A Rose by Any Other Name: Would it Smell as Sweet?

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INTRODUCTION

What’s in a name, asked Juliet in Scene 2, Act II, of Shakespeare’s Romeo and Juliet. We examined how this question pertains to the world of scents: would the smell of a rose presented under another name “retain that dear perfection”? We conducted two experiments to investigate whether odor names play a role in how we perceive and react to odors.

Pleasantness seems to be a primary dimension in olfaction as affective responses to odors are very strong: as soon as we smell something, we know unmistakably whether it smells good or bad and whether we love it or hate it. Or do we? Almost 30 years ago, Cain and Johnson (1978) showed that presenting an odor for 30 min led to decreased liking of a pleasant, and to increased tolerance of an unpleasant, smell. Rolls and Rolls (1997) demonstrated that pleasantness of a food odor decreased after smelling it for several minutes. Several studies showed that ratings of odor pleasantness vary as a function of odor source than negative names, and vice versa; two-digit numbers were used as neutral names. All aspects of both experiments were approved by the local Research Ethics Board and informed written consent was obtained prior to participation.

METHODS

Experiment 1

SUBJECTS. Forty healthy university students (20 women), mean age = 20.6 yr (range: 18–27 yr), participated. All subjects reported a normal ability to smell. They were asked not to wear perfume on the day of testing and not to eat or drink anything other than water one hour prior to the experiment.

STIMULI. Fifteen experimental odorants were used with sufficient diversity to cover the full range of the pleasantness scale. Subsequent analyses of pleasantness ratings in the neutral name condition revealed that six odors could be classified as unpleasant (mean pleasantness ratings were significantly lower than 50 on a scale 0–100, one-sample t-test, P < 0.05), five as neutral (mean pleasantness ratings did not differ from 50), and four as pleasant (mean pleasantness ratings were significantly higher than 50, P < 0.05). Mean

