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The influence of verbal labeling on the perception of odors: Evidence for olfactory illusions?

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Abstract. Using the definition that an illusion is observed when a stimulus is invariant but context alters its perception, we examined whether verbal context could produce olfactory illusions. To test this effect, we chose five odors with minimally fixed sources and that could be interpreted with various hedonic connotations. The odors were violet leaf, patchouli, pine oil, menthol, and a 1 : 1 mixture of isovaleric and butyric acids. Subjects individually sniffed each odor at two different sessions separated by one week. At each session an odor was given a different verbal label (either positive or negative) and subjects rated the odors on several hedonic scales and provided perceptual and interpretative responses to them. Results showed that the perception of an odor could be significantly influenced by the label provided for it. We propose that the cases where verbal labels inverted odor perception are the first empirical demonstrations of olfactory illusions.

1 Introduction

"A rose by any other name would not smell as sweet."

According to Rozin and Fallon (1987, page 24) with regard to odor: "It is the subject's conception of the object, rather than the sensory properties of the object, that primarily determine its hedonic value". Mark Twain's *The Invalid's Story* (Clemens 1882) clearly illustrates this point. In this story, the protagonist is a stowaway on a railway car and is lying beside a large sack from which a smell is emanating. The character is paranoid about being caught and starts to believe that the sack beside him contains a dead body. As the carriage warms and the smell intensifies his fears are ever more confirmed. The story climaxes at the point where the stowaway can bear the smell no longer and jumps from the moving railway car, ultimately leading to his own death—never to find out that the sack contained just a lot of "innocent cheese". This story shows how the perceiver's context produced an expectation of what the source of the smell was that made his perceptual interpretation unbearably negative. Had the same individual been at a dinner party and smelled the same stimulus, thoughts of appetizing food would have likely entered his head, and his response to the same odor would have been entirely different.

It has been shown that visual and verbal context effects can influence odor quality perception. Zellner and Kautz (1990) reported that the perceived intensity of food odors was increased when the odor extracts were presented in colored as compared with colourless liquid. Likewise, when panelists rated fragrances with or without brand labels, differences in ratings of both sweetness and liking were found (Moskowitz 1979). Comparable context effects have been shown in other sensory systems. In vision, Duncker (1939) found that the shape of an object altered its perceived color. In his study, a leaf-shaped object was judged as more green than a donkey composed of the same color. Similarly, Delk and Fillenbaum (1965) found that red-associated objects such as hearts or lips were perceived as more red than identically colored circles or mushrooms. These examples illustrate that congruency between concept and physical attribute can alter qualitative aspects of perception. However, the dramatic misperceptions demonstrated by illusions are perhaps a better analogy for the olfactory example of mistaking cheese for a dead body.

Most generally, an illusion is a perception that does not correspond to reality (see Gregory 1997). Most visual illusions are created by the visual context that surrounds a target stimulus (Luo and Wang 1997). The Müller-Lyer illusion is the most definitive example, where the direction of the tails of the figure, either feathering (making the line look longer) or arrowhead (making the line look shorter), influence perceived length. A number of other experimental examinations support the influence of visual context in creating visual illusions (Künnapas 1955; Schiffman and Thompson 1978; Spivey-Knowlton and Bridgeman 1993). However, illusory effects are not limited to the situation where aspects within the same sensory system induce the illusion (ie visual context and a visual stimulus).

Social context has been shown to produce visual illusions in the autokinesis effect (a fixed light in a dark room appears to move). What is interesting about the autokinesis effect is that the degree of light movement is different for each observer, and is very susceptible to suggestion and group pressure. Sherif (1935, 1937) demonstrated that if instructions were given as to the direction the light should move, subjects tended to see movement in that direction. Even more striking, Rechtschaffen and Mednich (1955) told subjects that the light would spell out specific words and the subjects reported that it did. Moreover, the words were relevant to each subject's personal life and were embarassing to some of them.

