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Verbal Cues Modulate Hedonic Perception of Odors in 5-Year-Old Children as well as in Adults

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Abstract

The judgment of pleasantness/unpleasantness is the prominent reaction to the olfactory world. In human adults, the hedonic valence of odor perception is affected by various factors, among which is an individual's lexical knowledge about smells. The present study examined whether such top-down effects of lexical knowledge on hedonic judgment of olfactory input are similar in children (5–6 years) and adults (20–25 years). In both groups, the lexical knowledge was found to influence the perception of the least emotional (or most neutral) odors: the pleasantness of the smells of banana and mint was enhanced when participants were given the corresponding odor label before olfactory sensation. These results lend support to the notion that, during childhood, smells are not only encoded perceptually but that verbal encoding also steers contextual effects that may be prominent factors in the early memorization and categorization of odors.

Key words: children, emotion, hedonic processing, language, olfaction

Introduction

Affective evaluation certainly is one of the critical early stages in the cognitive processing of olfactory information. Odors are strong releasers of attraction or repulsion responses, and they may thus influence cognitive and social behaviors in various contexts (Ehrlichman and Bastone 1990; Herz 2002). The hedonic processing of odors is influenced by an individual's physiological and psychological states and is characterized by a high degree of plasticity in humans. In adults, odor hedonics is modulated by the characteristics of the stimulus (e.g., concentration; Henion 1971), by the subjects' previous experience (Cain and Johnson 1978), and by their current physiological status (e.g., prandial state, reproductive status; Dorries et al. 1989; Rolls ET and Rolls JH 1997).

Pleasantness judgments are also influenced by higher level cognitive factors, such as semantic knowledge and language. For example, Herz (2003) showed that the access to verbal information related with given odor sources can change the hedonic appreciation of the corresponding smells. Further, the hedonic meaning of the label assigned to an odorous mixture has even been shown to differentially affect the activation pattern of the orbitofrontal cortex elicited by the same olfactory mixture (De Araujo et al. 2005). Similarly, all perceptual properties of odor inputs—that is, their ratings of intensity, pleasantness, and familiarity—are enhanced when human subjects either can identify the odor or are provided with its name (Distel and Hudson 2001). Such top-down verbal influences on the organization of olfactory inputs, whereby high-level cognitive processing generates expectations, have been examined mostly in adults so far. In an attempt to characterize these top-down influences on the olfactory percept during childhood, Hvastja and Zanuttini (1989) tested children aged 6–10 years under conditions whereby odors were associated with pleasant or unpleasant visual objects or events during encoding. The participants were tested immediately after encoding and 1 month later for their olfactory recognition performances and pleasantness judgments. Their study showed that the visual cues that matched the odorants did not influence odor recognition at any age. However, in the youngest (6–8 years) children, odor

pleasantness judgments were influenced by the valence of the visual cues, in that odors were perceived as more pleasant when they were presented with a pleasant visual object during encoding.

Infants and children actively assess the olfactory facets of their physical and social environments, and they develop then more or less in-depth "awareness" and knowledge of their odor world (Engen 1988; Schaal 1988, 1999; Ferdenzi et al. 2007). Odors become part of children's semantic knowledge of objects, contexts, and people as they can name objects or persons after being presented only to their odor (Cain et al. 1995; Lehrner, Walla, et al. 1999; Mallet and Schaal 1998). Language and semantic representations of objects become then strong organizers of perception and of odor perception in particular (Engen T and Engen E 1997).

