A rose by any other name: Would it smell as sweet?

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Abstract

We examined whether presenting an odor with a positive, neutral or negative name would influence how people perceive it. In Experiment 1, 40 participants rated 15 odors for their pleasantness, intensity, and arousal. In Experiment 2, 30 participants passively smelled 10 odors while their skin conductance (SC), heart rate (HR), and sniffing were recorded. We found significant overall effects of odor names on perceived pleasantness, intensity and arousal. Pleasantness showed the most robust effect of odor names: the same odors were perceived as more pleasant when presented with positive than with neutral and negative names, and when presented with neutral than with negative names. In addition, odorants were rated as more intense when presented with negative than with neutral and positive names, and as more arousing when presented with positive than with neutral names. Furthermore, SC and sniff volumes, but not HR, were modified by odor names, and the SC changes could not be accounted for by sniffing changes. Importantly, odor names presented with odorless water did not produce any effect on skin conductance and sniff volumes, ruling out the possibility that the naming-related findings were triggered by an emotional reaction to odor names. Taken together, these experiments show that there is a lot to a name, at least when it comes to olfactory perception.
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 (Cain and Johnson 1978) showed that presenting an odor for 30 minutes led to decreased liking of a pleasant, and to increased tolerance of an unpleasant, smell. Rolls and Rolls (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 labels assigned to odors either by the experimenter (Herz and von Clef 2001; Lorig and Roberts 1990) or by the participant (Lundstrom et al. 2006). Lorig and Roberts (Lorig and Roberts 1990) presented one same odor (a tertiary mixture) under three different labels, and showed that perceived pleasantness of the same physical stimulus varied as a function of the label it was presented with. Herz and von Clef (Herz and von Clef 2001), using five odors, showed that perception of these odors, and in particular of their pleasantness, was influenced by whether odor names that they provided while presenting the odors had a positive or a negative affective connotation. Lundstrom and colleagues (Lundstrom et al. 2006) also showed that a same physical stimulus (androstenone) was perceived as less pleasant by participants who described it as a body odor compared with other participants who chose different (non-body odor) descriptors for it. Finally, the brain response to an odor varies as a function of the name with which it was presented, both in terms of electrophysiological (Lorig and Roberts 1990; Lundstrom et al. 2006)
and neuronal (de Araujo et al. 2005) responses. Taken together, these studies showed that odor pleasantness is a labile dimension easily affected by non-sensory processes.

The aim of the present study was to investigate effects of odor names on odor perception, measured via pleasantness, intensity and arousal ratings (Experiment 1), and via skin conductance, heart rate, sniff volumes and sniff amplitudes (Experiment 2). In both experiments, each odor was presented three times under different names: positive, neutral, and negative. Positive names were chosen to refer to a more pleasant 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.

EXPERIMENT 1

Method.

Subjects. Forty healthy university students (20 women), mean age = 20.6 years (range 18–27 years), 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, \( p < .05 \)), five as neutral (mean pleasantness ratings did not differ from 50), and four as pleasant (mean pleasantness ratings were significantly higher than 50, \( p < .05 \)). Mean pleasantness, intensity and arousal ratings of the 15 experimental odors in the neutral name condition are shown in Table S1.
published online as supplementary material. 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 or more 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 seconds. In each trial, participants read aloud an odor name presented on a card. The odor was then presented for 2 seconds, 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 treatment. 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 explore 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.

Results.

The effect of Odor name on perceived pleasantness was significant, $F(2,78) = 71.31, p < .001$, Figure 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 $p < .001$).

The effect of Odor name on perceived intensity was also significant, $F(2,78) = 8.29, p = .001$, Figure 1B. Odors presented with negative names are perceived as stronger than when they are presented with positive ($p = .02$) or neutral ($p = .001$) names, while the difference between intensity with positive versus neutral names was not significant ($p = .65$).

Arousal ratings showed a significant effect of Odor name, $F(2,78) = 4.64, p = .01$, Figure 1C: odors presented with positive names are perceived as more arousing than the same odors
presented with neutral names, $p = .02$, while there was no difference between perceived arousal with positive versus negative ($p = 1.00$) and neutral versus negative ($p = .11$) 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, $F(30,130) = 4.49, p < .001$. The univariate $F$-test was significant ($p < .05$) in 12 out of 15 odors (Figure 2), and in two others it showed a tendency towards significance ($p = .05$ for 2-Heptanone and $p = .07$ for Anethole). Pyridine was the only odor that did not show an effect of odor name manipulation ($p = .18$). 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%) 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, $F(2,24) = 19.51$, $p < .001$ and the overall effect on perceived intensity tended to be significant, $F(2,24) = 2.82$, $p = 0.08$.

In summary, forty 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 skin conductance, heart rate, and sniff volumes and amplitudes.

EXPERIMENT 2

Method.

Subjects. Thirty healthy university students (15 women), mean age = 20.8 years (range 18-29 years) 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 1) based on the effects of names on pleasantness ratings (Figure 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.

