Grammatical gender affects odor cognition

Laura J. Speed (l.speed@let.ru.nl)[1] **Asifa Majid (asifa.majid@let.ru.nl)[1,2,3]**
[1]Centre for Language Studies, Radboud University, Nijmegen, NL
[2]Max Planck Institute for Psycholinguistics, Nijmegen, NL
[3]Donders Institute for Brain, Cognition, and Behaviour, Radboud University, Nijmegen, NL

Abstract

Language interacts with olfaction in exceptional ways. Olfaction is believed to be weakly linked with language, as demonstrated by our poor odor naming ability, yet olfaction seems to be particularly susceptible to linguistic descriptions. We tested the boundaries of the influence of language on olfaction by focusing on a non-lexical aspect of language (grammatical gender). We manipulated the grammatical gender of fragrance descriptions to test whether the congruence with fragrance gender would affect the way fragrances were perceived and remembered. Native French and German speakers read descriptions of fragrances containing ingredients with feminine or masculine grammatical gender, and then smelled masculine or feminine fragrances and rated them on a number of dimensions (e.g., pleasantness). Participants then completed an odor recognition test. Fragrances were remembered better when presented with descriptions whose grammatical gender matched the gender of the fragrance. Overall, results suggest grammatical manipulations of odor descriptions can affect odor cognition.

Keywords: olfaction; odor memory; grammatical gender; linguistic relativity; French; German

Introduction

"*…a warm passionate fragrance that combines the uniquely liberating notes of crispy apple and white florals with a vanilla and sandalwood heart. They fuse to create a warm, inviting and free-spirited scent, that you can wear with passion*."

Boss Orange Woman – The Perfume Shop

Choosing a personal fragrance can be a difficult undertaking. But how much of what we perceive about a fragrance is based on smell alone? Does the language used in advertisements, product descriptions, and magazine reviews influence us? With over five hundred new fragrance launches every year, sniffing fragrances individually would be an arduous and tiring task. Instead, reading fragrance descriptions can be the most efficient means by which to make a decision. But what do we imagine when we read something like: "*white florals with a vanilla and sandalwood heart*"?

Research has shown we are, in fact, poor at imagining odors (Crowder & Schab, 1995). Moreover, we are bad at identifying and naming odors. It is estimated that we can correctly name only around 50% of common odors, such as coffee or peanut butter (e.g., Cain, 1979; de Wijk, Schab, & Cain, 1995).

There are a number of possible explanations for these facts. One theory claims the olfactory cortex is poorly linked with semantic and linguistic information in the brain (Olofsson & Gottfried, 2015). Olfactory information is processed by fewer channels than other sensory domains, and is argued to be linked with lexical information more directly than modalities such as vision (Olofsson & Gottfried, 2015). This may mean olfactory information is less elaborated by the time lexical retrieval occurs, making it hard to link an odor with a name. Another possibility is the difficulties with olfaction are a product of cultural experience (Majid, 2015). In the West, we lack experience attending to and talking about smells (e.g., San Roque et al., 2015). However, speakers of some languages, such as the Jahai in the Malay Peninsula, are, in fact, just as good talking about smells as they are talking about colors (Majid & Burenhult, 2014). For people in such cultures, odor is an integral part of their daily lives, featuring in their cultural practices and belief system (Burenhult & Majid, 2011).

Research has shown that because of the limitations in thinking and talking about odors, verbal labels and descriptions can easily influence how odors are perceived (Herz, 2003; 2005). This is comparable to the proposal that language is more powerful at influencing thought for more abstract domains, such as time (e.g., Boroditsky, Schmidt, & Phillips, 2003). That is, similar to time, odor is a domain that can be difficult to conceptualize and verbalize, and so is a modality in which language has a strong influence. In fact, Herz (2003) suggests olfaction should be influenced by language more than other perceptual modalities because we cannot see odors, we cannot easily spatially locate them, nor can we easily identify them. So, instead we search for any other contextual information (such as language) to inform odor perception. In sum, it has been suggested that because conceptual representations of odors are weak, they can more easily be shaped by other sources of information, such as words.