The aim of the present study was to assess whether semantic and lexical representations of odors may modulate and organize the hedonic representation of smells during early childhood, at a period when concepts and language become increasingly sophisticated. To achieve this aim, we tested the hypothesis that activating semantic and linguistic representations would affect the classification of a "neutral" odorant into more clear-cut hedonic categories: that is, from indifferent or neither-pleasant-nor-unpleasant to either clearly pleasant or clearly unpleasant. Our prediction was that odors that are already pleasant and unpleasant would not be affected by verbal labels because they are already emotionally labeled and stably categorized. In contrast, relatively neutral odors would be more sensitive to the effects of lexical information. To test this hypothesis, children were exposed to odorants that cover a wide range of hedonic responses (pleasant, neutral, and unpleasant) under conditions whereby a verbal cue was (name condition) or was not (control condition) presented before odor presentation. Further, to assess gross age differences in the verbal modulation of hedonic rating, the results of these children were compared with those of a group of young adults.

Participants and methods

Subjects

Thirty-six subjects participated in the study, in 2 groups: 18 children (8 girls, 10 boys; mean age ± standard deviation (SD): 5.39 ± 0.5 years, range: 5–6 years) recruited from a nursery school in Lyon (France) and 18 students (15 women, 3 men; mean age ± SD: 22.88 ± 3.06 years, range: 20–29 years) recruited from Université Claude Bernard, Lyon. An informed consent was obtained from the children's parents and from the young adults.

Stimuli

The stimuli were selected on the basis of a pilot study with 5 children (aged 6–12 years) and 5 adults (aged 18–28 years) who were presented unpleasant, neutral (i.e., neither pleasant nor unpleasant), and pleasant odorants. The participants were required to rate the pleasantness of 6 odorants on a 9-point rating scale presented below (Procedure). This pilot study indicated that fish (mean ± standard error of the mean: 3.00 ± 0.61) and garlic (1.40 ± 0.27) were rated as unpleasant, banana (5.50 ± 0.69) and mint (5.10 ± 0.90) as neutral, and orange (7.20 ± 0.47) and apple (7.00 ± 0.59) as pleasant.

Six odorant were thus selected: orange, apple, mint, fish, garlic (purchased from Euracli, Chasse-sur-Rhône, France), and banana (*trans*-2-hexenyl acetate; donated by Givaudan, Dübendorf, Switzerland). These stimuli were presented in 15-ml opaque glass jars (opening diameter: 1.7 cm; height: 5.8 cm). All odorants were diluted at 10^{-2} v/v in mineral oil (Sigma, Steinheim, Germany). The solutions (5 ml) were absorbed on a scentless polypropylene fabric (3 × 7 cm; 3M, Valley, NE) to optimize evaporation and air/oil partitioning.

Procedure

For children, testing was performed in a room that was adjacent to the classroom in the nursery school. For adults, testing was performed in the laboratory, in a 2 × 3–m ventilated room dedicated to olfaction studies. The experiment was composed of 2 separate sessions. In the first, the participants smelled all 6 odorants presented in a random order that was specific to each subject. For both adults and children, odorants were administered by either a female (C.R.) or a male (M.B.) experimenter. Instructions given to the subjects were as follows: "You are going to smell several odors, one after the other. Following each sniff, you will have to estimate odor intensity and odor pleasantness using the following scales. To estimate odor intensity, you will have to place a cross on or between any of the 5 manikins that range from smelling something weak to smelling something strong. To estimate odor pleasantness, you will have to place a cross on or between any of the 5 manikins that range from frowning to smiling."

The experimenter held the appropriate stimulus under the participant's nose for one or two sniffs for about 3 s. The interstimulus interval was set at 1 min. After the delivery of each stimulus, the participants reported their responses using a version of the Self-Assessment Manikin (SAM) (Bradley and Lang 1994) adapted so as to graphically represent 2 dimensions: pleasantness and intensity. For the pleasantness dimension, the manikin expressions ranged from smiling to frowning in 5 steps; for the intensity dimension, the expressions represented reactions to sniffing weaker or stronger smells, again in 5 steps. For both scales, the respondents had to place a cross on or between any of the 5 manikins, resulting in a 9-point scale. Both children and adults received similar training before experimental session (although for children training was more time consuming). Indeed, prior to the experiment, the children had been extensively trained by their teacher to use the SAM scale on both

pleasantness and intensity dimensions. Ratings of odor pleasantness were usually easier to explain than intensity estimates. Experimenters and the teacher referred systematically to the concept of strength for the latter when explaining the procedure.