These instances show how verbal context (ie the experimenter's instructions) can induce visual illusions. Verbal labels as manipulators for olfactory perception may be even more potent than they are in vision because we are so visually and verbally oriented and automatically search for visual – verbal referents to our olfactory experiences (Herz 2000). Moreover, for olfaction, despite the contrast of two modalities, verbal labels may be more reliable perceptual frames for olfactory perception than other odors are because of the sensory confusion arising from odor mixing—for example smelling—"cheese" in a restaurant filled with other food aromas. Thus, the word "cheese" is an ecologically relevant and uncontaminated perceptual reference frame for an olfactory experience. Verbal labels for odors and the visual arrowheads and feathers in the Müller-Lyer illusion can thus be considered analogous in that each provides perceptually expected and 'reliable' information regarding the frame of reference for the stimulus.

It is well acknowledged that verbal context regularly causes olfactory misperceptions; however, they are usually minor and extensions of reality. For example, smelling garlic while walking past a pizza restaurant and misperceiving the smell to be pizza itself (see Engen 1987). However, in some instances the effect of verbal context can be very dramatic—for example, misperceiving the same stimulus to be either cheese or a dead body depending on the verbal context the odor is perceived through. Importantly, although all odors are susceptible to verbal cueing, some may only be susceptible to verbal-context misperceptions within close approximation to their object category. For example, telling someone that the smell of lime is actually lemon may be acceptable, but telling them that it is coconut is less believable, and that it is pizza even less so (Cain and Potts 1996). For the present research we were interested in odors which could show dramatic verbal context effects and which would be believed to be products of both very pleasant and unpleasant odor sources. By definition such odors should not have a fixed source but at least two possible anchors with large differences in hedonic connotation from each other. We called these odors "ambiguous" and developed a set of five odors to test in the present experiment. We did not expect all odors to be equally affected by the verbal-label manipulation, but did not know to what degree they would vary and which odors would be most strongly or weakly affected. Therefore, the individual odors used were separately assessed as an independent factor in the present study.

The aim of our study was to evaluate, as potential evidence for olfactory illusions, the effect of providing verbal labels with opposing hedonic connotations on the perception of odors. Using the definition that an illusion occurs when a stimulus is invariant but context alters its perception, we assessed whether verbal context in the form of labeling could cause olfactory illusions. In the present scenario, the odorant is the invariant physical stimulus, the context is the verbal label used to describe the chemical stimulus, and the illusion is demonstrated by perception being altered as a function of the verbal label applied. We propose that cases where perception of a specific odor is inverted as a function of the verbal label it is presented with demonstrate an olfactory illusion.

2 Method

2.1 *Subjects*

Eighty undergraduates (forty male, forty female; mean age = 21.25 years) from the University of Pennsylvania served as subjects. Subjects were individually tested and paid for their participation. Subjects were prescreened in a telephone interview prior to participation, and only nonsmokers without chemical allergies were selected. On the days of testing, subjects were asked not to wear any fragrance (other than their usual soap and shampoo). All subjects had a self-reported normal sense of smell and were free from respiratory infections when they participated.

2.2 *Odorants and verbal labels*

The following chemical odorants were used: menthol, patchouli, violet leaf, pine oil, and a 1 : 1 combination of isovaleric and butyric acids (I – B acid). Pine oil, menthol, and patchouli were prepared as 100% solutions, violet leaf was diluted to a 50% solution, and I – B acid to a 1% solution. The odorless solvent used to prepare the dilutions was diethyl phthalate. All odors were supplied by Haarmann and Reimer Corp. (300 North Street, Teterboro, NJ 07608, USA), except for isovaleric and butyric acids which were purchased from Aldrich Chemical Company, Inc. (PO Box 2060, Milwaukee, WI 53201, USA). To produce the olfactory experience, one diethyl phthalate pellet saturated with each odorant was prepared and placed into a white opaque plastic jar and covered with pure cotton. To smell an odorant, subjects unscrewed the lid of the jar when instructed and sniffed at the cotton inside. There were no visual cues by which the odors (jars) could be discriminated. Table 1 shows each odor with its two alternate verbal labels. The alternate verbal labels for each odorant were chosen on the basis of pretesting with a group of volunteers who were demographically similar to the study participants. Volunteers sniffed each odorant and then generated as many names as they could for what they thought the odor stimuli might be. The most

Table 1. Odor labels and hedonic order by group and session.