**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 commercially available software (CHART 5.0.2.26, A. D. Instruments, Milford, MA). 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 GSR electrodes. Sniff parameters were recorded birhinally with a nasal cannula coupled with a pneumotachograph that relayed changes in intranasal pressure to an amplifier (PowerLab 4SP, A. D. Instruments, Milford, MA).

**Procedure.** As in Experiment 1, olfactory function was assessed with a “Sniffin’ sticks – Screening 12 test” (Kobal et al. 1996). All subjects identified 10 or more correctly, indicating adequate smell function. In this experiment, two factors were manipulated: Odor name (positive, 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 (inhalation of stimuli was preceded by exhalation to mark sniff onsets). The interstimulus interval was 45 seconds. 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 three-minute 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-second window following the two-second stimulus presentation, using the five seconds preceding the warning signal as a baseline recording. Tonic changes in SC to stimulus presentation were analyzed as the mean activity within the 10-second 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 (less than 0.5
seconds) were removed before analysis. Due to increased signal noise at the end of the sniff, long sniffs were truncated at 2.5 seconds; hence, sniff durations were not analyzed. 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 (more than 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.

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. Mean SC level showed a significant interaction between Odor name and Stimulus, $F(2,58) = 4.11, p = .02$. Subsequent post-hoc tests within the Stimulus factor revealed that when odor names were followed by odors, SC were higher for positive versus neutral ($p = .03$) and for negative versus neutral ($p = .001$) names, Figure 4A. Skin conductance with positive versus negative names was not significantly different ($p = .09$). 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, Figure 4B: SC was higher when negative odor names were followed by odors than when followed by water, $p = .02$. This difference was not seen for positive ($p = .16$) or neutral names ($p = .95$). In addition to the interaction effect, the main effect
of Odor name was significant, $F(2,58) = 7.45$, $p = .001$, whereas the effect of Stimulus was not, $F(1,29) = 2.38$, $p = .13$.

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 online (Figure 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 $p > .05$).

ANOVA on sniff volumes showed a significant interaction between Odor name and Stimulus, $F(2,48) = 3.60$, $p = .03$. Subsequent post-hoc tests within Stimulus revealed that when odor names were followed by odors, sniff volumes were larger for positive than for neutral ($p < .001$) and negative ($p = .001$) names, Figure 5A, while there was no difference in sniff volumes between neutral and negative names ($p = .31$). 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 ($p = .002$) and negative ($p = .004$) odor names were followed by water than by odors, whereas they did not show this difference for positive names, $p = .28$, Figure 5B. In addition to the interaction effect, the main effect of Odor name was significant, $F(2,46) = 16.12$, $p < .001$, with sniff volumes being larger
for positive versus neutral \((p < .001)\) and for positive versus negative \((p = .004)\) names, while
there for no difference between neutral and negative names \((p = .30)\). The effect of Stimulus was
also significant, \(F(1,23) = 9.14, p = .006\): sniffs were larger with water than with odors.

Finally, an ANOVA on sniff amplitudes showed a significant effect of Odor name,
\(F(2,48) = 4.59, p = .015\), Figure 6A. Post-hoc tests showed that sniff amplitudes were bigger
with positive than with neutral names \((p = .03)\), and there was a tendency for them to be bigger
with positive than with negative names \((p = .09)\). The effect of Stimulus type was also
significant, \(F(1,24)= 7.66, p = .011\); sniff amplitudes were bigger when water was presented
compared with real odors, Figure 6B. The interaction between Odor name and Stimulus was not
significant, \(F(2,48) = 1.65, p = .20\).

**DISCUSSION**

We chose 15 odorants ranging from unpleasant to pleasant, and presented each one with a
positive (e.g., “carrot juice”), 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
psychophysiological 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. odor pleasantness was greater for positive then 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 negative names. These results are consistent with previous findings on effects of odor names
on perceived odor pleasantness (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, affectively 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 observed 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 categorization of odors into pleasant, neutral and unpleasant. The question 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 (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 non-sensory factors can affect perception of odor intensity was replicated with different odors, including isobornyl acetate (Dalton 1999; 1996), acetone (Dalton et al. 1997), methyl salicylate and butanol (Dalton 1999). Distel and Hudson (Distel and Hudson 2001) also showed that providing odor names when smelling odors affects perceived 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 (Bensafi et al. 2002) showed that ratings of arousal and intensity for six odors were strongly correlated ($r = .99$). We also found a significant, but lower ($r = 0.45$), correlation between ratings of arousal and intensity, consistent with the 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 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 to “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 than when we do not know what kind of smell to expect or when we expect a negative 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 skin conductance. 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 (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. While sniff volumes and amplitudes increased for odors with positive compared to neutral and negative names, SC increased for odors with positive and negative compared to neutral names. If changes in sniffing behavior systematically altered the SC, a SC decrease for odors with positive names would be expected, whereas we found SC increase. Third, we observed changes elicited by odor names on skin conductance but not on heart rate, and both of these physiological processes can be affected by breathing (Stern and Anschel 1968). The fact that our findings are specific to skin conductance lends further support to the conclusion that the changes in skin conductance 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 non-olfactory 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 excluding 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 skin conductance 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 (Bensafi et al. 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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Table 1. Stimuli used in Experiment 1 (E1) and Experiment 2 (E2). Fifteen experimental and 18 foil odors from E1 are listed in the first column; for all experimental odors, a short name (used in Figure 2) is given in parentheses. Experimental stimuli are grouped into three 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 three 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 three experimental odors marked with a star (*) were modified from Herz and von Clef (Herz and von Clef 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.