After completion of the first session, there was a pause of 5 min before beginning the second session. The same protocol was used, except that the participants were told the name of each stimulus (one unpleasant, one neutral, and one pleasant) before its presentation (name condition), whereas for the 3 remaining stimuli (one unpleasant, one neutral, and one pleasant), no names were provided (control condition). Half of the participants were provided the names of the orange (pleasant), mint (neutral), and fish (unpleasant) odorants and the other half the names of the apple (pleasant), banana (neutral), and garlic (unpleasant) odorants. During this second session, name-associated and control odorants were presented in random order for each subject. Here again, the interval between consecutive stimulations was set at 1 min.

Statistical analyses

To investigate whether verbal cues modulated intensity and hedonic ratings in children and adults, the subjects' ratings of intensity and pleasantness were entered into 2 separate analyses of variance (ANOVAs) with age group (adults vs. children) as between-subjects variable and session (first vs. second), condition (control vs. name), and odor valence (unpleasant, neutral vs. pleasant) as within-subject variables.

Results

Effects of labeling on intensity ratings

The intensity ratings from one child were excluded from analysis because of missing data. The statistical analyses performed on the 35 remaining subjects revealed main effects of age group ($F[1,33] = 5.21$, $P < 0.03$; power = 0.60) and of odor valence ($F[2,66] = 4.86$, $P < 0.02$; power = 0.79) on odor intensity ratings. The children group generally rated the odor stimuli as more intense than did the adult group (Figure 1a), and post hoc analyses revealed that the unpleasant odorants were rated as more intense than the neutral odorants ($t(34) = 3.12$, $P < 0.01$) (Figure 1b). No significant difference in intensity rating was reached either between unpleasant and pleasant odorants ($t(34) = 1.659$, $P > 0.05$) or between pleasant and neutral odorants ($t(34) = 1.33$, $P > 0.05$). Further, no significant interactions between factors were noted ($P > 0.05$ in all cases). Thus, in the present experimental conditions, the explicit acquisition of the name of the odorants, regardless of their valence, has no effect on the rating of their intensity.