Odorant	Label, session 1	Label, session 2	Hedonic order
Group 1			
I – B acid	parmesan cheese	vomit	positive, negative
Menthol	chest medicine	breath mint	negative, positive
Patchouli	musty basement	incense	negative, positive
Violet leaf	fresh cucumber	mildew	positive, negative
Pine oil	spray disinfectant	Christmas tree	negative, positive
Group 2			
I – B acid	vomit	parmesan cheese	negative, positive
Menthol	breath mint	chest medicine	positive, negative
Patchouli	incense	musty basement	negative, positive
Violet leaf	mildew	fresh cucumber	positive, negative
Pine oil	Christmas tree	spray disinfectant	positive, negative

consistently applied positive and negative labels were then retested with another set of volunteers to determine validity. The second group of volunteers was given each odor with alternate verbal labels and asked to assess how much they agreed with the verbal descriptors. The present alternate labels were then selected from the most agreed-upon matches for the specific odor in question.

2.3 *Design*

A randomized block design was followed to produce two label-order groups of twenty subjects within each gender. The two label-order groups are referred to as group 1 and group 2. The experience of subjects within group 1 and group 2 was identical except that the order of labels provided at session 1 and session 2 was reversed. This allowed us to examine what effect the order of labels would have on perception of a specific odorant. The labels given to each odor at each session by group are shown in table 1. Subjects assessed the same five odors one at a time, at two different sessions separated by one week. Odors were presented in different orders at each session. At the first session, the odorant was given either a positive or negative label, and at the second session the labels were reversed. Subjects were not told that they were smelling the same odors at both sessions. Twenty different random orders of odor presentation were prepared and then repeated four times (once for each of males and females in group 1 and group 2). Gender was considered in the present design because it has been shown that under certain conditions women show greater olfactory sensitivity to odors, as well as greater verbal fluency with odor naming, than do men (Cain 1982; Doty et al 1981).

2.4 *Procedures*

Subjects were told that the purpose of the experiment was a general investigation of odor perception. At the start of session 1, subjects were familiarized with the odor-smelling and rating procedures, and any questions were addressed. The experiment began with the experimenter handing the first jar to the subject and saying the designated odor name for that subject and session (eg "this is chest medicine", for menthol). The subject then unscrewed the lid of the jar and sniffed at the cotton inside for a few seconds. Subjects were allowed to sniff the odor as many times as they needed to make their evaluations. After sniffing the odor, the subjects filled in a questionnaire which asked for their ratings of the odorant on three 9-point hedonic scales: pleasantness, familiarity, and intensity (1 = extremely unpleasant, unfamiliar, weak; 9 = extremely pleasant, familiar, strong). The subjects were then asked to provide written answers for: (i) what the odor made them want to do / how they would use it, (ii) whether it evoked a memory (and if so to describe it briefly), and (iii) what they would call the odorant. The order of question items was the same for all subjects at both sessions.

The three written descriptive measures were evaluated together by two independent judges who were blind to the experimental conditions to determine whether the subjects thought they were smelling a different odor (or not) at each session. From this assessment, the measure of *perceptual interpretation* was derived. If the responses to these questions were generally the same at each session, perceptual interpretation was scored as 'same'. If the responses to these questions were generally different at each session, then perceptual interpretation was scored as 'different'. An example for 'same' interpretation would be if, for I – B acid, a subject wrote different food-related memories at each session, and at both sessions said that the odorant would go well with pasta and called it "cheese". An example for 'different' interpretation would be if, for I – B acid, the subject at the first session recalled a memory and at the second did not, and at session 1 said he or she would like to eat, and at session 2 that he or she would like to run out of the room, and if he or she indicated that the odorant should be called "parmesan cheese" at session 1, and "vomit" at session 2. Obviously there were many permutations of responses possible for each trial. When the judges disagreed on an interpretation, the subject's responses were discussed until consensus was achieved.

After completing a trial for one odor, the experimenter handed the next odor to the subject until assessments for the five odors were completed. Subjects were not under any time constraints to make their evaluations. After rating the five odors, subjects were dismissed and asked to return in one week for further testing. When subjects returned a week later they were presented with the same five odors in a different order, and this time told the alternate name for each odor (eg "this is breath mint", for menthol). Subjects completed the same questionnaires (rating scales, written responses) as before for each odor. At the end of session 2, subjects were fully debriefed and probed to see if they had guessed the experimental hypothesis. No subjects correctly ascertained the experimental aims.

