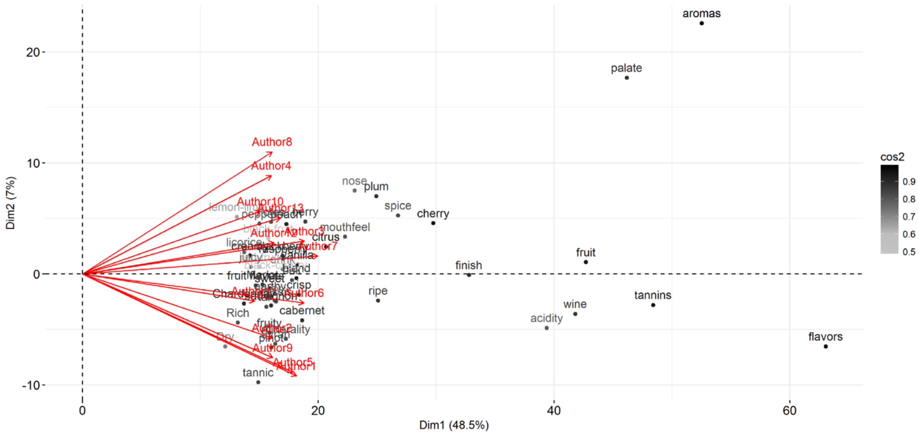


Figure 2.1 Biplot of the (scaled) principal components of the PCA analysis that was conducted on the Termhood weighted wordlists (n = 1000) for each author. Terms are shown as cases, grey-scaled by their relative contribution towards the solution (*cos*2 weighed; Abdi & Williams, 2010), and authors are shown in red. Red vectors indicate the relative correlation between the resapective author and both dimensions. To ease interpretation, only the 50 most influential terms in the solution are plotted in this graph.

The same analysis was repeated with the first 100 terms that ranked highest on Termhood for each author, leading to 1,300 terms across authors. There were 573 unique terms, with 74 terms used only by one author, meaning 96.4% of the terms were used by at least 2 authors. Conversely, 146 terms were used by all authors. So, one could conclude there are 146 terms that are used distinctly, i.e., compared to the use of those terms in Standard English, and conventionally, i.e., used by all authors, for wines.

The results of this second PCA were similar to the first. The eigenvalues (eigenvalues: factor 1 = 6.57; factor 2 = 1.05; factor 3 = 0.85) and screeplot suggested a two factorial solution. The first dimension explained 50.5% of the data, and the second dimension 8.0% (see Figure 2.2). Authors all loaded positively and with comparable influence on the first dimension (shown by the red vectors in Figure 2.2). Inspection of term loadings showed the first dimension ranged roughly from specific words (*peach, crisp, vanilla, pinot noir*) to more general words (*flavors, fruit, palate, aromas*). The second dimension was reversed with respect to the first PCA analysis, i.e., ranged from *flavors* to *aromas*, but as the scale of PCA factors is arbitrarily determined, is comparable to the first analysis. The authors showed some dispersion on this second dimension, with positive loadings for Author 1 to negative loadings for Author 8, on the extremes. The term loadings showed that, similar to the first PCA analysis, the second dimension ranged from flavors (e.g. *tannic, acidity, soft, tannins*) to aromas (*cherry, peach, plum, palate*).

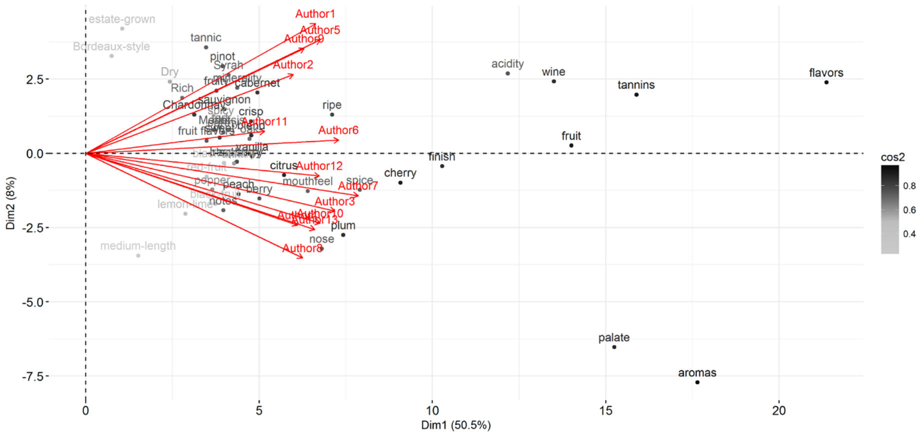


Figure 2.2 Biplot of the (scaled) principal components of the PCA analysis that was conducted on the Termhood weighed wordlists (*n* = 100) for each author. Terms are shown as cases, colored by their relative contribution towards the solution (*cos2* weighed; Abdi & Williams, 2010), and authors are shown in red. Red vectors indicate the relative correlation between the respective author and both dimensions. To ease interpretation, only the 50 most influential terms in the solution are plotted in this graph.

To summarize, the two PCA analyses indicate the same conclusion: authors are generally consistent with each other in their descriptions, and these descriptions can be explained using a low-dimensional space. The first dimension of the PCA solution revealed the consensus between authors, and can be interpreted as representing the use of specific to general terms. The second dimension, however, showed some dispersion in the wine-specific vocabulary authors used. However, the variance explained by this dimension was very low in both analyses. Terms used to indicate flavors, including aspects such as taste, or broader concepts such as grape types loaded positively on the second dimension, while source terms referring to aromas such as *plum* loaded negatively on this dimension. This suggests that while authors are remarkably consistent overall, authors differed in their strategy to describe wines by either taking a more "flavor driven approach", for example Author 1 and Author 5, versus a more "aroma driven approach", exemplified by Author 8.

2.4.2.2 Comparison of wine vocabulary

The previous analyses show wine reviews are informative and wine experts write consistently in these reviews. In addition, reviews contain domain-specific vocabulary that is not frequently found in Standard English. But what is this vocabulary of wine, and how does it compare to other, established lists of wine vocabulary?

Previously, scholars have compiled lists of wine vocabulary. Notably, Lehrer (2009) describes three wine wheels, i.e., the aroma wheel (Noble et al., 1984, 1987), the sparkling wine wheel (Noble & Howe, 1990), and the mouthfeel terminology wheel (Gawel, Oberholster, & Francis, 2000). As introduced before, a wine wheel is a list of terms that can be used to describe a wine, organized by specificity: the most general terms are listed on the middle tier, and more specific words are listed on the outer tiers (see Figure 2.3 for an example). For the present analysis, the words on these three wine wheels were compiled into a single list of 244 unique terms. In addition, the Termhood list was compared to two other vocabulary lists, i.e., Robert Parkers' glossary of 117 wine terms (Parker, 2017), and the 61 references used in the Le Nez du Vin wine aroma kit[6] (Lenoir, 2011). These existing lists of wine vocabulary were compared to the domain-specific vocabulary that was found in the current corpus of wine reviews. To this end, the 146 terms that ranked highest on Termhood and that were used by all authors were compared to previously constructed wine word lists.

[6] The le Nez du Vin *Masterkit* contains 54 labelled smells. These were supplemented with the 12 reference terms from the *New Oak* kit. After removal of duplicate terms that occurred in both kits, 61 terms remained.

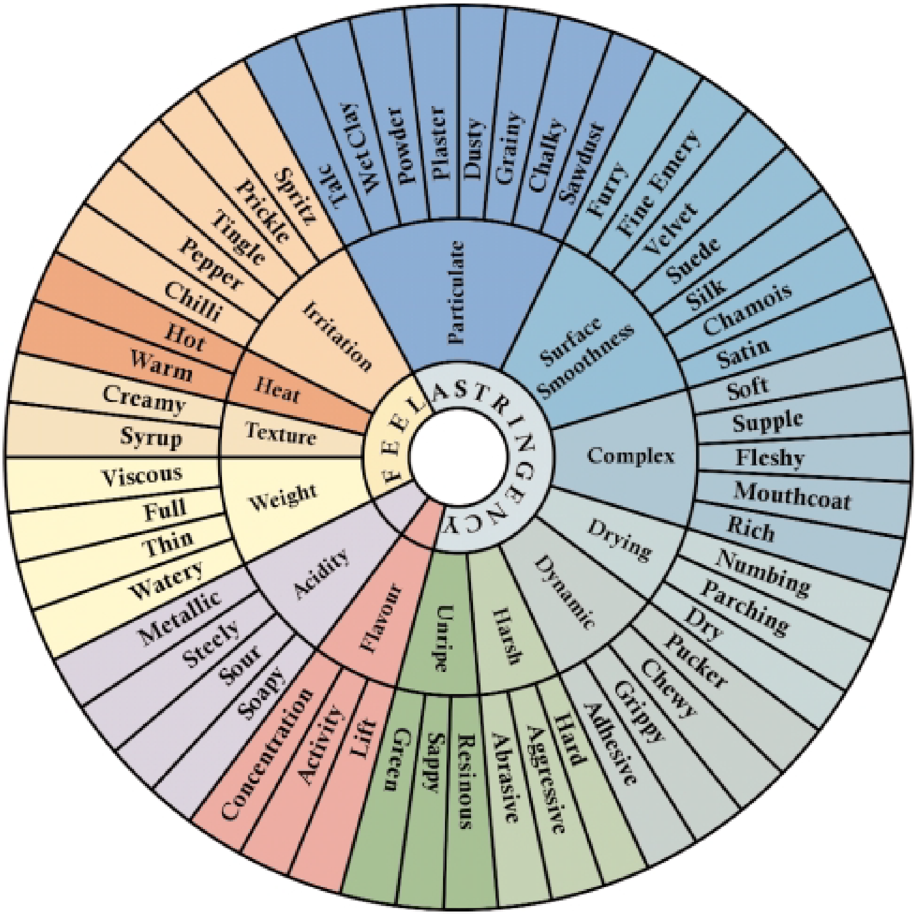


Figure 2.3 the mouthfeel terminology wheel showing a hierarchical representation of terms that can be used to describe the mouthfeel of red wine

The terms in each list were pre-processed. Spelling mistakes were taken out, and spelling variants were recoded into a single term (e.g., *black currant* and *blackcurrant* were standardized into *blackcurrant* across all lists). Some words had double entries, e.g., the singular *fruit* and plural *fruits*. Adverbial phrasings like *fruity* possibly apply to more, and different smells than *fruit*, so these were kept distinct, as was *cherry flavors*, which possibly covers more flavors than *cherry* alone. This pre-processing was kept to a minimum, for example, *drying* and *dry* were kept as unique entries.

The lists were compared to see how much overlap exists between the different word lists. This analysis shows which words uniquely appear in the Termhood list, indicating new and previously unestablished wine vocabulary. And the analysis shows which terms have lists in common, showing words that wine experts use frequently, but are also described before. The output of this analysis can be found in Table 2.7.

Terms occurring on the Termhood list and on 3 wine wheels (*n* = 34)	Terms occurring on the Termhood list and in Parker's glossary (*n* = 13)	Terms occurring on the Termhood list and in the Le Nez Du Vin references list (*n* = 21)
acidity; apple; apricot; berry; black pepper; blackberry; caramel; cherry; chocolate; cinnamon; citrus; cocoa; creamy; fruity; grapefruit; honey; lemon; lime; melon; menthol; oak; peach; pear; pepper; pineapple; prune; raspberry; spicy; strawberry; supple; texture; tobacco; tropical; fruit; vanilla	acidity; aroma; intensity; jammy; nose; peppery; ripe; spicy; supple; tart; toasty; tobacco; velvety	apple; apricot; blackberry; caramel; cherry; cinnamon; grapefruit; honey; leather; lemon; melon; oak; peach; pear; pepper; pineapple; prune; raspberry; strawberry; toast; vanilla

Table 2.7 Words occurring both in the Termhood highest ranked list as well as established wine vocabulary lists

Out of the 244 terms occurring on the list composed of the three wine wheels, thirty-four words also occurred on the Termhood list (i.e., 13.9%). Thirteen terms occurred both in Parker's glossary as well as on the Termhood list (i.e., 11.1%). Twenty-one terms occurred both on the Termhood list as well as the Le Nez du Vin reference list, which is almost 30% of the 61 terms on the Le Nez du Vin list. In total, there were 45 terms that occurred on any one of the three established lists of wine vocabulary and on the Termhood list. This suggests some overlap between the established wine vocabularies and the words used in wine reviews, but also that there are many words listed in wine vocabulary lists that are not frequently used in actual wine descriptions (at least in this corpus). One possibility is that the words not attested in the corpus of wine reviews denote very specific aromas and flavors, not commonly found in wines and thus not often used.

Of further interest are the terms that are unique on the Termhood list. These 89 terms are used very often in online wine reviews; in fact, they were used by all 13 authors, and all with much higher frequency than there are likely to occur in everyday English, but these terms are not included in reference word lists such as the Noble wine wheel and Parker's glossary. These were terms such as *black cherry*, *blueberry, cassis, cherries, cocoa, fruit, lime, mocha, red berry, red fruit, ripe fruit, smoke, spice, stone fruit, tannins, wood, zest*. Some of these words were adjectives, i.e., *bright, creamy, crisp, delicious, dense, firm, juicy, minty, racy, smooth, zesty*; while other terms picked out intensity or complexity, such as *accents, layers, hint, notes, plenty, richness, scents*. Others indicated location/modality in which the flavor is perceived their quality, i.e., *finish, midpalate, mouth, mouthfeel, palate, sweet, structure, touch*. These words may be beneficial for wine students to learn. The full list of these terms, as well as the full list of unique terms in the other wine wordlists, can be found in Appendix A.

This overview suggests there is a core vocabulary of words that is frequently used to descrbie wine, and that this vocabulary has overlap with previously established lists of wine vocabulary, which in turn suggests there is a conventionalized, core vocabulary for wines. However, it also shows there are terms wine experts often use to describe wines that are not found in previous wine vocabulary lists, which suggests there may be room for further improvement of pedagogical sources for budding wine enthusiasts.

Taken together, the results of these analyses show wine experts use a set of domain-specific words in a consistent manner, and that the reviews they write are informative, even though different authors can have a personal writing style.

2.5 DISCUSSION

Controversy surrounds wine expert descriptions of wine. On the one hand, tasting notes are criticized, and described as uninformative (e.g., Quandt, 2007; Shesgreen, 2003) and idiosyncratic (Lawless, 1987). On the other, experts have been found to display a level of detail in their descriptions not matched by novices (Gawel, 1997; Zucco et al., 2011), and describe wines more consistently (see Chapter 3). By training a computational algorithm on a set of reviews and testing the algorithm on reviews written by a different author, this study shows wine reviews are informative enough to predict properties of a wine; at least the color and grape variety. This further suggests that despite their individual style, wine experts are consistent with other experts. In addition, the results show wine experts use conventionalized language in a consistent manner, and the words found in this list overlaps with previously composed lists of wine vocabulary.

Previous studies have suggested smells are difficult to talk about (e.g., Yeshurun & Sobel, 2010), and even raised the possibility smells are ineffable in Western languages (Levinson & Majid, 2011). This study investigated whether smells and flavors of wines were codable for wine experts. Something is codable (cf. R.W. Brown & Lenneberg, 1954) when it is described concisely, consistently and has specific words in a language. The results of the current study suggest wine experts describe wines consistently. The current study examined this issue at a very large scale, by analyzing thousands of reviews. Using two different methods, a leave-one-author out classification analysis and a Termhood analysis combined with Principal Components Analysis, this study shows wine experts are consistent with other experts when describing wines. This suggests at least one of the criteria for codability, i.e., consistency, has been met.

Turning to another criterion for codability; i.e., the conventional use of a dedicated lexicon, wine experts were found to use a distinct set of words in their reviews. The Termhood analysis revealed 146 words that all wine experts used in a domain-specific way (i.e., compared to how these words are used in everyday English). This set of words showed some overlap with previously established lists of wine vocabulary, established by Noble and colleagues (1984; 1987), Parker (2017) and Lenoir (2017), and as described by Lehrer (2009). Additionally, the comparison revealed a list of words used by experts but not incorporated in these established "wine wheels". These words, ranging from basic taste vocabulary, modifiers, as well as specific and general source terms, suggest possible candidate words that may be incorporated into existing lists of wine vocabulary. This could help students studying wine and wine language in the process of becoming wine experts. Taken together, the results of the study suggests wine experts use a dedicated set of domain-specific words to describe the odors and flavors found in wine.

Why are smells and flavors describable for wine experts, whereas novices appear to struggle with this? Solomon (1997), when studying expert's descriptions and conceptual organization of wine knowledge, proposes that when novices become wine experts, they undergo a conceptual shift. Knowledge structures become more refined, and the conceptual categories become more specific (cf. Carey, 2009). Solomon (1997) further proposed that wine expert knowledge about wine is organized by grape type. Later studies have shown wine experts indeed consistently sort wines by grape type, while novices use other more haphazard strategies (Ballester et al., 2008; Solomon, 1997; Urdapilleta et al., 2011). The current study shows different experts describe wines made from different grape types consistently, which is further evidence for the hypothesis that the conceptual structure of wine knowledge is structured by grape type.

Nevertheless, wine is highly multidimensional, and its flavor is influenced by more than just grape variety. The color of wine affects how experts describe wines (Morrot, Brochet, & Dubourdieu, 2001; Parr, White, & Heatherbell, 2003), and color of a wine affects how sweet a wine is perceived to be (Pangborn, Berg, & Hansen, 1963). When experts do not taste wines blind, their perception and descriptions are influenced by what they see. The perception of flavor entails more than smell and taste, and is influenced by vision too (Auvray & Spence, 2008; Smith, 2012; Spence, 2015b). So it is interesting to note that in the current study the color of wine is consistently reflected in descriptions from experts, further underlining its importance.

We hypothesized wine experts would vary in their descriptions of wines from different regions. A recent study suggested terroir, i.e., the place where wine is made, has a bigger influence on the smell of a wine than grape type (Foroni et al., 2017). In the current study, we tried to predict the origin of a wine by examining whether reviews distinguished wine made in the old world or new world. This distinction is often made by wine experts (Remaud & Couderc, 2006), but received criticism too (Banks & Overton, 2010; Remaud & Couderc, 2006). Banks and Overton (2010) have argued that the wide availability of modern wine making techniques allow the winemaker to make a modern wine with characteristics of traditional old world wines. Conversely, old world wine makers may use the latest techniques to produce consumer driven flavor profiles in their wines (Banks & Overton, 2010; Cholette, Castaldi, & Fredrick, 2005; Remaud & Couderc, 2006). That the classification paradigm used in this study did not yield reliable results suggests the old/new world distinction is not consistently reflected in wine experts' descriptions, and further suggests experts might not think about wines along this dimension.

As with computational modelling studies in general, the quality of the output of this computational linguistics study is determined by the quality of the input, i.e., the corpus of wine reviews that was used. A strong feature of this corpus was that it contained many (i.e., 73,329) wine reviews, giving it sufficient power to detect how descriptions differ. However, the range of authors was limited, and future studies could try to achieve a wider range of authors, possibly including wine descriptions from different websites. One interesting angle would be to include reviews written in different countries. Do some languages allow finer distinctions to be made in the descriptions, for example in French? And is there a difference in descriptions from authors from wine producing (e.g., USA, Australia), versus wine consuming countries (e.g., UK)?

This study shows wine experts can consistently and informatively describe wines. Wine consumers benefit from information about a certain wine, as this can inform their purchases (Cardebat & Livat, 2016; Oczkowski & Doucouliagos, 2015). The current results show wine experts describe wines informatively and consistently in their reviews, even though they may use a personal style. In addition, the results revealed wine experts use a domain-specific vocabulary for wine, consisting of some 145 words. Odors and flavors are difficult to describe, but there is room to improve on this skill. The word lists published in this chapter can be used to further restructure and polish wine vocabulary used by wine students. With sufficient expertise, wine writers can successfully provide informative descriptions of the smell and flavor of wine.

3

NOT ALL FLAVOR EXPERTISE IS EQUAL: THE LANGUAGE OF WINE AND COFFEE EXPERTS[7]

3.1 ABSTRACT

People in Western cultures are poor at naming smells and flavors. However, for wine and coffee experts, describing smells and flavors is part of their daily routine. So are experts better than lay people at conveying smells and flavors in language? If smells and flavors are more easily linguistically expressed by experts, or more "codable", then experts should be better than novices at describing smells and flavors. If experts are indeed better, we can also ask how general this advantage is: do experts show higher codability only for smells and flavors they are expert in (i.e., wine experts for wine and coffee experts for coffee) or is their linguistic dexterity more general? To address these questions, wine experts, coffee experts, and novices were asked to describe the smell and flavor of wines, coffees, everyday odors, and basic tastes. The resulting descriptions were compared on a number of measures. We found expertise endows a modest advantage in smell and flavor naming. Wine experts showed more consistency in how they described wine smells and flavors than coffee experts, and novices; but coffee experts were not more consistent for coffee descriptions. Neither expert group was any more accurate at identifying everyday smells or tastes. Interestingly, both wine and coffee experts tended to use more source-based terms (e.g., *vanilla*) in descriptions of their own area of expertise whereas novices tended to use more evaluative terms (e.g., *nice*). However, the overall linguistic strategies for both groups were en par. To conclude, experts only have a limited, domain-specific advantage when communicating about smells and flavors. The ability to communicate about smells and flavors is a matter not only of perceptual training, but specific linguistic training too.

3.2 INTRODUCTION

Wine, coffee, cheese, and chocolate would all taste bland without the sense of smell. Even though smells are omnipresent in our daily lives, people struggle with odor and flavor naming (i.e., the multisensory experience in the mouth including gustatory, olfactory, and somatosensory sensations; Small & Prescott, 2005; Spence, 2015). If asked to name everyday odors, like peanut butter, cinnamon or strawberry, most people can only name

[7] This chapter is based on: Croijmans, I., & Majid, A. (2016). Not all flavor expertise is equal: The language of wine and coffee experts. *PLoS One*, 11(6), e0155845

half of them correctly (Cain, 1979; Engen, 1987; Olofsson & Gottfried, 2015; Yeshurun & Sobel, 2010).

At the same time, there is a lucrative industry around language and flavor. Influential wine experts have considerable impact on the price and sales of a wine just through their reviews (Horverak, 2009). This is an interesting state of affairs, as some wine authors themselves acknowledge the limits of language when describing smells and flavors (Gluck, 2003; Quandt, 2007; Weil, 2007).

English, like other Western languages, appears to have a restricted vocabulary for smells and tastes (Myers, 1904; Sperber, 1975). A simple comparison of the brute number of terms for the senses leaves smell and taste at the bottom of the hierarchy (Levinson & Majid, 2014; San Roque et al., 2015) . When English speakers do try to name smells and flavors they overwhelmingly rely on source-descriptions (e.g., *it smells like a banana; it tastes like chicken*) or metaphors (e.g., *it smells green; it tastes wicked*). Furthermore, English speakers show low accuracy, consistency and agreement in how they describe smells and flavors (e.g., Cain, de Wijk, Lulejian, Schiet, & See, 1998; Lawless & Engen, 1977; McAuliffe & Meiselman, 1974; O'Mahony, Goldenberg, Stedmon, & Alford, 1979; O'Mahony & Ishii, 1986).

Recently the universality of these findings has been questioned (Burenhult & Majid, 2011; Majid, 2015) For example, Jahai (Burenhult & Majid, 2011; Majid & Burenhult, 2014) and Maniq (Wnuk & Majid, 2014), two Aslian languages spoken in the Malay Peninsula by hunting-gathering communities, have dedicated vocabulary for smells. The smell of different perfumes, flowers, durian and bearcat (*Arctitis binturong*) is described by the Jahai as *ltpit*, whereas Maniq might describe the smell of some food (e.g., tubers), bearcat, clean clothes, and some trees with *lspəs* (Burenhult & Majid, 2011; Wnuk & Majid, 2014). Majid and Burenhult (2014) also found Jahai speakers name odors as easily as colors, unlike English speakers who struggled to name the same odors. This raises the possibility that the difficulty people have in naming smells and flavors could be a WEIRD (Western, Educated, Industrialized, Rich, Democratic; Henrich, Heine, & Norenzayan, 2010) affair.

Odors play an important role in Jahai daily life. This is reflected not only in language, but in various aspects of Jahai culture, such as religion and medicine (Burenhult & Majid, 2011). According to the Jahai, some types of illness are cured by healing magic involving fragrant smells from plants and burnt resins, for example. Similarly, personal names are often drawn from the names of fragrant plants and flowers. For the Jahai, a cultural preoccupation with odors, therefore, aligns with their dexterity in talking about smells.

In the West, naming odors and flavors is also important for some people. Like perfumers, wine experts have years of training and experience in appreciating and describing odors, as well as flavors (Herdenstam et al., 2009). This is illustrated by "tastings", during which experts describe and discuss wines, and compare notes. So wine experts can be considered to be part of a distinct sub-culture with its own communicative practices and rituals around smells and flavors (cf. Silverstein, 2004). Considering the significance of flavor in their occupation, then, are wine experts, or other flavor experts, better at describing smells and flavors than novices? And, if so, what linguistic strategies do they use? The previous literature shows no general agreement on these matters, as described below.

3.2.1 THE LANGUAGE OF WINE EXPERTS

Wine is a complex entity, with as many as 800 different aromatic volatiles that together create a high dimensional flavor experience (Ortega-Heras, González-SanJosé, & Beltrán, 2002). How do wine experts and novices convey their personal wine experience to each other given this complexity? Cain (1979) has suggested wine experts appreciate flavors in a different way than novices. A casual perusal of wine reviews certainly adds to this impression. Consider this tasting note:

> *"The 2001 Batard-Montrachet offers a thick, dense aromatic profile of toasted white and yellow fruits. This rich, corpulent offering reveals lush layers of chewy buttered popcorn flavors. Medium-bodied and extroverted, this is a street-walker of a wine, making up for its lack of class and refinement with its well-rounded, sexually-charged assets. Projected maturity: now-2009." (Suarez-Toste, 2007, p. 57)*

As Suarez-Toste (2007) notes, this description contains many figurative and metaphorical constructions. Metaphors are ubiquitous in experts' wine descriptions (Caballero & Suarez-Toste, 2010; Paradis & Eeg-Olofsson, 2013; Suarez-Toste, 2007; Wipf, 2010): wines are described as having a body (e.g., 'this rich, corpulent offering'; Suarez-Toste, 2007) and persona (e.g. 'making up for its lack of class and refinement'; Suarez-Toste, 2007). Wines are also described as if they were animate, and capable of motion (e.g., 'This wine bursts from the glass with violets'; Caballero, 2007) .

So, it seems as if wine experts are vague and literary in their descriptions. However, other studies suggest experts use more concrete words (e.g., *blackberries* instead of *fruity*; Chollet & Valentin, 2000; Lawless, 1984; Solomon, 1990, 1997), and provide more precise labels (e.g., *gooseberry* instead of *fruit*; Zucco, Carassai, Baroni, & Stevenson, 2011). It has also been suggested experts use more wine-domain-specific terminology (e.g., *metallic*, *mineral*, *unripe*; Lehrer, 1983; Melcher & Schooler, 1996), more technical terms (e.g., aldehyde), and make less reference to hedonic value (e.g., *unpleasant*; Sezille, Fournel, Rouby, Rinck, & Bensafi, 2014). Thus, there is contradictory evidence about the types of strategies experts use to convey their experiences.

Turning to whether experts have more communicative success than novices, the jury is also out. On the one hand, there are studies suggesting wine experts might have an advantage over novices in how they communicate about wines. Wine experts appear to agree with each other more about how to name wine-related odors than novices or intermediate wine students (Bende & Nordin, 1997; Lehrer, 1975; Tempere, Hamtat, de Revel, & Sicard, 2015; Zucco et al., 2011). Some studies have also found expert descriptions are more often matched to the correct wine than descriptions composed by novices (Gawel, 1997; H. T. Lawless, 1984; Solomon, 1990). This fits with the idea proposed by Smith (2013) that experts agree more on the smell and flavor of wine, given their shared experiences.

On the other hand, other studies suggest experts are not better at describing flavors than novices. For example, Lawless (1984) compared expert wine descriptions to those of novices, and found expert descriptions were highly idiosyncratic, with most terms used only once by one participant. This suggests there is little systematicity between experts. In another study, experts showed similar levels of agreement as novices in their descriptions of wine-related odors (Parr, Heatherbell, & White, 2002). However these studies can be interpreted in a different way. Lawless (1984) did not directly compare the two groups on consistency, so we cannot be sure whether experts and novices were similar or different on this measure. Similarly, a closer look at the data in Parr et al. (2002) shows experts had numerically higher identification and consistency rates than novices, leaving open the possibility the study was underpowered (as suggested by the authors also, on p. 752). Overall, the few studies conducted to date contradict each other, and leave open the question of whether experts are better at naming odors and flavors.

3.2.2 HOW GENERAL IS EXPERTISE?

If wine experts are indeed better at naming odors and flavors, this leads to the question of how well odor naming in one domain generalizes to another. That is, if there is an odor naming advantage for wine experts, does it hold for odors outside of their domain of expertise? Zucco and colleagues (2011) found wine experts were better at naming odors than intermediate wine students, but this advantage was restricted to wine-related odors only, and did not extend to household odors. A more recent study (Sezille et al., 2014) compared the language different experts (flavorists and perfumers) used to describe common odors. Flavorists and perfumers used different words than novices, but they found no difference between expert groups, which could indicate flavor experts possess a general ability to express smells and flavors in language.

Sezille et al. (2014) are unusual in comparing flavorists and perfumers. Most previous studies focus exclusively on wine experts, and compare them to novices (for a recent review, see Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013). In fact, there are many expert domains which would make for an interesting comparison to wine. Take coffee, for example. Just like wine, coffee contains more than 800 volatile aroma components (cf. Grosch, 2001; Shibamoto, 1991). There is an extensive literature regarding the growth, harvest, processing, production, and marketing of both wines and coffees. In addition, experts in both domains typically undergo extensive training: it takes many years of experience to become an expert in either specialty.