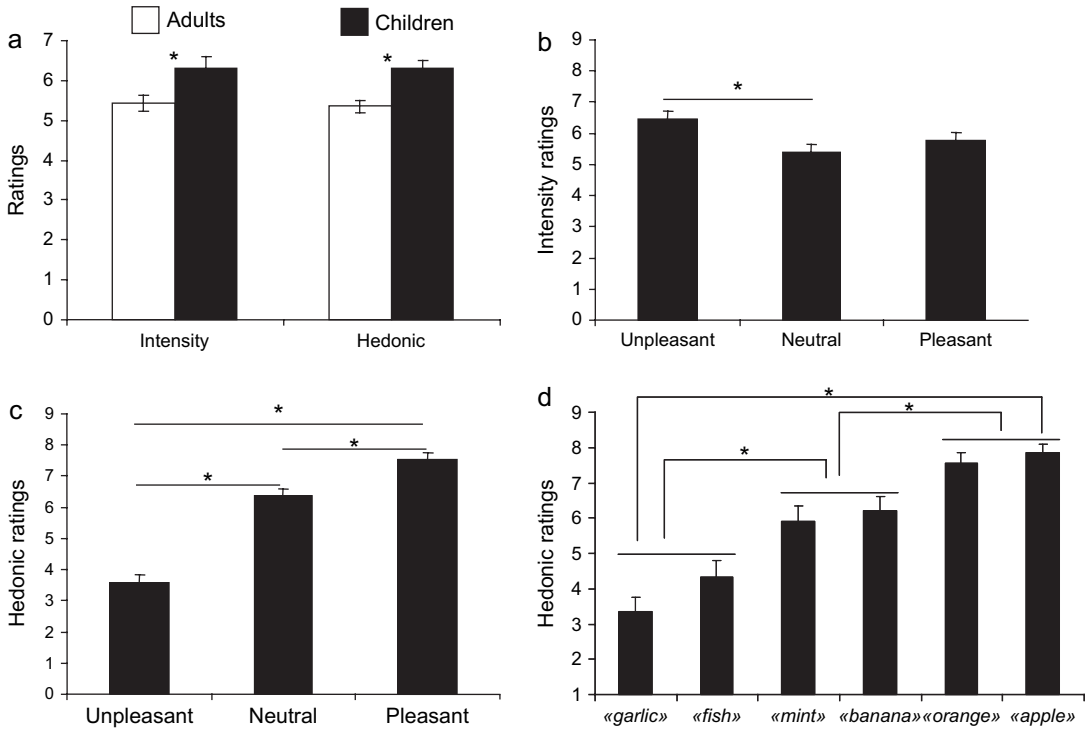

Figure 1 Intensity and hedonic ratings. **(a)** Adults rate the odorants as less intense and less pleasant than children. **(b)** Unpleasant odors are rated as more intense than neutral odors. **(c)** Unpleasant odors (as so defined in the pilot study) were rated as less pleasant than neutral and pleasant odors, and pleasant odors were rated as more pleasant than neutral odors. **(d)** Odor hedonic ratings from session 1 only. *$P < 0.05$.

Effects of labeling on hedonic ratings

The ANOVA showed main effects of the age group ($F[1,34] = 13.157$, $P < 0.01$; power = 0.96) and of odor valence ($F[2,68] = 82.935$, $P < 0.01$; power = 1.00) on the hedonic ratings. This means that the children judged the odorants as overall more pleasant than adults (Figure 1a). Further, the odors a priori categorized as "unpleasant" were actually rated as less pleasant than those categorized as "neutral" and as "pleasant" ($t(35) = 8.22$ and 11.65, respectively, $P < 0.01$ in both cases), and the odors a priori categorized as pleasant were rated as more pleasant than those categorized as neutral ($t(35) = 4.789$, $P < 0.01$) (Figure 1c). These results indicate indeed that the 3 categories of odorants (unpleasant, neutral, and pleasant) induced hedonic ratings in the direction expected from those obtained in the pilot study (see Participants and Methods). To avoid any potential effects of the verbal labels given during the second session, we performed a complementary analysis including only odor hedonic ratings from the first session. This analysis replicated the above results by indicating that mint and banana ($t(35) = 5.328$, $P < 0.01$) and apple and orange ($t(35) = 11.509$, $P < 0.01$) were rated as more pleasant than fish and garlic and that apple and orange were rated as more pleasant than mint and banana ($t(35) = 4.974$, $P < 0.01$) (Figure 1d).

In contrast to the intensity ratings, the "condition by session" interaction ($F[1,34] = 15.173$, $P < 0.01$; power = 0.98) and the "condition by session by odor valence" interaction ($F[2,68] = 3.887$, $P < 0.03$; power = 0.68) reached significance on hedonic ratings. This indicated that odor pleasantness ratings decreased from the first to the second session in the control condition ($t(35) = 2.997$, $P < 0.01$) but that they increased in the name condition ($t(35) = 2.58$, $P < 0.01$) (Figure 2a). Post hoc comparisons of the means defined by the condition by session by odor valence interaction pointed that the decrease in odor pleasantness from "session 1" to "session 2" in the control condition was specific to the unpleasant odors ($t(35) = 2.85$, $P < 0.01$), whereas the corresponding increase in the name condition was specific to the neutral odors ($t(35) = 4.32$, $P < 0.01$). The remaining comparisons were not significant (Figure 2b–d).