3 Results

3.1 *Perceptual interpretation*

This measure assessed whether subjects perceived an odor as being the same or different at the two sessions as a function of verbal context (label) and was key to our determination of olfactory illusion effects. The numbers of subjects who perceived the odors to be different at each session are shown in table 2.

Table 2. The number of subjects who perceived the odorants as different as a function of label and order.

Odorant	Group 1	Group 2				
	odor label order	N	percentage	odor label order	N	percentage
I–B acid	parmesan cheese vomit	33	83	vomit parmesan cheese	33	83
Pine oil	spray disinfectant Christmas tree	25	63	Christmas tree spray disinfectant	24	60
Menthol	chest medicine breath mint	20	50	breath mint chest medicine	27	68
Violet leaf	fresh cucumber mildew	33	83	mildew fresh cucumber	35	88
Patchouli	musty basement incense	32	80	incense musty basement	33	83

N = the number of subjects who perceived the odorant as different as a function of label. Maximum $N = 40$.

Because the order of labels given may have influenced perceptual interpretation, group 1 and group 2 were considered separately (see table 2). As can be seen, 83% of subjects in group 1 perceived both I–B acid and violet leaf as being different odors at each session. Patchouli followed closely behind and was perceived as a different odor at each session by 80% of subjects. Percentage comparison tests (nonparametric test for significance between two proportions, Statistica®) showed that there were no differences between these three groups. Pine oil and menthol were less affected by verbal context. Percentage comparison tests showed that the number of subjects who perceived pine oil and menthol to be different was significantly less ($p < 0.01$) than the number of subjects who perceived I–B acid, violet leaf, and patchouli to be different. In particular, menthol was the least influenced by verbal context and was considered to be a different odor at the two sessions by only half (50%) of the subjects.

For subjects in group 2, violet leaf was the odor most often perceived as being a different odor at each session (88%). I–B acid and patchouli tied for being the next most likely to be perceived as different odors (83%). Percentage comparison tests showed that there were no differences between these three odors ($p > 0.05$). Pine oil was the least likely to be perceived as a different odor at each session (60%), followed closely by menthol (68%). Percentage comparison tests showed that the number of subjects who perceived pine oil to be a different odor at each session was significantly less than for all other odors except menthol ($p < 0.01$). Notably, percentage comparison tests showed that significantly more subjects in group 2 perceived menthol to be 'different' than subjects in group 1 (68% versus 50%; $p = 0.05$).

3.2 *Pleasantness evaluations*

To assess how each odor was hedonically evaluated as a function of the verbal context it was presented in, analyses of variance (ANOVAs) were conducted on the pleasantness rating-scale data. Four-way mixed design ANOVAs with Gender and Order (positive label first, negative label first) as the between-subjects variables, Odor as the within-subjects variables, and Label (positive, negative) as the repeated measure was performed. Newman–Keuls, $p < 0.01$, a posteriori comparisons were used to further inspect the data when significant findings were obtained.

A significant Odor by Label interaction was found for odor pleasantness ($F_{4,380} = 23.00$, $p < 0.01$)—see figure 1. As can be seen, all odors were influenced by the label manipulation; however, I–B acid was most strongly affected by verbal context, and changed from a mean rating of 5.06 when called "parmesan cheese" to 1.68 when called "vomit". Menthol was the least affected by verbal context, and changed by only 0.76 rating points between being labeled "breath mint" or "chest medicine".

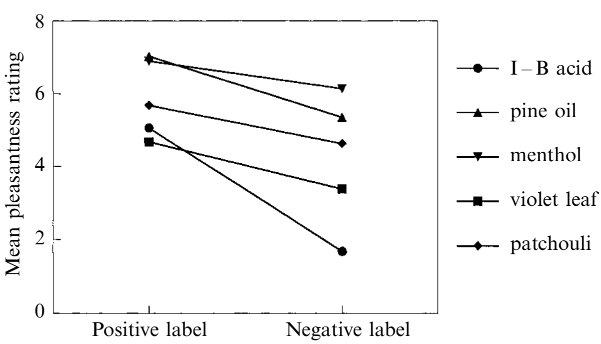

Figure 1. Odor by label interaction for ratings of pleasantness. Rating scale: 1 = extremely unpleasant, 9 = extremely pleasant.