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Experimental odors

<table>
<thead>
<tr>
<th>Odor Name</th>
<th>Concentration, %</th>
<th>Positive Name</th>
<th>Negative Name</th>
<th>Neutral Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyridine (Py): E1</td>
<td>10</td>
<td>Sea weed</td>
<td>Rotten fish</td>
<td>Fifty-three</td>
</tr>
<tr>
<td>Parmesan cheese (Par)*</td>
<td>100</td>
<td>Parmesan cheese</td>
<td>Dry vomit</td>
<td>Thirty-two</td>
</tr>
<tr>
<td>Carrot seed oil (Car)</td>
<td>100</td>
<td>Carrot juice</td>
<td>Moldy vegetables</td>
<td>Thirty-six</td>
</tr>
<tr>
<td>Indole (Ind)</td>
<td>1</td>
<td>Countryside farm</td>
<td>Human feces</td>
<td>Forty-four</td>
</tr>
<tr>
<td>Cumin oil (Cum)</td>
<td>1</td>
<td>Curry spice mix</td>
<td>Dirty clothes</td>
<td>Twenty-five</td>
</tr>
<tr>
<td>2-heptanone (2-h): E1</td>
<td>100</td>
<td>Banana bread</td>
<td>Nail-polish remover</td>
<td>Forty-six</td>
</tr>
<tr>
<td>Juniperberry (Jun)</td>
<td>100</td>
<td>Green mango</td>
<td>Hospital disinfectant</td>
<td>Twenty-one</td>
</tr>
<tr>
<td>Fir needle oil (Fir)*</td>
<td>100</td>
<td>Pine needles</td>
<td>Old turpentine</td>
<td>Thirty-one</td>
</tr>
<tr>
<td>Isoamyl acetate (IAA)</td>
<td>100</td>
<td>Ripe banana</td>
<td>Paint thinner</td>
<td>Thirty-five</td>
</tr>
<tr>
<td>Geraniol (Ger)</td>
<td>100</td>
<td>Red geraniums</td>
<td>Cheap perfume</td>
<td>Thirty-nine</td>
</tr>
<tr>
<td>Anethole (An): E1</td>
<td>100</td>
<td>Black licorice</td>
<td>Cough syrup</td>
<td>Twenty-three</td>
</tr>
<tr>
<td>Cineole (Cit)*: E1</td>
<td>100</td>
<td>Eucalyptus oil</td>
<td>Vick’s Vapo-Rub</td>
<td>Fifty-four</td>
</tr>
<tr>
<td>Eugenol (Eug): E1</td>
<td>100</td>
<td>Dried cloves</td>
<td>Dentist’s office</td>
<td>Twenty-eight</td>
</tr>
<tr>
<td>Almond extract (Alm)</td>
<td>100</td>
<td>Almond extract</td>
<td>Glue stick</td>
<td>Fifty-one</td>
</tr>
<tr>
<td>Citral (Cit)</td>
<td>100</td>
<td>Squeezed lemons</td>
<td>Insect repellant</td>
<td>Twenty-six</td>
</tr>
<tr>
<td>Peanut butter: E1</td>
<td>100</td>
<td>Peanut butter</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>100</td>
<td>Orange peel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jasmine</td>
<td>100</td>
<td>Jasmine tea</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cinnamon bark oil: E1</td>
<td>100</td>
<td>Cinnamon stick</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grapefruit oil</td>
<td>100</td>
<td>Grapefruit juice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peppermint oil</td>
<td>100</td>
<td>Spearmint gum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Civet artificial</td>
<td>1</td>
<td></td>
<td>Dead animal</td>
<td></td>
</tr>
<tr>
<td>Acetone: E1</td>
<td>100</td>
<td></td>
<td>Chemical solvent</td>
<td></td>
</tr>
<tr>
<td>Ham</td>
<td>100</td>
<td></td>
<td>Spoiled ham</td>
<td></td>
</tr>
<tr>
<td>Isovaleric acid</td>
<td>1</td>
<td></td>
<td>Old socks</td>
<td></td>
</tr>
<tr>
<td>Butyric acid</td>
<td>10</td>
<td></td>
<td>Rotten meat</td>
<td></td>
</tr>
<tr>
<td>1-heptanol: E1</td>
<td>100</td>
<td></td>
<td>Cleaning detergent</td>
<td></td>
</tr>
<tr>
<td>PEA: E1</td>
<td>100</td>
<td></td>
<td>Forty-five</td>
<td></td>
</tr>
<tr>
<td>Bergamot</td>
<td>100</td>
<td></td>
<td>Forty-three</td>
<td></td>
</tr>
<tr>
<td>Ylang ylang</td>
<td>100</td>
<td></td>
<td>Twenty-seven</td>
<td></td>
</tr>
<tr>
<td>Garlic oil: E1</td>
<td>100</td>
<td></td>
<td>Forty-one</td>
<td></td>
</tr>
<tr>
<td>Celery seed oil</td>
<td>100</td>
<td></td>
<td>Twenty-four</td>
<td></td>
</tr>
<tr>
<td>Castoreum res</td>
<td>100</td>
<td></td>
<td>Thirty-four</td>
<td></td>
</tr>
</tbody>
</table>

Fifteen experimental and 18 foil odors from E1 are listed in the first column: for all experimental odors, a short name (used in Fig. 2) is given in parentheses. Experimental stimuli are grouped into 3 categories based on pleasantness ratings in the neutral name condition: 6 unpleasant odors, 5 neutral odors, and 4 pleasant odors. Foil odors are grouped into 3 categories: 6 pleasant odors presented with positive names, 6 unpleasant odors presented with negative names, and 6 odors (2 pleasant, 2 unpleasant and 2 neutral) presented with neutral names. Names for 3 experimental odors marked with a star (*) were modified from Herz and von Cled (2001). A subset of 10 experimental odors and 12 foil odors from E1 were used in E2. The odors that were used in E1 only are marked in the first column with E1.

pleasantsness, intensity and arousal ratings of the 15 experimental odors in the neutral name condition are shown in Table S1. In addition, 18 foil odors were presented: six of these were associated with a positive, six with a negative, and six with a neutral name. The experimental and foil odorants and their names are shown in Table 1. Foil odorants were presented to reduce the likelihood that participants would notice that experimental odors were presented repeatedly under different names. Repetitions of experimental odors were separated by at least five odor trials. Odorants were presented in 30-ml amber glass bottles containing 10 ml of odor solution. Odorants were absorbed by a piece of polypropylene rolled inside the bottle to prevent spilling. Most odorants were presented in full concentration with several exceptions (Table 1) in which case diethyl phthalate was used as a diluent.