To examine whether the effect of the verbal label was similar in both children and adult participants who liked or disliked the smell of mint and banana, we computed a complementary descriptive statistical analysis based on odor hedonic ratings from the verbal condition (Figure 3). In this analysis, data were presented by odorant (fish, garlic, mint, banana, orange, and apple) and by group of individuals. The subjects were classified into 3 groups based on their own

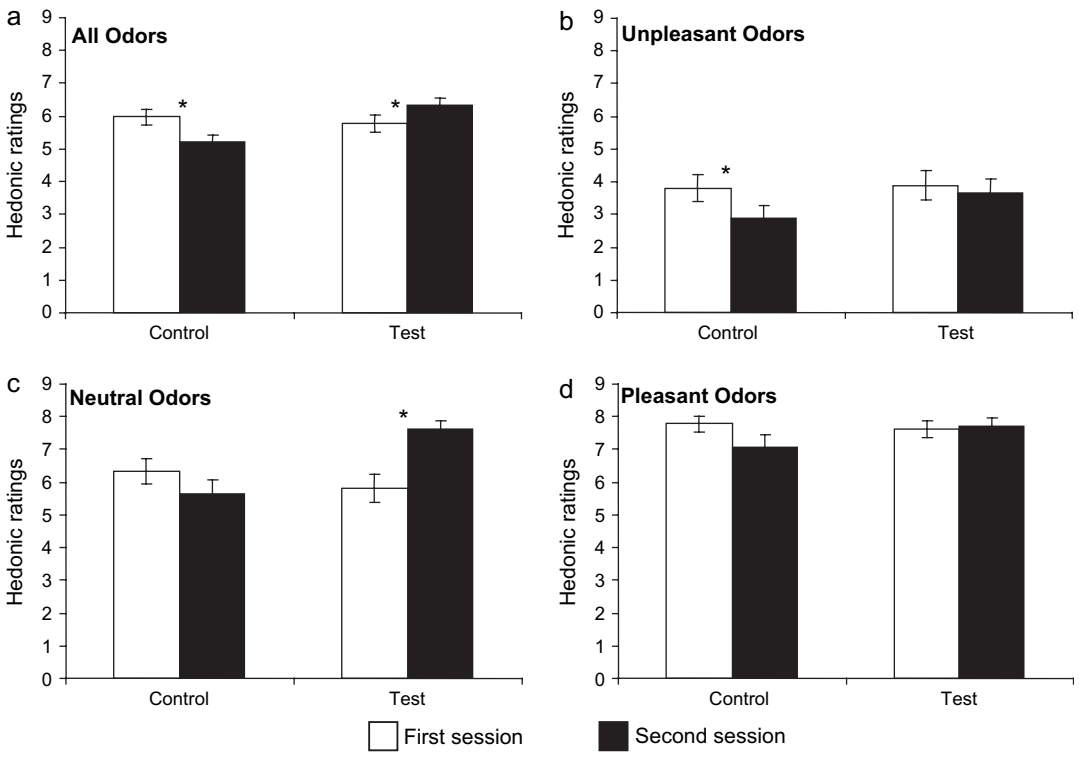

Figure 2 Hedonic ratings in the control and name conditions during the first and second sessions. **(a)** Hedonic ratings for all odors decreased significantly from the first to the second session in the control condition and increased significantly in the test condition. **(b)** Unpleasant odors became significantly more unpleasant from the first to the second session in the control condition. **(c)** Neutral odors became significantly more pleasant from the first to the second session in the test condition. **(d)** The hedonics of pleasant odors did not differ between sessions in either the control or the test condition. *$P < 0.05$.