Hedonic ratings of odors, for example, differ when odors are given verbal labels compared to when they are presented alone (Herz, 2003). De Araujo, Rolls, Velazsco, Margot, and Cayeuk (2005), and Herz and Clef (2001) found odors were rated as more pleasant when they were labeled with positive (e.g., *cheese*) instead of negative terms (e.g., *body odor*). Verbal labels modulated regions of the brain thought to be activated by odor pleasantness, suggesting the labels affected perception of the pleasantness of the odor rather than simply biasing pleasantness ratings (de Araujo et al., 2005). Similarly, Zellner, McGarry, Mattern-McClory, and Abreu (2008) found explicitly labeling unisex fragrances as

male (or *female*) made participants perceive the fragrance as more masculine (or feminine) (measured by colors matched to fragrances). These effects have been described as "olfactory illusions" (Herz, 2003; 2005).

Previous studies examining effects of language on olfaction have used explicit labels, so it is possible participants in these studies were strategically using the linguistic information they were given. So, although de Araujo et al., (2005) find effects of labels on olfactory pleasantness in the brain, the effects could still be the result of top-down integration of explicit semantic information with an ambiguous olfactory percept. The current study aims to investigate the influence of language on odor cognition by moving away from explicit semantic information to implicit semantic cues provided through grammatical gender. By focusing on grammatical cues we can address, in a novel manner, the extent to which language can affect odor cognition. Specifically, we test whether the grammatical gender of descriptions of fragrances affects how a fragrance is perceived and remembered.

Grammatical gender divides nouns into classes according to the behavior of associated words (e.g., articles, adjectives; cf. Corbett, 2006). In some languages, nouns possess a gender based on natural gender, or "sex", i.e., masculine, feminine. Grammatical gender is typically semantically arbitrary for objects without a natural gender (that is, there is nothing inherently masculine or feminine about the objects to which grammatical gender is assigned). Moreover, grammatical gender of nouns can vary across languages (for example *apple* is masculine in German, *der Apfel*, and feminine in French, *la pomme*). Despite this apparent arbitrariness of gender assignment to nouns, grammatical gender has been shown to affect how speakers of such languages think about objects. For example, Spanish and German speakers are more likely to ascribe masculine qualities to grammatically male objects and feminine qualities to grammatically female objects: German speakers described a *key*, which has masculine grammatical gender in German, using terms such as "*hard, heavy, jagged, metal, serrated and useful*", whereas Spanish speakers, for which the grammatical gender is female, instead used terms such as "*golden intricate, little, lovely, shiny and tiny*" (Boroditsky et al., 2003).

Effects of grammatical gender have been found in tasks that do not explicitly promote the use of grammatical categories, suggesting grammatical gender information is accessed automatically and implicitly (Boutonnet, Athanasopoulos, & Thierry, 2012). Using ERPs during a semantic categorization task of pictures, grammatical gender consistency affected LAN amplitude, an ERP marker of morphosyntactic processing, in Spanish-English bilinguals, but not English monolinguals (Boutonnet et al., 2012). This effect was found within an all English context, suggesting grammatical gender information can be accessed automatically and implicitly (although see, e.g., Vigliocco, Vinson, Paganelli, & Dworzynski, 2005).

This study builds on previous work in two fundamental ways. First, we test a non-lexical verbal manipulation on odor: i.e., grammatical gender. Second, we test the effects of grammatical gender on thought in a new way. Instead of explicitly judging the referent objects of nouns (e.g., Boroditsky et al., 2003), here participants judged odors associated with nouns possessing male or female grammatical gender.

We gave French and German speakers the same perfumes and the same descriptors, differing only in their grammatical gender: if the descriptors were masculine in one group, they were feminine in the other. Participants read the descriptions of odors (with masculine vs. feminine nouns), then smelled masculine and feminine fragrances, and rated the fragrance on a number of dimensions. After that, participants completed a recognition test for the fragrances they had smelled. Note, participants were never explicitly told whether the perfumes were masculine or feminine (cf., Zellner et al., 2008). This information was implicitly conveyed through the nouns by virtue of their grammatical class. We predicted the perception and memory of the fragrances would be affected by the congruence between grammatical gender of the nouns used to describe the fragrance and the gender of the fragrance.

Method

Participants

30 native German speakers (21 female; average age 26.9, SD = 9.9) and 31 native French speakers (20 female; average age 31.2, SD = 12.8) participated in the experiment.

Material

Eight fragrances were used, four marketed as masculine scents and four marketed as feminine scents. Fragrances were selected according to online "bestseller" lists in Germany and France (see Table 1). In addition, a further eight fragrances (four masculine, four feminine) were selected to be used as distractors in the recognition test at the end of the experiment. To present each fragrance, plastic pellets were sprayed with a small amount of a fragrance and then placed inside a squeezy bottle.