**PROCEDURE.** Olfactory function was screened using the “Sniffin’ sticks—screening 12 test” (Kobal et al. 1996), consisting of 12 familiar odorants presented with four alternative names for identification. All subjects identified ≥10 correctly, indicating adequate olfactory function. The experiment consisted of 63 trials (45 experimental—15 odors with three names each—and 18 foil ) presented in a pseudorandom order, which was different for each participant. The interstimulus interval was 30 s. In each trial, participants read aloud an odor name presented on a card. The odor was then presented for 2 s, and subjects rated its intensity, arousal, and pleasantness using visual analog scales. Each scale consisted of a 100-mm line with a vertical mark in the middle and appropriate descriptors at each end (extremely pleasant to extremely unpleasant, not perceptible to extremely intense and, for arousal, very calm to very excited). For rating arousal, the experimenter explained to participants that they should use one end of the scale (“very calm”) for odors that leave them indifferent, and the other end of the scale (“very excited”) for odors that affect them in a strong way, regardless of whether they love them or hate them. Therefore the intention was to measure the strength of their emotional reaction rather than its quality. For analysis, these ratings were computed as numbers on a scale from 0 to 100. At the end of the experiment, participants completed a questionnaire on their understanding of the experimental procedure and study rationale.

**DATA ANALYSES.** The effects of odor name (positive, neutral, and negative) on ratings of pleasantness, intensity, and arousal were analyzed in three separate one-way repeated-measures ANOVAs with
data from the 15 experimental odors averaged together. Greenhouse-
Geisser correction was applied when the sphericity assumption was
violated. Significant overall effects were followed up with post hoc
tests using Bonferroni adjustment for multiple comparisons. To ex-

plore the effect of odor name on perceived pleasantness in individual
odors, a multivariate repeated-measures analysis (MANOVA) was
conducted in which odor name was the within-subject factor and each
of the 15 odors was a separate measure.

Experiment 2

SUBJECTS. Thirty healthy university students (15 women), mean
age = 20.8 yr (range: 18–29 yr) who reported a normal ability to
smell and did not participate in experiment 1, were tested. They were
asked not to wear perfume on the day of testing and not to eat or drink
anything other than water one hour prior to the experiment.

STIMULI. The stimuli were 22 odors selected from among those used
in experiment 1 (Table I) based on the effects of names on pleasant-
ness ratings (Fig. 2). Ten experimental odorants and 12 foils were
used. Each experimental odor was presented three times, once each
under a positive, neutral, or negative name; four of the 12 foils were
associated with a positive, four with a negative, and four with a
neutral name. Ten amber bottles containing 10 ml of water absorbed

by polypropylene were used for a water condition.

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PSYCHOPHYSIOLOGICAL MEASURES. Skin conductance (SC), heart
rate (HR), and sniffs were continuously recorded at 100 Hz using
Power Lab 4 SP recording system (A. D. Instruments, Milford, MA).
The transduced signals were displayed and analyzed with commer-
cially available software (CHART 5.0.2.26, A. D. Instruments). SC
was measured in microsiemens (µS) via two electrodes attached to the
index and middle fingers of the nondominant hand. HR was measured
via an IR photoplethysmograph, clipped on the earlobe on the same
side as the SC electrodes. Sniff parameters were recorded binarily
with a nasal cannula coupled with a pneumotachograph that relayed
changes in intranasal pressure to an amplifier (PowerLab 4SP, A. D.
Instruments).

PROCEDURE. As in experiment 1, olfactory function was assessed
with the “Sniffin’ sticks—screening 12 test” (Kobal et al. 1996). All
subjects identified ≥10 correctly, indicating adequate smell function.
In this experiment, two factors were manipulated: odor name (posi-
tive, neutral, and negative) and stimulus (odor, water). The odor name
manipulation was identical to experiment 1. For the stimulus factor, in
half of the trials, odor names preceded the presentation of odorants,
whereas in the other half, the same odor names preceded odorless
water. In this part of the session, participants were informed that an
odor name would be followed by an odorless stimulus. Thus the
experiment consisted of 42 odor trials and 42 water trials. Participants
were tested in two sessions held on separate days, and in each session,
they completed 21 odor trials and 21 water trials. The order of stimuli
was pseudorandomized within each set of 21, and the orders of sets
and conditions (odor, water) were counterbalanced across subjects.