A three-way interaction between Odor, Order, and Label indicated that pleasantness perception was also variably altered as a function of the specific odor and which label was given first ($F_{4,380} = 3.96$, $p < 0.01$). To investigate this finding further, two-way mixed-design ANOVAs with Order as the between-subjects factors and Label as the repeated measure, were performed on the pleasantness data obtained for each odor. Analyses showed significant Order by Label interactions for pine oil ($F_{1,76} = 61.83$, $p < 0.01$) and menthol ($F_{1,76} = 3.96$, $p < 0.05$)—see table 3. A posteriori comparisons indicated that pine oil as "Christmas tree" was perceived as smelling more pleasant and as "spray disinfectant" more unpleasant when the negative label ("spray disinfectant") was given first, compared with when "Christmas tree" was given as the first label.

For menthol, positive and negative labels elicited equivalent pleasantness ratings, when the positive label ("breath mint") was given first. However, if the negative label ("chest medicine") was given first, menthol was rated as significantly more pleasant when called "breath mint" (at session 2) than when it was called "chest medicine" (at session 1).

Table 3. Pleasantness ratings as a function of label order and label hedonics.

Label order	Label hedonics	Mean $\pm$ SEM
Pine oil		
Christmas tree Spray disinfectant	positive: Christmas tree negative: spray disinfectant	6.70 ± 0.24 5.70 ± 0.30
Spray disinfectant Christmas tree	positive: Christmas tree negative: spray disinfectant	7.38 ± 0.25 5.00 ± 0.30
Menthol		
Breath mint Chest medicine	positive: breath mint negative: chest medicine	6.63 ± 0.20 6.20 ± 0.23
Chest medicine Breath mint	positive: breath mint negative: chest medicine	7.18 ± 0.23 6.08 ± 0.32

3.3 *Subsidiary ratings*

A significant interaction between Odor and Label was obtained for *familiarity ratings* ($F_{4,380} = 2.34$, $p < 0.05$)—see table 4. I–B acid was rated as significantly less familiar when given a negative label than when given a positive label. For the other odors there were no differences in familiarity ratings as a function of label. That is, the difference in perceived familiarity as function of verbal context changed more for I–B acid than any other odor.

A significant Odor by Order interaction was also observed ($F_{4,380} = 4.48$, $p < 0.01$). For I–B acid, pine oil, and menthol whether a positive or negative label came first did not influence familiarity ratings. However, for violet leaf and patchouli the order of the labels given did matter. For violet leaf, subjects who were given the positive name "fresh cucumber" first and the negative name "mildew" second, rated violet leaf as more familiar overall than subjects who received the names in the reverse order. However, for patchouli, subjects who received the positive name "incense" first followed by "musty basement" rated patchouli as lower in familiarity than did subjects who received the names in the reverse order. Thus, there appears to be something about the prototypicality of the name given to the odor in question which influences odor perception (eg familiarity) more so than whether the hedonic valence of the odor name is positive or negative.

Table 4. Familiarity and intensity ratings as a function of odor and label (mean $\pm$ SEM).

Odorant	Familiarity ratings		Intensity ratings	
	positive label	negative label	positive label	negative label
I–B acid	parmesan cheese 7.66 ± 0.17	vomit 6.75 ± 0.22**	parmesan cheese 7.31 ± 0.15	vomit 7.46 ± 0.19
Pine oil	Christmas tree 7.14 ± 0.21	spray disinfectant 6.81 ± 0.18	Christmas tree 7.22 ± 0.13	spray disinfectant 7.04 ± 0.14
Menthol	breath mint 7.91 ± 0.10	chest medicine 8.06 ± 0.11	breath mint 7.09 ± 0.14	chest medicine 7.24 ± 0.16
Violet leaf	fresh cucumber 5.51 ± 0.24	mildew 4.94 ± 0.27	fresh cucumber 6.00 ± 0.19	mildew 6.75 ± 0.17**
Patchouli	incense 5.63 ± 0.25	musty basement 5.30 ± 0.22	incense 6.29 ± 0.16	musty basement 6.45 ± 0.18