Nevertheless, coffee and wine expertise also differs in some interesting respects. Whereas wines are usually elaborately described in tasting notes, menus, and on placards in stores, the descriptions of coffees tend to be less frequently encountered. This can be quantified further in a number of ways. For example, there are at least 10 different subscription magazines to be found about wine on Amazon.com, but not a single one for coffee (retrieved December 1st 2015). A simple Google search on both topics reveals a similar asymmetry: a Dutch query for wine tasting notes ("*wijn*" AND "*proefnotitie*") returned 77,000 web pages containing wine tasting notes, while a similar query for coffee ("*koffie*" AND "*proefnotitie*") returned a mere 10,000 web pages containing coffee tasting notes (retrieved October 16th 2015). The same query in English revealed a similar picture: 501,000 results for wine tasting notes ("*wine*" AND "*tasting note*") versus only 81,000 for coffee tasting notes ("*coffee*" AND "*tasting note*", retrieved December 8th 2015). Likewise, any reasonably priced restaurant will provide a written description of wines on the menu; most supermarkets provide additional information about the wines they sell. But comparably detailed descriptions of coffees are rare. This asymmetry could be attributed to the number of wine vs. coffee experts, but this still could have relevance for sensory language. Studies have demonstrated that more exposure to more varied input from different people can influence language use (e.g., Lev-Ari, 2015). For this reason, in this study we compared coffee experts to wine experts on the same flavor and odor naming tasks. If domain-specific linguistic experience matters, then wine and coffee experts should behave differently because there are more (in number) and more varied (number of people producing) descriptions for wines than coffees.

The question we asked is whether smells and flavors are linguistically expressed more easily by wine and coffee experts than by novices. Are they more "codable"? Items that are more codable in language have (1) shorter lengths; (2) dedicated vocabulary for their expression; and (3a) are named more consistently and (3b) correctly (cf. R. W. Brown & Lenneberg, 1954; Majid & Burenhult, 2014). We tested whether experts and novices differ on these measures in how they describe smells and flavors.

If the chemical senses are easier to communicate about for experts who have perceptual expertise and training in smells and flavors, like the wine and coffee experts in this study, then smells and flavors should be more linguistically codable for them than they are for novices. And this should be true regardless of the specific smells and flavors. That is, if wine or coffee expertise is equivalent to the kind of "expertise" the hunting-gathering Jahai have, then experts should be better at describing smells (and flavors) regardless of the source. If, on the other hand, expertise is limited, i.e., experts only have domain-specific expertise, then wine experts should show higher codability for wines; coffee experts for coffee; and neither group should differ from each other, or the novices, on basic odors and tastes. Finally, if the kind of language games around expertise is important (e.g., how often people write and talk about their domain of expertise), we might expect wine experts to show higher codability than coffee experts, because they engage in discussions over their specialty more often and receive more varied input.

3.3 METHODS

3.3.1 ETHICS STATEMENT

Each participant was informed about the purpose and methods of the study, and written consent was obtained before the experiment began. The study was approved by the institutional Ethics Assessment Committee of Radboud University.

3.3.2 PARTICIPANTS

Sixty-three participants (22 women, M_{age} = 43.7 years, SD = 11.7, age range: 24 - 70 years) including wine experts, coffee experts, and novices participated in the experiment (see Table 3.1). Participants were actively recruited by approaching experts in stores, word-of-mouth, via websites and e-mail, and social media. Participants were not paid, but were reimbursed for travel as appropriate.

	Wine experts	Coffee experts	Novices
Number	22	20	21
Gender (number of women)	7	8	7
Mean age	45.8	38.9	45.9
Age Range	29-61	26-52	24-70

Table 3.1 Participant characteristics

All participants were native speakers of Dutch, except for one wine expert, who moved from France to the Netherlands at a young age and spoke Dutch at near-native level. They were otherwise relatively homogenous. Wine experts had a vinologist degree and/or worked as a qualified, experienced vinologist or sommelier (cf. Melcher & Schooler, 1996; Parr et al., 2002). Coffee experts worked as qualified baristas, coffee roasters, or coffee brokers. The only criterion for novices was consumption of at least one glass of wine and one cup of coffee per week, to ensure they were familiar with the smell and flavor of both. In fact, the groups differed in wine and coffee consumption. Wine experts consumed significantly more wine than coffee experts or novices, χ^2 (6, N = 65) = 24.0, p = .001, Cramer's V = .43, while coffee experts consumed more coffee than wine experts or novices, χ^2 (6, N = 65) = 12.3, p = 0.056, Cramer's V = .31.

To validate the expertise levels of the wine and coffee experts, each participant completed three questionnaires: the Wine Knowledge Test (see Appendix B; Hughson & Boakes, 2001; Lehrer, 1983; Melcher & Schooler, 1996), Coffee Knowledge Test (constructed in analogy to the Wine Knowledge Test, see Appendix C), and a shortened version of the Odor Awareness Scale (Smeets, Schifferstein, Boelema, & Lensvelt-Mulders, 2008).

An ANOVA revealed there was a significant difference between groups on the Wine Knowledge Test $F(2, 60) = 57.7$, $p < .001$, $\eta^2 = .66$. Pairwise comparisons showed wine experts had significantly higher scores ($M = 13.6$, $SD = 1.0$) than coffee experts ($M = 9.1$, $SD = 1.7$), $p < .001$, $d = 3.23$ (Bonferroni correction is applied to pairwise comparisons throughout as appropriate), and novices ($M = 9.6$, $SD = 1.8$), $p < .001$, $d = 2.74$; while coffee experts and novices did not differ from each other $p = .708$. Similarly, the groups differed on the Coffee Knowledge Test $F(2, 59) = 50.6$, $p < .001$, $\eta^2 = .63$. Coffee experts had significantly more coffee knowledge ($M = 11.9$, $SD = 2.8$) than wine experts ($M = 5.0$, $SD = 2.1$), $p < .001$, $d = 2.79$, and novices ($M = 4.4$, $SD = 2.9$), $p < .001$, $d = 2.63$; whereas scores of novices and wine experts did not differ, $p > 1.0$. Finally, the scores of the Odor Awareness Scale also differed across groups $F(2, 59) = 9.07$, $p = .001$, $\eta^2 = .24$: Novices had significantly lower scores ($M = 23.9$, $SD = 9.2$) than wine experts ($M = 31.6$, $SD = 8.3$), $p = .001$, $d = .88$, and coffee experts ($M = 30.3$, $SD = 5.7$), $p = .030$, $d = .84$, but both expert groups were equally aware of their sense of smell in daily life, $p = .460$. This further confirms olfaction is more important for both expert groups than the ordinary person.

3.3.3 MATERIALS

3.3.3.1 Wines

The five red wines originated from different countries, had different vinification styles, and were chosen for their distinct flavor profiles (in consultation with a vinologist who did not participate in the study; see Table 3.2). The bottles were opened at least 20 minutes before each testing session, checked for faults (e.g., corkstain), kept at room temperature (20 ± 2° C) in between sessions, and were kept refrigerated overnight. New bottles were opened every three days. Approximately 50 ml of each wine was poured in numbered, transparent crystal wine glasses with a volume of 400 ml.

wine	name	country of production
1	Jean Bousquet Malbec	Argentina
2	Zenato Valpolicella Superiore	Italy
3	Altos R Rioja Temperanillo	Spain
4	Vallon des Sources Vacqueyras	France
5	Castello de Molina Cabernet Sauvignon	Chile

coffee	name	country of production
1	Santa Helena Caturra	Colombia
2	Kirimiro Red Bourbon	Burundi
3	Knots Family Heirloom varietals	Ethiopia
4	Fazenda Rainha Yellow Bourbon	Brazil
5	Hacienda Sonora Villa Sarchï	Costa Rica

Table 3.2 Wines and coffees used in the study

3.3.3.2 Coffees

Five types of coffee beans from different countries with single estate origin were chosen for their distinct flavor profiles, in analogy with the selected wines (Table 3.2). These were selected in consultation with a Specialty Coffee Association Europe (SCAE) certified coffee roaster who did not participate in the study. The coffees were roasted in the same way in one batch. Immediately after roasting, the beans were sealed in dark aluminum coated plastic bags, in small lots of 100 grams. To ensure freshness of the coffee, at most three hours prior to testing 13.5 grams of each coffee was weighed and ground medium-fine. New sealed bags of coffee were opened every three days. The experimenter was trained by an independent SCAE barista to prepare the coffee following the Specialty Coffee Association America (SCAA) guidelines for cupping ("Specialty Coffee Association of America," n.d.). The coffees were presented in double-walled transparent cups of 250 ml and covered with numbered porcelain saucers until preparation.

3.3.3.3 Comparability of wine and coffee stimuli

As stated, wines and coffees were chosen to be equally distinct from one another. To verify whether the relative perceptual differences between wines and coffees were comparable, a separate experiment was conducted. Twenty naïve participants (13 women, M_{age} = 24 years, SD = 4.8, age range = 18–38) were asked to sort the five wines and five coffees based on how similar they were to one another. Half the participants sorted wines first; half coffee first. Participants indicated similarity by placing the glasses containing the drink on an

A2 (42x49 cm) sheet of paper. The closer 2 stimuli were placed next to each other, the more similar the participant deemed them to be. The *x*- and *y*-coordinates of each stimulus were recorded in millimeters and transformed into interstimulus distances for each stimulus pair.

The mean distance for wines (M = 254, SD= 53) was not significantly different to the mean distance between coffees (M = 237, SD= 55) across participants $t(19) = 1.88$, $p = .074$, indicating wines and coffees were comparably perceptually different to each other. There was also a significant correlation between the relative distances between wines and coffees, $r(18) = .703$, $p < .001$, so if a participant sorted wines with a small interstimulus distance, they sorted the coffees in a similar way.

To further explore the perceptual space the wines and coffees occupied, two separate Multiple Factor Analyses were performed using the R package *FactoMineR* (Lê et al., 2008; Pagès, 2005). For both stimulus types, the data was best fitted with a maximal, four-dimensional solution, with eigenvalues for the four dimensions explaining respectively 42.8%, 23.3%, 18.3%, and 15.6% of the variance for the wines, and 38.8%, 25.6%, 19.6%, and 15.9% of the variance for coffee. This also points to the relative perceptual comparability of the two stimulus sets.

3.3.3.4 Odor stimuli. Participants had to name ten different odors

The odors were presented using Sniffin' Sticks (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997), and were a mixture of edible and inedible objects, covering the pleasantness continuum. The odors were lemon, apple, garlic, rose, chocolate, clove, mushroom, grass, leather, and cinnamon.

3.3.3.5 Taste stimuli

A total of eight taste solutions, sweet, salty, bitter and sour, in strong and weak concentrations, were prepared. Refined sugar (10 grams, 292mM, *sucrose*), salt (7.5 grams, 1283mM, *sodium chloride*), quinine (0.05 grams, 1.54mM, *quinine hydrochloride*) and citric acid (5 grams, 237mM) were dissolved in 100 ml of filtered, boiled water to make strong solutions. Weak solutions were half the concentration (O'Mahony et al., 1979; O'Mahony & Ishii, 1986; Prescott, 1998; Robinson, 1970).

3.3.4 PROCEDURE

Participants started naming either the wines or coffees first (order counterbalanced). For wines, participants were instructed to first smell and taste each wine, without talking, to familiarize themselves with the stimuli. The participant was then asked: 'Could you smell the first wine and describe the smell as precisely as possible?' (in Dutch: *Wilt u nu de eerste wijn ruiken en de geur zo precies mogelijk beschrijven?*). After describing the smell, the participant was asked: 'Could you now taste the wine and describe the flavor as precisely as possible?' (*Wilt u nu de wijn proeven en de smaak zo precies mogelijk beschrijven?*). They then moved to the next stimulus until complete. The coffee flavor naming task was the same, with a familiarization phase, followed by describing the smells and then the flavors.

After the wine and coffee naming tasks, participants completed the two expertise questionnaires and odor awareness questionnaire, and then participated in the odor and taste naming tasks. For the odor naming task, each odor pen was uncapped by the experimenter and handed to the participant with the instruction: 'Can you describe the smell as precisely as possible?' (*Kunt u de geur zo precies mogelijk beschrijven?*). For the taste naming task, participants were first warned some of the sprays might taste unpleasant. The participants were instructed: 'Could you now spray the taste on your tongue, and describe what you taste?' (*Wilt u nu de smaak op uw tong sprayen, en beschrijven wat u proeft?*). Participants were allowed to spray the tastant a second time if they wished. After each taste, participants drank some filtered water. All stimuli were presented in a fixed order within each block, and there was a delay of at least 20 seconds between them (following Hummel, Kobal, Gudziol, & Mackay-Sim, 2007). In practice, the interstimulus interval was between 30 and 35 seconds. The sessions took place in a well-lit, well-ventilated room. All answers were recorded using an audio-recorder.

3.3.5 DATA PROCESSING

Audio-recordings were transcribed, and coded separately for the smell and flavor of wine and coffee, the smell of odor stimuli, and taste of basic tastants. To recap, things that are codable in language should be (1) concise; (2) have dedicated terminology; (3a) be described consistently and (3b) correctly. We operationalized each of these measures as follows:

First, the length of the description was measured by counting the number of characters in the fully transcribed response. Short descriptions would indicate higher codability than longer descriptions.

Second, we coded the types of responses participants gave in order to test whether experts differed from novices in the strategies they used to describe smells and flavors. Three categories were identified: (1) Source-based terms, i.e., words referring to objects that could emit that odor or flavor, e.g. *kersen* 'cherries', *fruitig* 'fruity'; (2) Evaluative terms, i.e., words describing hedonic evaluation, e.g., *lekker* 'pleasant', *mooi* 'nice', *gadverdamme* 'disgusting', and (3) Non-source-based terms, i.e., words not referring directly to an object. This latter category is included following Majid and Burenhult (2014) who identified a third category of abstract or "basic" terms. In Dutch this includes terms such as *aromatisch* 'fragrant/aromatic' and *muf* 'musty'. Participants rarely used this strategy; however, they did use other non-source-based descriptions such as cross-modal metaphors (e.g., *zoet* 'sweet', *bitter* 'bitter', *groen* 'green'), reference to a general state (e.g., *gekookt* 'cooked'), or associations with events or situations (e.g., *winters* 'wintery', *bij de slager* 'at the butcher'). We could, therefore, test whether experts and novices differed in the extent to which they gave evaluations, referred to a concrete source, or gave more abstract non-source-based descriptions.

Finally, we measured if speakers agreed in how they described smells and flavors. One way to operationalize this is in terms of naming accuracy. This is applicable to basic odors and tastes for which a correct or veridical answer could be said to exist. But this does not apply to the wines and coffees, since descriptions for these refer to components of the smell and flavor profile, and there is no "correct" answer. Therefore for the wines and coffees, we calculated whether participants agreed with one another in their descriptions (R. W. Brown & Lenneberg, 1954; Majid & Burenhult, 2014). To do this, the main responses from the fully transcribed descriptions were identified. For example, a speaker gave the description for a wine displayed in Box 3.1.

> *Em kersen in de mond. Kersen, ja amarena kersen daar gaat het naartoe. Lichte tannines, beetje bitter, maar mooi. Denk dat hij wel wat houtlaging heeft gehad maar niet overheersend.*
> Em, cherries in the mouth. Cherries, yes, amarena cherries that's what it's heading off to. Light tannins, a little bit bitter, but nice. I think he had some wood aging, but it's not overpowering.

Box 3.1. Example of a Dutch wine expert's description for the taste of Wine 4, the Vallon des Sources Vacqueyras from France.

From this description the main qualitative descriptors *kersen* 'cherries', *amarena kersen* 'amarena cherries', *tannines* 'tannins', *bitter* 'bitter', *mooi* 'nice', and *houtlagering* 'wood aging' were coded. Modifiers and hedges were ignored unless their exclusion changed the quality description. For example, *licht* 'light' in *lichte tannines* 'light tannins' was not coded since *light* only indicates the strength of the taste (or confidence of the participant). But *amarena kersen* 'amarena cherries' was coded as a whole response including *amarena*, because amarena cherries may have a different quality of smell than generic cherries. Repeated responses (e.g., when a person mentioned *kersen* twice, as in the example above) were only coded once. Once the main responses were identified, the consistency between speakers was calculated using Simpson's Diversity Index (Simpson, 1949), a measure of diversity in a given population, or in this case, diversity of words, following Majid and Burenhult (2014). For the odor stimuli and basic tastants, where "correctness" can be determined, both agreement and accuracy were measured. Accuracy was measured by calculating the percentage of veridical answers.

3.4 RESULTS

3.4.1 ARE WINES AND COFFEES MORE CODABLE FOR WINE EXPERTS AND COFFEE EXPERTS?

3.4.1.1 Length

Items that are highly codable typically receive more concise descriptions. Is this true for how wine and coffee experts describe wines and coffees? To test this, a mixed ANOVA with expertise (wine experts, coffee experts, novices) and naming task (wine smell, wine flavor, coffee smell, coffee flavor) was conducted, separately over participants (F_1) and items (F_2). Overall, participants had more to say about the flavors than smells of wines and coffees, $F_1(3, 180) = 22.87$, $p < .001$, $\eta_p^2 = .28$; $F_2(3, 16) = 34.96$, $p < .001$, $\eta_p^2 = .87$. In addition, wine experts talked more than novices, who in turn talked more than coffee experts, $F_1(2, 60) = 3.68$, $p = .031$, $\eta_p^2 = .11$; $F_2(2, 32) = 75.29$, $p < .001$, $\eta_p^2 = .83$. There was also an interaction between expertise and naming task, $F_1(6, 180) = 4.50$, $p < .001$, $\eta_p^2 = .13$; $F_2(6, 32) = 12.75$, $p < .001$, $\eta_p^2 = .71$. Contrary to the prediction, wine experts said more about the smell of wine ($M = 307$, $SD = 213$) than coffee experts ($M = 156$, $SD = 136$), $p = .008$, $d = .85$, but not more than novices ($M = 232$, $SD = 203$), $p = .375$. The same pattern was found for the flavor of wine: wine experts ($M = 423$, $SD = 200$) gave longer descriptions than coffee experts ($M = 223$, $SD = 129$), $p = .001$, $d = 1.18$, but their descriptions did not differ from novices ($M = 322$, $SD = 220$), $p = .139$. Turning to coffee, there were no significant differences in the length of the smell descriptions between coffee experts ($M = 160$, $SD = 115$), wine experts ($M = 205$, $SD = 161$) or novices ($M = 215$, $SD = 185$), all *ps* > .05. The same pattern was found for the flavor descriptions of coffee; again there was no difference between coffee experts ($M = 270$, $SD = 132$), wine experts ($M = 301$, $SD = 154$) or novices (M = 261, $SD = 170$), all *ps* > .05. So, wine experts said more about wines than the other groups, but coffee experts said the same amount as wine experts and novices about coffees, and were more succinct in general.

3.4.1.2 Strategy

Did the groups rely equally on evaluative, source-based, and non-source-based terms? The answer is no (see Figure 3.1). Descriptions for the smell $\chi^2(4, N = 1115) = 21.80$, $p < .001$, Cramer's $V = .10$, and flavor $\chi^2(4, N = 1378) = 37.80$, $p < .001$, Cramer's $V = .12$ of wine depended on expertise. Wine experts used fewer non-source-based terms (e.g., *chemisch* 'chemical') for wine smells $z = -3.0$, $p = .001$, while coffee experts and novices used more non-source-based terms, $z = 1.8$, $p = .036$, and $z = 2.0$, $p = .023$, respectively. Wine experts also used more source-based descriptors (e.g., *vanille* 'vanilla') for wine flavors $z = 1.8$, $p = .036$, and fewer non-source-based terms, $z = -2.4$, $p = .008$. Coffee experts used fewer evaluative terms for wine flavors $z = -2.6$, $p = .005$, while novices used more $z = 3.4$, $p < .001$. Novices also used fewer source-based descriptors for wine flavors $z = -2.5$, $p = .006$ than either the wine or coffee experts. So, overall, wine experts used more source-based descriptions to describe the smells and flavors of wines; coffee experts used fewer evaluative terms for wine flavor; while overall, novices used more evaluative descriptions.

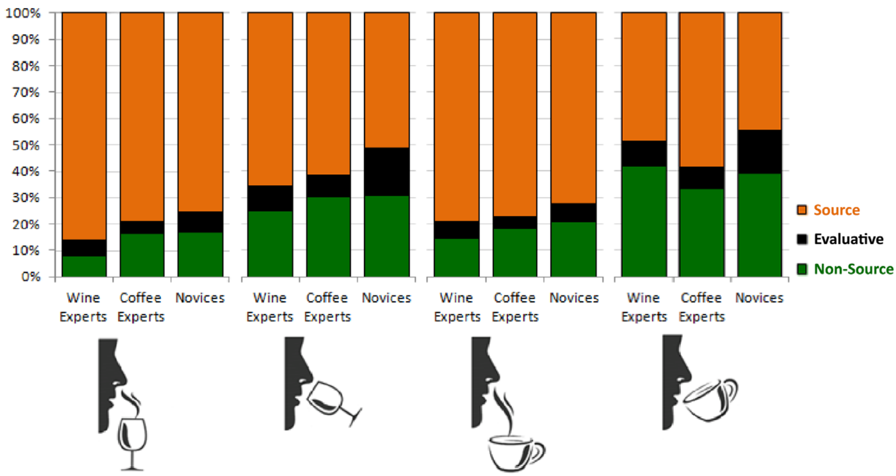


Figure 3.1. Description strategies used by wine experts, coffee experts and novices. Overall, experts and novices overwhelmingly relied on source-based descriptions (orange). However, wine experts used relatively more source-based terms to describe the smell and flavor of wine, and coffee experts used relatively more source-based terms to describe the flavor of coffee. Novices used more evaluative terms than the experts (black) to describe the smell and flavor of both coffee and wine.

For coffee smells there was no significant difference in description strategy $\chi^2(4, N = 891) = 5.24$, $p = .263$, Cramer's $V = .05$, but there was for coffee flavor $\chi^2(4, N = 1097) = 22.61$, $p < .001$, Cramer's $V = .10$. Just like the wine experts with wines, coffee experts gave significantly more source-based descriptors for coffees $z = 2.0$, $p = .023$. They also appeared to give fewer evaluative terms $z = -1.6$, $p = .060$, and non-source-based terms $z = -1.6$, $p = .060$. Similarly, novices gave more evaluative descriptors $z = 2.8$, $p < .001$, and fewer source terms $z = -1.6$, $p = .060$, just as they did for wines.

Overall, then, experts gave more source-based, concrete descriptions for the smells and flavors of the stimuli for which they were expert. Novices, in contrast, appeared to rely more heavily on evaluative terms, especially to describe flavors.

3.4.1.3 Consistency

Do experts agree with one another more in how they describe wines and coffees? To test this, an expertise (wine experts, coffee experts, novices) by naming task (wine smell, wine flavor, coffee smell, coffee flavor) mixed ANOVA was conducted using Simpson's Diversity Index calculated over first responses. There was a main effect of expertise, showing wine experts were more consistent than coffee experts or novices, $F(2, 12) = 17.69$, $p < .001$, $\eta_p^2 = .75$, and a main effect of task, with the smell and taste of wine and taste of coffee described more consistently than the smell of coffee, $F(3, 36) = 3.27$, $p = .032$, $\eta_p^2 = .21$. More importantly, there was a significant interaction between expertise and naming task $F(6, 22) = 2.76$, $p = .037$, $\eta_p^2 = .43$. Planned comparisons showed wine experts had higher agreement with each other when describing the smell of wine ($M = 0.09$, $SD = 0.05$) than novices ($M = 0.03$, $SD = 0.012$), $p = .037$, $d = 1.65$, but there was no significant difference between wine experts and coffee experts ($M = 0.04$, $SD = 0.02$), $p = .112$. However, when describing the flavor of wine, wine experts had higher agreement ($M = 0.09$, SD = 0.03) than novices (M = 0.05, $SD = 0.02$), p = .011, $d = 1.56$, and coffee experts ($M = 0.04$, $SD = 0.02$), $p = .007$, $d = 1.96$. In contrast, coffee experts did not agree more when describing the smell of coffee ($M = 0.04$, $SD = 0.02$) than novices ($M = 0.03$, $SD = 0.01$) or wine experts (M = 0.03, SD = 0.02), $p > .05$. In fact, they agreed less (M = 0.03, SD = 0.005) than the wine experts (M = 0.09, SD = 0.02) about the flavor of coffee, p = .025, d = 4.11. The results revealed no significant differences between coffee experts and novices, p = .237, nor between novices and wine experts, p = .717 for the flavor of coffee (see Figure 3.2). So while wine experts are more consistent in how they describe the smells and flavors of wines, coffee experts are not. This suggests expertise only has a limited role to play in linguistic codability.

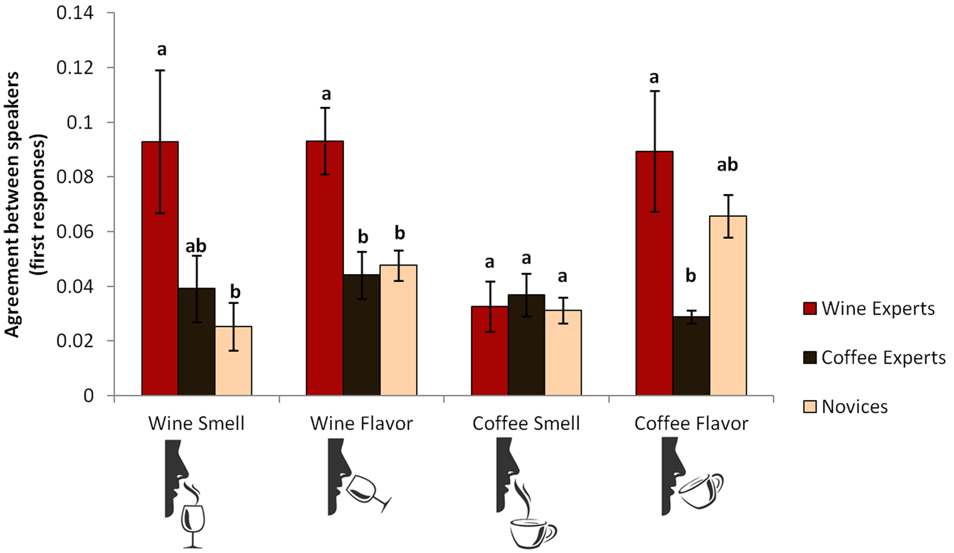


Figure 3.2. Agreement between experts and novices for wines and coffees. Wine experts were more consistent with each other in how they described the smell and flavor of wines than novices and coffee experts. In contrast, coffee experts were not more consistent than wine experts and novices for the smells and flavors of coffees. Letters indicate significant differences between groups; error bars represent ± 1 standard error.

The previous analysis only considered agreement on first responses. However, the analyses of description length earlier demonstrated the groups differed in the length of their descriptions. For example, wine experts described wines more elaborately than both other groups. When wine experts talk more, do they identify and name components that were identified by other experts? Or do the longer descriptions diverge more from one another?

Taking all responses into account, there remained a main effect of naming task, $F(3, 36) = 12.47$, $p < .001$, $\eta_p^2 = .51$, but not of expertise, $F(2, 12) = 1.75$, $p = .215$. There was an interaction between task and expertise, $F(6, 22) = 3.19$, $p = .020$, $\eta_p^2 = .47$. Wine experts no longer showed more agreement on the smells of wines ($M = 0.02$, $SD = 0.001$) than coffee experts ($M = 0.018$, $SD = 0.004$), $p = .822$ or novices ($M = 0.02$, $SD = 0.007$), $p > .05$, nor did they show more agreement for the flavors of wines ($M = 0.018$, $SD = 0.004$) than coffee experts ($M = 0.018$, $SD = 0.004$), $p > .05$, or novices ($M = 0.014$, $SD = 0.005$), $p > .05$. So, talking more does not seem to increase the likelihood of converging on descriptions of smell and flavor. However, when considering all responses coffee experts showed more agreement on the smell of coffee ($M = 0.02$, $SD = 0.003$) than wine experts ($M = 0.01$, $SD = 0.003$), $p = .033$, $d = 3.33$, but not more than novices ($M = 0.012$, $SD = 0.004$), $p = .302$; nor did the novices differ from wine experts, $p = .737$. But similar to the analysis for the first responses, coffee experts agreed significantly less on the taste of coffee ($M = 0.012$, $SD = 0.002$) compared to novices ($M = 0.025$, $SD = 0.005$), $p < .001$, $d = 3.4$, and wine experts ($M = 0.025$, $SD = 0.004$), $p = .001$, $d = 4.11$.

Taken together, the results lend some support to the proposal that experts have higher codability for smells and flavors. But this agreement is rather limited in nature. Wine experts showed higher consistency when describing the smells of wines than novices, and when describing the flavor of wine and coffees than coffee experts. This suggests the wider linguistic and communicative experiences of wine experts may play a critical role for describing smells and flavors, since they perform even better than the coffee experts. However, this main effect is modulated by an interaction revealing domain-specific expertise. Wine experts agree with one another more about the smells and flavors of wines, but only when considering their first responses. When considering all responses, however, this agreement seems to disappear, possibly because each expert is isolating different components of the wine and coming to a unique linguistic profile for their experience. Coffee experts, on the other hand, only showed more agreement on the smells of coffees when taking all responses into consideration. Neither group showed a general advantage over novices across domains.

So, it seems there is only a modest role of expertise when communicating about the smells and flavors of wines and coffees.

It is surprising that coffee experts show significantly less consistency for describing coffee flavors, considering describing these flavors is their core business. To better understand why this might be, we visualized the descriptions using word clouds (Figure 3.3 and Figure 3.4). In a word cloud, the relative size of a word indicates its relative frequency, with the largest words being the most frequent. The word clouds were made using the R package *wordcloud* (Fellows, 2013). It is clear from Figure 3.3 that wine experts and novices primarily described the coffees as *bitter* 'bitter' or *zuur* 'sour'. And as was demonstrated by the earlier analyses, novices described items as *aangenaam* 'pleasant' or *onaangenaam* 'unpleasant'. In contrast, coffee experts picked out specific flavors using source-based terms (such as *chocolade* 'chocolate', *bessen* 'berries', *kruiden* 'herbs'). They also identified sour and bitter components, but intriguingly their most frequent taste descriptor for the same coffees was *zoet* 'sweet'.

A comparison across the five coffees showed wine experts and novices barely distinguished between the different coffees in their descriptions, while the coffee experts identified distinct flavor profiles. For example, Coffee 4, a Brazilian Yellow Bourbon, was described by the coffee experts as 'sweet', 'chocolate', 'balanced', and as having 'acidity'. This parallels the descriptors given by an independent coffee expert in a non-blind tasting: "known for its good balance between acidity, body and sweetness and for its excellent aftertaste[8]." . Similarly, Coffee 5, a Costa Rican Villa Sarchï, was described as having 'fruit', 'sweet', and 'acidity', again paralleling a non-blind tasting: "Fruit acidity that's very clean; fruit driven sweetness that's intense[9]." ("Has Bean Coffee - Villa Sarchi," n.d.).