The experimental procedure is shown in Fig. 3; it comprised a
visual warning/preparation signal, odor names shown and read aloud,
and passive smelling of stimuli (inhalaion of stimuli was preceded by
exhalation to mark sniff onsets). The interstimulus interval was 45 s.
Talking and movement, other than the requested reading, exhalation
and sniffing, were not allowed during testing. When participants
attempted to talk during the experiment, the experimenter made sure
that they were comfortable and reminded them to raise questions or
share comments during the break. Before the experiment, participants
underwent five practice trials to ensure familiarity with the procedure,
followed by a 3-min relaxation period. Participants were instructed to
remain calm and still throughout the session.

DATA PROCESSING AND ANALYSES. Psychophysiological responses
for each stimulus were analyzed in the 10-s window after the 2-s
stimulus presentation, using the 5 s preceding the warning signal as a
baseline recording. Tonic changes in SC to stimulus presentation were
analyzed as the mean activity within the 10-s time window. Mean HR
response (beats per minute) within the same time window was
extracted and used as the HR value. Logarithmic transformations were
used to normalize the SC and HR data. Sniff parameters obtained from
the sniff measurements were analyzed on a group level for each
condition. Subsequently, individual values were extracted and used as
covariates in additional analyses. Sniffs deemed to be of extreme
values due to their short-duration (<0.5 s) were removed before
analysis. Due to increased signal noise at the end of the sniff, long
sniffs were truncated at 2.5 s; hence, sniff durations were not ana-
lyzed. All sniffs were standardized by dividing each individual value
within a measured time unit (1 Hz) by the sum of that time unit. Sniff
volumes (area under the curve) were calculated for each condition
using the trapezoid sum method, and maximum sniff amplitudes were
also extracted. Sniff data from four subjects were excluded owing to
inadequate recordings, and the values of two subjects were deemed to
be outliers (>2.5 SD beyond the group means) for sniff volumes, and
one of them also had outlier values for sniff amplitudes. Therefore the
data of 24 participants were kept for the analyses of sniff volumes and
of 25 participants for the analyses of sniff amplitudes.

RESULTS

Experiment 1

The effect of odor name on perceived pleasantness was
significant, F(2,78) = 71.31, P < 0.001, Fig. 1A. Post hoc tests
revealed that odors were rated as more pleasant with positive
than with neutral or negative names and as more pleasant with
neutral than with negative names (all P < 0.001).

[Graphs showing perceived pleasantness, intensity, and arousal ratings for positive, neutral, and negative odor names.]
The effect of odor name on perceived intensity was also significant, $F(2,78) = 8.29$, $P = 0.001$, Fig. 1B. Odors presented with negative names are perceived as stronger than when they are presented with positive ($P = 0.02$) or neutral ($P = 0.001$) names, whereas the difference between intensity with positive versus neutral names was not significant ($P = 0.65$).

Arousal ratings showed a significant effect of odor name, $F(2,78) = 4.64$, $P = 0.01$, Fig. 1C: odors presented with positive names are perceived as more arousing than the same odors presented with neutral names, $P = 0.02$, whereas there was no difference between perceived arousal with positive versus negative ($P = 1.00$) and neutral versus negative ($P = 0.11$) names.

A multivariate repeated-measures analysis (MANOVA) with odor name as the within-subject factor and each of the 15 odors as a separate measure was also conducted. The omnibus multivariate F-test was significant, $F(30,130) = 4.49$, $P < 0.001$. The univariate F-test was significant ($P < 0.05$) in 12 of 15 odors (Fig. 2), and in 2 others, it showed a tendency toward significance ($P = 0.05$ for 2-heptanone and $P = 0.07$ for anethole). Pyridine was the only odor that did not show an effect of odor name manipulation ($P = 0.18$). Ten of these odors showed the expected pattern of results by which pleasantness was rated as higher with positive than with neutral and negative names, and higher with neutral than with negative names. These 10 odors are: parmesan cheese, indole, cumin oil, 2-heptanone, juniper berry, fir needle oil, isoamyl acetate, geraniol, almond extract, and citral. Three additional odors showed a predicted difference between pleasantness with positive versus negative odor names but with no difference between positive versus neutral names: carrot seed oil, anethole, and eugenol. The only two odors that did not show a difference in pleasantness ratings in positive versus negative names were pyridine and cineole.