<table>
<thead>
<tr>
<th>EXPERIMENTAL ODORS</th>
<th>Conc.</th>
<th>Positive name</th>
<th>Negative name</th>
<th>Neutral name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyridine (Pyr): 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 (Ane): E1</td>
<td>100%</td>
<td>Black licorice</td>
<td>Cough syrup</td>
<td>Twenty-three</td>
</tr>
<tr>
<td>Cineole (Cin)*: : 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>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FOIL ODORS</th>
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</tr>
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<tbody>
<tr>
<td>Peanut butter: E1</td>
<td>100%</td>
<td>Peanut butter</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>100%</td>
<td>Orange peel</td>
<td></td>
</tr>
<tr>
<td>Jasmine</td>
<td>100%</td>
<td>Jasmine tea</td>
<td></td>
</tr>
<tr>
<td>Cinnamon bark oil: E1</td>
<td>100%</td>
<td>Cinnamon stick</td>
<td></td>
</tr>
<tr>
<td>Grapefruit oil</td>
<td>100%</td>
<td>Grapefruit juice</td>
<td></td>
</tr>
<tr>
<td>Peppermint oil</td>
<td>100%</td>
<td>Spearmint gum</td>
<td></td>
</tr>
<tr>
<td>Civet artificial</td>
<td>1%</td>
<td>Dead animal</td>
<td></td>
</tr>
<tr>
<td>Acetone: E1</td>
<td>100%</td>
<td>Chemical solvent</td>
<td></td>
</tr>
<tr>
<td>Ham</td>
<td>100%</td>
<td>Spoiled ham</td>
<td></td>
</tr>
<tr>
<td>Isovaleric acid</td>
<td>1%</td>
<td>Old socks</td>
<td></td>
</tr>
<tr>
<td>Butyric acid</td>
<td>10%</td>
<td>Rotten meat</td>
<td></td>
</tr>
<tr>
<td>1-heptanol: E1</td>
<td>100%</td>
<td>Cleaning detergent</td>
<td></td>
</tr>
<tr>
<td>PEA: E1</td>
<td>100%</td>
<td></td>
<td>Forty-five</td>
</tr>
<tr>
<td>Bergamot</td>
<td>100%</td>
<td></td>
<td>Forty-three</td>
</tr>
<tr>
<td>Ylang ylang</td>
<td>100%</td>
<td></td>
<td>Twenty-seven</td>
</tr>
<tr>
<td>Garlic oil: E1</td>
<td>100%</td>
<td></td>
<td>Forty-one</td>
</tr>
<tr>
<td>Celery seed oil</td>
<td>100%</td>
<td></td>
<td>Twenty-four</td>
</tr>
<tr>
<td>Castoreum res</td>
<td>100%</td>
<td></td>
<td>Thirty-four</td>
</tr>
</tbody>
</table>
References


Figure 1. Perception of odors as a function of odor names (positive, neutral, negative) collapsed across 15 odors. Error bars show standard errors. Stars above the bars indicate significant post-hoc tests (*: p < .05, and **: p < .01). A. Effect of odor names on pleasantness ratings. B. Effect of odor names on intensity ratings. C. Effect of odor names on arousal ratings.

177x76mm (300 x 300 DPI)
Figure 2. Pleasantness of odors as a function of odor names in 15 odors, ordered from the most unpleasant to most pleasant. Shortened names of 15 odors (as listed in Table 1) are presented on X-axis. Stars beside odor names on the x-axis indicate the significant effect of the name condition on that odor (*: p < .05, **: p < .01).
Figure 3. Experiment 2: Schematic presentation of the experimental procedure. A warning signal (green screen) lasting two seconds announced the appearance of an odor name. Five seconds later, the odor name was shown for two seconds and the participant read it out loud. Then the word Exhale appeared on the screen for one second, during which the subject exhaled. Following this, the instruction Sniff appeared for 2 seconds, at which time a bottle was presented under the nose. In the following 10 seconds, the participant breathed normally; the psychophysiological state was recorded during this period.
Figure 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 < .05, and **: p < .01). A. Odor name × Stimulus interaction (within each stimulus condition). B. Odor name × Stimulus interaction (within each odor name condition).
Figure 5. Sniff volumes as a function of Odor name (positive, neutral and negative) and Stimulus (odor, water). Stars above the bars indicate significant post-hoc tests (*: p < .05, and **: p < .01). A. Odor name × Stimulus interaction (within each stimulus condition). B. Odor name × Stimulus interaction (within each odor name condition).
Figure 6. Sniff amplitudes as a function of Odor name (positive, neutral and negative) and Stimulus (odor, water). Stars above the bars indicate significant post-hoc tests (*: p < .05, and **: p < .01). A. Effect of Odor names on sniff amplitudes. B. Effect of Stimulus type on sniff amplitudes.