To see whether wine experts also distinguished between the different wines, the same analysis was repeated for the flavor of wine (Figure 3.4). Interestingly, wine experts described the flavor of all five wines fairly similarly, by using the source-based descriptor *fruit* 'fruit'. They also commented on the presence or absence of *tannine* 'tannins', noted *zuur* 'sour', *droog* 'dry', and used specific source-based descriptors, e.g. *kers*, 'cherry', braam 'blackberry', and *vanille* 'vanilla'.

[8] Retrieved from "Coffee origins of the world" (internet). http://www.specialtycoffee.nl/en/coffee/origins, accessed 09-06-2015

[9] Retrieved from "Has Bean Coffee—Villa Sarchi" (Internet). http://www.hasbean.co.uk/blogs/varietals/15254989-villa-sarchi, accessed 29-06-2015

Figure 3.3. Word clouds of the 20 most frequent terms for coffee flavors. Wine experts and novices agreed more in their descriptions and predominantly describing all coffees as bitter and sour. Coffee experts, on the other hand, gave distinct flavor profiles to each coffee.

Figure 3.4. Word clouds of 20 most frequent descriptors for wine flavors. Wine experts agreed on two main qualities: fruit and whether the wine contained tannins. In addition, they identified further distinctive qualities in their descriptions. Novices commented on a number of taste qualities (e.g., zuur 'sour', droog 'dry', wrang 'tart', bitter 'bitter'), and gave evaluative descriptions (e.g., aangenaam 'pleasant').

3.4.1.4 Summary

Experts used different linguistic strategies to describe their domain of expertise. Wine experts had more to say about the smell and flavor of wine, and had higher consistency in their first descriptions. Coffee experts, on the other hand, only showed higher agreement on the smells of coffees when considering their full responses. Despite these differences, both expert groups relied more on source-based descriptions to describe the stimuli from their expert domain, while novices took a more evaluative stance.

Although coffee experts did not show higher levels of agreement in their descriptions of coffee tastes, their responses appear to be more distinctive for each type of coffee than wine experts' or novices'. In fact, their descriptions provided when blind-tasting coffees overlapped considerably with expert coffee descriptions from a non-blind tasting. This suggests although coffee experts did not show higher agreement, they nevertheless were distinctive in their linguistic descriptions. A parallel analysis of the wine experts' descriptions of wine showed the wine experts agreed on the same two main characteristics for all the wines, and that some coffee experts and novices recognized those too, albeit to a lesser extent.

3.4.2 DO EXPERTS HAVE AN ADVANTAGE IN NAMING BASIC SMELLS AND TASTES?

To further test the domain-specificity of linguistic descriptions of smells and tastes, we tested experts and novices on simple everyday odors (e.g., cinnamon, lemon) and tastes (e.g., sweet, sour), as well. We first consider whether there was a general expertise advantage for smells and then tastes.

3.4.2.1 Odor naming task

Length: Do experts give more concise descriptions for smell stimuli outside their domain of expertise? A one-way ANOVA comparing the different groups on the number of characters in the descriptions showed an effect of expertise $F_1(2, 62) = 2.61$, $p = .082$, $\eta^2 = .08$, $F_2(2, 27) = 12.71$, $p = .001$, $\eta^2 = .59$. Coffee experts gave the shortest descriptions (*M*

= 102, *SD* =103); significantly shorter than wine experts (*M* = 146, *SD* = 125) p = .002, d = .38, and novices (*M* = 144, *SD* =127), p = .012, d = .36. Wine experts and novices did not differ from each other, however, $p > 0.5$.

Strategy: Odors were described differently depending on expertise, $\chi^2(4, N = 1698) = 22.90$, $p < .001$, Cramer's $V = .08$. Wine experts used more non-source-based terms $z = 2.2$, $p = .015$, while coffee experts used them less frequently $z = -2.0$, $p = .025$. In contrast, coffee experts used more source-based terms, $z = 1.8$, $p = .036$. In addition, coffee experts also used fewer evaluative terms $z = -2.3$, $p = .010$, while novices used more, $z = 1.9$, $p = .029$.

Agreement: Comparing agreement using Simpson's Diversity Index showed no significant effect for expertise in either first $F(2, 29) = .90$, $p = .417$, $\eta^2 = .06$ or all responses $F(2, 29) = 1.25$, $p = .302$, $\eta^2 = .09$.

Accuracy: We also compared the percentage of correct answers in the full descriptions. There was no difference between groups $F_1(2, 62) = .07$, $p = .936$, $\eta^2 = .01$, $F_2(2, 28) = .40$, $p = .677$, $\eta^2 = .04$ (see Figure 3.5).

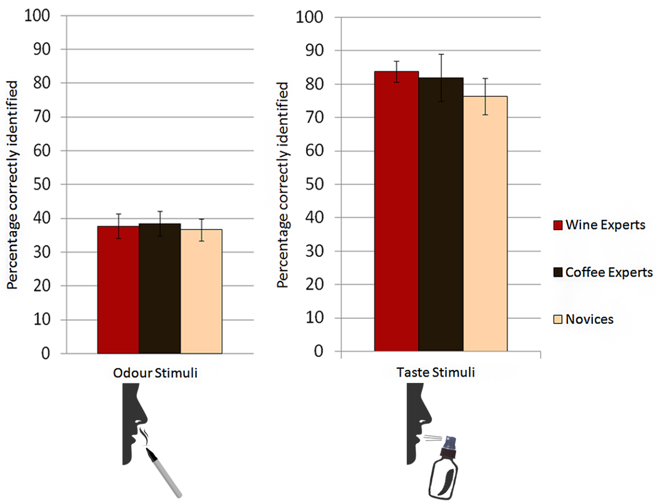


Figure 3.5. Correct responses for smell and taste stimuli. There was no significant difference between groups in the percentage of correctly named smells or tastes. Error bars represent ± 1 standard error.

3.4.2.2 Taste naming task

Length: There was a significant effect of expertise on length $F_1(2, 62) = 3.24$, $p = .046$, $\eta^2 = .10$; $F_2(2, 14) = 24.82$, $p = .002$, $\eta^2 = .78$. Wine experts ($M = 113$, $SD = 18$) and novices ($M = 112$, $SD = 31$) gave descriptions of the same length, $p = .964$, $d = .01$. However, coffee experts gave significantly shorter descriptions ($M = 67$, $SD = 19$) than novices, $p = .002$, d = 2.51, and wine experts, $p = .003$, $d = 1.76$.

Strategy: The groups differed in the linguistic strategy used to describe tastes, $\chi2(4, N = 1496) = 16.91$, $p = .002$, Cramer's $V = .08$. Coffee experts used significantly fewer evaluative terms $z = -2.6$, $p = .005$ than the wine experts or the novices. No other word type frequencies were statistically different from the expected model.

Agreement: There was no difference between groups in agreement in first responses, $F(2, 23) = 1.49$, $p = .249$, $\eta^2 = .12$. However, there was an effect of group when considering all descriptions $F(2, 23) = 16.46$, $p < .001$, $\eta^2 = .61$. Coffee experts agreed with one another more in how to describe basic tastes ($M = 0.23$, $SD = 0.06$) than wine experts ($M = 0.14$, $SD = 0.04$), $p = .001$, $d = 1.77$, and novices ($M = 0.12$, $SD = 0.02$), $p < .001$, $d = 2.46$, while novices and wine experts did not differ from each other, $p = .107$.

Accuracy: There was no difference between the groups in the percentage of correctly identified tastes in full descriptions $F_1(2, 62) = .54$, $p = .584$, $\eta^2 = .02$, $F_2(2, 14) = 3.01$, $p = .082$, $\eta^2 = .30$ (see Fig 3.5).

3.4.2.3 Summary

Overall, when describing everyday smells and basic tastes, wine experts appeared to talk the most, and coffee experts the least. Novices tended to give more evaluative responses for both smells and tastes than experts. Agreement and accuracy did not differ between groups, apart from a slight advantage for naming basic tastes by coffee experts, when all responses were considered. This may have to do with the fact that coffee experts' are trained to seek a coffee that is the perfect balance of bitter, sour, and sweet.

3.5 DISCUSSION

The smell and flavor of wine and coffee seems to be described differently by wine and coffee experts in comparison to novices. Wine experts agreed more on the smell and flavor of wine, and this coincided with the use of more specific source-based terms compared to novices. Coffee experts used a similar strategy for the smell and flavor of coffee, and their descriptions were more succinct than those of novices. But this did not lead to higher agreement between the speakers for the smell and flavor of coffee. The results did not show a general influence of expertise on flavor naming. Differences in talk between wine and coffee experts, where apparent, only appear in their own domains of expertise. So, wine and coffee training only appears to play a limited role in how people talk about smells and flavors.

3.5.1 WINE SPEAK

It was unclear from the prior studies whether wine experts really were better at describing the smells and flavors of wines than non-experts. Previous studies differed in the stimuli used to test the verbal abilities of wine experts, and in the criteria used to measure those descriptions. Some studies used simple odors (Parr et al., 2002; Sezille et al., 2014), while other studies used wines (Gawel, 1997; Melcher & Schooler, 1996; Solomon, 1990). Some studies examined the types of terms experts use (H. T. Lawless, 1984; Melcher & Schooler, 1996; Solomon, 1990; Zucco et al., 2011), while others took more quantitative measures, such as agreement between speakers (Parr et al., 2002). The present study combined these qualitative and quantitative approaches, to get a better understanding of what happens when flavor experts communicate about smells and flavors. We found wine experts talked more, and used more specific source-based terms to describe the smell and taste of wine, which converges with some previous findings (Chollet & Valentin, 2000; H. T. Lawless, 1984; Solomon, 1990). In addition, and contrary to other findings (cf. Parr et al., 2002), wine experts reached higher agreement than novices when describing wines.

In contrast to previous studies (Caballero & Suarez-Toste, 2010; Paradis & Eeg-Olofsson, 2013; Suarez-Toste, 2007), we found wine experts used very few metaphors.

This could be because of the specific task we used. Tasting notes on websites and in magazines written by wine experts serve an entertainment, or literary function in addition to giving information about wine. Examination of these materials tends to show an enhanced reliance on metaphor. In this experiment, participants were asked to give descriptions as precisely as possible, which did not encourage (nor discourage, particularly) metaphorical constructions. This context is comparable to how wine experts communicate during "tastings", or when they sell wines to consumers face-to-face. In this context, experts seem to rely on more concrete vocabulary.

One notable aspect in this study was the different linguistic behavior of wine and coffee experts. This difference between groups of experts is surprising given that a previous study (Sezille et al., 2014) revealed no apparent differences in smell descriptions between flavor experts. In the present study, wine experts were verbose and agreed on the descriptions for wine; the coffee experts were overall more succinct. These differences in descriptions in the present study are unlikely to be caused by intrinsic properties of the stimuli, as the wines and coffees were sorted in comparable ways by novice participants in a control study. Both groups were also comparable in amount of expertise. Wine and coffee experts were both professionals, earning their living with their knowledge. These criteria were independently confirmed by the expertise questionnaires. Moreover, the odor awareness questionnaire showed both expert groups were equally aware of odors in daily life (and more so than the novices). So the differences between expert groups are unlikely to be due to these factors.

Instead we suggest wine experts differ from coffee experts because of the different language games surrounding these two industries. While "wine talk" is an attested genre, there is little comparable "coffee talk" (i.e., about coffee, rather than over coffee). As we suggested in the introduction, wine experts have more opportunities to read, listen, and talk about the smells and flavors of wines (e.g., in magazines, menus, tastings, etc.), than coffee experts do for coffees. This means the two expert groups are doing different things when communicating about smells and flavors in their daily life. As Silverstein (2006) suggests, wine experts are arguably indexing how much they know about the wines, as much as they are describing the properties of the wine itself.

3.5.2 CODABILITY

We had asked whether smells and flavors were linguistically expressed more easily by experts than novices. Linguistic expressibility is a complex notion that can be operationalized in various ways (cf. Levinson & Majid, 2011). We focused on length of description, types of responses, agreement between speakers and accuracy, following the classic work of Brown and Lenneberg (Majid & Burenhult, 2014; R. W. Brown & Lenneberg, 1954). They (R.W. Brown & Lenneberg, 1954) asked English speakers to name colors and found exactly those colors with concise descriptions also had short reaction times, and within- and across-speaker agreement. They then derived a single composite measure of linguistic "codability", combining these measures, and found color chips with high codability were also remembered better. This suggests differential linguistic coding can have wider impact on memory and perception, a proposal that has recently found further support in the domain of color, for example (Davidoff, Davies, & Roberson, 1999; Mitterer, Horschig, Müsseler, & Majid, 2009; Regier, Kay, & Cook, 2005; Winawer et al., 2007).

Our results did not show the same alignment of length and agreement found in these earlier studies. Wine experts had higher agreement yet gave longer descriptions, while coffee experts gave short descriptions but did not agree. So, perhaps this way of examining the linguistic behavior of experts needs to be reconsidered. It seems as if length is not a diagnostic measure in this study, since longer talk appears to index the speaker's orientation, rather than indicate how difficult the entity was to describe. More importantly, earlier studies (which have found length to coincide with agreement) have asked speakers to name stimuli, rather than describe them. In sum this suggests agreement is likely the more informative measure in our study. On this measure we find a small advantage for experts when describing stimuli from their own domain of expertise.

Across the board, people tended to use source-based descriptions (e.g., *berry,* *vanilla*), but both expert groups tended to use more such descriptions in their domain of expertise. It appears that expert descriptions may be more informative. Compare a coffee expert's descriptions for coffee number five—e.g., "a fruity, acidic coffee with a fermented aroma and hints of caramel, honey and citrus"—with a novice's—e.g., "a sour and unpleasant coffee with some hints of berry", for example. In order to verify this, future studies could also examine whether people find it easier to understand expert descriptions than novices', by conducting a director-matcher task, where people have to match wines and coffees to descriptions (cf. Lehrer, 1983). Some previous work, indeed, suggests descriptions from experts are better matched to the original stimulus than those produced by novices (Chollet & Valentin, 2001; Gawel, 1997; Solomon, 1990). Our current results indicate there may be differences depending on the expert and the domain. It would be interesting to examine whether wine and especially coffee expert descriptions are equally informative when given to other experts or novices.

Finally, prior research in other domains (e.g., color) shows a tight link between linguistic coding and memory, which raises the question whether expert memory might also be linguistically mediated. Some studies have found wine experts' recognition memory to be superior to that of novices' (Melcher & Schooler, 1996; Parr et al., 2002; Parr, White, & Heatherbell, 2004; Zucco et al., 2011), although a link between experts' language use and recognition memory has not been reliably demonstrated. This is a matter for future research.

3.5.3 CULTURE AND SUB-CULTURE

For wine and coffee experts, smells and flavors play an important role in their daily routine, and experts can be seen as part of a sub-culture, with specific practices revolving around smell and flavor (Herdenstam et al., 2009). One explanation for the finding wine experts are better at describing the smells and flavors of wine is that wine experts often engage in talk about wine (cf. Silverstein, 2004), which trains them to use language in a specific way. This suggests that to become better at describing smells and flavors, not only is it important to have abundant perceptual experience (cf. Hughson & Boakes, 2001; Kellman & Massey, 2013), but also to train verbalizing these experiences.

Yet another possibility to explain the differences between wine and coffee experts lies in the way these experts appreciate wine and coffee, respectively. During a normal wine tasting or judgment session, wine experts first note the color, before the wine is smelled (cf. Herdenstam et al., 2009). Smelling is sometimes composed of two parts, where the wine is first smelled when it rests still in the glass, and second when the glass is swirled to release additional aromas. Flavor appreciation comes after this, where among other things, experts pay attention to how sweet or dry a wine is, what mouthfeel it produces, and how long the aftertaste lingers.

Coffee experts approach coffee judgments during cupping in a slightly different manner. As with the wine experts, coffee experts first note the color of the ground coffee. But for the coffee experts, the smelling component of cupping is divided into three parts: first the dry, freshly ground coffee is smelled (the so-called "fragrance of the coffee"). Water is then poured on the coffee. The "crust" that has formed on top of the coffee is then "broken" by stirring it gently with a spoon. The aroma of the coffee is smelled at this stage too. Finally, after the coffee has steeped for a while, the aroma of the coffee is judged a final time. The three orthonasal parts are combined in a single aroma quality judgment. The coffee is then tasted from a spoon, to get as much air as possible with the coffee sample in the mouth. During this stage, coffee experts, similar to wine experts, pay attention to how sweet the coffee is, what (retronasal) flavors are in the sample, etc. ("Specialty Coffee Association of America," n.d.). In the present study, to make the tasks and subsequent data more comparable across the two domains, participants were only able to smell the coffee when it had already steeped for some time. It could be the case that coffee experts would achieve higher agreement were they to smell and describe during these other phases. Future studies specifically investigating coffee expertise are required in order to test coffee experts' abilities to describe the various aspects of orthonasal coffee olfaction.

Overall, however, the main expert advantage we found was when wine experts described stimuli from their own domain of expertise. In contrast, the Jahai are better in describing smells regardless the domain or category the smell comes from (Majid & Burenhult, 2014). An indirect comparison of the present study to the study by Majid and Burenhult (2014) appears to indicate that Jahai speakers have higher codability for smells they have never encountered before than wine experts have for smells from sources encountered every day. Even after many years of experience, experts do not appear to show the linguistic prowess for smells the Jahai have. Why might this be so?

There are at least two possible explanations. First, there may be some genetic difference between Jahai speakers and Western speakers that enables the Jahai to talk about smells with relative ease. There are wide-spread differences between populations in olfactory genes (Gilad & Lancet, 2003; Menashe, Man, Lancet, & Gilad, 2003), and different sensitivity for specific odorants (Keller, Zhuang, Chi, Vosshall, & Matsunami, 2007). In addition, populations differ in olfactory discrimination (Sorokowska, Sorokowski, & Frackowiak, 2015; Sorokowska, Sorokowski, & Hummel, 2014; Sorokowska, Sorokowski, Hummel, & Huanca, 2013).

A second possibility has to do with the age of acquisition of smell and flavor vocabularies. Children with different cultural backgrounds are socialized in different ways with regard to the senses, and in some communities children are taught smell is an important part of the world (cf. Classen, 1999). In particular, Jahai speakers learn smell vocabulary as children as part of normal language acquisition, unlike wine and coffee experts. Training for experts does not begin until they are adults, long past any critical period for language acquisition. It could be the wine and coffee experts simply cannot overcome this maturational limitation.

3.5.4 CONCLUSION

In sum, it appears sensory experience and cultural preoccupation alone is not enough to overcome the boundaries of language. Wine and coffee experts have only a small advantage over novices when describing smells and flavors, limited to their domain of expertise. We suggest more emphasis needs to be given to the verbal practices around smells and flavors, in addition to aspects surrounding expert perceptual training. After all, in order to decide what wine or coffee to buy, or to choose a food and drink pairing, or simply to convey our aesthetic appreciation, we use language. Our perceptual experiences are shared through our common tongue.

To conclude, perceptual experience alone is not enough to overcome the boundaries of language; verbal training is also essential in order to effectively communicate about smells and flavors.

4

IMAGERY OF WINES AND SMELLS IN WINE EXPERTS AND NOVICES[10]

4.1 ABSTRACT

The existence of olfactory imagery is disputed in novices, but is reported to be easier for olfaction experts. It plays an important role in wine expertise, as wine experts frequently engage in odor and flavor imagery; for example when they describe wines and want to give a comparison with a previous vintage, or suggest wine-food pairings. In addition, previous research in other domains of expertise shows experts' cognitive abilities do not transfer beyond their domain of expertise, raising the question of how general wine experts' imagery is. To investigate imagery in wine experts, a new questionnaire measuring the vividness of multisensory imagery for wines (i.e., the color, smell and flavor) was constructed and validated against existing imagery questionnaires. We then compared wine experts and novices' vividness of imagery for the color, smell, and flavor of wine, as well as their vividness of imagery for common odors. We found wine experts were better than novices at imagining wines in all modalities (i.e., color, smell, and flavor), but not better at imagining smells in general. In line with the previous literature, novices reported strongest imagery for the visual appearance of wine, followed by smell and taste, but experts showed no differences between the senses. This study shows that wine experts have more vivid imagery for different aspects of wines than novices. Imagery, even for smells, can improve with expertise. But the vivid imagery of wine experts is restricted to the domain of expertise, i.e., wine. Imagery in general seems malleable, and may be trained.

4.2 INTRODUCTION

Mental imagery is the ability to create an inner "image" in any sensory modality, in the absence of the physical stimulus (Freeman, 1981; Pylyshyn, 1973). Imagery can be thought of as reconstructions of perceptual experiences from the past, to anticipate on experiences yet 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 et al., 2006), and it has been linked to different aspects of cognition, such as memory and spatial reasoning (Kosslyn et al., 1995). Often, language is the initiator of

[10] Part of this chapter is adapted from Croijmans, Speed, Arshamian & Majid (2017). Experts are better than novices when imaging wines, but not odors in general. Accepted for the 39th Annual Conference of the Cognitive Science Society. London, UK, July 26-29.

imagery; for example while listening to a lively story told by a talented storyteller, when reading a book and consciously reflecting on the content, or when answering questions about the vividness of imagery (Marschark & Cornoldi, 1991). In addition, high imagery words are remembered better than low imagery words (Nittono, Suehiro, & Hori, 2002), suggesting an interaction between imagery, memory and language.

Although there is currently little doubt that people are able to recreate visual scenes, sounds, and spatial information in their minds (cf. Marks, 1973; Paivio, 1986), the existence of imagery for odors has been disputed (Engen, 1991; Herz, 2000; Schab, 1991). In a sense, the imagery debate—with proponents of a purely propositional account on the one hand (cf. Pylyshyn, 1973), and proponents of a perceptual representational account on the other (cf. Kosslyn et al., 1995) —is still reflected in the field of olfactory imagery (Stevenson & Case, 2005). On the one hand, opponents of olfactory imagery argue imagery for odors is driven by semantic representations (e.g., Crowder & Schab, 1995; Herz, 2000), in line with the propositional account of imagery (Pylyshyn, 1973). On the other, proponents of olfactory imagery argue olfactory imagery involves percept-like processes (Cain & Algom, 1997; Stevenson & Case, 2005), similar to a perceptual representational account of imagery (Kosslyn et al., 1995). One of the underlying reasons for the lack of clarity pertaining to odor imagery is the considerable individual differences reported in odor imagery ability (Arshamian, 2013; Arshamian & Larsson, 2014). Some people report they are not able to maintain an olfactory image at all, while others have less difficulty in generating these images (Delon-Martin et al., 2013; Plailly, Delon-Martin, & Royet, 2012). This variation could be interpreted as evidence for the non-existence of olfactory imagery (cf. Royet, Delon-Martin, et al., 2013). In contrast, this inter-individual variation also opens up the possibility to explore the mechanisms underlying why some people are good at olfactory imagery, and others are not.

Two decades ago, Crowder and Schab (1995) reviewed the available literature, and tested experimentally whether imagining an odor had an effect on the sensitivity for that odor. Their conclusion was that: "people cannot really generate and maintain a true olfactory image, their intuitions to the contrary notwithstanding." (Crowder & Schab, 1995, p. 104). Recent studies, however, have suggested olfactory imagery *does* exist, and that it resembles imagery in other sensory modalities (for a review see Arshamian & Larsson, 2014). As with imagery in other modalities, some people report vivid olfactory imagery during dreams and hallucinations (Stevenson & Case, 2004, 2005). In addition, imagined odors are rated similarly to real odors on intensity, pleasantness and similarity (Bensafi et al., 2014; Carrasco & Ridout, 1993); they can interfere with perception of other odors (Djordjevic, Zatorre, Petrides, & Jones-Gotman, 2004); and—contrary to the findings of Crowder and Schab (1995)—can improve sensitivity to the same odor (Tempere, Hamtat, Bougeant, de Revel, & Sicard, 2014), or related taste (Djordjevic, Zatorre, & Jones-Gotman, 2004). Finally, brain-imaging studies show that mental imagery of odors activates similar areas to the perception of a real odor (i.e., the piriform cortex) (Bensafi, Sobel, & Khan, 2007; Djordjevic, Zatorre, Petrides, Boyle, & Jones-Gotman, 2005). Taken together, these studies suggest that odor imagery exists.

Some aspects of odor imagery, however, set it apart from mental imagery in other modalities. As outlined above, compared to imagery in other senses, there appears to be more individual variation in odor imagery than imagery in other modalities (Arshamian & Larsson, 2014; Köster, Stelt, et al., 2014). Semantic knowledge, perceptual experience, and olfactory interest are all thought to have more influence on imagery for odors than it has on imagery in other modalities (Arshamian & Larsson, 2014). In addition, the self-reported frequency of mental imagery differs across sensory modalities (H. T. Lawless, 1997; Lindauer, 1969), with vision being imagined most often, and smell and taste least often. Similarly, when the senses are pitted against each other using vividness of imagery questionnaires, people report the most vivid imagery for vision, followed by sound and touch, with smell and taste imagery being the least vivid (Andrade, May, Deeprose, Baugh, & Ganis, 2014).

This order coincides with the place smell and taste usually receive in in the hierarchy of the senses in Western philosophy (e.g., Plato, as cited in Vroon, Amerongen, &

Vries, 1997; or Descartes, as cited in Wook Hwang, 2008) and language (Levinson & Majid, 2014; Viberg, 1984). Recently, the universality of this hierarchy has been questioned, as cultural experiences can shape the relative importance of the senses (Majid & Burenhult, 2014; Majid & Levinson, 2011; O'Meara & Majid, 2016; San Roque et al., 2015; Wnuk & Majid, 2014). Early reports suggest the relative vividness of imagery for the different senses can differ across cultures. Marsella and Quijano (1974) found participants from the Philippines reported more vivid odor imagery than Americans, relative to other modalities. This suggests that particular experiences can influence mental imagery, which raises the question of imagery in expertise.

Previous studies show expert abacus users, for whom visual imagery is pertinent, are better at visually imagining pictures and words (Hatta & Miyazaki, 1989). Likewise, professional athletes have better motor imagery (R. Weinberg, 2008), and expert musicians were found to be more consistent in recalling musical pieces from memory, a process for which they engage in auditory imagery (Herholz, Lappe, Knief, & Pantev, 2008). Similarly, there is evidence expertise can improve olfactory imagery. Expert perfumers report more ease in evoking odor images than novices (Royet, Delon-Martin, et al., 2013), although their reported vividness for visual imagery is the same (Gilbert et al., 1998). There is also evidence of functional changes in brain regions involved in odor imagery in expert perfumers compared to novices (Plailly et al., 2012). Similarly, Bensafi and colleagues found that chefs were faster to respond when imagining the similarities between fruit smells, while musicians were faster when asked to imagine the similarities between two types of musical instrument timbre (Bensafi et al., 2017; Bensafi, Tillmann, Poncelet, Przybylski, & Rouby, 2013). These studies suggest experts are better than novices in odor imagery, but the extent of this difference is unknown. To our knowledge, no study has established whether experts are also better at flavor imagery.

Imagery of odors and flavors is important for wine experts. Flavor—the multisensory experience of what is perceived in the mouth—is closely related to smell (Small, Jones-Gotman, Zatorre, Petrides, & Evans, 1997; Spence, 2015b), and uses overlapping physiological mechanisms (Shepherd, 2006). Wine experts' ability to describe a wine might in part hinge on their ability to mentally compare a given wine with prototypical wines in terms of color, smell and flavor. In addition, similar to chefs creating a novel culinary dish (Bensafi, Fournel, Joussain, Poncelet, Przybylski, Rouby & Tillmann, 2017), a successful novel wine-food pairing may require experts to imagine the combination of flavors not physically present. Experts have more perceptual experience with smells and flavors, possibly affecting their imagery ability too. In addition, their experience engaging in mental imagery, as stated above, might improve the vividness of imagery too.

Another possibility is that olfactory imagery is mediated by language. Language is often necessary to initiate imagery, for example simply when reading imagery task instructions, or when reading a recipe of a meal to decide if it is worth making it. As the link between smells and language is poor in novices, they may not be able to engage in proper olfactory imagery either (Stevenson & Case, 2005a). As wine experts are better at describing both the smell and flavor of wines (Chapter 3), their imagery ability might improve in parallel, as the link between olfaction and language is reinforced.

A second related question is to what extent experts' superior abilities generalize. While experts are often better than novices at various cognitive tasks, this is often restricted to the domain of expertise (Kimball & Holyoak, 2000). So expert chess players have better memory for meaningful chess layouts than beginning chess players, but not for random chess layouts (Gobet & Simon, 1996). Likewise, wine experts have better memory for wines, but not for everyday smells like garlic and pineapple (Zucco et al., 2011). Moreover, in Chapter 4, I showed wine experts' better memory did not even generalize to wine-related smells, but was restricted to wines alone. Similar effects are found in language. Wine experts are more consistent than novices when describing the odor of wines, but not when describing the odor of coffees or everyday smells and basic tastes (Chapter 3), further suggesting any effects of expertise are rather restricted. Based on these findings, it was predicted that the heightened ability to imagine smells and flavors in wine experts would be restricted too.

In the present study we investigated whether wine experts are better at imagining the color, odor and flavor of wines. In order to become a wine expert, people practice their verbal abilities to describe odors (see Introduction and Chapter 3), they engage in perceptual training to detect particular aromas in wine, and also train combining wines with food (cf. Bensafi et al., 2017). Vision has previously been proposed as a particularly important sensory modality for wine (Ballester, Abdi, Langlois, Peyron, & Valentin, 2009; Morrot et al., 2001), and is usually the modality in which the most vivid imagery is reported (e.g., Andrade et al., 2014; Gilbert et al., 1998; Marsella & Quijano, 1974). In a specialized domain such as wine, visual imagery for the color of wine might be further boosted. Nevertheless, the relative effect of expertise is expected to be the smallest for the visual modality, as, based on previous literature, (Andrade et al., 2014; Gilbert et al., 1998; Marsella & Quijano, 1974), novices are expected to report the most vivid imagery for visual imagery, and the least vivid imagery for smell and flavor. Wine experts are expected to have more vivid imagery for wine in all sensory modalities than novices. Moreover, it was hypothesized that the effect of expertise would be restricted to stimuli from the expert domain, i.e., to wine, and we expect no difference between experts and novices in general odor imagery.

To test these hypotheses, a questionnaire targeting wine imagery in the visual, olfactory and flavor modality, i.e. the Vividness of Wine Imagery Questionnaire (VWIQ), was constructed and validated (Study 1). In a follow-up study, wine experts and novices completed this newly constructed questionnaire (Study 2) to test the first hypothesis, that wine experts are better at imagining perceptual aspects of wine. To test the second hypothesis, that this heightened ability is domain-specific and does not transfer, participants in Study 2 also completed a questionnaire assessing general olfactory imagery ability, i.e., the Vividness of Olfactory Imagery Questionnaire (VOIQ; Gilbert et al., 1998). This enabled us to compare wine-specific olfactory imagery to general olfactory imagery in experts and novices.