The postexperimental questionnaire showed that the majority of participants (27 or 67.5%) had not guessed the experimental rationale and were unaware of any repetition of odors or the odor name manipulation. Nine participants (22.5%) reported having noticed that a few odors were repeated, but they did not realize that different names were given with the repetitions or that this was the focus of the study; these participants were classified as having a partial understanding of the experimental rationale. Finally, 10% (4 participants) reported having realized that some odors were presented under different names; these participants were classified as having a complete understanding of the experimental rationale. Even when we separately analyzed the results of only those participants who showed partial and complete insight ($n = 13$), the overall effect of odor names on perceived pleasantness was still significant, $F(2,24) = 19.51$, $P < 0.001$ and the overall effect on perceived intensity tended to be significant, $F(2,24) = 2.82$, $P = 0.08$.

In summary, 40 participants in experiment 1 rated 15 different odors for their pleasantness, intensity, and arousal. Each of these 15 odors was presented three times, once with a positive, once with a negative, and once with a neutral name. Results showed a major effect of odor name on perceived pleasantness: odors were rated as more pleasant when presented with a positive then with a neutral or negative name and as more pleasant when presented with a neutral then with a negative name. In addition, odor names also exerted some effects on perceived intensity: odors were rated as stronger when presented with negative than with neutral and positive names. Finally, odor names also affected rated arousal, as odors were rated as more arousing when presented with positive than with neutral names. We therefore replicated and extended previous findings showing that assigning different names to odors affects perception of these odors as measured by ratings of their properties. In experiment 2, we addressed whether expectations...
created by odor names have an impact on psychophysiological responses to odors. For this, we measured SC, HR, and sniff volumes and amplitudes.

**Experiment 2**

Four two-way ANOVAs were conducted with repeated factors odor name (positive, neutral, negative) and stimulus (odor, water) to examine their effects on the four psychophysiological measures (see Fig. 3 for experimental procedure). Mean SC level showed a significant interaction between odor name and stimulus, $F(2,58) = 4.11, P = 0.02$. Subsequent post hoc tests within the stimulus factor revealed that when odor names were followed by odors, SC were higher for positive versus neutral ($P = 0.03$) and for negative versus neutral ($P = 0.001$) names, Fig. 4A. Skin conductance with positive versus negative names was not significantly different ($P = 0.09$). In contrast, when odor names were followed by water, SC did not vary as a function of odor name. An examination of the interaction within the odor name factor revealed that the change in SC was significant only for negative names, Fig. 4B: SC was higher when negative odor names were followed by odors than when followed by water, $P = 0.02$. This difference was not seen for positive ($P = 0.16$) or neutral names ($P = 0.95$). In addition to the interaction effect, the main effect of odor name was significant, $F(2,58) = 7.45, P = 0.001$, whereas the effect of stimulus was not, $F(1,29) = 2.38, P = 0.13$.

We used analyses of covariance (ANCOVAs) to determine whether the significant interaction effect for SC remains significant when the influence of breathing differences are covaried out of the analyses. We conducted four separate ANCOVAs in which sniffing effects were statistically removed: sniffing effects were expressed both as difference values between positive versus negative and positive versus neutral names in the odor condition, and these were calculated both for sniff volumes and amplitudes. Given that these are only control analyses, their results are presented as supplementary material published on-line (Figs. S1 and S2). The overall finding was that the pattern of SC results remained unchanged when the effect of odor name on sniff parameters was covaried out.