Eight fragrance descriptions were used (four female grammatical gender, four with male grammatical gender) (see Table 2). Each description contained three nouns of the same grammatical gender. Nouns were selected so that their grammatical genders were different in German and French. For example, one set of ingredients was *pumpkin*, *sage*, *marjoram*, with all ingredients masculine nouns in German (*Kürbis, Salbei, Marjoran*), but feminine nouns in French (*citrouille, sauge, marjolaine*).

Each fragrance was paired once with a grammatically female description and once with a grammatically male description, distributed across two experimental lists.

Table 1. Male and female fragrances

Fragrance	Gender
Hugo Boss - Boss Orange	*f*
Armani - Si	*f*
Calvin Klein - Eternity	*f*
Dior - J'adore	*f*
Chanel - Bleu de Chanel	*m*
Joop! Homme	*m*
Davidoff- Cool Water	*m*
Hugo Boss - Boss Bottled	*m*

Table 2. Masculine (*m*) and feminine (*f*) fragrance descriptions.

German		French	
Kürbis, Salbei, Marjoran	*m*	citrouille, sauge, marjolaine	*f*
Apfel, Rhabarber, Kardamom	*m*	pomme, rhubarbe, cardamom	*f*
Zitrone, Sonneblume, Melone	*f*	citron, tournesol, melon	*m*
Iris, Ringelblume, Makrone	*f*	iris, souci, macaron	*m*
Muskat, Farn, Lehm	*m*	muscade, fougère, argile	*f*
Schiefer, Lavendel, Zimt	*m*	ardoise, lavande, canelle	*f*
Gewürznelke, Kiefer, Seife	*f*	girofle, pin, savon	*m*
Eiche, Magnolie, Zeder	*f*	chêne, magnolia, cèdre	*m*

Procedure

E-Prime (Version 2.0) was used to present written fragrance descriptions and collect participants' responses. Participants were instructed to carefully read the description of each fragrance that included key ingredients. To make sure participants paid attention to the descriptions, they were told they would need to remember the fragrances and descriptions at the end of the experiment. When they had read a description, the experimenter placed the squeezy bottle beneath the participants' nose and instructed them to smell as it was squeezed. The bottle was squeezed three times with a gap of around four seconds between each squeeze. Order of fragrance presentation was randomized. After smelling the fragrance, participants pressed the space bar on the keyboard to continue to ratings of the fragrance. Participants were then asked to rate the fragrance in terms of pleasantness, intensity, how likely they would be to buy the fragrance for their father or brother, their mother or sister, how much they would be willing to pay for the fragrance, and how clearly they could smell the ingredients in the fragrance. Ratings were made on a scale of 0 to 100, and participants responded by moving a mouse along a scale and clicking. After completing the five ratings, a 2000ms blank screen was presented before the next trial.

After all fragrances had been rated, participants were told they must complete a recognition test. They smelled sixteen fragrances, half they had smelled before, and half were new. As before, the squeezy bottles were placed beneath the participants' nose and they were asked to smell when the bottle was squeezed by the experimenter. If the fragrance was new, participants were told to click in a box labeled "new", but if the fragrance had been smelled previously they were to click in a box labeled "old". Each box turned red when a response had been made.

Results

Linear mixed effect models in R (R Core Team, 2013), using the lme4 package (Bates, Maechler, Bolker, & Walker, 2014), were conducted on the rating scores for each rating question separately, and for accuracy in the recognition test (proportion of fragrances correctly recognized as "old"). Fragrance gender (male vs. female), grammatical gender (male vs. female), language (German vs. French) and the interaction were entered as fixed factors and fragrance item and participant were random factors.[1] We predicted ratings and memory of the fragrances would be different when the gender of the fragrance matched the grammatical gender of the descriptors compared to when they did not match. For brevity sake, we only report significant effects.

As would be expected, participants indicated they were more likely to buy a female fragrance than a male fragrance for their mother or sister ($t = 2.62$, $p < .01$), and vice versa more likely to buy a male fragrance for their father or brother ($t = 5.27$, $p < .001$). Overall, male fragrances were rated as more pleasant than female fragrances ($t = 1.95$, $p = .05$).

For ratings of ingredient clarity there was a significant interaction between fragrance gender and language ($t = 2.8$, $p < .01$) such that ratings were higher for French descriptions than German descriptions for female, but not male fragrances. There was also a significant three-way interaction between grammatical gender, fragrance and language ($t = 2.64$, $p < .01$). This three-way interaction reflects a significant interaction between grammatical gender and language for male fragrances ($t = 4.29$, $p < .001$), but not for female fragrances ($t = .97$, $p = .33$). Participants indicated they could perceive the ingredients in male fragrances more clearly with masculine descriptions in French, but with feminine description in German (see Figure 1). There were no other effects in the ratings of fragrances.