4.3 QUESTIONNAIRE CONSTRUCTION

The Vividness of Wine Imagery Questionnaire (VWIQ) was constructed using the same principles and structure as two well-validated mental imagery questionnaires: the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) and the Vividness of Olfactory Imagery Questionnaire (VOIQ; Gilbert et al., 1998). The VVIQ and VOIQ contain different scenarios in which the participant is asked to imagine specific visual (VVIQ) or olfactory (VOIQ) aspects of a scene. For example, in the VVIQ, the participant is asked: "*Think of the front of a shop which you often go to. Consider the picture that comes before your mind's eye*", or in the VOIQ, "*Think of an outdoor barbeque. Consider the smells that occur*". In the VWIQ, participants were asked to imagine a scene involving wine, e.g., "*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*". The participant is then asked to imagine the appearance ("*The color of the wine as the sun is reflected in your glass*"), sound ("*The sound of the bubbles as the wine is being poured*"), odor ("*The smell of the wine as you place your nose in the glass*"), and flavor ("*The taste of the wine when you have your first sip*") of the wine in that scene. Similar to the VVIQ and VOIQ, in the VWIQ the vividness of imagery was rated on 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 vivid as the real situation*"[11] . Participants answered the questions by circling the option they thought fit best with the vividness of the imagined scene.

Six different scenes were constructed in which wine plays an important role, and were evocative for all sensory modalities (i.e., vision, sound, smell and taste) involved. The scenes were set in a vineyard, a restaurant, a bistro, a relaxing night at home, and two wine tastings. The subsequent vividness questions in each scenario focused on the color (e.g., the color of the wine, the sun reflected in the glass), sound (e.g., the sound of the wine pouring, glasses clinking together), odor (e.g., the smell of the wine) and flavor (e.g., the taste of the wine). Across all six scenarios each sensory modality (i.e., vision, sound, smell, and taste) was assessed using four questions, resulting in a total of 24 questions. Each sensory

[11] In the VOIQ, 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"*

domain had a resulting minimum score of 6 and a maximum score of 30. The full questionnaire has a minimum score of 24, and a maximum score of 120. This questionnaire Version 1 can be found in Appendix D. To test the validity of the newly made questionnaire, an initial online validation study was undertaken.

4.4 FIRST QUESTIONNAIRE VALIDATION STUDY

4.4.1 METHODS

4.4.1.1 Participants

One hundred participants were recruited through Amazon's Mechanical Turk. Participants gave their informed consent by clicking 'accept' to a standardized consent form before the start of the questionnaire. Seven participants were rejected and replaced based on their fixed response patterns, completing all questionnaires in less than 6 minutes, or taking the survey twice. Participants were paid $1.80 for completion of the survey, which took on average 13 minutes to complete.

The sample consisted of participants (age M = 38.9, SD = 11.3; 34 women) with mixed educational backgrounds: all participants at least completed their high-school education. All participants were fluent in English. Ninety participants were native speakers of English, other native languages were Tamil, Hindi, and Spanish.

Participants were informed that it was possible to take part in a follow-up study, for which they could earn a bonus of $1. This follow up questionnaire consisted only of the newly developed VWIQ, and took on average 3 minutes to complete. Fifty-nine participants completed this follow-up questionnaire.

4.4.1.2 Procedure

Participants were asked to complete the VWIQ, and additionally completed four other questionnaires: the VOIQ, measuring vividness of olfactory imagery; the VVIQ, measuring vividness of visual imagery; the Plymouth sensory imagery questionnaire (PSI-Q;

Andrade, May, Deeprose, Baugh, & Ganis, 2014), measuring vividness of imagery in 7 sensory domains; i.e., vision, sound, touch, taste, smell, bodily sensations, and feelings; and a wine knowledge test (WKT; see Chapter 3, section 3.3.2 or Appendix B). Participants also reported demographic information, including age, gender, their native language and other fluent languages spoken, and average wine consumption in glasses per week.

4.4.2 RESULTS

After identifying outliers (= $M \pm 2$ SD) on the VWIQ total scores, five participants were removed. The remaining full sample was n = 95, and follow-up sample n = 57. The participants in the sample were on average 39 years old (SD = 11.35). Most (n=93) participants were native speakers of English, the remaining two participants were native in Tamil and Hindi.

To validate the VWIQ, a principal component analysis (PCA), with oblique rotation to maximize the difference between the different components, was conducted to investigate whether the structure of imagery ratings reflected the four sensory modalities. Correlation analyses with the VVIQ, VOIQ and PSI-Q were conducted to test construct validity, and additionally, test-retest reliability and internal consistency were analyzed.

The sample size was adequate (following Field, 2009), based on the Kaiser-Meyer-Olkin test (KMO = .903), Anti-Image correlation matrix (values ranging .829-.941) and communalities of the different factor loadings (with minimal ranges .596-.886 for vision, .533-.827 for sound). The scree plot and eigen-values indicated four factors, explaining a total of 70.8% of the variance. The first factor had strong loadings from both odor and flavor questions, and explained 50.5% of the variance. The sound questions loaded on the second factor, explaining a further 9.2% of the variance. The questions about vision loaded highly on the third factor, explaining 6.1% of the variance. Finally, the questions on smell loaded negatively on the fourth factor, explaining a further 4.2% of the variance. It is interesting to note that smell and flavor both loaded on the first factor, with a separate factor for smell.

Internal consistency (Cronbach's α and retest reliability) of the different subscales and overall scale was also analyzed. Retest reliability was operationalized in three different ways: typical error (i.e., the difference in ratings given on two test occasions), the change from the mean (i.e., whether the two test occasions have significantly different means), and the correlations between the two test occasions.

Internal consistency was high to very high (ranging from $\alpha = .839$ to $\alpha = .960$). Retest reliability analysis also showed relatively little change between the two test sessions (expressed as *typical error*). The two test occasions also correlated highly with each other. The change from mean analysis showed that only the sound subscale differed significantly on the two test occasions: people reported slightly lower imagery for sounds on the second occasion than on the first (see Table 4.1).

	Cronbach's α	Typical error	Change from mean	Retest correlations
	[n = 95]	M (SD) [n = 57]	t (p) [n = 57]	r (p) [n = 57]
VWIQ TOTAL	.954	0.579 (8.93)	0.490 (.626)	.879 (< 0.001)
VWIQ SOUND	.841	-0.825 (3.02)	-2.06 (.044)*	.804 (< 0.001)
VWIQ VISION	.839	0.842 (3.25)	1.96 (.055)	.751 (< 0.001)
VWIQ SMELL	.931	0.298 (3.06)	0.735 (.466)	.866 (< 0.001)
VWIQ FLAVOR	.960	0.263 (3.5)	0.566 (.573)	.834 (< 0.001)

Table 4.1 Internal consistency and retest reliability of the VWIQ. Typical error is measured as the difference between the two means on both occasions, with standard deviations in brackets. Change from mean is measured using t-tests, with p-values reported in brackets. Retest correlations are reported as Pearson's r, with p-values reported in brackets.

Inter-item correlations between the questions of the different modality subscales were medium (.3) to very high (>.8). Only one item in the sound subscale (question 5; see Appendix D) correlated unsatisfactorily ($r = .243$) with one other sound item (question 1; see Appendix D). The analysis showed the entire scale and all subscales had good internal consistency. The internal consistency and reliability analyses were then conducted again for each scene separately in the VWIQ, to check that all questions fit well within the different scenarios. The internal consistency of all scenes was reasonable (>.7), but the analysis showed Cronbach's α would improve if the questions on sound would be removed (for the different scenes, the increase of Cronbach's α on average would be α = .012), while removal of the other questions would lead to a decrease in internal consistency.

To further test construct validity, the VWIQ subscales were correlated with questionnaires on related concepts, i.e. the VOIQ, VVIQ, PSI-Q, and WKT. Data for all scales was relatively normally distributed, except for wine consumption. This analysis showed the wine imagery construct was related to visual imagery (VVIQ), olfactory imagery (VOIQ) and imagery in multiple modalities (PSI-Q). In addition, vividness of wine imagery in all modalities was related to wine knowledge, except for imagery of the sound of wine (see Table 4.2).

4.4.3 Summary.

Overall, the validation of the VWIQ indicated good internal consistency, reliability and construct validity on all subscales. However, the sound subscale revealed deviant internal consistency and construct validity compared to the other scales. As a solution to these issues, the questionnaire was changed and validated again.

	VWIQ overall	VWIQ sound	VWIQ vision	VWIQ smell	VWIQ flavor
VOIQ	.569**	.434**	.394**	.556**	.532**
VVIQ	.466**	.466**	.421**	.411**	.350**
PSI-Q	.553**	.473**	.433**	.353**	.487**
PSI-VISION	.544**	.440**	.470**	.465**	.486**
PSI-SOUND	.286**	.293**	.225*	.240*	.229*
PSI-SMELL	.547**	.444**	.405**	.515**	.490**
PSI-TASTE	.657**	.556**	.539**	.589**	.564**
WKT	.341**	.146	.284**	.346**	.361**
Wine consumption	.240*	.122	.189	.193	.295**

Table 4.2 Pearson correlation coefficients between the VWIQ and related concepts (n = 95). * means correlation is significant at the .05 level; ** means correlation is significant at the .001 level (all two tailed).

4.5 SECOND QUESTIONNAIRE VALIDATION STUDY

To reconcile the issues with Version 1, the order of the different scenes was changed. In Version 1, the order of the questions for each modality was not the same for each scene, possibly causing confusion. In Version 2, the questions always followed the same pattern (vision – sound – smell – flavor). In addition, the scenes and questions with lowest reliability and internal consistency were reworded. The resulting questionnaire was validated again, using the same validation paradigm. This Version 2 of the questionnaire can be found in Appendix E.

4.5.1 METHODS

One hundred participants were again recruited through Amazon's Mechanical Turk. Participant inclusion and exclusion followed the same criteria as the first study. The sample consisted of participants (age M = 40.9, SD = 10.8; 55 women) with mixed educational backgrounds: all participants at least finished high-school, and all except for one participant were native speakers of English. Two validation questions were included in the VWIQ (*"Please answer '4 – clear and reasonably vivid' to Question 2"*) and in the WKT (*"The color of red wine is usually? A. White, B. Red; C. Rosé; D. I don't know"*) to further confirm that participants attentively read all questions. Again, participants were invited to complete a follow-up questionnaire, consisting of the VWIQ, 2 days after they completed the main questionnaire. Fifty-five participants completed this follow-up questionnaire. Three participants from the follow-up questionnaire were rejected based on incorrect responses to the two validation questions, or showing clear response patterns in the whole survey.

4.5.2 RESULTS

Outlier analysis (M ± 3 SD) identified one outlier on several of the questionnaires. This participant was subsequently removed from further analyses. This remaining 98 participants with 52 completing the follow-up questionnaire. To validate Version 2 of the VWIQ, PCA with oblique rotation was once again conducted, with additional analyses to measure internal consistency and construct validity.

As in the first validation study, the sample size was sufficient, following the Kaiser-Meyer-Olkin test of sampling adequacy (KMO = .917), anti-image correlation matrix values (range = .882-.947) and communalities of the factor loadings (all > .6). The PCA showed four factors (following the scree plot, factor loadings, and eigenvalues), which together explained 76.8% of the variance. As in Version 1, questions of smell and flavor loaded strongly on the first factor (explained variance: 58.0%), vision loaded mainly on the second factor (explained variance: 8.7%), sound on the third factor (explained variance: 5.6%), while sound and both vision loaded on the fourth factor (explained variance: 4.5%).

Internal consistency, i.e., Cronbach's α and retest reliability showed internal consistency and reliability was high throughout (see Table 4.3). The questionnaire subscales again correlated highly to questionnaires measuring other types of imagery, but there was no correlation between the WKT or wine consumption and the VWIQ (see Table 4.4). The sound subscale again attested the lowest correlations.

	Cronbach's α	Typical error	Change from mean	Retest correlations
	[n = 95]	M (SD) [n = 57]	t (p) [n = 57]	r (p) [n = 57]
VWIQ TOTAL	.967	-1.17 (9.0)	-.94 (.353)	.889 (< .001)
VWIQ SOUND	.872	-1.71 (3.3)	-3.7 (<.001)*	.778 (< .001)
VWIQ VISION	.887	-.02 (3.3)	-.04 (.966)	.787 (< .001)
VWIQ SMELL	.944	.37 (3.3)	.79 (.434)	.829 (< .001)
VWIQ FLAVOR	.961	.19 (3.0)	.46 (.649)	.863 (< .001)

Table 4.3 **internal consistency and retest reliability of the VWIQ**

	VWIQ overall	VWIQ sound	VWIQ vision	VWIQ smell	VWIQ flavor
VOIQ	.527**	.521**	.500**	.444**	.433**
VVIQ	.377**	.390**	.413**	.290**	.274**
PSI-Q full	.547**	.506**	.531**	.452**	.478**
PSI-VISION	.511**	.481**	.520**	.423**	.419**
PSI-SOUND	.334**	.319**	.338**	.246*	.299**
PSI-SMELL	.504**	.430**	.457**	.458**	.460**
PSI-TASTE	.506**	.472**	.504**	.434**	.414**
WKT	.128	.059	.135	.157	.109
Wine consumption	.078	-.058	.051	.095	.174

Table 4.4 Pearson correlation coefficients between the VWIQ without sound question 1 and 6, and related concepts (n = 99). * means correlation is significant at the .05 level; ** means correlation is significant at the .001 level (all two tailed).

4.5.3 SUMMARY

It can be concluded that Version 2 of the VWIQ is better than Version 1 for the following five reasons: (I) the KMO value was higher, suggesting a better fit between the sample and the questionnaire (.923 versus .903); (II) the four factors from the PCA explained more variance in Version 2 (77.7% versus 70.1% in Version 1); (III) Cronbach's alpha values and the retest correlations, measuring internal consistency, were higher for the full and sub-scales; (IV) the reliability of the items showed internal consistency would not improve if any of the items were to be deleted; and (V) the questionnaire correlated highly with the other questionnaires, for all subscales. This indicates that the VWIQ successfully measures the same construct (mental imagery) as the previous questionnaires.

However, in Version 1, the questions for each modality loaded more uniquely on each of the factors. In Version 1, there was less overlap between the four factors, meaning the modalities were better distinguished. In addition, Version 2 did not correlate with the wine questionnaires, i.e., wine knowledge and wine consumption, in contrast to Version 1, where the subscales for smell and taste did correlate to wine knowledge and wine consumption. Moreover, in Version 2, the factors for vision and sound showed more overlap than in the first version. In addition, the sound subscale showed sub-optimal internal consistency. This was true in both versions, despite best attempts to optimize the sound questions. This suggests some of the concerns that were present for Version 1, that sound is not an appropriate aspect of wine imagery, still exist in the revised Version 2.

Sound may not be related in an important way to the multisensory experience of wine, and this could explain the differences in internal consistency and construct validity between the sound subscale and other subscales. Importantly, when experts evaluate wine, they do not typically include auditory aspects of the wine, but discuss what they see, smell and taste. Based on the instability of the sound subscale, and the responses gleaned from the two versions of the questionnaire, sound questions were removed from the final version of the questionnaire. The final questionnaire therefore contained the subscales for vision, taste, and odor, which had proved to be reliable across both validations. So, the final version of the VWIQ contained 6 scenarios, each with 3 rating questions covering vision, smell and flavor (see Table 4.5 for the final version of the VWIQ).

Instructions: 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
Scene 1	**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

Scene 2	**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
Scene 3	**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
Scene 4	**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
Scene 5	**You are in a bistro. You are having a light lunch, and you have selected a glass of 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
Scene 6	**Imagine you are having a relaxing night at home, and decide to have you are having 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

Table 4.5 Final version of the VWIQ; rating scales are omitted for brevity. In the actual questionnaire, the word "scene" and scene numbers were omitted.

4.6 COMPARISON OF WINE EXPERTS AND NOVICES

It was hypothesized that wine experts would differ in their vividness of imagery for wines compared to novices. If wine experts' imagery is domain-specific, their imagery for general odors should not differ from novices. On the other hand, if it is domain-general, experts and novices are also predicted to differ on the general olfactory imagery questionnaire.

To test this, wine experts and novices completed the newly created VWIQ, in addition to the VOIQ and the WKT.

4.6.1 METHODS

4.6.1.1 Participants

In total, 146 Dutch participants participated in this study. Sixty-nine participants were wine experts; i.e., they were either experienced professionals in the field of wine (e.g., vinologists, certificated sommeliers), or amateur connoisseurs with an attested interest in wine (e.g., had an extensive wine collection or a vineyard). However, after their participation, it turned out three participants did not meet these criteria, and were excluded, leaving 66 participants (20 female, mean age 48.7, age range 21-70). Seventy-seven novices participated too, of which 66 were matched to the expert participants in age and gender (20 female, mean age 49.0, age range 24-70) and included in the analyses.

4.6.1.2 Materials

The established odor imagery questionnaire (VOIQ; Gilbert et al., 1998), the newly constructed VWIQ, and a test of wine knowledge—the Wine Knowledge Test (WKT, see Chapter 3, section 3.3.2)—were used. All questionnaires were translated to Dutch checked through back-translation to English.

4.6.1.3 Procedure

Written consent was obtained before the experiment began. Participants completed the two questionnaires during a break of a different experiment (see Chapter 5), also involving wine. Participants were instructed to imagine each scenario and rate the vividness of the mental images. The questionnaires were completed using paper and pencil, and were always completed in the same order: i.e., the VWIQ first, followed by the VOIQ and WKT. This order was chosen to minimize potential order effects.

4.6.2 RESULTS

4.6.2.1 Wine knowledge

First, the wine knowledge questionnaire was analyzed to independently confirm the levels of wine expertise in both participant groups. Data was severely skewed in both participant samples, violating the assumptions of a *t*-test. Instead, a non-parametric Mann-Whitney-U test was performed. This analysis confirmed experts (M = 13.6, SD = 1.2) had significantly higher wine knowledge scores than novices (M = 7.9, SD = 2.2), U = 33.0, $p < 0.001$, r = 0.85.

4.6.2.2 Multimodal wine imagery

The VWIQ questions were summed separately for each perceptual modality: wine color (VWIQ-C), wine smell (VWIQ-S), and wine flavor (VWIQ-F). The VOIQ had a single total score since it only assessed smell. Total scores were divided by the number of questions on each (sub-)scale for comparability.

To test whether experts were better than novices in imagining the different properties of wine, the scores on the subscales of the VWIQ were compared between groups using a mixed ANOVA, with modality (three levels: VWIQ-C, VWIQ-S, and VWIQ-F) as a within-participants factor and expertise (two levels: wine experts and novices) as a between-participants factor. Corrections in the degrees of freedom for sphericity assumption violations, as well as Bonferroni corrections for multiple comparisons, were applied when appropriate.

Wine experts reported more vivid imagery for wines than novices overall, $F(1, 130) = 28.9$, $p < .001$, $\eta_p^2 = .18$. In addition, there was a main effect of modality, $F(1.7, 222.3) = 15.0$, $p < .001$, $\eta_p^2 = .10$. But this main effect must be interpreted in the context of a significant interaction between modality and expertise, $F(1.7, 222.3) = 5.2$, $p = .009$, $\eta_p^2 = .04$. Pairwise comparisons showed that for novices, visual imagery (M = 3.6, SD = .62) was more vivid than flavor (M = 3.3, SD = .67), $p = .002$, d = .59, and smell imagery (M = 3.2, SD = .73), $p < .001$, d = .46; and flavor imagery, in turn, was more vivid than smell imagery, p

= .04, d = .14. In contrast, wine experts showed no difference in vividness of imagery across modalities, $ps > .05$. When comparing the two participant groups on each modality, a similar picture appeared. For each modality, novices had significantly less vivid imagery than experts (visual imagery: p = .001, d = .59; smell imagery: $p < .001$, d = 1.14; flavor imagery: $p < .001$, d = .86). As hypothesized, the relative difference (Cohen's d) between experts and novices in imagery vividness was least for visual imagery (see Figure 4.1a).

In sum, vividness of imagery across sensory modalities in novices followed the previously reported hierarchy of sensory imagery in Western participants (Andrade et al., 2014; H. T. Lawless, 1997). However, with wine expertise this asymmetry across sensory modalities disappeared. Whereas novices reported more vivid imagery for visual aspects of wine (i.e., the color), than for the flavor or smell—modalities that are traditionally regarded as difficult to imagine—wine experts reported equally vivid imagery for all modalities. That is, unlike novices, experts had equally vivid imagery of the smell or flavor of a wine, as they did for its color.

4.6.2.3 Domain-specific imagery

The previous analysis showed experts reported more vivid imagery for wines than novices. To test whether the imagery ability of experts generalized to olfaction in general, the scores on the VWIQ-S scale and the VOIQ were compared using a mixed ANOVA, with questionnaire (two levels: VOIQ and VWIQ-S) as a within-participants factor and expertise (two levels: wine experts and novices) as a between-participants factor.

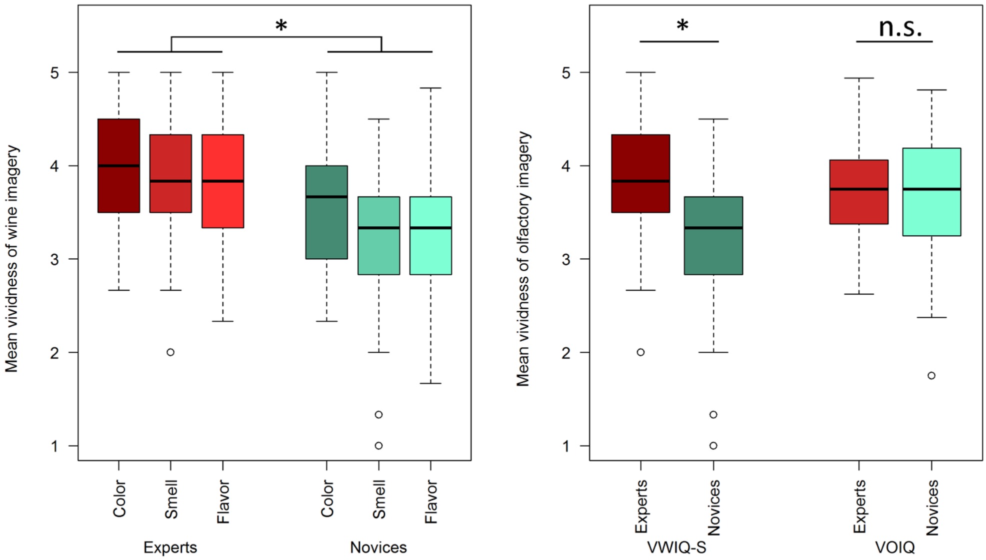


Figure 4.1a (on the left): Mean vividness ratings for the color, smell and flavor of wine, as measured by the VWIQ. * $p < 0.001$. **Figure 4.1b (on the right)**: Mean vividness ratings of olfactory imagery for wine smells on left (VWIQ-S) and everyday smells on the right (measured using VOIQ). * $p < 0.001$.

The analysis showed a main effect of expertise, $F(1, 130) = 16.1$, $p < .001$, $\eta_p^2 = .11$ and a main effect of questionnaire, $F(1, 130) = 19.6$, $p < .001$, $\eta_p^2 = .13$. More importantly, the analysis revealed a significant interaction between questionnaire and expertise, $F(1, 130) = 28.4$, $p < .001$, $\eta_p^2 = .18$. Pairwise comparisons showed that wine experts reported significantly more vivid imagery for smells of wines (VWIQ-S) ($M = 3.8$, $SD = .65$) than novices ($M = 3.2$, $SD = .73$), $p < .001$, $d = 1.0$ (see Figure 4.1b). In contrast, wine experts ($M = 3.8$, $SD = .55$) and novices ($M = 3.7$, $SD = .65$) did not differ in vividness of general olfactory imagery (VOIQ), $p = .245$, $d = .16$. So, wine experts' olfactory imagery is only superior for wines, not all odors.

Taken together, wine experts had more vivid imagery overall for wines than novices—in vision, odor and flavor. However, their imagery was no different to novices for everyday odors.

4.7 DISCUSSION

Wine experts have enhanced imagery for the color, smell and flavor of wines compared to novices. In contrast, experts and novices reported similar vividness for the imagery of smells in general. While previous studies have found enhanced odor imagery with olfactory expertise (e.g., Gilbert, Couch, & Kemp, 2008, Bensafi et al., 2013), we found this enhanced imagery is domain-specific. This is in line with experts in other domains that demonstrate domain-specific enhanced cognitive performance. For example, chess experts have a better memory for the layouts of chess games than novices, but not for non-meaningful chess layouts (Gobet & Simon, 1996; Vicente & de Groot, 1990). The present domain-specificity of wine imagery mirrors the domain-specificity of wine expertise found elsewhere; i.e., in language (Chapter 3), and memory (Chapter 4; Zucco et al., 2011). Therefore, we conclude the effect of expertise on cognition has limited transfer across domains (Kimball & Holyoak, 2000).

The results are also in line with other findings regarding imagery in experts. For example, trained abacus users were found to have better visual imagery compared to novices (Hatta & Miyazaki, 1989), auditory cortical areas are recruited in trained musicians when imagining a song in the same way as when singing a song (Schürmann, Raij, Fujiki, & Hari, 2002; Zatorre & Halpern, 2005), and professional musicians appear to have a superior ability to imagine songs compared to novices (Herholz et al., 2008; Kleber, Birbaumer, Veit, Trevorrow, & Lotze, 2007). Using diverse methodologies, experts from various domains, such as chess (e.g., Milojkovic, 1982), sports (e.g., Arvinen-Barrow, Weigand, Thomas, Hemmings, & Walley, 2007), dance (e.g., Poon & Rodgers, 2000), and transportation (Durso & Dattel, 2006), have also shown to be better at imagery in these domains than novices. The current study adds to this literature with the finding that domain expertise can also improve vividness of smell and flavor imagery.

In the hierarchy of sensory imagery, vision is found to be the dominant sense (Andrade et al., 2014; Lawless, 1997), and our results also support this for non-experts. Novices reported the highest vividness for the visual imagery of wine, followed by flavor imagery and smell imagery last. In contrast, wine experts reported no dominant modality, with equally high vividness for the color, smell and flavor of wines. This suggests mental imagery of the senses is malleable, and that perceptual modalities can become more important with experience (cf. Majid, Speed, Croijmans, & Arshamian, 2017).

Why do some people become wine experts, or olfaction experts more broadly, while other people would often report to be "bad at smelling"? One possibility is that some people are self-selecting to become a wine expert based on sensory ability, e.g., a brain more attuned to smells, or a particularly sensitive palate (Hayes & Pickering, 2011). For example, some people might be predisposed to become wine experts because genetically they are more sensitive to particular odors and tastes (cf. Bartoshuk, 1993; Hayes & Pickering, 2011). Similarly, some people might be predisposed to better imagery, meaning these people are particularly good candidates to become wine experts. Given the present results, these explanations of wine expertise are unlikely, as the results show a domain-specific effect of expertise for wine imagery, and not for olfactory imagery in general. Instead, we propose that olfactory cognition changes through specific experience.

There are at least three possible mechanisms by which wine expertise could lead to improvement in imagery ability: through perceptual experience, semantic knowledge, and imagery training. First, mere exposure to perceptual stimuli, such as the smell and flavor of wine, might improve the ability to imagine these (cf. Arshamian & Larsson, 2014). Perceptual learning may be involved in this, as perceptual learning may make particular aspects of a stimulus more salient, shaping its representation (Goldstone, 1998; R. O. Walk, 1966). This improvement might be restricted to stimuli to which people are frequently exposed, and might not transfer to other stimuli in the same perceptual modality, e.g., general smells in the case of wine experts.

A second possibility is that imagery is rooted in semantic associations. For novices, there is a weak link between language and olfaction (Cain, 1979; Herz, 2000). Wine experts are more adept at describing wines (Chapter 2 and 3; Solomon, 1990), and an imagery effect might be attributed to improved semantic associations, as suggested by Crowder and Schab (1995) and Stevenson and colleagues (2007). For wine experts, wines are easier to name, and may thus also give rise to more vivid images, as the semantic associations are strengthened. However, this account does not readily explain the findings that odor imagery training improves odor sensitivity (Tempere et al., 2014), or that odor imagery can interfere with perception of other odors (Djordjevic, Zatorre, Petrides, et al., 2004). Previous findings also suggest wine experts do not store memories of wines by their verbal codes (Chapter 4), which makes it also probable that bringing wines to consciousness, i.e., by imagery, is not achieved through verbal codes. Nevertheless, more refined semantic representations may still influence the ability to imagine wines.

Finally, better imagery may arise through specific training (cf. Bensafi et al., 2013). Wine experts work with wines on a daily basis and imagery of smells and flavors plays an important role in wine expertise. Wine experts often imagine wine-food pairings (Harrington, 2005), and for novel combinations they may imagine how the flavors and textures of food match those of a wine. Through their engagement with smells and flavors, wine experts might encode odor and flavor memory representations better, leading to improved imagery (cf. Arshamian & Larsson, 2014). In novices, the difficulty of evoking odor imagery may arise from a weak link between language and olfaction, but for experts, perceptual representations of odors are strengthened, bypassing this weak link (cf. Stevenson & Case, 2005a, p. 261). The need to imagine wines as part of wine experts' activities could lead to strengthened perceptual representations, and improvements in the ability to evoke wine imagery. Future studies, in which novices and experts are trained using different learning paradigms (e.g., through language, through imagery or through perceptual experience) might disentangle the role of perceptual experience, linguistic abilities, and specific imagery.