Heart rate measurements did not show a significant odor name × stimulus interaction, and the main effects of odor name and stimulus were also not significant (all $P > 0.05$). ANOVA on sniff volumes showed a significant interaction between odor name and stimulus, $F(2,46) = 3.60, P = 0.03$. Subsequent post hoc tests within stimulus revealed that when odor names were followed by odors, sniff volumes were larger for positive than for neutral ($P < 0.001$) and negative ($P = 0.001$) names, Fig. 5A, whereas there was no difference in sniff volumes between neutral and negative names ($P = 0.31$). In contrast, when odor names were followed by water, sniff volumes did not vary as a function of the names. Examination of the same interaction within odor name revealed that sniff volumes were larger when neutral ($P = 0.002$) and negative ($P = 0.004$) odor names were followed by water than by odors, whereas they did not show this difference for positive names, $P = 0.28$, Fig. 5B. In addition to the interaction effect, the main effect of odor name was significant, $F(2,46) = 16.12, P < 0.001$, with sniff volumes being larger for positive versus neutral ($P < 0.001$) and for positive versus negative ($P = 0.004$) names, whereas there was no difference between neutral and negative names ($P = 0.30$). The effect of stimulus was also significant, $F(1,23) = 9.14, P = 0.006$: sniffs were larger with water than with odors.

Finally, an ANOVA on sniff amplitudes showed a significant effect of odor name, $F(2,48) = 4.59, P = 0.01$, Fig. 6A. Post hoc tests showed that sniff amplitudes were bigger with positive than with neutral names ($P = 0.03$), and there was a tendency for them to be bigger with positive than with negative names ($P = 0.09$). The effect of stimulus type was also

![Figure 3](http://jn.physiology.org/)

**Fig. 3.** Experiment 2: schematic presentation of the experimental procedure. A warning signal (green screen) lasting 2 s announced the appearance of an odor name. Five seconds later, the odor name was shown for 2 s and the participant read it aloud. Then the word “Exhale” appeared on the screen for 1 s, during which the subject exhaled. Following this, the instruction “Sniff” appeared for 2 s, at which time a bottle was presented under the nose. In the following 10 s, the participant breathed normally; the psychophysiological state was recorded during this period.

![Figure 4](http://jn.physiology.org/)

**Fig. 4.** Skin conductance (SC) as a function of Odor name (positive, neutral, and negative) and Stimulus (odor, water). Error bars show standard errors. Stars above the bars indicate significant post-hoc tests (*: $P < 0.05$, and **: $P < 0.01$). A: Odor name × Stimulus interaction (within each stimulus condition). B: Odor name × Stimulus interaction (within each odor name condition).
intense odors. Second, this is the first study that explicitly
served significant odor name effects for both less and more
(e.g., pyridine and parmesan cheese) intensity, and we ob-
ods also ranged from low (e.g., cumin oil and indole) to high
across a wide range of odors. In addition to pleasantness, the 15
analyzed together and also individually as 13 odorants showed
the predicted difference in pleasantness between positive and
neutral (a two-digit number, e.g., “thirty-six”), and negative
(e.g., “moldy vegetables”) name. We showed that expectations
created by odor names followed by odors modify not only
perceived pleasantness, intensity, and arousal but also psycho-
physiological measures such as skin conductance and sniff
volumes.

Among the rated odor properties, pleasantness showed the
most robust effect of odor names in the expected direction, i.e.,
or pleasantness was greater for positive than negative names.
This effect was clear when data from all 15 odors were
analyzed together and also individually as 13 odorants showed
the predicted difference in pleasantness between positive and
neutral names. These results are consistent with previous
findings on effects of odor names on perceived odor pleasant-
ness (de Araujo et al. 2005; Herz and von Clef 2001; Lorig and
Roberts 1990; Lundstrom et al. 2006), but they are also an
important extension of the previous work. First, we used a
large set of odorants, whereas previous studies used smaller
sets. More importantly, our odor set included unpleasant,
affectionately neutral, and pleasant odorants and thus enabled us
to demonstrate the generalizability of the odor name effect
across a wide range of odors. In addition to pleasantness, the 15
odors also ranged from low (e.g., cumin oil and indole) to high
(e.g., pyridine and parmesan cheese) intensity, and we ob-
erved significant odor name effects for both less and more
intense odors. Second, this is the first study that explicitly
included neutral names and showed that the pleasantness
ratings of odors presented with neutral names fall between
those obtained with positive and negative names. The ratings in
the neutral name condition were important as they provided estimates of how affective aspects of the odors were perceived
without the contribution of odor names, permitting categoriza-
tion of odors into pleasant, neutral and unpleasant. The ques-
tion remains as to what odor property and/or their combination
is a crucial determinant for the odor name effect, and also to
what extent the fit between the provided name and odor quality
plays a role in producing this effect.