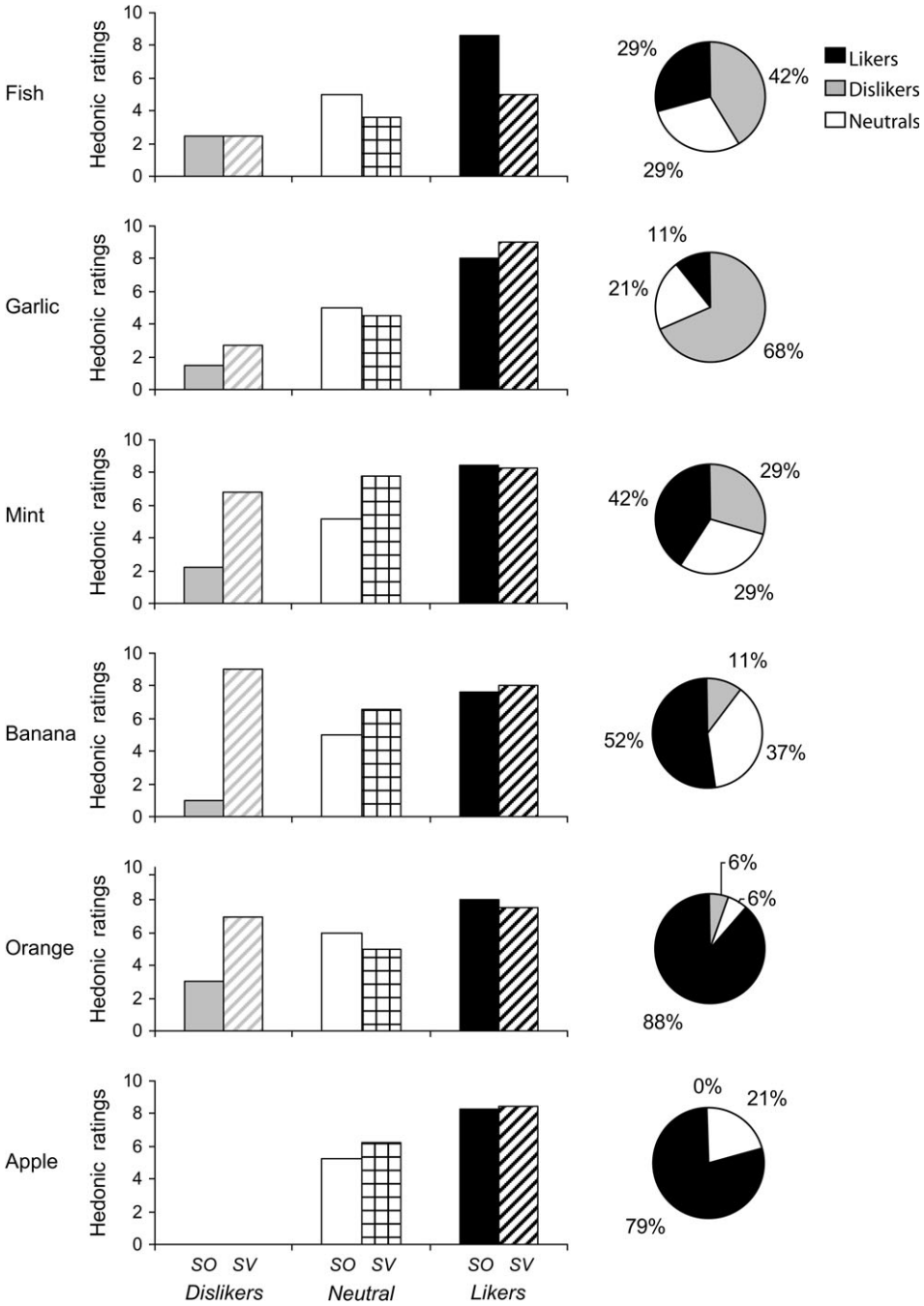

Figure 3 Hedonic ratings during the verbal condition presented by odors (fish, garlic, mint, banana, orange, and apple) and by group of individuals. Dislikers (gray) = individuals who rated the odor in session 1 between 1 and 3; neutral (white) = individuals who rated the odor in session 1 between 4 and 6; likers (black) = individuals who rated the odor in session 1 between 7 and 9. In the bar graphs, within each group of individuals (dislikers, neutral, or likers), hedonic ratings from session 1 correspond to the first bars (plain bars) and hedonic ratings from session 2 are illustrated by the second bars (bar filled with a pattern). Percentage of subjects in each of the 3 categories (dislikers, neutral, and likers) is illustrated in the pie charts. For example, banana was estimated as unpleasant for 11% of the subjects, neutral for 37%, and pleasant for 52%. It is noticeable that for the smell of banana, the effect of verbal label was not present in subjects who rated the smell as pleasant. SO means Smell Only and SV means Smell and Verbal.

ratings during the present experiment: "dislikers" (those who rated the odor in session 1 between 1 and 3) "neutrals" (those who rated the odor in session 1 between 4 and 6), and "likers" (those who rated the odor in session 1 between 7 and 9). The analysis revealed that 1) the hedonic ratings of the smells of banana and mint are widely distributed (for banana, 11% of the subjects estimated it as unpleasant, 37% as neutral, and 52% as pleasant; for mint, these

percentage were, respectively, 29%, 29%, and 42%); 2) the ''mint'' and the ''banana'' labels had similar effects on odor hedonic ratings; and 3) for both odors, the effect of the verbal label was not present in subjects who rated the smell as pleasant.

Discussion

The present study was aimed to assess whether the influences of lexical knowledge on the hedonic judgment of olfactory inputs were similar in children and adults. The first result of interest was that 5- to 6-year-old children perceived the present set of odorants as more intense and as more pleasant than did adults. Second, the influence of the lexical knowledge was similar in both age groups, but it was heterogeneous as a function of the