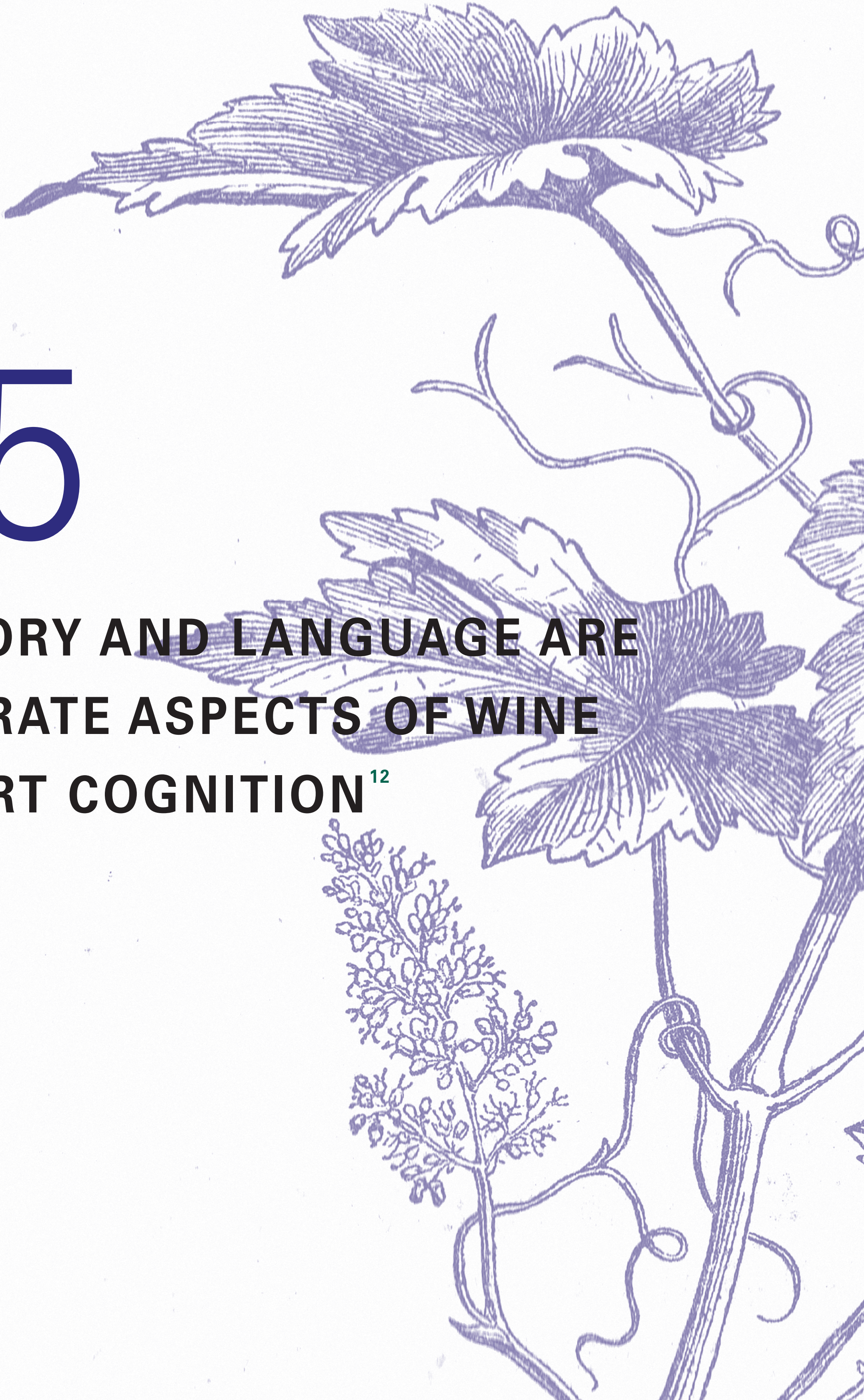
Previous work suggests imagery training can improve sensitivity for particular odors (Tempere et al., 2014). Yet, in most formal wine education, imagery is given no explicit role in the curricula. This stands in stark contrast to imagery in other types of expertise; for example, professional sports, where motor imagery is used to improve performance

(Weinberg, 2008). With a better understanding of wine imagery, it could be deployed as a tool for individuals learning to distinguish and describe wines, and to combine wine and food, thus improving the efficacy of wine education. A questionnaire measuring imagery, like the VWIQ, could be used as an easy starting point to integrate imagery in smell and flavor curricula. In addition, as the VWIQ combines imagery for different senses in a single scene, it provides an interesting starting point for comparing imagery in multiple modalities; for example, what the relationship might be between the different senses in flavor imagery (cf. Auvray & Spence, 2008; Small & Prescott, 2005; Smith, 2012; Spence, 2015b).

We have shown that wine expertise enhances the vividness of imagery of wine. However, in line with effects found for memory (Chapter 5; Zucco et al., 2011) and language (Chapter 3), the superior imagery wine experts have does not extend beyond their domain of expertise. To conclude, there is considerable plasticity in mental imagery—and cognition in general—which demonstrates the importance of considering human behavior in its diverse contexts (cf. Speed, Wnuk, & Majid, 2017). Moreover, a focus on imagery lends itself to interesting possibilities for future research and application within wine education. Experience affect imagery ability in particular, and cognition in general, but the specifics of the experience are important.

5

MEMORY AND LANGUAGE ARE SEPARATE ASPECTS OF WINE EXPERT COGNITION[12]



5.1 ABSTRACT

Experts have better memory for stimuli from their expertise domain. Olfactory expertise, however, is still relatively under-explored. The present study addressed three questions: whether wine experts have better memory for wines, whether this better memory is domain-specific or more general, and whether any memory advantage can be explained by language. In two experiments, memory for wines, wine-related odors and common odors was tested in wine experts and novices. The use of language was manipulated in Experiment 1 by means of a naming versus no-naming condition, and in Experiment 2, by means of a verbal interference task. The results showed that wine experts have better memory for wines, but not for wine-related or common odors, indicating their better memory is domain-specific. Wine experts were also found to be more accurate than novices in their descriptions of wines, and were also found to be more accurate than novices in their descriptions for common odors (although this effect was much smaller than for wines). But there was no relationship between experts' ability to name wines and their memory for them. This suggests experts' odor memory advantage is not linguistically mediated. In conclusion, the ability to name and memorize wines seem to be two distinct aspects of wine expert cognition.

5.2 INTRODUCTION

5.2.1 MEMORY OF EXPERTS

Studies of expertise have informed research into a wide range of topics in cognition, such as perception, decision-making, artificial intelligence, and memory (Charness, 1992; Ericsson & Lehmann, 1996). Memory has been found to improve as a result of knowledge in a specific domain. For example, chess grandmasters have better memory for chess game layouts than chess novices (Chase & Simon, 1973; Vicente & de Groot, 1990). Similarly, waiters and waitresses can remember many orders from different customers simultaneously and with ease (Bennett, 1983; Ericsson & Polson, 1988). In addition, music experts are better at recalling musical pieces than non-musicians (e.g., Williamson,

[12] This work was done as a collaboration project: Croijmans, Arshamian, Speed & Majid (in preparation): The role of language in the memory of wine experts and novices for wines and common smells. Part of this chapter is based on: Croijmans, I., & Majid, A. (2016). Language does not explain the wine-specific memory advantage of wine experts. In *38th Annual Meeting of the Cognitive Science Society (CogSci 2016)* (pp. 141-146). Cognitive Science Society.

Baddeley, & Hitch, 2010), and expert interpreters have a better memory for words in the languages they translate to and from than bilingual students (Christoffels, de Groot, & Kroll, 2006).

In the expertise literature, a recurring question is whether the cognitive benefits for stimuli in one domain extend to stimuli outside of the domain of expertise. These so-called "transfer effects" (Gick & Holyoak, 1987) have been found to occur, but are usually limited (for a review, see Kimball & Holyoak, 2000). For example, expert chess players are found to have better memory for chess positions, but not for randomly placed pieces (i.e., in non-meaningful positions) on a chess board (Chase & Simon, 1973). In contrast, a different study suggests that even for non-meaningful chess layouts, experts might have better memory than novices, although the difference is much smaller than for meaningful positions (Gobet & Simon, 1996). Similarly, some studies have found limited transfer effects to occur to tasks outside the domain of expertise (cf. Kimball & Holyoak, 2000). For example, airplane electronics (i.e. avionics) technicians were found to transfer their domain-specific knowledge of avionics to other devices (Gott, Hall, Pokorny, Dibble, & Glaser, 1993), and Iranian chess players were found to have better memory for spoken words than non-players, a task unrelated to chess (Fattahi, Geshani, Jafari, Jalaie, & Salman Mahini, 2015). So, while most research suggests expertise is domain-specific (see Ericsson & Lehmann, 1996 for a review), there is some evidence in favor of transfer too.

As the examples demonstrate, expertise has been studied in various sensory modalities and expert domains. However, research on expertise in sensory modalities other than vison or audition is still relatively scarce, even though there are important and interesting reasons to go beyond them. Recent studies have shown that in various cultures around the world, olfaction plays an important role in daily life, including in religious and cultural practices (Classen, 1992; Majid & Levinson, 2011), and this coincides with how people in these cultures talk and think about smells (Majid & Burenhult, 2014; O'Meara & Majid, 2016; San Roque et al., 2015; Wnuk & Majid, 2014). Olfactory cognition seems malleable. In addition, the contrast between novices and olfaction experts is potentially exaggerated compared to other sensory modalities, as novices have even less experience and knowledge about smells than in other modalities. So olfactory expertise is a particularly interesting alley to explore.

5.2.2 WINE EXPERT MEMORY

Previous research suggests odors are easily remembered, illustrated for example by a slow decline in the recognition for odors over time, compared to other sensory modalities (e.g., Lawless & Cain, 1975). However, these findings have more recently been questioned (see Larsson, 1997 for a review), with studies suggesting that relative to other sensory modalities, memory for smells is poor, and forgetting curves for smells are relatively similar to those for other modalities (Kärnekull, Jönsson, Willander, Sikström, & Larsson, 2015; Köster, Møller, et al., 2014). What role does knowledge and experience play in olfactory memory? Previous studies investigating the memory of olfactory experts focused primarily on wine experts (cf. Royet, Plailly, Saive, Veyrac, & Delon-Martin, 2013). One study investigated whether participants could recognize the flavor (i.e., the multisensory counterpart of smell, combining orthonasal and retronasal olfaction and taste, for example) of a wine. This study suggested experts have better short term memory for wines than novices (Melcher & Schooler, 1996). A similar study, where wine experts and novices had to smell a wine and then had to recognize that wine among four options, similarly revealed wine experts were better at immediate recognition of wines than novices (Zucco et al., 2011). Finally, two studies in which wine experts and novices had to memorize several wine-related odors (i.e., smells resembling aromas that can be found in wines), showed wine experts have better memory for wine-related odors (Parr et al., 2002, 2004). These findings suggest wine expertise might improve different aspects of olfactory memory.

Similar to research in other domains of expertise (cf. Kimball & Holyoak, 2000), a better memory for wines in wine experts may transfer to other odors too. However, other aspects of wine expert cognition, i.e., the ability to name and imagine the odor and flavor of wine better than novices, were found to be domain-specific (cf. Chapters 3 and 4). This raises the question of whether wine experts are better at remembering odors in general, or whether their superior memory for odors is restricted to wines. Only one study has compared wine experts to novices for their memory for common odors and wine odors, but the authors found no evidence for transfer of wine expert memory (Zucco et al., 2011). However, in the study by Zucco et al. (2011), performance on the task was near ceiling, so any possible differences between participant groups might have been obscured (Zucco et al., 2011, Figure 2, p.601). This leaves open the issue whether experts have better memory for all odors.

5.2.3 THE RELATIONSHIP BETWEEN MEMORY AND LANGUAGE

Whereas novices struggle to name smells and flavors, even when they originate from common and familiar objects, such as peanut butter or cinnamon (Olofsson & Gottfried, 2015; Yeshurun & Sobel, 2010), wine experts are able to describe highly complex wines (Chapter 2 and 3; Ortega-Heras et al., 2002). Wine experts review wines in a consistent and informative manner (Chapter 2). When wine experts describe wines, they are more precise and use more specific terms than novices (Chollet & Valentin, 2000; H. T. Lawless, 1984; Lehrer, 2009; Melcher & Schooler, 1996; Sezille et al., 2014; Solomon, 1990, 1997; Zucco et al., 2011). Similarly, the results from Chapter 3 showed experts differ not only in the quality of their descriptions, but are also more consistent than novices when describing the smell and flavor of wines.

When a percept is expressed more consistently and concisely in language (i.e., when it is “codable”), it is remembered better (R. W. Brown & Lenneberg, 1954). In addition, being able to rehearse something by repeating its name improves memory for that object (e.g., Darley & Glass, 1975; Maki & Schuler, 1980). Language has also been suggested to influence olfactory memory in novices, although this claim is somewhat controversial (cf. Herz & Engen, 1996; Larsson, 1997). In line with this, when odors are labelled by the experimenter, participants remember odors better than when odors are not labelled, suggesting language helps odor memory (Cessna & Frank, 2013; Jehl, Royet, & Holley, 1997; Olsson, Lundgren, Soares, & Johansson, 2009; Russell & Boakes, 2011). Similarly, odors are remembered better when participants generate an accurate label during encoding of smells compared to when they generate an inaccurate label (Cessna & Frank, 2013; R. A. Frank, Brearton, Rybalsky, Cessna, & Howe, 2011; Jehl et al., 1997; Lehrner, Walla, Laska, & Deecke, 1999; Olsson et al., 2009; Russell & Boakes, 2011).

Other evidence for the role of language in odor memory comes from interference studies. In a verbal interference study, the to-be encoded stimulus is preceded by a verbal stimulus, often a series of digits, that the participant has to simultaneously rehearse during an encoding phase. A visual condition, where participants have to keep an abstract visual stimulus in mind, serves as an active control condition to control for the dual-task effect. This type of study is often used to test the effects of language on cognition. For example, Roberson and Davidoff (2000) tested whether memory for colors was influenced by language, using a verbal interference paradigm. In this study, it was investigated whether in English, color stimuli from different color categories in language, i.e., blue and green, were remembered better than color stimuli from the same category, i.e., two stimuli from the blue category. Critical to causally attest the influence of language in this study were two things. First, the stimuli used were equally perceptually distinct, meaning two stimuli from the same color category (e.g., two blues) were equally different from each other, measured by physical color distance, as the stimuli from two different categories (e.g., one green and one blue). Second, by asking participants to repeat words aloud during encoding of the various stimuli, the categorical advantage, in case of the blue-green stimuli, disappeared (Roberson & Davidoff, 2000). This study shows that language plays a causal role in memory for colors. In addition, this study shows this verbal interference paradigm can be used to test online effects of language on thought. Thus, verbal interference can be used to interfere with verbal encoding of odors. If odors are remembered by their names, memory for odors should deteriorate under verbal interference, as participants cannot use language to remember the odors. By comparison, memory for odors should remain at the normal level under visual interference. In an early study, Walk and Johns (1984) found memory for odors was reduced when participants were asked to name an additional, unrelated odor during the encoding phase. Two later studies (Annett, Cook, & Leslie, 1995; Perkins & Cook, 1990) showed pairing an unrelated verbal interference task with an odor encoding task made subsequent odor recognition performance poorer, suggesting odors are coded at least partially through language (Annett & Leslie, 1996; cf. Paivio, 1986). These studies suggests language plays a causal role in odor memory.

If language plays a role in odor memory, and wine experts are better at describing wines, does wine experts' aptitude for describing wines play a role in their superior memory for (wine) odors? Previous evidence is inconclusive. For example, Melcher and Schooler (1996) found no difference when experts gave a verbal description of wines compared to a non-verbal condition, although experts remembered the wines they tasted better than novices and intermediates. Similarly, Parr and colleagues (2002; 2004) found no significant relationship between the ability to name wine-related odors and subsequent memory for those odors, although wine experts were again better at remembering odors than novices. However, when inspecting the results more closely (Parr et al., 2004, Table 2, p. 416), a significant difference in recognition between experts and novices was found only in the condition where participants labeled the stimuli (instead of rating the pleasantness of odors), leaving open the possibility that wine experts' memory is verbally mediated. The high, but not statistically significant, correlation between memory for correctly identified odors and memory for all odors observed in the expert group (r = .70; Parr et al., 2004, table 3, p. 418) suggests a role for odor identification in expert odor memory. That the correlations failed to reach significance could be due to the study being underpowered, an explanation the authors also raised (Parr et al., 2004; p. 417). This suggests that the question of whether wine experts better odor memory can be explained through their ability to describe odors remains unanswered.

In this paper, we ask three questions regarding wine expertise. First, are wine experts better than novices at remembering the smells of wines? Second, are wine experts also better than novices at remembering other smells, or is their better odor memory limited to wines? And finally, if wine experts do have better odor memory, is this mediated by their ability to name odors, or are the abilities to name odors and to memorize odors two separate aspects of expertise? We hypothesized that experts have better memory for wines, but that this is restricted to wine odors and that their better memory does not transfer to other smells. In addition, we hypothesized that wine experts' better memory for wines is mediated by their ability to name wines.

To test these hypotheses, we conducted two experiments. In Study 1 we asked wine experts and novices to remember wines, wine-related odors, and common odors unrelated to wine. One group of participants named the odors during encoding (verbal condition), while the other group simply smelled the odors (baseline condition). In Study 2, the causal role of language on odor memory was tested by using a verbal interference paradigm.

5.3 STUDY 1: REMEMBERING WINE ODORS WITH AND WITHOUT WORDS

5.3.1 METHOD

5.3.1.1 Participants

Forty-eight people participated in the experiment. Twenty-four were experts (6 women, M_{age} = 49, *SD* = 9, age range 29 – 60), and worked as qualified vinologists, sommeliers or wine producers, and 24 were novices (6 women, M_{age} = 47, *SD* = 13, age range 26 – 71). To confirm wine expertise, all participants completed a questionnaire assessing their knowledge of wine (see section 3.3.2 for an explanation; Appendix B). Because the data was severely skewed, a non-parametric Mann-Whitney U-test was used, to confirm all wine experts had significantly higher wine knowledge (M = 14.5, SD = .59) than novices (M = 7.2, SD = 2.80), U = 0.0, $p < 0.001$, r = 0.87. In addition, participants completed two other questionnaires whose results are not reported here.

All participants were native speakers of Dutch, and were paid with a €15 voucher. Half the participants from each group were randomly allocated to the verbal condition, and half to the baseline condition. All participants were informed about the methods and task, and signed informed consent forms before they began the study.

5.3.1.2 Materials

Forty-eight odors were used. There were 16 wines, 8 red and 8 white. The wines were selected for their distinctiveness, and were made from various grape types and originated from different countries. In addition, there were 16 wine-related odors from the "*Le nez du vin*" kit (Lenoir, 1995), i.e., aromas that can be found in wine, including wine faults. Finally, there were 16 common odors considered to be of relative high familiarity for Dutch participants. The common odors varied in pleasantness, and were real odor objects, i.e., products with a smell. All stimuli, including the wines, were presented in small 30 ml brown screwtop jars. A small tuft of scentless polyester hollow fiber in each jar obscured the object inside so the participant could not see it (see Table 4.1 for the full stimulus list). Twenty-four randomly sampled encoding sets were made, containing four white and four red wines, eight wine-related odors, and eight common odors, making each set 24 smells in total. The odors for each set were chosen at random from the full set of 48, meaning that across all participants, each odor could serve as either target or distractor. Each set was used twice, once for an expert and once for a novice.

5.3.1.3 Procedure

The experiment followed a classic recognition memory paradigm. Participants were first informed they had to memorize a set of odors, and were told there were three types of odors: wines, wine-related odors and common odors. All participants were told they would be tested for their odor memory later.

In the encoding phase participants smelled half the stimuli. Half the participants were allocated to the naming and half to the silent condition. In the silent condition, participants only smelled the odors at encoding for three seconds. In the naming condition, participants smelled the odors for three seconds at encoding and also named the smell as quickly and precisely as possible.

After 10 minutes, in the recognition phase, all participants smelled all odors again, and had to indicate whether they had smelled the odor previously or not (i.e. they were asked "is this smell new or old?"). They then rated the pleasantness and familiarity of each odor on a 7-point scale, and provided a label for the odor. During the break, participants completed the wine knowledge test (see Participants section) and two other questionnaires.

5.3.1.4 Data analysis

Following signal detection theory (Macmillan & Creelman, 1991), hits and false alarms were coded from recognition responses for each odor type. A hit (H) was coded when a participant correctly recognized a stimulus from the encoding set, and a false alarm (FA) was coded when a participant mistakenly recognized a new stimulus as coming from the encoding set. From these values, d-prime (*d*') was calculated by taking the standardized ratio, i.e., the *Z*-score, of corrected hits and false alarms for the different stimulus types for each participant (Macmillan & Creelman, 1991; Parr et al., 2002), using the following formula:

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

A larger *d'* indicates better ability to discriminate between old and new odors, while a *d'* of zero indicates performance at chance level.

Odor labels given during the recognition phase were coded for accuracy. An answer was considered correct if participants gave the same answer as the pre-determined "veridical" label. For wines a response was considered correct if participants gave the correct color, grape type, or production country. Coding was completed by the experimenter and one independent researcher, achieving an inter-rater agreement of κ = .89, indicating almost perfect agreement (McHugh, 2012). Cases on which raters disagreed were resolved through discussion.

The analysis followed the same structure as Parr et al. (2002): first, the overall effect of the different naming conditions on memory (d') were analyzed by means of ANOVA. Subsequently, this analysis was followed up by an analysis of odor naming accuracy, consistency, and odor familiarity. Finally, the relationship between naming and memory were investigated further with simple correlation analyses between memory, and naming accuracy and consistency.

Wines	Wine-related odors	Common odors
Manoir Grignon Chardonnnay, France	Glue	Rosemary (dried)
Glasklar Silvaner, Rheinhessen Germany	Cherry	Suntan cream
Uvanova Vino De Mesa, Spain	Almond	Peanut butter (Calvé brand)
Rivoire Sauvignon Blanc, Languedoc France	Rose	Soap (unperfumed soft soap)
Le Volcanic Rouge De Pierre Besinet, Merlot Petit Verdot Cabernet Franc blend, France	Cedar	Spirit of camphor
Il Pumo Malvasia nera, Salento Italy	Thyme	Beer (Grolsch pilsener)
Legado Munoz Tempranillo, Castillia Spain	Moldy/earthy	Green tea (Japanese sencha)
La Rose Du Pin Merlot Cabernet Sauvignon, Bordeaux France	Smoke	Bleach
Colloredo Mels Pinot Grigio, Venezia Giulia Italy	Horse	Turmeric root (dried, ground)
La Rose Du Pin Sauvignon Blanc Semillon blend, Bordeaux France	Banana	Juniper Berry (dried, crushed)
Gascogne Par Plaimont Producteurs Ugni Blanc Colombard blend, Gascogne France	Prune	Broth (chicken, powdered)
Zimmermann-Graeff Savignon Blanc, Castillia Spain	Peach	Incense (olibanum)
Dauré Wine Of Chile Cabernet Sauvignon, Central Valley Chile	Muscat	Black tea (English blend)
Feudo Arancio Nero d'avola, Sicily Italy	Vanilla	Cardamon (dried, ground)
Zimmermann-Graeff Syrah, Castillia Spain	Cork	Dill (dried)
Manoir Grignon Cabernet Sauvignon Syrah blend, France	Honey	Perfume (female, 'la rive–cuté')

Figure 5.1 Stimuli used in Study 1

5.3.2 RESULTS

5.3.2.1 Odor memory

To test the hypothesis that wine experts have better memory for wines, a mixed ANOVA was performed on *d'*, with odor type (wine, wine-related odors, and common odors) as a within-participant factor, and expertise (wine experts and novices) and naming condition (naming and silent) as between-participant factors. If wine experts have better memory for smells, a general effect of expertise on memory is expected. If this effect is domain-specific, wine experts are expected to only have better memory for wine, and not common odors. Finally, if wine experts' memory relies on language, a three-way interaction is expected between naming condition, expertise and odor type.

The main effect of odor type was significant, $F(2, 43) = 41.5$, $p < .001$, $\eta_p^2 = .49$. Pairwise comparisons[13] showed both wine-related odors and common odors were remembered better than wines, both *ps* < .001, with no difference between memory for wine-related odors and common odors, $p > .5$. There was no significant effect of expertise, $F(1, 44) = .64$, $p = .427$, $\eta_p^2 = .01$, and no significant main effect of naming condition, $F(1, 44) = .46$, $p = .503$, $\eta_p^2 = .01$. Turning to the interaction effects, the analysis revealed no significant three-way interaction between odor type, expertise and naming condition, $F(1, 43) = .97$, $p = .388$, $\eta_p^2 = .04$. There was also no significant interaction between odor type and expertise, $F(1, 43) = 2.34$, $p = .108$, $\eta_p^2 = .10$, nor between odor type and naming condition, $F(1, 43) = .13$, $p = .875$, $\eta_p^2 = .01$, nor expertise and naming condition, $F(1, 43) = .12$, $p = .887$, $\eta_p^2 = .04$.

This analysis showed no effect of naming condition, suggesting wine experts' memory for wines is not mediated by language. In addition, it was hypothesized that wine experts would have better memory for wines, and that this effect might not extend to other odors. To test this specific hypothesis, *d*' for each odor type was analyzed separately with ANOVAs with expertise and condition as a between-participants factor.

For wine odors, there was a main effect of expertise, $F(1, 44) = 4.70$, $p = .036$,

[13] Bonferroni correction is applied to all pairwise comparisons in this chapter, to control for inflation of the Type 1 error rate with multiple tests.

η_p^2 = .096, showing wine experts were better at remembering wines than novices. There was no effect of naming condition, $F(1, 44) = .71$, $p = .406$, $\eta_p^2 = .016$. And there was no interaction between expertise and naming condition, $F(1, 44) = .000$, $p = .984$, $\eta_p^2 = .00$.

For wine-related odors, there was no main effect of expertise, $F(1, 44) = .74$, $p = .394$, $\eta_p^2 = .016$, or of naming condition, $F(1, 44) = .28$, $p = .599$, $\eta_p^2 = .006$, nor was there an interaction between expertise and naming condition, $F(1, 44) = .20$, $p = .655$, $\eta_p^2 = .004$. Finally, for common odors, there was no effect of expertise, $F(1, 44) = .366$, $p = .984$, $\eta_p^2 = .008$, naming condition, $F(1, 44) = .003$, $p = .960$, $\eta_p^2 = .00$, or interaction between expertise and naming condition, $F(1, 44) = 2.48$, p = .122, $\eta_p^2 = .053$,

Overall, these analyses suggest wine experts were better than novices at remembering wine odors (see Figure 5.1). However, there was no difference between wine experts and novices in recognition of wine-related odors and common odors. The results also suggest naming wines explicitly during encoding did not boost memory for any odor type, for experts or novices, suggesting experts' superior memory for wines is not verbally mediated.

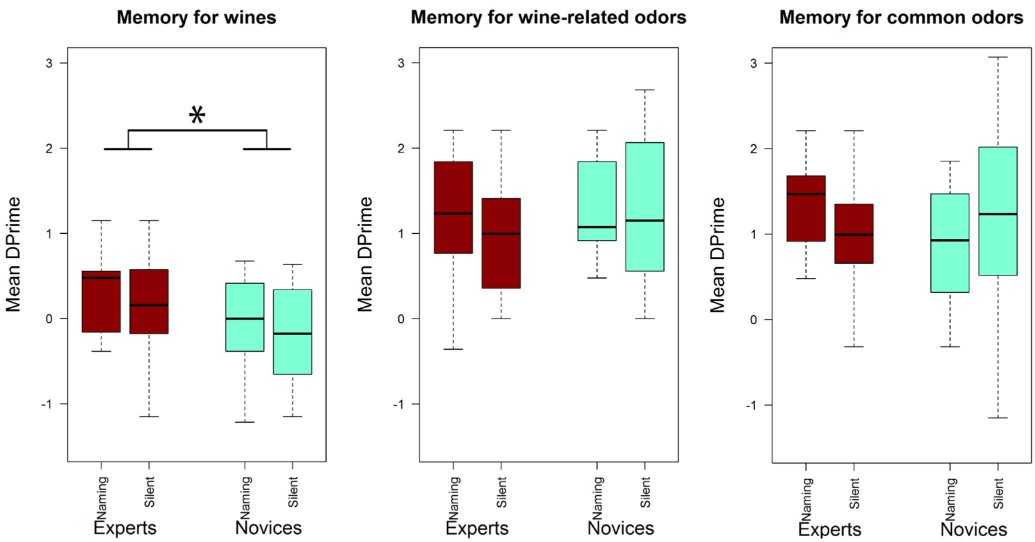


Figure 5.1 Mean *d'* by naming condition for experts and novices by odor type: wines, wine-related odors, and common odors. Asterisks mark a significance difference ($p < .05$).

5.3.2.2 Odor naming

Half the participants named odors twice during the experiment (verbal condition); i.e., during encoding and then again during recognition. The answers for those participants were coded for accuracy and consistency.

To test the effects of expertise on naming accuracy, measured by taking the percentage of correct responses (see Section 5.3.1.4) a mixed ANOVA was performed on the percentage of accurately named odors, with expertise and naming condition (naming and silent) as a between-participant factor and odor type as a within-participants factor. Wine experts (M = 33.0, SD = 17.0) named more odors correctly than novices (M = 24.8, SD = 19.2), $F(1, 44) = 4.95$, $p = .031$, $\eta_p^2 = .10$, and wine odors were more often correctly named than wine-related odors or common odors, $F(2, 43) = 5.70$, $p = .006$, $\eta_p^2 = .20$. There was no effect of naming condition, $F(1, 44) = 0.01$, $p = .944$, $\eta_p^2 = .00$. The three-way interaction between naming condition, expertise and odor type was not significant, $F(2, 43) = .29$, $p = .748$, $\eta_p^2 = .01$. There was no interaction between expertise and naming condition, $F(1, 44) = 2.3$, $p = .135$, $\eta_p^2 = .05$, and no interaction between odor type and naming condition, $F(2, 43) = .92$, $p = .404$, $\eta_p^2 = .02$.

Additionally, there was no interaction between expertise and odor type, $F(2, 92) = 1.6$, p = .217, $\eta_p^2 = .03$. To further explore this finding this pairwise group comparisons for each level of odor type were done. This revealed that wine experts (M = 44.8, SD = 25.4) were more accurate in naming wine odors than novices (M = 29.7, SD = 26.1), p = .048, d = .59, but this was not the case for wine-related odors (wine experts M = 26.8, SD = 12.7 vs. novices M = 20.3, SD = 14.4), p = .104, d = .48 or common odors (wine experts M = 27.6, SD = 13.0 vs. novices M = 24.5, SD = 17.1), p = .480, d = .20. This suggests the wine experts' superior naming, i.e., the main effect of expertise, was driven by their accuracy for naming wine odors. Figure 5.2 displays these results.