In addition to the major effect on odor pleasantness, odor
names have a modest effect on perceived odor intensity:
odorants are rated as stronger when presented with negative
than with neutral and positive names. These results differ
somewhat from those reported by Herz and von Clef (2001).
However, our findings are consistent with work of Dalton and
colleagues, in which an odor’s intensity was rated differently
as a function of the information provided about that odor’s
health effects. The demonstration that such nonsensory factors
can affect perception of odor intensity was replicated with
different odors, including isobornyl acetate (Dalton 1996,
1999), acetone (Dalton et al. 1997), and methyl salicylate and
butanol (Dalton 1999). Distel and Hudson (2001) also showed
that providing odor names when smelling odors affects per-
ceived odor intensity.

The rating task also showed a modest but significant effect
of odor names on perceived arousal. Odors presented with
positive names were rated as more arousing than the same
odors presented with neutral names. In a previous study,
Bensafi and colleagues (2002) showed that ratings of arousal
and intensity for six odors were strongly correlated ($r = 0.99$).
We also found a significant, but lower ($r = 0.45$), correlation
between ratings of arousal and intensity, consistent with the

![FIG. 5. Sniff volumes as a function of Odor name (positive, neutral, and negative) and Stimulus (odor, water).](image)

![FIG. 6. Sniff amplitudes as a function of Odor name (positive, neutral, and negative) and Stimulus (odor, water).](image)
notion that arousal in olfaction is closely related to odor intensity (Anderson et al. 2003; Bensafi et al. 2002; Winston et al. 2005). In the present study, arousal was defined as the strength of the emotional reaction to odors, and as such this rating probably depended on the odor’s perceived intensity but also on its pleasantness. At this point, we consider the construct validity of rated arousal to be questionable, and future studies need to determine whether arousal is an independent dimension in olfaction or whether it could be accounted for by some combination of pleasantness and intensity.

Additionally, we showed that odor names modify skin conductance during perception of odors: odors presented with positive and negative names elicited increased skin conductances (SC) compared with odors presented with neutral names. Even though highly aversive words can on their own induce enhanced skin conductance (Silvert et al. 2004), results in our water condition clearly show that odor names presented with odorless stimuli did not produce this effect, ruling out the possibility that the increased SC was triggered by emotional reactions to names alone. We hypothesize two reasons for the lack of an effect in the water condition. First, negative names were “negative” as compared with “positive” names, and some (rotten fish, moldy vegetables, dry vomit, human feces), but not all, could be considered aversive on their own. Similarly, not all positive names were positive in absolute terms, but they were chosen to refer to a more positive (or less negative in some cases) odor source than the negative names used for the same odors. Second, this experiment was not designed to compare reactions to aversive versus neutral words; the focus was on odor evaluation. Our results clearly show that odor names can modify the autonomic nervous system response to real odors but not to odorless water. Notably the decision to have the neutral name condition, in addition to the positive and negative conditions, was essential: skin conductance findings were revealed when positive and negative name conditions were contrasted with the neutral name condition, whereas SC findings would have been insignificant had only positive and negative names been used.

We also observed interesting effects of odor names on sniffing. Sniff volumes were greater when odors were presented with positive than with negative and neutral names, whereas names did not make any difference in volumes when participants knew that they were inhaling water. This result is in keeping with previous findings on the relationship between sniff volume and odor pleasantness (Bensafi et al., 2003; Frank et al. 2003) and intensity (reviewed in Mainland and Sobel 2006). Importantly, in the present investigation, differences in sniff volumes were elicited by expectations created by odor names rather than by actual/physical differences in odor properties.

An unexpected finding was that sniff volumes were not different between odors with neutral and negative names, and they did not follow the pattern of pleasantness ratings. A possible explanation for this result may be that people are conservative with their sniffing when they do not know what the odors are (such as in the neutral name condition). Therefore they treat odors from an unknown source similarly to odors with expected negative qualities, whereas they sniff liberally when expecting pleasant smells. In addition, sniffs were larger with water than with odors when neutral and negative names were provided, whereas no such difference was found for positive names, again confirming less restricted sniffing when pleasant odors are expected.