pleasantness of the odorant as shown by analyses based on both a priori and a posteriori odor ratings. According to the analysis based on a priori ratings (see Figure 2), making an odorant's name available changed the hedonic ratings of neutral odorants (mint and banana), but it had no impact on the rating of odorants that were already affirmed as pleasant (apple and orange) or unpleasant (fish and garlic). This suggests that the access to an odorant's name may favor the classification of a neutral odorant into more clearly defined hedonic categories. However, this effect of the name did not influence the hedonic categorization of odorants that were more resolutely classified as pleasant and unpleasant. The analysis based on odor ratings from the subjects of the present study (a posteriori) brings up similar results (see Figure 3). However, an exception was seen in that verbal labels affected ratings of children and adults who estimated mint and banana as neutral and unpleasant. This difference is nevertheless weakened by the fact that only 20% of the subjects rated both odorants as unpleasant.

The 5- to 6-year-olds and the young adults reacted differently in terms of intensity and hedonic ratings. First, perceived odor intensity was higher in children than in adults. This may be explained by children's better olfactory sensitivity than adults. However, there are very few adult–child comparisons of olfactory thresholds and they bring up mixed results, some showing lower thresholds in children (Dorries et al. 1989; Wysocki and Gilbert 1989; Solbu et al. 1990) and some showing equivalent sensitivity from childhood to adulthood (Rovee-Collier et al. 1975; Lehrner, Glück, Laska 1999; Schaal 1999; Chalouhi et al. 2005, for review). Second, pleasantness ratings of children were, on average, higher than those of adults, in line with the early observations by Engen (1974). This suggests another plausible explanation for adult–child differentiation that would involve the differential use of the rating scales. In the present conditions and in comparison with adults, children rate all odorants as more pleasant than adults, indicating perhaps that they may have a systematic bias to prefer the ''more'' (intense or pleasant) end of a continuous scale.