[1] A separate set of participants smelled each fragrance and judged whether they thought it was for a man or woman. Based on these ratings Joop was classified as a female fragrance instead of a male fragrance.

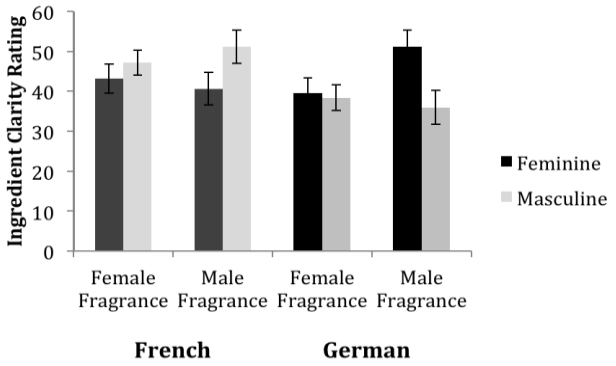

Figure 1: Fragrance ratings for question "How clearly can you perceive the ingredients in the fragrance?"

Importantly, and in line with our predictions, we found an interaction between fragrance gender and grammatical gender in memory performance (t = 2.0, p = .05). Participants were more likely to correctly recognize a fragrance when the gender of the fragrance matched the grammatical gender of the description than when it did not match (see Figure 2). There were no further significant effects in memory.

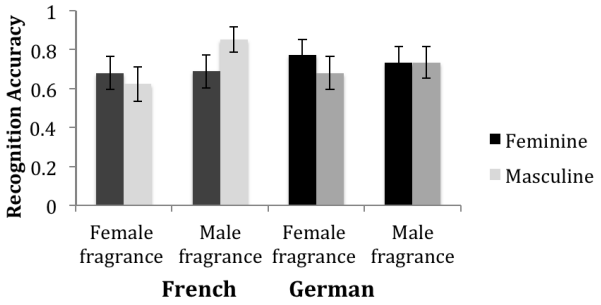

Figure 2: Recognition accuracy for male and female fragrances described with masculine and feminine nouns in French and German

Discussion

We found memory for male and female fragrances was greater when the fragrance was described using nouns with grammatical gender matching the fragrance gender. This finding parallels previous work examining gender information during sentence processing, showing processing is enhanced for gender congruent information compared to gender incongruent or neutral information (Friederici & Jacobsen 1999; Guillelmon & Grosjean, 2001). Similarly, Boroditsky and Schmidt (2000) found memory for the sex of proper names given to objects (e.g., Erica) was higher when the sex matched the grammatical gender of the object.

What could explain these effects? There are, at least, three possible mechanisms to consider. Grammatical gender information from the descriptions could be combined with gender information from the fragrance, so that the more similar the information, the stronger the memory trace formed. Alternatively, grammatical gender information could have primed a specific gender construal, making it easier to subsequently process information matching in gender – meaning fragrances of the same gender were more easily processed, and hence remembered better. Similar findings have, however, been explained as inhibition in processing when there is incongruent gender information (e.g., Jakubowicz & Faussart, 1998). That is, information is more difficult to process, or the memory trace is interfered with, when gender information is mismatching.

Odors are difficult to name and identify: we cannot see them and we have difficulty localizing them in space (Engen, 1982). We therefore rely more heavily on external context to extract meaning (Herz, 2003). Herz (2003) proposes there may be a dual-coding system for olfaction (similar to Paivo's (1971) original dual-coding theory) in which olfactory perception is sensitive to both verbal context and sensory experience. Thus, verbal labels attributed to odors can be a crucial factor in odor interpretation. Previous studies have concluded that odor memory is improved with the addition of verbal labels in general (e.g., Rabin & Cain, 1984; Lyman & McDaniel, 1986) because they provide extra retrieval paths (Lyman & McDaniel, 1990), for example. Here we show the type of label is important for memory, with memory being enhanced only when features of the verbal label match odor features.