Another sniff parameter (amplitude) showed significant main effects of odor names and stimulus type. Overall, sniff amplitudes were larger when water was presented than when odors were presented, regardless of names. Similarly, sniff amplitudes were larger with positive than with neutral names and with positive than with negative names, regardless of whether odors or water followed. However, an important difference in the pattern of response between sniff amplitudes and sniff volumes lay in the significance of the interaction effect: the interaction was significant for sniff volumes, but not for sniff amplitudes. In other words, in the case of sniff volumes, the effect of odor names was specific to odors and did not occur when odorless water was presented. In contrast, sniff amplitudes varied as a function of odor names regardless of the stimulus type; i.e., whether odors or water were inhaled. This somewhat different pattern of results illustrates that these sniff parameters, even though related, measure different processes.

Our data suggest that sniff volumes are adjusted according to two different pieces of information integrated together. These are the knowledge of the type of incoming stimulus and the expectation of its affective value: when we expect to inhale a pleasant smell, sniff volumes are larger then when we do not know what kind of smell to expect or when we expect an unpleasant smell. Importantly, sniff volumes do not vary with names alone, as we found no difference when subjects know that a name will not be followed by a corresponding odor. In contrast, sniff amplitudes vary with names, both when it is known that the names will be followed by odors and also when it is known that they will be followed by water.

An important issue is the relationship between sniffing and SC. It is well known that breathing patterns directly modify autonomic nervous system responses and that deeper breaths lead to a decrease in skin response and to an increase followed by a decrease in heart rate (HR) (Stern and Anschel 1968). Therefore it was important to exclude the possibility that sniffing patterns in the present investigation could account for any changes observed in SC. We have several arguments indicating that this was not the case. First, the experimental design and the extraction of psychophysiological data were made such that the period taken for psychophysiological recordings did not include odor presentation and sniffing. Second, the pattern of sniffing was different from the pattern of SC findings. Whereas sniff volumes and amplitudes increased for odors with positive compared with neutral and negative names, SC increased for odors with positive and negative compared with neutral names. If changes in sniffing behavior systematically altered the SC, an SC decrease for odors with positive names would be expected, whereas we found SC increase. Third, we observed changes elicited by odor names on SC but not on HR, and both of these physiological processes can be affected by breathing (Stern and Anschel 1968). The fact that our findings are specific to SC lends further support to the conclusion that the changes in SC observed in this study were not caused by breathing variations. Finally, the SC findings remained unchanged when the sniffing differences were statistically controlled for with ANCOVAs. Altogether, our findings show that semantic factors modulate the autonomic nervous system and the sniffing response to odors independently.
The nature of the relationship between ratings and SC remains unclear. Previous studies conducted in nonolfactory modalities have established that psychophysical (ratings) and psychophysiological measures of arousal are strongly correlated (Bradley 2000; Lang et al. 1993). Similar trends have been shown for the olfactory modality (Alaoui-Ismaili et al. 1997; Bensafi et al. 2002). In the present investigation, self-report ratings and psychophysiological recordings were obtained in two separate experiments and with two separate samples of subjects, unfortunately precluding the possibility of direct correlational analyses. However, the pattern of SC findings in experiment 2, with stronger responses to odors with positive and negative than with neutral names, corresponds more to the pattern obtained in experiment 1 for intensity and arousal than for pleasantness ratings. These similarities in response patterns suggest that SC may be related to perceived intensity and arousal of odors and not to their perceived pleasantness, which would be consistent with Bensafi et al.’s (2002) findings.

Therefore we conclude that the name given to an odor modulates the “subjective” and the “objective” emotional reactions to the odor. A rose by the name of “rotting flower” would not smell as sweet as if it were introduced as “fresh rose”, and it would smell stronger and less invigorating. Call it a fresh rose or a rotting flower, your SC should jump up, but your sniff volume in response to it when called fresh rose should be larger than when called rotting flower. Taken together, odor names constitute an important determinant of odors’ affective properties.

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