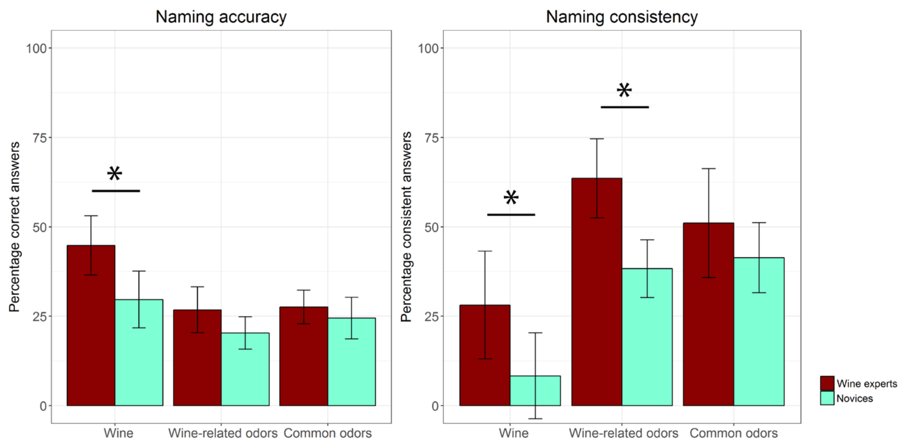


Figure 5.2 Naming accuracy and naming consistency for each odor type, plotted separately for experts and novices.

Looking at naming consistency, i.e., the percentage of trials on which the participant gave the same answer during both encoding and recognition (see Section 5.3.1.4), a mixed ANOVA with expertise (wine experts and novices) and odor type (wine odors, wine-related odors, and common odors) as factors, and percentage of consistently named odors as the dependent variable, showed wine experts (M = 47.5%, SD = 23.8) gave more consistent labels than novices (M = 29.3%, SD = 19.0), $F(1, 22) = 12.24$, $p = .002$, $\eta_p^2 = .36$. There was also a main effect of odor type, $F(2, 44) = 16.37$, $p < .001$, $\eta_p^2 = .42$. Pairwise comparisons showed common odors (M = 46.2%, SD = 23.9) were more consistently named than wine odors (M = 18.2%, SD = 21.2), $p = .018$, $d = .8$. Wine-related odors (M = 50.9%, SD = 24.8) were also more consistently named than wine odors, $p = .009$, $d = 1.0$. There was no difference between common odors and wine-related odors, $p = .332$. There was no interaction between expertise and odor type, $F(2, 44) = 0.82$, $p = .448$, $\eta_p^2 = .04$, suggesting experts were more consistent than novices when naming odors, irrespective of the odor type. To further investigate the extent of this effect, the analysis was followed by pairwise comparisons by group for each level of odor type. The pairwise comparisons showed wine experts gave more consistent answers for wine odors (M = 28.1%, SD = 21.4) than novices (M = 8.3%, SD = 16.3), $p = .018$, $d = 1.0$. Wine experts also gave more consistent answers for wine-related odors (*M* = 63.5%, *SD* = 24.1) than novices (*M* = 38.3%, *SD* = 19.0), *p* =.009, *d* = 1.2. But there was no difference between wine experts (*M* = 51.0%, *SD* = 25.8) and novices (*M* = 41.4%, *SD* = 21.8), *p* = .332, for common odors.

5.3.2.3 Direct relationship between odor memory and odor naming

Following Parr et al. (2004), the relationship between naming accuracy, naming consistency, and memory was also investigated, by calculating correlations between *d'* for each odor type and naming, for experts and novices separately.

The correlation analyses showed that novices have better odor memory for common odors they named correctly, *r* = .523, *p* = .004, as well as for wine-related odors they named correctly, *r* = .518, *p* = .005, replicating previous analyses (e.g., Cessna & Frank, 2013). No other correlations were significant for this group.

For wine experts, there was a similar trend of better memory for correctly named common odors *r* = .309, *p* = .071, but this was not significant. Similarly, there was a positive correlation between naming accuracy and memory for wine-related odors, *r* = .463, *p* = .011. Critically, however, memory for wine odors and naming consistency and accuracy were not positively correlated (see Table 5.2). Taken together, these results suggest the superior memory for wine odors displayed by wine experts is not verbally mediated, even though they seem to remember wine-related odors and common odors by their names, like novices.

		Wine experts		Novices	
Naming	**Odor type**	***r***	***p***	***r***	***p***
	Wine odors	.041	.449	-.320	.155
Naming consistency	Wine-related odors	.381	.111	.130	.343
	Common odors	.385	.108	.328	.149
	Wine odors	-.151	.241	-.036	.433
Naming accuracy	Wine-related odors	.463	.011	.523	.004
	Common odors	.309	.071	.518	.005

Figure 5.2 Correlations between odor memory and naming consistency and accuracy for wine experts and novices (Pearson's correlation coefficients, reported *p*-values are one-tailed)

5.3.3 SUMMARY

The results of Study 1 suggest wine experts have a better memory for wine odors than novices. However, this effect was restricted to wines, and did not extend to wine-related odors, or common odors. There was no interaction between naming condition, odor type, and expertise, suggesting wine experts are not aided by overtly naming the odors. In addition, while there was a relationship between odor naming accuracy and odor memory for wine-related and common odors, this did not hold for wine odors.

For wine experts, there was no relationship between naming and memory for wine odors. This suggests language does not explain the memory advantage wine experts have for wines. However, participants may have named the odors subvocally even though not instructed to do so in the silent condition. Experts, because they are used to giving descriptions of odors (cf. Herdenstam et al., 2009), may have generated a silent verbal code automatically in the control condition too. This could also explain the absence of a significant difference between the naming and control condition, as these would not be distinctive. To control for the possibility that participants subvocally named the odors, Study 2 was conducted using a verbal interference paradigm (following Winawer et al., 2007) with visual interference as an active control condition.

5.4 STUDY 2: THE ONLINE ROLE OF LANGUAGE IN WINE ODOR MEMORY

5.4.1 METHOD

5.4.1.1 Participants

A total of 132 new participants took part in this experiment. Sixty-six participants (20 women, M_{age} = 49, age range 21 – 71) were experts in the field of wine, and either worked professionally with wine (e.g., as vinologist, sommelier or wine maker) or possessed a more than average interest in wine with a proven track record (e.g., had an extensive wine collection, gave wine courses on a non-professional basis). Sixty-six participants were novices (20 women, M_{age} = 49, age range 24 – 70), and were matched to the wine experts in age (± 5 years), and gender. Participants were randomly allocated to one of three conditions: (I) control condition; (II) verbal interference condition; and (III) visual interference condition. To confirm the difference in wine expertise between the two groups, all participants completed a wine knowledge test (see Chapter 3; Section 3.3.2, and Chapter 5, section 5.3.1). This analysis confirmed experts had significantly higher wine knowledge scores (M = 13.6, SD = 1.2) than novices (M = 7.9, SD = 2.2), U = 33.0, p < 0.001, r = 0.85.

5.4.1.2 Materials

In Study 1, experts and novices only differed in their memory for wines, and not wine-related odors or common odors. To reduce the number of odors participants had to smell we therefore removed wine-related odors in Study 2. In addition, to make the difference between odor types more salient, the wines and common odors were presented in separate blocks.

Twenty wines were selected, including red, white and rosé wines, as well as a dessert and a sherry wine. Sixty ml of each of the wines was presented in black opaque, *Tritan* plastic wine glasses, obscuring the color of the wine to the participant. These glasses had a volume of 510 ml, with the opening being smaller than the biggest circumference of the glass. The common odors were presented in 30ml dark brown glass jars. As in Experiment 1, a small tuft of hollow fiber wool obscured any visual cues as to the object in the jar. Half of the wines and half of the common odors served as targets, and the other half were distractors in the recognition phase of the experiment (see Table 5.3).

Number	type	Common odors	Wines
1	Targets	Whisky	Finca de los Arrandinos Rioja Crianza, Spain
2		Black tea	Chakana Mendoza Malbec, Argentina
3		Peanut butter	Villalta Valpolicella Ripasso, Verona Italy
4		Crushed coriander seeds	Panul Cabernet Sauvignon, Colchagua Valley Chile
5		Jasmine essential oil	Misty Cove Sauvignon Blanc, Marlborough New Zealand
6		Ground nutmeg	Dr Loosen Riesling Trocken, Mosel Germany
7		Orange essential oil	Vignoble Cogné Sauvignon Blanc, Loire France
8		Patchouli essential oil	Chateau Lassalle Grave Blanc 50% Semillon 50% sauvignon blanc, Bordeaux France
9		Cocoa powder	La Goya Manzanilla Pasada, Sanlúcar Spain
10		Dried rosemary	Domaine de Rimauresq Provence Cru Classé Rosé 50% Cinsault 50% Tibouren, Provence France
11	Distractors	Mint essential oil	Maison Roche de Bellene Cuvee Terroir 80% Gamay 20% Pinot Noir, Bourgogne France
12		Eucalyptus essential oil	Villa Wolf Spatburgunder, Pfalz Germany
13		Vanilla essential oil	Paul Jaboulet Ainé Syrah, Rhone France
14		Camomile essential oil	Wolf Blass Red Label Shiraz Cabernet Sauvignon, Barossa Valley Australia
15		Incense	Nicky Hahn Oaked Chardonnay, California United States
16		Sage essential oil	Domaine de l'Arjolle Muscat sec, Languedoc-Roussillon France
17		Cleaning soap	The Pavillion Chenin Blanc, Boschendal South Afrika
18		Ginger	Curvos Avesso Vinho Verde, Minho Portugal
19		Chai tea	Maray Reserva late harvest muscat, Limarí valley Chile
20		Baby oil	Ogio Zinfandel Rosé, Puglia Italy

Table 5.3 Stimuli used in Study 2

5.4.1.3 Procedure

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

Since people differ in their working memory capacity (Baddeley, 1994; Miller, 1956), the effect of verbal interference (and similarly, visual interference) needs to be equated across participants (see for example the discussion in: M. C. Frank, Fedorenko, Lai, Saxe, & Gibson, 2012, p. 85). This problem was solved by adjusting the difficulty level of interference tasks for each participant, and this also made the visual and verbal interference tasks comparable in difficulty. This meant that in the verbal and visual interference condition, each participants' threshold for their verbal or visual memory was established, depending on the condition they were in.

In the verbal interference condition, participants' verbal span was first established with a threshold task. Participants were presented with a sequence of digits for 2,000 ms. After a 3,500 ms interval, they saw two digit sequences and had to indicate which had been presented previously. The task increased in difficulty level, starting with a sequence of four digits and increased to 11 digits. Each level contained 11 trials. When a participant reached 80% correct on a given difficulty level, they continued to the next level. If their accuracy was less than 80%, they stayed on that level. The task ended when accuracy was less than 80% on two series of trials within the same level. The last difficulty level for which accuracy was 80% or more was then assigned as the participant's difficulty level.

The visual interference threshold task followed the same structure as the verbal interference task. Participants were first presented with images of black and white blocks in random patterns (based on Winawer et al. 2007), for 2,000 ms. The difficulty levels for this task ranged from a three-by-three grid with four black squares to a five-by-five grid with 12 black squares. Participants' maximum difficulty level was established in the same way as the verbal interference task. Once individual thresholds were established, participants took part in the main odor memory experiment. In both memory blocks (for wine odors and common odors), participants smelled 10 target odors for three seconds, with 30 seconds in between, in a random order. In the verbal and visual interference conditions, before smelling each target odor, participants saw either a series of digits that they were instructed to silently rehearse, or a visual grid that they had to keep in mind. After smelling the wine, the participant had to choose from two options which of the series of digits or visual grids they had seen before by pressing 'z' or 'm' on the keyboard.

Following encoding, participants continued with the recognition phase of the study, in which they smelled 20 odors, including the 10 target odors. For each odor, they had to answer whether they had smelled the odor before. In addition, participants rated how certain they were about their answer, how familiar the odor was, and how pleasant it was on 7-point Likert scales. They were then asked to name the odor aloud as quickly and precisely as possible. When naming the wines during recognition, participants were instructed they could think about the color, grape type, country of origin, or aromas the wine could resemble. In the common odor task, no specific instructions were given to name the odors. Between blocks participants completed the wine knowledge questionnaire and two other questionnaires (see Chapter 5).

5.4.1.4 Data analysis

The data was processed and analyzed in the same way as Study 1. Coding was completed by the experimenter and independently by another researcher, reaching an inter-rater agreement of $\varkappa = .95$, which indicates almost perfect agreement (McHugh, 2012). Cases on which both raters disagreed were resolved through discussion.

5.4.2 RESULTS

5.4.2.1 Odor memory

Data was inspected for normality and outliers and other violations. A mixed ANOVA was conducted on the *d'* values, with odor type (wine odors and common odors) taken as within-participant measure, and expertise (wine expert and novice) and interference type (control, verbal and visual) as between-participant factors.

As in Study 1, if wine experts have better memory for smells, a main effect for expertise would be expected. If their better memory is domain-specific, i.e., restricted to wines, this effect is only to be expected for wine odors, but not for common smells. Finally, if wine expert memory for wine odors is mediated by language, a significant three-way interaction between expertise, condition and odor type should be obtained.

The analysis showed there was a significant main effect of odor type, $F(2, 126) = 70.90$, $p < .001$, $\eta_p^2 = .36$, with common odors ($M = 1.01$, $SD = .66$) easier to remember than wine odors ($M = .37$, $SD = .57$). In addition, there was a significant main effect of expertise, $F(2, 130) = 6.00$, $p = .003$, $\eta_p^2 = .017$, indicating wine experts ($M = .78$, $SD = .59$) had better odor memory than novices ($M = .60$, $SD = .61$). There was no significant main effect of interference type $F(2, 130) = .57$, $p = .567$, $\eta_p^2 = .009$. Turning to the interactions, the three-way interaction between odor type, expertise and interference type was not significant, $F(2, 126) = .66$, $p = .518$, $\eta_p^2 = .01$, contrary to the hypothesis that wine experts memory for wines is mediated by language. The interaction between odor type and expertise was not significant, $F(1, 126) = 1.23$, $p = .270$, $\eta_p^2 = .01$, nor was the interaction between expertise and interference type, $F(2, 126) = .45$, $p = .640$, $\eta_p^2 = .007$, or was the interaction between odor and interference type $F(2, 126) = .11$, $p = .895$, $\eta_p^2 = .002$.

There was no effect of interference type on memory for smells, suggesting odor memory is not mediated by verbal or visual encoding. In addition, the analysis suggests a main effect of expertise on odor memory, which confirms the hypothesis that wine experts are better at remembering odors in general, i.e., that their better odor memory transfers to odors other than wine odors. However, inspection of the means in each group per odor type suggests this effect was driven by a difference between the groups on wine odors. To further explore this hypothesis, additional analyses were conducted on the wine odors and common odors separately.

For wine odors, there was a significant main effect of expertise, $F(1, 126) = 7.82$, $p = .006$, $\eta_p^2 = .058$. Wine experts were found to have better memory for wine odors than novices. The main effect of interference type was not significant, $F(2, 126) = .51$, $p = .603$, $\eta_p^2 = .008$. There was no interaction between expertise and interference type, $F(2, 126) = 1.09$, $p = .339$, $\eta_p^2 = .017$.

The same analysis for common odors showed no significant effect of expertise, $F(1, 126) = .84$, $p = .361$, $\eta_p^2 = .007$, no effect for interference type, $F(2, 126) = .24$, $p = .791$, $\eta_p^2 = .004$, and no interaction between expertise and interference type, $F(2, 126) = .18$, $p = .839$, $\eta_p^2 = .003$.

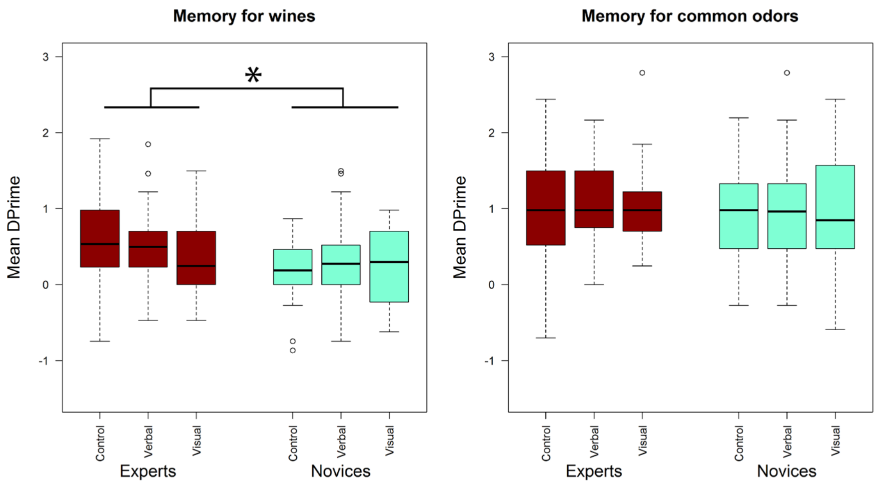


Figure 5.3 *d'* values, per expertise type and condition. Asterisks mark a significance difference ($p < .05$).

This shows the main effect of expertise is indeed driven by the difference between the groups for wines, and that the memory advantage experts have is restricted to odors from their domain of interest, replicating the first experiment (see Figure 5.3). In addition, the analysis shows that interference did not reduce memory for wine odors or common smells, suggesting wine experts' better memory for wine odors does not rely on verbal encoding.

5.4.2.2 Odor naming

To test whether wine experts were better at describing wine odors than novices, the percentage of correct answers was analyzed by means of a mixed ANOVA, with expertise (wine expert and novice) and interference type (control, verbal, and visual) as between-participant factors, and odor type (wine odors and common odors) as a within-participants factor.

The analysis revealed a main effect of odor type, as common odors were described more accurately than wine odors, $F(1, 126) = 153.1$, $p < .001$, $\eta_p^2 = .55$, and a main effect of expertise, with wine experts more accurate in their descriptions than novices, $F(1, 130) = 84.7$, $p < .001$, $\eta_p^2 = .40$. There was no effect of interference type during encoding on naming accuracy during recognition, $F(1, 126) = .98$, $p = .378$, $\eta_p^2 = .02$. The three-way interaction between odor type, expertise, and interference type was not significant, $F(2, 126) = .66$, $p = .516$, $\eta_p^2 = .01$. There was no interaction between interference type and odor type, $F(1, 126) = .04$, $p = .963$, $\eta_p^2 = .001$, and no interaction between expertise and interference type, $F(2, 126) = .15$, $p = .863$, $\eta_p^2 = .002$. However, the interaction between expertise and odor type was significant, $F(1, 130) = 31.3$, $p < .001$, $\eta_p^2 = .19$. Pairwise comparisons between groups for each level of odor type showed that for wine odors, wine experts had significantly higher accuracy ($M = 20.3\%$, $SD = 9.6$) than novices ($M = 2.8\%$, $SD = 4.0$), $p < .001$, $d = 2.4$. For common odors, wine experts also had significantly higher accuracy ($M = 27.3\%$, $SD = 10.4$) than novices ($M = 21.1\%$, $SD = 11.4$), although the effect size was much smaller here, $p = .002$, $d = .60$. This suggests wine experts are more accurate than novices, in particular when describing wine odors, but also when describing common odors (see Figure 5.4).

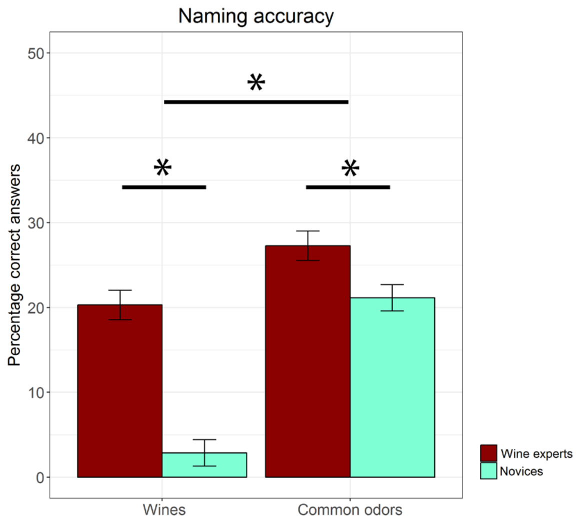


Figure 5.4 Naming accuracy as percentage of correct answers for wines and common odors. Asterisks denote a significant difference ($p < .05$).

5.4.4.3 Relationship between naming accuracy and memory

These results indicate experts are better at remembering wines and also at naming wines. As a final test of the hypothesis that wine expert memory superiority for wine is mediated by language, similar correlation analyses as Study 1 were performed, correlating percentage of correctly named odors to odor memory (*d'*).

For novices, accuracy was found to be significantly correlated with memory for common odors, $r = .366$, $p = .001$, but not with memory for wine odors, $r = -.007$, $p = .476$. For experts, a similar picture emerged, as accuracy in responses was significantly correlated with wine experts' memory for common odors, $r = .501$, $p < .001$, but not memory for wine odors, $r = .121$, $p = .167$.

This analysis further confirms that wine experts' memory for wine odors is not mediated by their ability to accurately describe wines, and replicates Study 1. On the other hand, memory for common odors is related to how accurately the odor can be named, an effect that was found for experts and novices alike, replicating Study 1.

5.4.3 SUMMARY STUDY 2

As predicted, wine experts were found to have better memory for wine odors, but this did not extend to common odors. We hypothesized that if language plays a role in memory for complex odors, such as wines, the difference between experts and novices should disappear for wines in the verbal condition, but would still be present under visual interference and in the control condition. The findings, however, showed the difference between experts and novices for wines was still present under verbal interference. This suggests wine experts' better memory for wine odors is not directly mediated by language.

5.5 DISCUSSION

Wine experts are superior in naming wine odors compared to novices (Chapter 3). And for novices, language influences odor memory (Cessna & Frank, 2013; R. A. Frank, Rybalsky, Brearton, & Mannea, 2011; Jehl et al., 1997; Lehrner, Walla, et al., 1999). However, the present studies show no evidence in support of the idea that wine experts' better memory for wine odors is due to online use of language. In Study 1, experts were no better at remembering wine odors in the naming condition than the silent condition. In Study 2, verbal interference did not affect wine experts' memory for wine odors. Moreover, in both experiments, there was no significant correlation between memory for wine odors and naming accuracy. This suggests wine experts do not rely on verbalization to memorize wines.

In novices and experts alike, memory was not affected by verbal interference during encoding, in contrast to previous findings (Annett, Cook, & Leslie, 1995; Perkins & Mclaughlin Cook, 1990). However, the previous results are not without controversy. Annett and Leslie (1996) did not only find an effect of verbal interference, but also found an effect of visual interference on odor recognition memory. The results of the current study show that after controlling for individual participants' working memory span, there was no effect of interference on odor memory. Perhaps, as Annett and Leslie propose (Annett & Leslie, 1996, p.458), an olfactory modality specific working memory store may also explain the results. This part of working memory is thought to temporary store odor information, and could be investigated as a possible alternative explanation instead of the verbal encoding hypothesis (also see Andrade & Donaldson, 2007; Zelano, Montag, Khan, & Sobel, 2009). In sum, the result of the present study suggests that memory for odors is not directly affected by online verbal encoding.

What could explain the finding that wine experts were better than novices at remembering wine odors if not verbal encoding? Even though language is not directly involved in wine odor memory, language may still shape the way wine experts think about wines through more offline means. One way in which language can shape thought is by directing attention to particular features (Majid et al., 2004, Box 2). While wine experts do not use a verbal code to remember wines online, the fact they for example discuss particular features of wine during tastings may shape conceptual representations they have for particular wines. One finding argues against this suggestion: Melcher and Schooler (1996) also found a better short term memory for wines in intermediates—wine drinkers with moderate to high perceptual expertise, but with low verbal expertise—compared to novices. This finding argues for a more perceptually guided mechanism to remember wines. Nevertheless, what specific kind of experience, verbal, perceptual, or perhaps a combination of both, is necessary to better remember wines than an average person merits further investigation.

Wines can contain up to 800 different volatiles (Ortega-Heras, González-SanJosé, & Beltrán, 2002). When remembering the odors of wines, experts may remember the whole gestalt rather than the individual components of a wine, with specific components fitting a particular wine template (Gobet & Simon, 1996). An analogy can be made to memory for faces. Humans are excellent at remembering faces, yet perform poorly when having to recall individual features of faces, such as a nose, eye, or mouth (Tanaka & Farah, 1993). A similar analogy can be made to chess experts. Chess experts are better at remembering the layout of chess plays than novices (Frey & Adesman, 1976; Gobet & Simon, 1996). However, these layouts have to be possible configurations that are encountered during real chess games rather than randomly assembled layouts (Chase & Simon, 1973). This suggests chess experts have learned to remember particular configurations of arrays in a holistic way. Similarly, wine experts may have learned to process particular configurations of odor molecules, that frequently occur together in particular wines, in a holistic way.

The absence of a correlation between how well wines are named and how they are remembered support the suggestion that wines are stored in a different way than common odors in experts. Wines may be memorized holistically, with the particular memory trace containing different types of information about the wine, and common odors more as a single object (Olofsson, Bowman, Khatibi, & Gottfried, 2012). Wines may be described in a featural fashion, as wine reviews often contain descriptions of particular features using concrete source terms alongside overall impressions and metaphors. The difference in holistic processing for memory yet featural description strategy, might help explain the dissociation between wine experts' better memory for wines and their better ability to describe it. Through their years of experience, wine experts may have learned to describe wines in a featural fashion (cf. Gibson & Gibson, 1955; Melcher & Schooler, 1996), whereas their memory for wines works in a more holistic, or configural fashion, similar to memory for faces, bird recognition in ornithologists, or chess masters' memory for chess layouts (Righi & Tarr, 2004). Consistent with this, one study found wines are remembered better when participants are primed into configural instead of featural processing using Navon letter stimuli (Lewis, Seeley, & Miles, 2009). When memorizing wines, wine experts might process wines more holistically, and efficiently extract salient perceptual chunks that match the whole template (cf. Gobet & Simon, 1996), through perceptual learning (Gibson & Gibson, 1955; Kellman & Garrigan, 2009). This is in line with the proposal that as wine students become experts, a conceptual shift occurs, encouraging holistic processing of wines (Solomon, 1997), using more refined wine templates. Aside from the perceptual gestalt, this representation of a wine likely includes knowledge about that specific wine, including information about a particular region and grape variety (Ballester et al., 2008; Solomon, 1997).

Wine experts were no better than novices at remembering common household odors, or wine-related odors. This corroborates the hypothesis that wine experts' superior memory for odors is domain-specific, and does not transfer to other odors (cf. Zucco et al., 2011; Kimball & Holyoak, 2000). This further suggests wine experts remember common odors and wine-related odors differently than wine odors. That is, wine-related odors, when presented out of the context of a specific wine, seem to be processed similarly to common odors. This is also exemplified by the positive correlation between language and memory for wine-related and common odors in both experts and novices; and the corresponding absence of such a relationship for wine-related odors in wine experts.

Both studies in the present chapter show correlations between how accurately common odors are named and how well they are remembered, for experts and novices alike. Previous research suggests semantic factors can play a role in common odor memory. Familiarity is known to influence odor memory (Kärnekull et al., 2015; Rabin & Cain, 1984). In addition, familiarity influences how accurately people name odors (Engen, 1987; Lehrner, Glück, & Laska, 1999). In the present study, the relationship between naming accuracy and odor memory may, at least in part, reflect different levels of familiarity between different odors.

In addition to familiarity, the complexity of the smell might play a role in odor memory. The result of both studies show a clear difference between how easily different odor stimuli are remembered: wine odors were found to be more difficult to remember than simpler wine-related odors in Study 1, and common odors in both studies. Wine odors may be more similar to each other and may therefore be harder to distinguish and remember, whereas common smells were all clearly distinct. The differences in the stimulus sets may have made the task of remembering wine odors relatively more complex. Previous studies indicate visual and verbal memory capacity decreases when the relative complexity of the stimulus increases (Eng, Chen, & Jiang, 2005; A. G. Goldstein & Chance, 1971; La Pointe & Engle, 1990), and the present results suggest this is also true for olfaction. While memory for smells might be poorer than memory in other sensory modalities (e.g., Larsson, 1997), there are notable similarities between odor memory and memory in other modalities, for example for complex visual stimuli (faces) (Kärnekull et al., 2015). The current study suggests how well people can remember odors also depends on the complexity of the stimulus, and the level of experience of the participant.

In conclusion, after years of experience, wine experts become better at remembering wines. However, their improved olfactory memory does not extend to smells beyond their domain of expertise. This finding suggests wine expertise shows noteworthy similarities with expertise in other domains. In addition, we provide further evidence that wine experts are better than novices at describing wine and wine-related odors. However, wine experts' better memory for wine odors does not seem to be based on experts' ability to name wine odors.

6
GENERAL DISCUSSION

In this dissertation, I have investigated the effect of wine expertise on language and cognition, and the relationship between them. Odors and flavors seem to play very little role in Western conscious behavior, thought and language; but for wine experts, this is different. Using computational linguistics techniques, I showed that wine experts can describe odors and flavors in an informative way, using dedicated vocabulary (Chapter 2). Next, I showed that not all flavor expertise is equal (Chapter 3). By comparing wine experts to coffee experts, I showed that specific linguistic experience, e.g., reading and writing about wines versus coffees, is as relevant as perceptual experience for how consistent experts are in their flavor descriptions. I further showed that wine experts are better at describing the odor and flavor of wine, but not of coffee, common odors or basic tastes. In Chapter 4, I studied one aspect of cognition, i.e., imagery, and found wine experts have more vivid imagery for the appearance, smell and flavor of wines. Finally, in Chapter 5, I demonstrated that wine experts are better at remembering wines, but not common odors. In addition, I demonstrated that language is not used online by wine experts when they remember wine odors. This suggests the ability to describe wines and to remember wine odors are two separate aspects of wine expert cognition.

Similar to other expert domains, wine expertise has pronounced effects on cognition—on language, imagery and memory —and similar to other expert domains, these effects are found to be restricted to the domain of expertise. The studies in this dissertation found minimal evidence for transfer of these effects to other smell domains.

6.1 ARE SMELLS AND FLAVORS MORE CODABLE FOR WINE EXPERTS?

In the first chapters of this dissertation, I investigated whether wine experts are able to describe the smell and flavor of wine informatively, consistently and accurately. Previously, Brown and Lenneberg (1954), and later Levinson and Majid (2014) and Majid and Burenhult (2014) defined that when an item is more codable in language, it (1) is described more concisely, (2) has dedicated vocabulary, and is named (3a) more consistent and (3b) correctly.

If wine expert descriptions are uninformative, or *bullshit* (cf. Quandt, 2007), it would be impossible to use them to predict particular features of the described wines. On the contrary, using a machine learning approach on a corpus of around 70,000 wine reviews, I showed in Chapter 2 that it is possible to reliably predict the color and grape variety of a wine. This shows wine experts were able to informatively describe wines. In addition, the results indicated wine experts were remarkably consistent in their description of wines in their reviews.