Providing the names of the odorants affected the hedonic rating of odors but not to the extent that may have been expected from a related study by Herz (2003) on adults. Here, in the condition where no name was provided (control condition), the positive hedonic ratings of odors decreased for all repeated stimuli. Conversely, in the name condition wherein subjects were given a verbal label between the first and the second odor presentation, the average hedonic rating for all odors increased. When the hedonic value of individual odorants was considered, the preference ratings decreased in the control condition, but only for the most intense and unpleasant stimuli, whereas the increased preference in the name condition was specific to the most neutral stimuli. At first sight, this result is not in line with Herz's results, in which pleasantness ratings increased for positive odors and decreased for negative odors when a verbal label was explicitly provided for the odorants (Herz 2003). This discrepancy between the present and Herz's results may be due to methodological differences linked with odorant selection or study design. In our case, as far as odorant selection is concerned, the pleasantness of the 6 stimuli was progressively distributed from the very unpleasant to the very pleasant; Herz used 4 pleasant and 4 unpleasant odorants in a more ''discontinuous'' fashion. Regarding the design, in the present study, the participants were in a language-minimal context in phase 1 of the experiment (no verbal label and no instructions to self-generate a verbal label were provided); in comparable conditions, Herz's experiment involved verbal elaboration, in that she asked the subjects to sample each odorant and decide whether they thought it was made from all-natural sources, all-synthetic sources, or a combination of both.

Our results showed that mint and banana were 2 odorants rated as relatively neutral in the present sample of children and adults. Both smells were estimated as more pleasant when the participants were provided the verbal labels (respectively mint and banana). A priori, these verbal labels may not be considered as unpleasant. Thus, one question that may be raised from the above finding is whether a negative label would have the opposite effect. De Araujo et al. (2005) noted that this was indeed the case in adults. For a given olfactory stimulus, providing a positive label had the opposite effect of providing a negative label on both neural responses and verbal hedonic judgments. This point would need further research in children, however.

At the cognitive level, the identification performance of odors in children aged 4–10 years have been found to be generally lower than in adults (Doty et al. 1984; Kobal et al. 2000; Frank et al. 2004), but olfactory identification is better in children when familiar smells (e.g., vanilla and mint) are provided (e.g., Chalouhi et al. 2005). Thus, in the 4- to 10-year age range, the ability to memorize and lexicalize odors develops progressively (Richman et al. 1992; De Wijk and Cain 1994; Cain et al. 1995; Lehrner, Walla, et al. 1999), opening early the way to top-down effects from language on

perceptual activity (Stagnetto et al. 2006). This growing odor vocabulary may have influenced children in the present investigation. Despite that they were not given instructions to generate a verbal label during the odor presentations, the children (and adults) may have spontaneously attempted to label the odorants, thus implicitly engaging in a semantic processing at least for the odors that were easy to name. If this were the case, such a strategy may be expected to have affected hedonic responses in both the control and the name conditions for all odorants (i.e., pleasant, neutral, and unpleasant). However, enhanced pleasantness ratings were observed specifically in the name condition and specifically for odors rated as neutral. This suggests that the effect of naming on odor evaluation was mainly due to the verbal label given before the odor presentation in the name condition. A future study should differentiate the cognitive impact of odor labels acquired during the experiment from the impact of odor labels already known prior to the experiment or self-generated during encoding.

In summary, the present study shows that odor preferences can be subject to short-term changes as a consequence of providing the name of the odorant and that this malleability works already from the age of 5. This modulation of hedonic judgments may take place through a reorganization of the sensory and cognitive attributes (verbal, in the present case) associated with the olfactory stimulus. These results are in line with the suggestion that the hedonic characteristics of actual odors are partially learned and affected by events experienced in other modalities, such as visual representations (Hvastja and Zanuttini 1989). Here, we extended these findings to the verbal representations, lending support to the notion that, during the period when high-level concepts and language are being established, smells are not only encoded perceptually but also verbally. Thus, verbal encoding may be sufficiently active to promote the memorization and categorization of odors in 5-year-olds. In sum, the present study suggests a susceptibility to lexical top-down effects on hedonic categories in children and adults: prior lexical knowledge may help to create and organize olfactory categories.

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