** denotes $p < 0.01$.

A significant main effect was found for *intensity ratings* by Order ($F_{1,380} = 4.94$, $p < 0.05$). Subjects who received a negative label first rated the odors as smelling stronger across both sessions (mean = 7.00) than subjects who received a positive label first (mean = 6.76). A significant Odor by Label interaction was also obtained ($F_{4,380} = 3.70$, $p < 0.01$)—see table 4. A posteriori comparisons indicated that for violet leaf the difference in ratings between when it was called "mildew" and when it was called "fresh cucumber" was greater than with any other odor.

Finally, a significant Gender by Label interaction was found ($F_{1,380} = 3.63$, $p = 0.05$). A posteriori comparisons revealed that when men were given a positive label they rated the odors as smelling weaker (mean = 6.60) than subjects in any other group. Means for females given positive and negative labels and men given negative labels were 6.97, 7.02, and 6.96, respectively. These means did not differ.

4 Discussion

The present experiment demonstrated that subjects' perceptual responses to an odor could be inverted as a function of the verbal label given to it. The claim was made at the outset of this article that if the influence of verbal context on the perception of certain odors could induce olfactory misperceptions in accord with our operational definition of an olfactory illusion (the chemical stimulus remains invariant but perception of the stimulus is altered as a function of the verbal context in which it was presented) then an olfactory illusion would be demonstrated. We propose that evidence of olfactory illusions was shown for violet leaf, patchouli, and, most significantly, I – B acid.

Previous research has shown that context can embellish olfactory perception (Moskowitz 1979; Zellner and Kautz 1990). Indeed, the perception of an odor can even be fabricated by verbal and expectation effects. In a classic early demonstration, Slosson (1899) opened a vial of 'odor' in a classroom and asked students to raise their hand when they detected it. The vial was completely empty but most students raised their hand. Even more striking, O'Mahoney (1978) showed that informing a television or radio audience that a certain sound frequency could produce the perception of odors was able to generate reports of odor detection and in some cases allergic reactions! More recently, Knasko et al (1990) found that the mere suggestion of an ambient pleasant or unpleasant odor in an unscented room could produce changes in mood that were consistent with odor expectation. These findings show how susceptible olfactory perception is to verbal suggestion. What we have shown in the present experiment is that the perception of an invariant physical stimulus (an odorant) can be inverted as a function of the verbal label that it is presented with. That is, opposite perceptions to the same physical odor stimulus can be produced merely by the verbal context it is presented in. We believe that this demonstrates a case for olfactory illusions.

Notably, not all of the odors tested were equally susceptible to our verbal-context manipulations. We did not anticipate that all the odors would be equally affected but we did not know to what extent they would vary and which odors would be most or least susceptible. An analysis of the specific odors used also helps us to understand what the mechanisms involved in verbally induced olfactory illusions may be. From the perceptual interpretation and rating-scale data it is clear that I – B acid was the most affected by verbal context (most illusory) and that menthol was the most weakly influenced, though illusory effects were still obtained in over half of the sample. We interpret the finding that different odors were more or less susceptible to the verbal labeling manipulation to be a function of experiential familiarity with the specific odor and the degree of anchoring the odor had with the verbal labels provided. It seems that the more equally anchored to the two possible labels the odor was, the more likely it was believed to be either of the two odorants. Thus, I – B acid could be experientially perceived as "vomit" or "parmesan cheese" equally well, whereas menthol was much more firmly rooted in the "chest medicine" than in the "breath mint" connotation. This idea is supported by the comments made by one subject, who was a German exchange student. She remarked that she only knew of the smell of menthol as breath mints and was unfamiliar with the chest medicine designation. For most North Americans, however, experience with menthol in medicine is more common than it is in candy. A similar cross-cultural variation exists between the US and UK regarding the perception of wintergreen (methyl salicylate). For people who have grown up in the USA, wintergreen is exclusively a pleasant mint candy smell, whereas in the UK this same odor is associated with medicine and tends to elicit highly negative odor ratings (Cain and Johnson 1978; Moncrieff 1966).