In Chapter 3, I further investigated what kind of experience matters in order to be better at describing odors and flavors, and whether wine experts were more consistent than novices in their flavor descriptions. Wine experts, coffee experts and novices were asked to describe the smell and taste of red wines, the smell and taste of coffees, common smells, and basic taste stimuli. Coffee experts are an interesting comparison group as their expertise gives them plenty of perceptual experience with flavors, but wine experts have comparably more verbal practice at describing smells and flavors. I found wine experts were more consistent in their descriptions for the smell and taste of wine, but not for any of the other smells and tastes. Coffee experts were not more consistent in their descriptions for coffee than novices. However, they were similar to wine experts in that they used more source-based descriptions and less evaluative descriptions than novices for stimuli in their domain of expertise. This suggests expertise changes how odors and flavors are described, making odors and flavors more codable. In addition, the kind of experience also matters.

Finally, in Chapter 5, I provided additional evidence for the effect of wine expertise on language. In the first study presented in this chapter, wine experts and novices were asked to name wine odors, wine-related odors and common odors twice, which allowed calculation of within-participant consistency in addition to accuracy in naming. The results showed wine experts were more accurate, and also more consistent over time in their descriptions of wine odors.

To recap these findings in the context of codability (R. W. Brown & Lenneberg, 1954; Levinson & Majid, 2014; Majid & Burenhult, 2014), wine experts use domain-specific language for wines (criterion 2); are more consistent than novices when describing wine, both with themselves over time, as well as with other wine experts (criterion 3a); and are more often correct in their descriptions of wine (criterion 3b). Nevertheless, wine experts do not give shorter descriptions than novices (criterion 1), in fact, their descriptions for wines were found to be significantly longer (Chapter 3). This could be because wine experts capture the complex nature of wines in their descriptions: a single word or short sentence simply does not capture the whole multimodal flavor experience of wine (cf. Shepherd, 2006, Box 1).

What underlying mechanism can explain why wine is more codable for wine experts? There are a few possibilities. The first candidate considered is olfactory awareness, i.e., how consciously aware one is of the smells around them. Olfactory awareness is linked to the ability to name odors in novices (Arshamian et al., 2011). Wine experts may have a higher odor awareness and this may in turn explain their ability to name wines. Indeed, the wine experts that participated in the experiment in Chapter 3 showed significantly higher odor awareness than the novices (Chapter 3, section 3.3.2). However, coffee experts also had significantly higher odor awareness than novices, but their ability to name the odor and flavor of coffee was not better than novices. This suggests odor awareness cannot be the whole story.

Another explanation may lie in the fact that wine experts have higher perceptual acuity—they may be more sensitive to smells. Training and experience has been found to heighten olfactory sensitivity, although this effect has been found to be limited in nature (Chollet & Valentin, 2001; Tempere et al., 2011; Tempere, Cuzange, Bougeant, Revel, & Sicard, 2012). Similarly, in a recent review, it was concluded that "while experts might not be more sensitive to smells in general, they may have lower detection thresholds for smells specific to their expertise" (Majid et al., 2017, p. 417). Parr and colleagues (2002) also investigated this explanation. Their results indeed showed a relationship between sensitivity and the ability to identify odors in novices, but for wine experts, this relationship was not found. Nevertheless, perceptual learning could cause particular aspects of wine to stand out more, making experts more sensitive to odors in wine. In turn, this could affect their naming too, as it may cause particular features to stand out more. The finding that coffee experts, who also greatly exceed novices in their perceptual experience for coffee odors, did not describe coffees more consistently than novices, suggests this link between sensitivity and naming requires further exploration.

Previous scholars have proposed that conceptual change underlies the linguistic differences between wine experts and novices (Solomon, 1997; Ballester et al., 2008). This hypothesis predicts that initial concepts become more refined through experience, and by (linguistic) exposure to a domain (Carey, 1999; Majid et al., 2004). Similarly, the basic level on which an object is perceived becomes more specific (Johnson & Mervis, 1997; Tanaka & Taylor, 1991). Where a novice may state 'red wine' when asked to say what they have in front of them, a wine expert may say 'pinot noir'. In the process of conceptual change, particularly characteristic features of an object in a class, i.e., a specific wine, become more salient as knowledge structures are enriched. Language, i.e., the act of talking about and describing wine, may play a role in this, as language may highlight these particular features, and provide a basis for how the knowledge is acquired (cf. Majid et al., 2004). These different mechanisms may work together, shaping the way wine experts talk about wine. Through using language, a personal vocabulary may become more consistent, and line up with the domain-specific vocabulary used by other experts.

In summary, this dissertation shows that the codability of smells and flavors changes with expertise, and that it matters what kind of experiences are part of that expertise. Domain-specific knowledge, perceptual experience, and verbal practice seem to have differential impact on the language of flavor experts. Verbal experience, i.e., practice in describing flavors, makes wine experts consistent in the vocabulary used for wine. Odors and flavors may be difficult to name as most Western languages lack the specific olfactory lexicon to describe them, but specific experience can help overcome these boundaries posed by language.

6.2 WHAT IS THE INFLUENCE OF WINE EXPERTISE ON OLFACTORY COGNITION?

In Chapters 4 and 5, I investigated the effect of wine expertise on two different aspects of cognition: imagery and memory. The existence of olfactory imagery has been disputed (Herz & Engen, 1996), and it has been suggested that only expert perfumers are able to engage in olfactory imagery (Royet, Delon-Martin, et al., 2013). Recent reviews, however, suggest olfactory imagery is real, and novices can engage in it (Arshamian, 2013; Arshamian & Larsson, 2014). How wine expertise shapes the ability to imagine odors, and/or the multimodal experience of wine has not been previously studied.

In Chapter 4, I described how a new measure of wine imagery was constructed and validated. This questionnaire can be used to measure the vividness of imagery of the color, smell, and flavor of wine. In Study 3 of Chapter 4 (Chapter 4, section 4.5), wine experts and novices completed this questionnaire, in addition to a general olfactory imagery questionnaire (VOIQ; Gilbert et al., 1998). We found wine experts reported more vivid imagery for the color, smell, and flavor of wines than novices. For novices, the results showed a ranking in how vivid imagery was in the different modalities, i.e., vision was most vivid, followed by flavor and finally, smell. This order is similar to what was found in previous modality comparisons of mental imagery (Andrade et al., 2014; Marsella & Quijano, 1974). Moreover, this ranking was not present in wine experts; they reported more vivid imagery for wine in all modalities, with no distinction between the modalities. In contrast, wine experts reported similar vividness of general olfactory imagery as compared to novices, suggesting their better imagery ability is restricted to wine.

Conceptual change, i.e., the novice-expert shift (Carey, 2009; Solomon, 1997), could again underlie the difference in thought between experts and novices. Through experience, the conceptual structures for wines may become more refined, making these perceptual representations more detailed and more vivid when brought to consciousness. A representation of a wine, for novices, may mostly contain information about the color of a wine—making imagery for color more vivid than for smell and flavor. For wine experts, the representation of wine may additionally contain detailed representations for the smell and flavor. The ability to imagine a wine and the ability to describe a wine may be the result of conceptual change.

Contributing to the debate on the existence of olfactory imagery, wine experts reported more vivid olfactory imagery for wines. On the one hand, scholars have argued olfactory imagery is based purely on semantic codes, and not on perceptual representations (Crowder & Schab, 1995). On the other hand, neuroimaging studies have shown the imagery of a smell causes similar activation in the brain as smelling real odors, and causes activation in the primary olfactory (piriform) cortex and the insula (Bensafi et al., 2007). Similarly, olfactory imagery causes differential brain activity depending on the level of experience the person has (Plailly et al., 2012), and olfactory imagery can interfere with the perception of actual odors and tastes (Djordjevic, Zatorre, & Jones-Gotman, 2004; Djordjevic, Zatorre, Petrides, et al., 2004). The present study underscores the existence of olfactory imagery in expert populations, such as wine experts.

The current results emphasize there is variability in the ability to imagine odors as compared to other sensory modalities (in line with Arshamian & Larsson, 2014), and that this could depend on how much specific experience one has with olfaction. As with professional chefs (cf. Bensafi et al., 2017), imagery potentially plays an important role in wine expertise, for example when a wine is reviewed, or when experts invent new wine-food pairings. Taken together, the results suggest mental imagery is malleable, and changes with expertise.

Turning to memory, in several domains, experts have been found to remember the stimuli in their domain of expertise better than novices. For example, musicians have better memory for musical pieces than novices (Williamon & Valentine, 2002; Williamson et al., 2010), and chess players have better memory for chess board layouts (De Groot et al., 1996; Frey & Adesman, 1976). Wine experts, with their experience and knowledge of wine, were also expected to have better memory for objects in their domain of expertise, i.e., wine, and that is what I found.

In Chapter 4, two experiments align in their findings that wine experts have better memory for the complex odor of wines, but not for common odors. In addition, the first experiment also suggested wine experts do not have better memory for wine-related odors, contrary to previous investigations (Parr et al., 2002, 2004), and corroborating the hypothesis that wine expert cognition is domain-specific. Wine experts' better odor memory is restricted to wine odors, and does not transfer to other odors.

One theory regarding expert memory is the template theory applied to chess expert memory (Gobet & Simon, 1996). This theory suggests that when people are memorizing something, the features of the object are extracted into chunks, and these need to be processed by short term memory (STM) first, before being stored in long term memory (LTM). The STM has a limited capacity of only around seven chunks (cf. Miller, 1956), severely limiting the capacity to store complex objects in memory. However, when a particular set of chunks is frequently encountered together, this may form a template. A template is easier to remember, as it takes less processing capacity of STM, leaving room for additional features specific to that wine. Experts, through their experience with the stimuli from their domain, can make use of these templates, making their memory for complex stimuli in the domain of expertise much more effective.

The template theory of expert memory has "the best performance in accounting for the empirical evidence" in chess expert memory studies (Gobet, 1998, p. 115). This theory may be applied to wine expert memory too. When experts remember and recognize wines, they may perceive the wine as composed of chunks, which could be made up of a few characteristic aromas (cf. Gobet, 1998). Early perceptual processes allow efficient feature extraction that make up these chunks, through perceptual learning mechanisms (Gobet, 1998; Kellman & Massey, 2013). When a wine is typical or familiar, this chunk could be further supplemented by contextual information such as color and other features. For frequently encountered wines, typical vintages or wines from notable regions, templates may be formed from chunks that frequently occur together. For example, a "red southern Rhône wine" template might be formed when an expert frequently encounters earthy, herbal and spicy aromas together with a relatively high tannin content in wines made of Grenache, Shiraz and Mourvèdre grapes (wine experts sometimes refer to this combination of grapes as the 'GSM' blend).

As shown above, applying the template theory of expert memory to wine expertise is possible, but there are many outstanding questions that require further research. The template theory has focused on visuospatial processes mainly, but whether these processes can be applied to olfaction is not clear. How are the chunks organized, and what information is stored in an olfactory chunk? One possibility is that the content of the chunks may be perceptual in nature, e.g., consisting of several aromas that frequently occur together. This would predict wine experts would be able to remember artificial combinations of aromas that often occur together in wines better than novices. Similarly, one finding important for the validity of the template theory of chess memory lies in the results of studies on early perceptual processes. Chess experts have shorter visual fixation times, their gaze covers more of the board, and they do so with less variance between experts than between novices (De Groot & Gobet, 1996). A prediction for wine experts along the same lines would be that their sniff latencies may be different and less varied than found in novices. Recently, sniffing has been suggested to be strongly related to memory for smells (Arshamian, Majid, Iravani, & Lundström, n.d. in preparation), possibly by reactivation of the piriform cortex or through odor imagery during consolidation (Gottfried, Smith, Rugg, & Dolan, 2004, p. 691). This suggestion makes the relationship between expert odor memory and sniffing an interesting alley to explore, as it would simultaneously provide insight into the template theory in another domain of expertise.

The better ability to imagine wine smells found in experts may also play a role in expert memory. Paivio (1983) described the dual coding theory as two channels whereby people can encode information, through verbal codes, or through perceptual codes. Thus, having better olfactory imagery ability may affect the way smells are encoded and remembered. If imagery is crucial for olfactory memory, having to imagine a different, non-related odor during encoding of a smell in a recognition experiment is expected to interfere with subsequent memory for that odor (see Speed & Majid, under review, for a similar paradigm). If imagery, rather than perceptual attention, is important for memory, the effect of this imagery interference condition would be expected to be more detrimental for memory than actually smelling an unrelated odor. This effect would not be expected if odor memory does not depend on imagery.

6.3 WHAT IS THE RELATIONSHIP BETWEEN LANGUAGE AND WINE EXPERT MEMORY?

In Chapters 2 and 3, wine experts were shown to be better at naming wines. This raises the question to what extent experts' ability to describe wines explains their better memory for wines. The underlying rationale for this question is that when a concept is more codable in language, it is easier to remember (Lachman et al., 1974), a phenomenon explored in work on linguistic relativity (Boroditsky, 2011; Majid et al., 2004; Wolff & Holmes, 2011).

To test this hypothesis, two experiments were conducted. In the first experiment of Chapter 5, experts and novices were given common odors and wine odors to remember, but depending on the condition they were allocated to, also named the stimuli they had to remember or were silent. In a second study, wine experts and novices were again asked to memorize different wines and common odors. Crucially, the experiment contained three different conditions; one passive control condition, one active control condition using visual interference, and one experimental condition using verbal interference (cf. Winawer, et al., 2007; Frank et al., 2012). These two studies allowed for testing the influence of language on memory. For experts and novices alike, no relationship was found between the ability to name wines and the memory for wines. Similarly, under verbal interference, wine experts were still better at recognizing wines than novices, suggesting wine experts do not employ language online to remember wines. Taken together, these two experiments convincingly suggest experts' better memory for wines is not mediated directly by their ability to name wines.

In the introduction, several mechanisms were outlined by which language may help memory. When something is nameable, it can be easily rehearsed and encoded (R. W. Brown & Lenneberg, 1954; Chrea et al., 2007). Dual coding theory proposes two routes by which stimuli are encoded—a perceptual route (Paivio, 1983), and a verbal route. In theory, having the words to describe wine makes the second route more efficient, explaining the difference between wine experts and novices. However, the findings from the studies in Chapter 4 argue against these direct, online linguistic mechanisms, as there was no effect of naming in Study 1 (Chapter 5, section 5.3), and no effect of verbal interference in Study 2 (Chapter 5, section 5.4). Thus, an online mechanism of language is not a plausible explanation for the better memory in wine experts, given this data.

Nevertheless, other mechanisms through which language may exert an influence on odor memory could still explain the observed pattern of results. Majid and colleagues (2004) propose four different mechanisms by which Whorfian effects on cognition can take place. First, wine students learn about wine through language. When their knowledge becomes refined, a conceptual change, or novice-expert shift takes place (Carey, 1999; Solomon, 1997). These refined concepts may allow wine experts to better distinguish between two wines, making it easier to distinguish between a wine that is smelled now, and one that was smelled previously. This mechanism could explain the difference between experts and novices, but needs further testing. For example, if grape type is the only driver for conceptual change in wine experts, this would predict the better memory for wines disappears when the stimuli used, i.e., the wines, are all made using the same grapes, even when they have different terroir characteristics (cf. Foroni et al., 2017). Future studies should evaluate whether this is in fact the case.

Another way in which language may shape expert memory is by directing selective attention towards salient features in a wine. When a particular aspect of the wine flavor is named, someone can focus their attention on it and consciously perceive it. The next time this feature is encountered, the label is also easier to recall, as that feature becomes associated with a label. Through this linguistic process, particular features in wines become more salient, as they can be named. Subsequently, these features may drive the process of distinguishing between wines. Language may initially play a stronger role in driving this process, but when attention becomes habitually attuned to these features, language may no longer have an online role. If this is true, then as students studying wine, e.g., a sommelier student, become experts, there should be a period in which language plays a stronger role when they remember wines. This would suggest that wine students' memory for wine should be particularly harmed by verbal interference during this time, but not later when their expertise grows. Melcher and Schooler (1996) indeed found that wine students were particularly vulnerable to verbal overshadowing—when wine students tried to identify a wine during encoding, their memory was impaired as compared to when they just smelled the wine. Tellingly, this effect was not found for wine experts, they were found to be immune to the verbal overshadowing effect (Melcher & Schooler, 1996). This suggests language-guided attention could play a role in wine expertise, especially during the process of becoming a wine expert.

So language could still plausibly play a role in wine expert cognition, although it does not appear to play an online role for established experts. In addition, the effects outlined above are not mutually exclusive, and may affect cognition at different stages of becoming a wine expert. While the studies in Chapter 5 show language does not play an online role in memory, language does play a large role in wine expertise, also shown by the results in Chapters 2 and 3. In fact, the template theory of expertise (Gobet, 1996) leaves room for linguistic descriptions (called *high-level* representations in this literature) to affect how templates and chunks are formed and remembered (e.g., Cooke et al., 1993). Gobet and Simon (1996), in their theory for chess memory, state that high-level representations form part of the knowledge structure of a particular template. Although template theory is not based on language, how templates are formed can still be shaped and modified by language. Future research could investigate the learning process in more detail to see what specific role language plays.

Finally, although there was no relationship between naming and memory for wine odors, Chapter 5 revealed a relationship between how accurately common odors were named, and how well they were remembered. This finding is in line with previous studies that show memory for odors is better when they are named accurately (Cessna & Frank, 2013; R. A. Frank, Brearton, et al., 2011; Jehl et al., 1997). Unlike previous findings, however, the effect was found only for simple odors, and not for the complex wine odors. One explanation, given in Chapter 5, is that both accuracy in labeling and memory may be mediated by the familiarity of an odor, a suggestion that is also supported by previous studies (Engen, 1987; Kärnekull et al., 2015; Lehrner, Glück, et al., 1999; Rabin & Cain, 1984; Stevenson & Mahmut, 2013).

Taken together, the results do not support an online role for language in wine expert memory. Nevertheless, wine experts are better at describing, imagining and memorizing wines.

6.5 IS WINE EXPERTISE DOMAIN-SPECIFIC, OR DOES IT TRANSFER TO OTHER SMELLS AND FLAVORS?

Throughout the chapters in this dissertation, the effects of expertise on the consistency in language use, odor imagery and odor memory, were found to be domain-specific, and did not transfer beyond the domain of expertise. Transfer effects of expertise have been found in other domains, but are rare (cf. Kimball & Holyoak, 2000). The studies in this dissertation have contrasted wines with other complex stimuli (i.e. coffee), wine-related smells, and common smells. The demarcation of wine expertise seems to be drawn at wine, suggesting wine expertise does not affect olfaction more generally.

In one study in Chapter 5, there was some evidence that wine experts might be better than novices when naming not only wines, but also common odors. This finding fits some previous work showing wine experts were better at naming common odors (Bende & Nordin, 1997). Nevertheless, the attested difference between novices and experts in Chapter 4 is much smaller for common odors than it is for wine odors. And the overall pattern of results from the studies in Chapters 3, 4, and 5 suggest limited transfer.

Previous studies on chess expertise have shown a similar pattern of results: the cognitive difference between experts and novices is largest for stimuli meaningful in the domain of expertise, but there can be a small effect for non-meaningful stimuli as well (Gobet & Simon, 2006). One explanation for this effect may relate to the higher odor awareness that is found in wine experts as opposed to novices. Odor awareness is not sufficient to explain the effect of expertise on naming or memory for wines. However, because of their high odor awareness, experts may be more attuned to odors they encounter in daily life, making those smells more familiar, which in turn may drive the effect found for accuracy in naming common odors. This suggests that given the right kind of stimuli and a sufficiently sensitive measure, some transfer effects may be found for wine expertise. Nevertheless, the majority of differences between wine experts and novices seems domain-specific, i.e., restricted to wine.

6.6 IMPLICATIONS AND FUTURE DIRECTIONS FOR (WINE) EXPERTS

This dissertation shows wine experts are better at describing, recognizing and imagining smells and flavors if these originate from wine. For wine experts who focus primarily on wine, their expertise enables them to deal with the challenges posed by their profession. Consumers are nowadays eager to learn about the background and origin of the products they purchase, and seek for authenticity in brands (Beverland, Lindgreen, & Vink, 2008). Because of this, brands want to provide information about a particular product, and wine experts are often asked to apply their skills to these smells and flavors outside the domain of wine. For this reason, wine experts are often asked to act as general food experts, and to inform and describe products outside their expert domain. The current findings place caveats with this practice, as it is clear wine expertise does not transfer to other flavor domains, such as coffee. Future research should investigate how much training is necessary to overcome the boundaries of expert domains.

This dissertation also provides insight into how to study wine. Theories previously used to describe other domains of expertise could apply to the domain of wine too. The findings suggest perceptual learning, mediated by language, could in part explain the effects wine expertise has on cognition. Additionally, perceptual learning offers a mechanism to learn about a specific domain, and acquire expertise too (Kellman & Massey, 2013). Implementing these techniques explicitly into wine curricula, or courses on other flavor domains, may allow more efficient acquisition of flavor lexicons. As the flavor industry is dependent on sensory analysts and other flavor experts, exploring a role for perceptual learning poses promising angles to the training of new flavor experts (L. Lawless & Civille, 2013).

Another relevant question to ask is whether training schemes that prepare novices for these professions can be optimized by paying attention to specific aspects of expert cognition. In various domains of expertise, for example in sports (Arvinen-Barrow et al., 2007; R. Weinberg, 2008), imagery is proven to be beneficial in becoming a professional athlete. Imagery was previously found to be as effective to train people to discriminate between particular visual features in a stimulus as actual training with these stimuli (Tartaglia, Bamert, Mast, & Herzog, 2009). This suggests imagery may be a useful addition to actual training. Just as athletes cannot train full-time, wine students cannot always drink or smell wine. Imagery could have a valuable role in training programs on olfactory and flavor expertise.

In conclusion, expertise shapes language and thought, showing cognition is malleable. In this dissertation I demonstrate that wine expertise changes the way people talk and think about wines. Smells and flavors can be put into words consistently and effectively given the right kind of expertise (Chapter 2 and 3); wine experts report more vivid imagery of smells and flavors of wines than novices (Chapter 4); and as in other expert domains, flavor expertise improves memory for complex smells, such as wines, (Chapter 5), although this is not directly mediated by the ability to describe those smells. Finally, resembling many other types of expertise, the different studies in this dissertation reveal that the effects of wine expertise on cognition are mostly domain-specific.

Although novices are not always consciously aware of odors and flavors, this is different for wine experts. Odors and flavors are more codable for wine experts, and how they think about wines is different too. This dissertation raises new questions around wine expert language and cognition, and proposes novel hypotheses, future directions, and practical implications for flavor expertise in general and wine expertise in particular. By using a range of multidisciplinary methods, this dissertation connects language, memory, imagery, expertise, and olfaction.

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NEDERLANDSE SAMENVATTING

Praten over wat we ruiken en proeven, oftewel onze olfactorische ervaringen, is moeilijk. Zelfs als je iemand die Nederlands spreekt vraagt om bekende geuren zoals sinaasappel of kaneel te benoemen, zal het antwoord in slechts 50% van de gevallen het juiste zijn (sinaasappel en kaneel respectievelijk). De rest van de antwoorden zijn dan vaak andere zogenaamde bronbeschrijvingen: woorden die verwijzen naar andere objecten die ruiken (zoals citrus of speculaas). In het Nederlands zijn er nagenoeg geen woorden om geurkwaliteiten goed te beschrijven, zoals er wel woorden zijn om kleuren op een abstracte manier te beschrijven (rood, groen, enzovoort). Het enige abstracte woord om geurkwaliteit te beschrijven is muf. In andere westerse talen, zoals in het Engels, is dat niet anders.

Geur en smaak (in het Engels "flavor") zijn nauw verbonden. Via een doorgang van de mond naar de neus (de "retronasale doorgang") stijgen geuren van eten in de mond op naar de neus. Volgens Charles Spence (2015) is meer dan 75% van wat we proeven toe te schrijven aan olfactie, aan ruiken dus. Omdat geur en smaak zo nauw verbonden zijn, is het ook lastig om te beschrijven wat we proeven. Voor het deel dat de tong registreert, de smaak, zijn er in het Nederlands enkele abstracte woorden (zoet, zuur, zout, bitter), maar voor de rest van wat we proeven geldt hetzelfde als voor ruiken. Onze olfactorische ervaringen zijn moeilijk te beschrijven.

Dat het lastig is om geuren te beschrijven, is eerder toegewezen aan de rudimentaire aard van het reukorgaan. Het lijkt alsof we onze neus niet meer nodig hebben, en daarom is er ook geen vocabulaire nodig om het te beschrijven. Een blik op het uitgavenpatroon van de gemiddelde Nederlander vertelt een heel ander verhaal. Vrijwel alle producten die te koop zijn in de supermarkt hebben een afgemeten geur en/of smaak. Daarnaast krijgen steeds meer winkels een "geurdecor", worden nieuwe auto's op een specifieke manier geparfumeerd, en zijn mensen steeds op zoek naar nieuwe geur- en smaakervaringen bij restaurants en parfumwinkels. Het lijkt erop dat met toenemende gemiddelde welvaart, geuren en smaken steeds belangrijker worden.

Daarnaast blijkt uit recent onderzoek dat er culturen zijn waar men wel woorden heeft voor geuren zoals er in het Nederlands woorden zijn voor kleuren. In Jahai en Maniq, talen gesproken door jager-verzamelaarsculturen in Maleisië, bestaan twaalf tot vijftien abstracte en specifieke woorden om geurkwaliteiten kort en krachtig te beschrijven. In de cultuur van deze volken speelt geur een grote rol: kinderen worden vernoemd naar geurige bloemen en kruiden, tijdens religieuze ceremonies worden zeer specifieke geuren ingezet om te communiceren met hogere krachten, eten wordt zo bereid zodat het een bepaalde geur heeft, en tijdens de jacht wordt geur gebruikt om prooi (uit) te zoeken. Voor de gelijknamige volken die Jahai en Maniq spreken, valt het hebben van woorden om geuren te beschrijven samen met een grote culturele rol voor geuren. Het zou kunnen dat wanneer geuren een grotere, bewuste rol in het dagelijks leven spelen, geuren (en smaken) makkelijker te benoemen zijn.

Daarnaast is het zo dat de manier waarop mensen hun ervaringen omzetten in taal beïnvloedt hoe ze over deze dingen nadenken. De taalrelativiteitshypothese voorspelt dat de manier waarop mensen hun ervaringen beschrijven, beïnvloedt hoe ze over de wereld denken. In extreme versies van deze hypothese wordt gesteld dat mensen denken met taal, en dat taal dus beperkt waar mensen over kunnen denken. Andere versies van dit gedachtegoed voorspellen dat de categorieën waarin taal ervaringen opdeelt het denken beïnvloedt, maar dat denken wel los staat van taal. Een voorbeeld is hoe talen omgaan met kleuren. Sommige talen hebben slechts enkele abstracte woorden voor kleuren, terwijl er in het Engels en het Nederlands ongeveer een tiental abstracte woorden zijn hiervoor. Uit onderzoek blijkt dat de categorieën waarin het kleurspectrum door taal wordt opgedeeld, beïnvloedt hoe mensen kleuren onthouden. Kleur is slechts een voorbeeld waarin effecten van taalrelativiteit zijn gevonden. Vergelijkbare effecten zijn gevonden beschrijvingen voor ruimte, geluid, getallen en beweging, maar ook meer basale elementen van taal zelf, zoals voorzetsels en grammaticale geslachtsbepalingen. Geurbeschrijvingen zijn nog niet vaak onderzocht op dit soort taalrelativiteitseffecten. En dat terwijl er juist veel verschil lijkt te zijn in hoe mensen hun olfactorische ervaringen in taal uitdrukken. Ervaring met geuren en hoe belangrijk ruiken en proeven in het dagelijks leven voor iemand zijn, lijken daarbij een rol te spelen.

In onze contreien zijn er ook mensen voor wie geuren en smaken een betekenisvolle en bewuste rol spelen in het dagelijks leven, bijvoorbeeld voor wijnexperts. Wijnexperts proeven en ruiken dagelijks aan wijn. Daarnaast speelt taal een belangrijke rol in wijnexpertise. Om wijn te verkopen, geven ze beschrijvingen van de smaak aan zowel andere experts als leken, bijvoorbeeld in restaurants en in winkels. Tijdens proeverijen praten wijnexperts met elkaar over wijn. Ze gebruiken dan veel woorden die verwijzen naar bepaalde geurige objecten, zoals vanille, kersen of rood fruit. Het lijkt er op dat wijnexperts dus wel in staat zijn over geuren en smaken te praten, terwijl een gemiddeld westers persoon of de gemiddelde wijn-leek dat erg moeilijk vind. Er is echter ook kritiek op deze manier van beschrijven: wijnbeschrijvingen reflecteren vaak de persoonlijke stijl van een wijnschrijver, en er worden vaak, soms vergezochte, metaforen gebruikt. Dat roept de vraag op of de beschrijvingen van wijnexperts wel consequent en informatief zijn, of simpelweg bloemrijk proza.

In de eerste twee hoofdstukken van dit proefschrift geef ik antwoord op de vraag of wijnexperts informatief en consequent wijn beschrijven, en of ze dat beter doen dan leken. In Hoofdstuk 2 laat ik zien dat Amerikaanse wijnexperts, ondanks een persoonlijke stijl, op een consequente manier wijn beschrijven. Daarnaast laat ik in dit hoofdstuk zien dat wijnexperts een domein-specifiek vocabulaire hebben van zo'n 140 woorden. Het gevonden vocabulaire overlapt deels met bestaande lijsten van wijnvocabulaire, maar er staan ook woorden in die nog niet eerder beschreven zijn in het gebruik voor wijn. In Hoofdstuk 3 ga ik dieper in op de vraag of wijnexperts wijn beter beschrijven dan leken. Ook worden in dit hoofdstuk Nederlandse wijnexperts vergeleken met Nederlandse koffie-experts. Koffie-experts ruiken en proeven dagelijks veel verschillende soorten koffie, maar het beschrijven van koffie lijkt een kleinere rol te spelen voor koffie-expert. Dit blijkt bijvoorbeeld uit het feit dat er in supermarkten wel beschrijvingen gegeven worden voor elke wijnsoort in het schap, maar niet voor elke koffiesoort. Restaurants hebben vaak uitgebreide wijnmenu's met beschrijvingen van de verschillende wijnsoorten, maar bieden geen beschrijvingen van de soorten koffie. Dit verschil in taalgebruik tussen wijnexperts en koffie-experts maakt het mogelijk te onderzoeken hoe specifieke verbale training het beschrijven van geur en smaak beïnvloedt. Uit dit onderzoek blijkt dat wijnexperts beter zijn in het beschrijven van de geur en smaak van wijn dan leken: wijnexperts waren als groep consequenter in hun beschrijvingen, en gebruikten meer concrete bronbeschrijvingen (vanille, tannine, kersen), terwijl leken meer evaluatieve beschrijvingen gaven (lekker, vies). Koffie-experts deden dat ook voor de geur en smaak van koffie: zij gebruikten meer bronbeschrijvingen (bessen, chocolade) dan leken. Echter, koffie-experts waren niet consequenter in hun beschrijvingen dan leken. Uit het verschil tussen wijnexperts en koffie-experts blijkt dat het soort ervaring (enkel proefgericht, of ook verbaal), mede bepaalt hoe goed je bent in het beschrijven van geuren en smaken. Dit blijkt ook uit de andere bevinding uit dit hoofdstuk: wijnexperts waren namelijk alleen beter in het beschrijven van wijn, en niet van koffie, losse geuren of basissmaken. Dit laat zien dat het vermogen om geuren en smaken van wijn te beschrijven domein-specifiek is, en niet generaliseert naar andere geuren en smaken.