We used fragrances in this study, which contain a mixture of scents. Odor perception is a configural process (Thomas-Danguin et al., 2014), with little access to constituent parts of an odor. Perceiving all individual ingredients within a fragrance is thus almost impossible (our ability to perceive odor constituents in a mixture is limited; Laing & Francis, 1989). Fragrances can be considered complex, and so we have tested odor cognition at its most vulnerable. Whether or not grammatical gender information could influence perception and memory for simpler or more familiar odors with more clearly identifiable sources is an open question.

Evidence from other perceptual domains suggests language is more likely to influence perception when perception is difficult. Results from Pavan, Skujevskis, and Baggio (2013) support the view that semantic information is more likely to interact with perception when the sensory signal is reduced or the task is more difficult. In a direction discrimination task, listening to direction verbs affected perceptual sensitivity when the visual stimuli were presented at threshold, but not when presented at suprathreshold. Similar findings are found in speech perception: watching a speaker's lip movements enhances speech comprehension, particularly in noisy environments (e.g., Ma, Zhou, Ross, Foxe, & Parra, 2009). Again, since odor cognition is more difficult to conceptualize than the other senses, we could expect language to have its maximal influence here (cf., Herz, 2003), and even more so for complex mixtures of odors.

We found an interaction between fragrance gender, grammatical gender and language in ratings of ingredient

clarity such that participants perceived the ingredients in male fragrances more clearly with masculine descriptions in French, but with feminine descriptions in German. We primarily included this rating question to encourage people to carefully read the fragrance description, as it would be possible to complete the other ratings based on the smell of the fragrance alone. Since this is the only rating specifically requiring participants to combine descriptions with the odor, it is not surprising this is where we see effects of language. However, the results are puzzling. Why would grammatical gender behave differently in French and German?

One possibility is the effect is not driven by grammatical gender, but another aspect of the words used, such as conceptual gender. That is, people may have masculine or feminine associations to the objects themselves. It is known that people "genderize", or assign conceptual gender to, objects (Yorkston & de Mello, 2005). Certain objects are associated more with maleness and potency, and others femaleness and beauty (Foundalis, 2002). For example, Sera, Berge, and Pintado (1994) found English speakers (for whom there is no grammatical gender) consistently judged natural objects as female, and artificial objects as male. In the present experiment, it is possible *slate*, for example, had more masculine associations than *magnolia*. If one set of words in our study had systematic masculine/feminine conceptual associations, then their congruence with the gender of the fragrance could affect responses. It would therefore be important in future work to carefully control stimuli such that grammatical and conceptual gender are manipulated orthogonally.

An alternative explanation for the difference between French and German is related to the transparency of the gender systems (e.g., Sera et al., 2002; Vigliocco et al., 2005). French has only two grammatical genders: masculine and feminine, but German has three: masculine, feminine and neuter. Famously, the mapping of natural gender to grammatical gender in German is not clear-cut. So although *woman* is feminine, as would be expected, *girl* and *wife* are neuter grammatical gender (Twain, 1880). In French grammatical gender information is widespread in every utterance: articles, nouns, and adjectives all carry morphological information about gender. But in German marking of grammatical gender is more haphazard, so not all indefinite articles and adjectives carry gender information. In addition, case interacts with gender in complex ways in German, but not French. If grammatical gender is learned by noticing the relationship between natural gender and grammatical gender, then an inconsistent relationship between natural and grammatical gender within a language would lead to weak effects of grammatical gender. This idea is supported by the fact that systematic and robust grammatical gender effects have been found in Romance languages (e.g., French and Spanish), but not in German (Sera et al., 2002; Vigliocco et al., 2005).

We found participants preferred female fragrances for female relatives and male fragrances for male relatives. This suggests the gender of a fragrance comes to mind readily when smelling it. Fragrances are typically marketed as male or female, thus over time associations are learned between certain types of odors and natural gender. So, although correctly identifying the source of an odor is difficult (e.g., Cain, 1979; de Wijk et al. 1995), gender may be one of the dimensions along which odors can be successfully described, along with pleasantness – at least for fragrances (cf., Yeshurun & Sobel, 2010).

Our results have further implications for marketing. We have shown information from language can be combined with information from odors, subsequently enhancing encoding and recognition. This is important from a marketing perspective: it is no good a fragrance being pleasantly perceived if the product itself cannot be remembered. When odor identification is weak, it becomes particularly vulnerable to contextual information, making it the ideal venue to use interesting marketing devices and ploys.

In sum, we have shown grammatical information can affect how odors are perceived and remembered. Thus, not only is odor cognition vulnerable to explicit semantic labels, it can also be affected by more subtle linguistic manipulations, such as grammatical gender.

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