The order of labels given to particular odors was also found to be linked to the degree of verbal-context susceptibility in some cases. In particular, menthol changed in terms of how much it was perceived to be the same or a different odor across the two sessions as a function of what name it had been given first. When menthol was first presented with the label "chest medicine", 50% of the subjects perceived the odor to be different at each session; however, when it was first labeled "breath mint", 68% considered it to be different at each session. Additionally, positive and negative labels elicited equivalent pleasantness ratings, when the first name was "breath mint", but if the first label applied was "chest medicine" the "breath mint" label elicited higher pleasantness ratings. For violet leaf, subjects who were given the positive name "fresh cucumber" first rated violet leaf as more familiar than subjects who received the negative name "mildew" first. However, for patchouli, subjects who received the positive name "incense" first rated patchouli as being less familiar than subjects who were told "musty basement" first.

This illustrates a *first-label effect*, where the connotation of the first label given influences subsequent responding to the same odor. The first-label effect shows that there is verbal priming in odor perception. Notably, perceptual priming by the first label appears to be linked to the degree of experiential anchoring and thus how susceptible the odor was to illusory perception. Perceptions of odors with weaker experiential anchoring (eg menthol) were primed more by the first label than odors with strong experiential anchoring (eg I – B acid). Therefore, both what one is primed to think of an odor as being as well as one's standard for experience play an important role in the manipulation of perception for certain odors.

A subsidiary issue in the present study was to examine the influence of gender on the responses obtained. Our data showed gender differences in perceived odor intensity only, with the finding that men rated odors given a positive label as smelling weaker than subjects in any other group. Typically when sex differences are found, they demonstrate greater sensitivity by females. However, our findings underscore the potency of the labeling effect, as the results suggest that gender-based expectations rather than gender-based olfactory sensitivity produced this outcome.

What is missing in the present study is a condition where the odorants were assessed without any verbal context. Subjects could have been asked to try to name and evaluate the odors purely on the basis of their personal interpretation. This condition would be useful to determine what the base-rates were for various alternate perceptions of the same odors. However, we did not consider it necessary to include this condition for the following reasons. First, the two alternate verbal labels for each of the odors were already chosen on the basis of pretesting subjects for what they thought the odor stimuli could be. Second, it is well established that odors are very difficult to identify verbally even when they are very familiar (eg Cain 1979; Desor and Beauchamp 1974); thus in many cases subjects would likely not have been able to provide themselves with much useful verbal information regarding the odors in question. As such, a label-free condition would have tapped into lexical-access issues, the "tip-of-the-nose phenomenon"

(Lawless and Engen 1977), rather than being an indication of the absence of a verbal context effect. Finally, the aim of this study was to evaluate the effect of verbal context on odor perception and thus we believed that it was necessary to provide subjects with a verbal context *prior* to their perception of the actual odorants. Had subjects smelled the odors without first being provided with verbal labels, they would have tried to generate some kind of label after smelling them and this would have confounded our goals.

The purpose of this study was to assess whether verbal context could produce illusory changes in the perception of a set of 'ambiguous' odors. Our data showed that the perception of certain odors could be inverted at both hedonic and perceptual levels as a function of the verbal context in which the odor was presented. Reber (1985) defines an illusion as any stimulus situation where that which is perceived cannot be predicted, prima facie, by a simple analysis of the physical stimulus. This account fits well with our olfactory case, as one would not be able to predict how I – B acid (for example) would be perceived in the absence of a verbal context. On the basis of our operational definition of illusion and that of Reber it would seem that we have provided the first empirical evidence for the existence of olfactory illusions. Notably, susceptibility to verbal context appears to be influenced by the degree to which prior experiential factors (prototypicality) bias perception. Among the odors tested, I – B acid showed the least bias and thus the greatest illusory effects, whereas menthol showed the most bias and, conversely, the least illusory effects. Future studies should assess a broad range of different odors under various verbal, visual, and environmental conditions to determine more comprehensively what the governing principles that define this phenomenon are.

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