Deze hoofdstukken laten zien dat wijnexperts de geur en smaak van wijn anders beschrijven dan leken. In Hoofdstuk 4 en 5 onderzoek ik vervolgens of experts en leken ook anders nadenken over geuren en smaken. Inbeeldingsvermogen (imagery in het Engels) is het (opnieuw) ervaren van iets zonder dat dit fysiek aanwezig is, bijvoorbeeld op basis van een eerdere ervaring, in beeld, geur of smaak. Een voorbeeld hiervan is het inbeelden van speculaas. Daar zou je een beeld ("bruin, rechthoekig, plat"), een geur ("kaneel, specerijen, karamel, koek") en een smaak ("zoet") kunnen inbeelden. Hoewel mensen uit westerse culturen over het algemeen goed zijn in het inbeelden van beelden, gaat het inbeelden van geuren hun minder goed af. Er zijn echter aanwijzingen dat het inbeeldingsvermogen ook afhangt van bewuste ervaring. In Hoofdstuk 4 introduceer ik een vragenlijst over het inbeelden van de kleur, geur en smaak van wijn. Vervolgens heb ik wijnexperts en leken gevraagd deze vragenlijst in te vullen, samen met een andere vragenlijst die het inbeeldingsvermogen voor algemene geuren meet. Leken rapporteerden, net als in voorgaande onderzoeken, dat hun inbeeldingsvermogen het meest levendig was voor de kleur van wijn, en het minste voor de geur van wijn. Voor leken was er ook geen verschil tussen het inbeelden van algemene geuren of geuren van wijn. Echter, voor wijnexperts bleek dat het inbeeldingsvermogen voor wijn over het algemeen beter was dan dat van leken. Daarnaast was er voor wijnexperts geen verschil of ze de kleur, geur of smaak van de wijn inbeelden: het inbeeldingsvermogen voor elk zintuig was even levendig. Bovendien hadden wijnexperts een levendiger inbeeldingsvermogen voor de geur van wijn dan voor algemene geuren, waaruit blijkt dat ook het effect van ervaring op inbeeldingsvermogen domein-specifiek is.

In het laatste hoofdstuk, Hoofdstuk 5, onderzoek ik hoe wijnexpertise het geheugen voor geuren en wijn beïnvloedt. Vorig onderzoek heeft laten zien dat leken beter zijn in het onthouden van geuren die makkelijk te benoemen zijn, dan geuren die lastig te benoemen zijn. Dit roept de vraag op of er voor wijnexperts een relatie bestaat tussen hoe zij de geur van wijn beschrijven, en hoe ze die onthouden. Als wijnexperts taal gebruiken om de geur van wijn te onthouden, bijvoorbeeld doordat ze de wijngeur eerst benoemen en vervolgens die naam onthouden in plaats van de geur zelf, dan zou dat een zogenaamd online effect van taal zijn. Daarnaast zou dat het verschil tussen wijnexperts en leken in het onthouden van geuren kunnen verklaren: wijnexperts zijn tenslotte beter in het benoemen van wijn dan leken (Hoofdstuk 2 en 3). In twee experimenten onderzoek ik het effect van taal op het onthouden van geuren in Nederlandse wijnexperts en leken. In experiment 1 kregen wijnexperts en leken wijngeuren, wijn-gerelateerde geuren (zoals vanille, of kers), en algemene geuren (zoals groene thee, of zeep) te ruiken die ze moesten onthouden ("encoderen"). Een helft van de deelnemers moest deze geuren ook benoemen, en de andere helft kreeg de geuren alleen te ruiken. Daarna kregen de deelnemers dubbel zoveel geuren te ruiken, waarvan de helft nieuw was. Ze moesten aangeven welke geuren ze eerder hadden geroken en welke nieuw waren. Wijnexperts gaven vaker correct aan dat ze een wijngeur eerder hadden geroken dan leken, maar voor de andere geursoorten was er geen verschil. Bovendien was er geen invloed van de verschillende taal-condities: het actief benoemen gaf geen beter geheugen dan ruiken alleen. In een tweede experiment heb ik dit verder onderzocht. Nieuwe groepen wijnexperts en leken kregen in dit experiment wijngeuren en gewone geuren te ruiken die ze moesten onthouden. De deelnemers werden opnieuw opgedeeld in verschillende experimentele condities. In de eerste conditie (de verbale interferentieconditie) moesten de deelnemers een reeks cijfers in gedachte houden tijdens het encoderen van de geuren. Als taal een actieve rol speelt in het onthouden van geuren, zou deze conditie het effect van taal moeten uitschakelen, omdat het verbale deel van het werkgeheugen bezet gehouden wordt door de cijferreeks tijdens het encoderen. In de tweede conditie moesten de deelnemers een blokkenpatroon in gedachte houden. Dit was een actieve controleconditie om te kijken wat het effect van een extra taak was op het geheugen voor geuren. In de laatste conditie kregen de deelnemers geen extra taak te doen; een simpele controleconditie. Als taal een actieve rol speelt in het onthouden van geuren voor wijnexperts, dan zou het verschil tussen leken en experts verdwijnen in de verbale interferentieconditie. Dit was echter niet het geval. Wijnexperts waren net als in het eerste experiment beter in het onthouden van wijn dan leken, maar niet in het onthouden van gewone geuren. Opnieuw was het effect van wijnexpertise dus domein-specifiek. Ze werden echter niet beïnvloedt door de verbale interferentietaak, waaruit blijkt dat taal geen actieve rol speelt in het geheugen van wijnexperts voor wijn.

In mijn proefschrift heb ik onderzocht hoe wijnexperts praten over geuren en smaken. Wijnexperts hebben een domein-specifiek vocabulaire voor wijnen, en deze woorden gebruiken ze consequenter dan leken. Dit effect blijft echter beperkt tot wijn. Om betere beschrijvingen te geven, maakt het dus uit hoe veel specifieke ervaring mensen hebben met het praten over geuren en smaken. Wijnexpertise beïnvloedt daarnaast hoe over geuren en smaken gedacht wordt. Wijnexperts hebben een helderder inbeeldingsvermogen voor wijn dan leken, maar dit geldt niet voor andere geuren. Ook hebben wijnexperts een beter geheugen voor geuren van wijn, maar wederom niet voor andere geuren. Samenvattend laat het onderzoek zien dat het effect van wijnexpertise op cognitie domein-specifiek is, maar ook dat ervaring verstrekkende gevolgen heeft voor de manier waarop iemand over geuren praat en nadenkt.

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APPENDICES

APPENDIX A UNIQUE TERMS IN ESTABLISHED AND CONSTRUCTED WINE WORDLISTS

Termhood Unique (n = 89)	Parker Unique (n = 83)	LeNez unique (n = 28)	Winewheel unique (n = 180)
blend Merlot hint smooth wines firm tannins firm sip Syrah red flavor vineyard zest pinot Riesling viognier minerality medium-bodied wine fruit cassis red fruit zesty Bright dense berry flavor tannins sauvignon wood currant red berry barrel black fruit crisp mouth soft tannins smoke fruit flavor Cabernet Sauvignon drink layers Petit Verdot fragrant character rosé plenty finish Verdot aromatics cherry flavor richness scents minty refreshing touch mineral sweetness juicy notes spice plum accents grape Chardonnay bottling black cherry aperitif sparkler Noir dishes cabernet Blanc stone fruit meat mocha ripe fruit wine franc racy midpalate Delicious herb palate white pepper white sweet mouthfeel blueberry Sauvignon Blanc structure	mouth-filling unctuous fat briljant reduction tightly knit round tannic stalky extract foudre silky decadent inox vats hollow corked overripe barnyard bouquet closed volatile brawny stale honeyed full-bodied focused double-decanting plummy massive angular browning body pigeage exuberant diffuse monocepage lean briary lively balance troncais oak ponderous backward shallow demi-muid leafy deep dumb acetic berrylike austere acidic off carbonic maceration pruny thick herbes de provence big kisselguhr filtration precocious forward concentrated vegetal hedonistic sharp perfumed flabby monopole elegant aftertaste meaty lush oaky delicate morsellated savoury musty raisiny long botrytis cinerea cuvee garrigue astringent	new leather clove lychee dark chocolate woody-spicy bilberry thyme truffle muscat musk furfural linden roasted hazelnut hawthorn green wood green pepper pharmaceutical note acacia cut hay redcurrant wine lees butter saffron quince blackcurrant bud roasted almond vanilla pod coconut	nutmeg artificial grape numbing burned irritation parching wet clay musty/moldy fishy abrasive vegetative acetic acid concentration sawdust black licorice acetaldehyde styrene aspirin spritz soy sauce wet baker's yeast activity toasted grain wet concrete moldy cork treefruit silk asparagus apple/pear blossom drying flavor fresh coconut blackcurrant/cassis tar toasted coconut suede sauerkraut filter pad cool wet straw orange blossom petroleum surface smoothness green tea driedfruit raisin root beer green olive strawberry jam heat malt extract dry warm hay toasted linalool skunk lift sour cream yeasty chalky grippy prickle furry vermouth diacetyl (butter) powder fresh yeast cognac green beans creamed butter cannedcooked vegemite ginger oxidized b vitamins other ethyl acetate satin talc resinous burnt chocolate stale powdered milk pucker leesy butyric acid burnt/toasted/charred sappy black olive steely sulfur soapy diesel peanut butter dynamic fresh bread alcohol garlic mouthcoat flor yeast tea lychee nut watermelon pine microbiological toasted almond dried horsey pungent tutti frutti mercaptan fusel alcohol grainy corky papery weight nutty lilac artificial fruit full musty (mildew) chilli kerosene bell pepper methyl anthranilate metallic particulate molasses plaster grape blossom cloves syrup hydrogen sulfide canteloupe stemmy sweaty dill dusty anise eucalyptus grass wet wool rancid butter burnt match plastic green apple sour watery tingle popcorn velvet hazelnut caramelized pickled onions lactic sorbate fine emery rubbery turpentine ethanol geranium microbial mint adhesive applesauce unripe lactic acid tomato soup artichoke chemical mousey butterscotch chamois phenolic cooked cabbage moldy fig sulfur dioxide carbon dioxide wet cardboard hay/straw

APPENDIX B WINE KNOWLEDGE TEST

1 INDICATE THE TRADITIONAL COLOR OF THE FOLLOWING VARIETIES OF WINE

1	**Cabernet Sauvignon**	white	red	don't know
2	**Riesling**	white	red	don't know
3	**Merlot**	white	red	don't know
4	**Pinot Grigio** (Pinot Gris)	white	red	don't know
5	**Shiraz** (Syrah)	white	red	don't know
6	**Sauvignon Blanc**	white	red	don't know
7	**Chardonnay**	white	red	don't know
8	**Pinot Noir**	white	red	don't know

2 IN WHAT WAY DO BOTRYTIS WINES DIFFER FROM STANDARD WINES?

A Sugar is added to standard still wine to increase sweetness
B Grapes are infected by a mould called botrytis
C Grapes of the botrytis variety are used
D Botrytis fermentation techniques are used
E None of the above answers is correct
F I don't know

3 WHICH WINE IS MADE WITH FLOR YEAST?

A Champagne
B Sherry
C Port
D Sauternes
E Some white wines from Austria
F I don't know

4 LATOUR, LAFITE, HAUT BRION AND MOUTON-ROTHSCHILD ARE..?

A Wine domains with the premier cru designation
B Typical grape varieties from France
C Sizes of oak barrels in which wine is matured
D Wine estates in the Paris region
E Names of different types of glassware used to drink wine from
F I don't know

5 WHAT IS THE DISTINCTION BETWEEN AROMA (PRIMARY AROMA) AND BOUQUET (SECONDARY/TERTIARY AROMA)?

A Bouquet comes from red grapes and aroma from white grapes

B Bouquet is found only in sparkling wines and aroma only in still wines
C Aroma is based on climate, bouquet on soils
D Bouquet comes from fermentation procedures whereas aroma has its origins in the grape alone
E Bouquet fades with bottle age whereas aroma does not
F I don't know

6 HOW DOES TRADITIONAL BRUT CHAMPAGNE GET ITS MOUSSE (BUBBLES)?

A By turning the bottles during fermentation
B Carbon is added to the wine in the bottle, which reacts to form carbon dioxide (bubbles)
C From the sugars that remain in the wine after fermentation
D Carbon dioxide is added mechanically to the bottled wine
E Sugar and yeast is added to wine in the bottle
F I don't know

7 WHICH GRAPE VARIETIES ARE PRIMARILY USED IN THE BORDEAUX REGION?

A Muscat and Carménère
B Shiraz and Pinot Noir
C Chardonnay and Gamay
D Merlot and Cabernet Sauvignon
E Zinfandel and Nebbiolo
F I don't know

8 WHAT COLOR IS THE SKIN OF THE GEWÜRZTRAMINER GRAPE?

A Red
B White
C Pink
D Purple
E Yellow
F I don't know

9 HOW OFTEN DO YOU DRINK WINE?

A Less than once a month
B 1-4 times a month
C At least once a week
D Every day

10 HOW MUCH HAVE YOU READ ABOUT WINE?

A Just the labels on wine bottles
B Less than one book
C 1-3 books or articles
D 3 or more books or articles

APPENDIX C COFFEE KNOWLEDGE TEST

1 FROM WHICH COUNTRY TYPICALLY ORIGINATES THESE SPECIALTY, SINGLE ESTATE COFFEES? (1/8 MARK PER CORRECT ANSWER)

1	**Blue Mountain**	Jamaica	Brazil	don't know
2	**Kona**	Kenya	Hawaii	don't know
3	**Sidamo**	Indonesia	Ethiopia	don't know
4	**Antigua**	Guatemala	Colombia	don't know
5	**Yirgacheffe**	Brazil	Ethiopia	don't know
6	**Java**	Vietnam	Indonesia	don't know
7	**Bourbon Santos**	Brazil	Colombia	don't know
8	**Tarrazu**	Costa Rica	Porto Rico	don't know

2 IN WHICH COUNTRY DOES COFFEE FIND ITS (ACCLAIMED) ORIGIN?

A Turkey
B Java
C Colombia
D Ethiopia
E India
F I don't know

3 WHICH OF THESE TYPES OF COFFEE BEANS IS PRODUCED THE MOST?

A Robusta (coffea Canephora)
B Arabica (coffea Arabica)
C Liberica (coffea Liberica)
D Mauritiana (coffea Mauritiana)
E Racemosa (coffea Racemosa)
F I don't know

4 WHAT IS "PEABERRY"?

A A qualification for very small coffee beans
B A specific variety of coffee beans from India
C A term for one instead of two beans per coffee berry
D A tool that is used for roasting coffee
E A coffee plant disease that prevents the coffee berry to ripen, keeping it green, resembling peas
F I don't know

5 THE AROMA IN COFFEE COMES MAINLY FROM..?

A Roasting
B The country of origin
C Brewing method
D Coarseness of grinding

E Fermentation of the coffee bean
F I don't know

6 COFFEE RUST IS BEST DEFINED AS

A A specific aroma in the coffee caused by the fungus Hemileia vastatrix during fermentation
B A coffee plant disease (Hemileia vastatrix) that can potentially destroy the plant
c A distinct metallic taste caused by rust in the coffee making equipment
D The ideal color of the coffee bean after roasting
E A term professional barista's use for the residue left in the cup after drinking
F I don't know

7 WHAT IS THE DIFFERENCE BETWEEN THE "WET" AND "DRY" METHOD FOR PROCESSING THE COFFEE BERRIES INTO GREEN COFFEE?

A The wet method requires complex machinery, the dry method is simpler
B In the wet method the outer layers of the coffee berry are removed before drying
C In the dry method, the coffee beans are dried in the sun
D The wet method uses a fermentation phase to remove some of the outer layers
E All of the above
F I don't know

8 WHAT IS THE PROPER WAY TO AGE COFFEE WITH THE INTENTION TO IMPROVE QUALITY?

A By grinding the roasted coffee and keeping it in an open jar for several weeks, allowing it to breathe
B By keeping roasted coffee beans in the fridge
C Drying the coffee berries for an extended time period
D Keeping the unroasted coffee under controlled conditions for several months to years
E By only using coffee beans from very old coffee trees
F I don't know

9 HOW MUCH COFFEE DO YOU DRINK?

A More than 4 cups a day
B 2-4 cups per day
C 1-2 cups per day
D Less than one cup per day

10 HOW MUCH HAVE YOU READ ABOUT COFFEE?

A More than 4 books or articles
B 1-4 books or articles
C Less than 1 book
D Nothing

APPENDIX D FIRST VERSION OF THE VIVIDNESS OF WINE IMAGERY QUESTIONNAIRE (VWIQ)

The following part of the questionnaire contains four sections. In each section, you will be given a description of a scene followed by four 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 different each scenario based mental image requested. You are then asked to rate how vivid several aspects of the image are:

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 sound of the bubbles as the wine is being poured
2. The color of the wine as the sun is reflected in your glass
3. The smell of the wine as you sniff it in your glass
4. 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 sound of you slurping the wine when you have a sip and slurp some air into your mouth
4. The taste of the wine

C YOU ARE IN A BISTRO NEAR THE COAST. YOU ARE HAVING A LIGHT LUNCH, AND YOU HAVE SELECTED A GLASS OF WINE TO PAIR WITH IT

1. The smell of the wine when the waiter asks you to check it
2. The color of the wine when the waiter pours you some to try
3. The sound of the glasses clinking together when you all raise your glasses for a toast
4. The taste of the wine when you have your first sip

D IMAGINE YOU ARE GOING TO A SHORT WINE TASTING AND YOU WILL TRY OUT SEVERAL DIFFERENT WINES. THE TASTING STARTS WITH A FRENCH WHITE WINE (A SAUVIGNON BLANC)

1. The sound of the cork when the host removes the cork from the bottle
2. The color of the wine when the host pours a little bit in your glass
3. The smell of the wine when you smell it in your glass
4. The taste of the wine when you have a sip of it and swirl it in your mouth

E YOU HAVE TASTED SEVERAL WINES, AND THE HOST PRESENTS THE FINAL WINE FOR THE TASTING. IT IS AN AMERICAN RED WINE (A CABERNET SAUVIGNON)

1. The sound of the wine being poured into your partner's glass
2. The color of the wine when you swirl it round in your glass
3. The smell of the wine when you place your nose in the glass to smell it
4. The taste of the wine when you have a sip and swirl it in your mouth to taste it

F IMAGINE YOU ARE BUYING THE WINE FOR A FANCY PARTY YOU ARE HOSTING. THE SHOP OWNER LETS YOU TRY SOME WINES

1. The sound when the shop owner opens a bottle of sparkling wine (an Italian Prosecco) for you to taste
2. The color of a white wine, a Chardonnay, that he gives you to try
3. The smell of the next red wine you try, a Pinot Noir
4. The taste of this red wine (Pinot Noir) when you try and taste the wine

APPENDIX E: SECOND REVISED VERSION OF 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 four 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:

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 sound of the bubbles fizzing loudly as you bring the glass to your mouth
3 The smell of the wine as you sniff it in your glass
4 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 sound of you slurping the wine when you have a sip and slurp some air into your mouth
4 The taste of the wine

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 sound of the cork when the hostess removes the cork from the bottle
2 The color of the wine when the hostess pours a little bit in your glass
3 The smell of the wine when you smell it in your glass
4 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 HOST PRESENTS THE LAST WINES FOR THE TASTING

1 The color of a white wine, a Chardonnay, that he gives you to try
2 The sound of the wine being poured into your glass
3 The smell of the next red wine you try, a Pinot Noir
4 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 GLASS OF WINE TO PAIR WITH IT.

1. The smell of the wine when the waitress asks you to check it
2. The color of the wine when the waitress pours you some to try
3. The sound of the glasses clinking together when you all raise your glasses for a toast
4. 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 YOU ARE HAVING A CASUAL GLASS OF WHITE WINE TO UNWIND. YOU ARE HAVING A YOUNG WHITE WINE, INTENDED TO BE CONSUMED FRESH.

1. The sound when you open the bottle by removing the screw cap by unscrewing it
2. The color of the wine when you swirl it round in your glass
3. The smell of the wine when you place your nose in the glass to smell it
4. The taste of the wine when you have a sip and swirl it in your mouth to taste it

CURRICULUM VITAE

Ilja Croijmans

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Website http://meaningculturecognition.ruhosting.nl/people/ilja-croijmans/
Twitter @icroy
LinkedIn https://nl.linkedin.com/in/iljacroijmans

Education

Sept. 2013 - Feb. 2018	PhD at the Centre for Language Studies, Radboud University Nijmegen
Sept. 2010 – May 2013	Research Master Neuropsychology at Maastricht University. GPA: 7.9. Please find a list of courses and grades uploaded as an attachment to this application
Sept. 2007 - July 2010	Bachelor Biological Psychology at Maastricht University. GPA: 7.5
Sept. 2001 - Aug. 2007	Gymnasium, Veluws College Walterbosch, Apeldoorn. GPA: 7.8
July 2015	Summerschool on Human Olfaction, Universitatsklinikum Carl Gustav Magnus, Dresden, Germany
October 2013	SWEN/SDEN2 Wine course (roughly comparable to WSET-I)

Work experience

Sept. 2017 – present	Teacher in the Communications and Information Studies department at the Radboud University Linguistics Faculty
Oct. 2017 – present	Part-time tour guide at Nijmegen brewery *Oersoep*, on call basis
Sept. 2013 – present	I am affiliated with the *Meaning, Culture & Cognition* group of Asifa Majid. Projects I am involved in, include: - Sound-smell congruence effects on consumer attitude and memory - Acquiring crossmodal associations with pitch, space, smell and touch - The role of language in smell-colour associations - Co-Organizing the Human Olfaction Conference 2017
Oct. 2012 – April 2013	Intern *Mondriaan* Addiction Healthcare Centre Tasks: diagnose clients; managing research project
Nov. 2011 – June 2012	Intern *University of Glasgow Sleep Centre* Tasks: carrying out research project; assisting lab personnel with polysomnography, diagnosis, and statistical analyses

Feb. 2010 – Sept. 2013 Student tutor *Maastricht University*

June 2004 – July 2010 Tool store sales employee *Karwei Apeldoorn Noord*

Publications

Journal papers

Majid, A., Speed, L., Croijmans, I., & Arshamian, A. (2017). What makes a better smeller? Perception, 46(3-4), 406-430.

Croijmans, I., & Majid, A. (2016). Not all flavor expertise is equal: The language of wine and coffee experts. *PLoS ONE* 5(5): e0155845.

In preparation

Peters Rit, M., Croijmans, I., & Speed, L.J. (in prep.) Sound-odor congruence effects on consumer attitude and memory.

Croijmans, I., Hendrickx, I., Lefever, E., Majid, A., & Van den Bosch, A. (in prep.). Olfactory language in expert reviews: content and consistency in a corpus of wine reviews.

Speed, L.J., Croijmans, I., Dolscheid, S., & Majid, A. (in prep.). Crossmodal associations emerge with age

Proceedings papers

Lefever, E., Hendrickx, I., Croijmans, I., Majid, A., Van den Bosch, A., (submitted). Discovering the Language of Wine Reviews: A Text Mining Account. *Submitted as a paper for the 11th edition of the Language Resources and Evaluation Conference (LREC2018)*

Croijmans, I., Speed, L.J., Arshamian, A., Majid, A. (2017). Experts are better than novices when imagining wines, but not odors in general. *Proceedings of the 39th Annual Meeting of the Cognitive Science Society (CogSci 2017), p. 258-259*

Speed, L.J., Croijmans, I., Dolscheid, S., Majid, A. (2017). Acquiring pitch associations across modalities: the role of experience. *Proceedings of the 39th Annual Meeting of the Cognitive Science Society (CogSci 2017), p. 3227-3228*

Croijmans, I., & Majid, A. (2016). Language does not explain the wine-specific memory advantage of wine experts. *Proceedings of the 38th Annual Conference of the Cognitive Science Society. Cognitive Science Society (CogSci 2016), p. 141-146*

Hendricks, I., Lefever, E., Croijmans, I., Majid, A., & Van den Bosch, A. (2016). Very quaffable and great fun: Applying NLP to wine reviews. *In Proceedings of the 54th Annual Meeting on Association for Computational Linguistics*. Association for Computational Linguistics.

Croijmans, I. & Majid, A. (2015). Odor naming is difficult, even for wine and coffee experts. *Proceedings of the 37th Annual Conference of the Cognitive Science Society (CogSci 2015)*. Austin, TX: Cognitive Science Society, p. 483-488.

Reviewing

Ad-hoc reviewer for *Perception, Chemosensory Perception, Chemical Senses*, and for the *CogSci proceedings*

Presentations

International peer-reviewed conference presentations

Annual conference of the cognitive science society (CogSci 2017); London, UK

Title: Experts are better than novices when imagining wines, but not odors in general

Meeting of Belgian-Netherlandic affiliate organization of the International Cognitive Linguistics Association (CogLing7); January 2017, Nijmegen, NL

Title: Predicting wine properties from expert wine reviews

Annual conference of the cognitive science society (CogSci 2015); Philadelphia, USA

Talk: Majid, A. & Croijmans, I. Odor naming is difficult, even for wine and coffee experts

Poster presentations

Annual conference of the cognitive science society (CogSci 2017); London, UK

Title: Speed, L.J., Croijmans, I., Dolscheid, S., & Majid, A. Acquiring pitch associations across modalities: the role of experience

International Symposium on Olfaction and Taste (ISOT 2016); Yokohama, Japan

Title: Language does not explain the wine-specific memory advantage of wine experts

Annual conference of the cognitive science society (CogSci 2016); Philadelphia, USA

Title: Language does not explain the wine-specific memory advantage of wine experts

Architectures and Mechanisms for Language Processing (AMLaP 2015), Malta

Title: The domain specific influence of expertise on flavour naming

International Conference for Psychological Science (ICPS 2015), Amsterdam, NL

Title: Flavour expertise and its influence on olfactory language

21st conference of the European Sleep Research Society (ESRS 2012); Paris, France

Poster: M. Crawford, S.D. Kyle, I.M. Croijmans, D.J. Bartlett, R.R. Grunstein, C.A. Espie. Sleep misperception in insomnia: Changes in the discrepancy between actigraphy and self-reported total sleep time during a 4-week sleep restriction intervention

Other presentations

Human Olfaction at the Intersection of Language, Culture & Biology; Nijmegen, the Netherlands
Talks: Flavor language of experts; Olfactory memory of wine experts and novices; Mental imagery in wine experts and novices

Invited general audience lecture "Olfactory language and cognition: Hunter-gatherers and wine experts" at Odorama "A vocabulary of fragrance" Mediamatic, Amsterdam

Invited HELIOS *Taalcafé* lecture "Olfactory language and cognition: Hunter-gatherers, Experts and Synaesthetes", Vrije Universiteit, Amsterdam

Awards

Radboud University Internationalization Travel Grant 2016. € 700

Radboud University Internationalization Travel Grant 2017. € 400

Science Live @Drongo award 2015 (Together with Asifa Majid, Josje de Valk, Ewelina Wnuk & Laura Speed) for best interactive presentation at Drongo Language Festival. € 5000

Selected public outreach

15-11-2017 Interview published in DRAFT Magazine: http://draftmag.com/psycholinguistics-beer-flavor-descriptions/
12-11-2017 InScience DIY lab demonstration "*Ruik jij dat ook?/Do you smell that too?*"
25-09-2017 *Interview met PhD student Ilja Croijmans*. Interview with Achter Glas: the Magazine of the Dutch Anosmia Council (ReukSmaakStoornis stichting): http://meaningculturecognition.ruhosting.nl/wp-content/uploads/2017/04/SKM-PR084117092515190.pdf
31-05-2017 *Talking about talking about taste and smell with linguist Ilja Croijmans*. Interview published in SPRUDGE magazine. http://sprudge.com/ilja-croijmans-interview-115849.html
07-02-2017 "*Is het soepgeur of toch knakworst?*" I appeared in a live broadcast item on a strange smell noticed by many people in the Dutch province of Brabant on Dutch national radio station BNR: https://www.bnr.nl/nieuws/binnenland/10317987/is-het-soepgeur-of-toch-knakworstgeur
Croijmans, I. (08-2016). "*Gelukkig kunnen we erover praten:* Over de kunst om geuren en smaken in woorden te omschrijven": I wrote a popular scientific opinion article in Dutch Coffee magazine *KoffieTCacao*
Majid, A. & Croijmans, I.M. (11-09-2016). The science of beer – Interactive beer tasting at Butcher's Tears brewery in Amsterdam.

Croijmans, I. (04-08-2016) *"Wijn recenseren kun je leren"*. Mini-lecture on Dutch national radio station BNR: https://www.bnr.nl/radio/wetenschap-vandaag/10308946/wijn-recenseren-kun-je-leren?disableUserNav=true

13-07-2016 *"Blauwe Wijn: hip maar moelijk"*. I appeared in a Dutch current affairs television show EenVandaag to give my expert opinion on the phenomenon of blue wine: http://binnenland.eenvandaag.nl/tv-items/68147/blauwe_wijn_hip_maar_moeilijk

21-06-2016 *"Getrainde neus beschrijft alleen 'eigen' geuren beter"* I was interviewed by Erica Renkens from Kennislink to disseminate the research on wine and coffee experts to a general audience: https://www.nemokennislink.nl/publicaties/getrainde-neus-beschrijft-alleen-eigen-geuren-beter?q=wijn