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The Effect of Emotion and Personality on Olfactory Perception

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Abstract

It is well established that both the emotional tone of sensory stimuli and the personality characteristics of an individual can bias sensory perception. What has largely been unexplored is whether the current emotional state of an individual has a similar effect, and how it works together with other factors. Here we carry out a comprehensive study to examine how olfactory perception is affected by the emotional tone of the stimuli, and the personality and current emotional state of the individual. Subjects reported experiencing happiness, sadness, negativity/hostility and neutrality when exposed to corresponding emotionally themed video clips, and in each case, smelled a suprathreshold pleasant, an unpleasant and a neutral odorant. The time taken for the subject to detect each odorant and the olfactory intensity were recorded. We found that women detected the pleasant odorant faster than the neutral one. In addition, personality modulated reaction time and olfactory intensity, such that neurotic and anxious individuals were selectively biased toward affective rather than neutral odorants. Finally, current emotional state augmented intensity in men but not in women, and differentially influenced the response time. These findings provided new insights into the effects of emotion and personality on olfactory perception.

Key words: emotion, olfactory perception, personality

Introduction

From an evolutionary perspective, emotions are believed to signal safety or imminent danger and motivate the individual for either an approach or avoidance behavior (Lang, 1995). There is considerable evidence for this view. Compared with their neutral counterparts, emotional words and human faces are processed more automatically (Anderson *et al.*, 2003), are recognized faster (Rogers and Revelle, 1998) and command greater attention (e.g. Derryberry, 1991; Vuilleumier and Schwartz, 2001). In addition, they activate both unique areas and greater number of areas in the brain (e.g. Lang *et al.*, 1998; Schupp *et al.*, 2000; Kesler/West *et al.*, 2001).

It has also been shown that personality biases the way emotional information is processed. Individuals who are emotionally labile—the neurotic and anxious—are believed to be more sensitive to unpleasant sensory information. For example, emotionally labile people are more sensitive and reactive to loud noise, unpleasant visual stimuli, bitter taste, and pain than stable and calm people (e.g. Corlis *et al.*, 1967; Antikainen and Niemi, 1983; Stansfeld *et al.*, 1985; Keogh and Birkby, 1999; Wilson *et al.*, 2000). Individuals high in neuroticism also demonstrate faster P300 latencies, suggesting that they are faster at making initial evaluations of external information (Pritchard, 1989; Stelmack *et al.*, 1993).

In the case of olfactory perception, the effect of personality appears more complex. There is evidence that personality can both facilitate and impede detections of both pleasant and unpleasant odors. For example, emotionally labile individuals have greater absolute sensitivity to some smells (butanol in men in Herbener *et al.*, 1989; linalool and isoamyl acetate in Pause *et al.*, 1998) and have better odor-naming performance (Larsson *et al.*, 2000), but have lower sensitivity to other smells (n-octanol in Rovee *et al.*, 1975; isovaleric acid in men and butanol in women in Koelega, 1994). Interestingly, introversion–extraversion does not appear to be a strong predictor of olfactory performance (e.g. Koelega, 1994; Pause *et al.*, 1998; Larsson *et al.*, 2000).

There have also been extensive studies on how people respond to emotionally valenced olfactory stimuli. Earlier studies found increases in subjects' heart rate and skin conductance (Brauchli *et al.*, 1995; Bensafi *et al.*, 2002), as well as startle-reflex amplitude (e.g. Ehrlichman *et al.*, 1997) when they were presented with unpleasant (as opposed to neutral or pleasant) odors. One recent work reported higher

sexual arousal when exposed to the odor of a sex-specific steroid than that of a control while watching an erotic video (Bensafi *et al.*, 2004).

In contrast, the effect of the current emotional state of the observer on olfaction has hardly been addressed. Such an effect would be expected, given that olfactory perception is highly context dependent (Dalton, 1999). We might also expect, in general, that the emotional state will interact with personality and the emotional content of stimuli. Indeed, this type of interaction has been found in the case of taste and audition: emotional state augments the intensity of both senses among the neurotic and anxious individuals but not in others (Dess and Edelheit, 1998).

One may also expect women to outperform men at processing smells in emotional contexts. For one thing, women tend to be more responsive to emotional signals (e.g. Brody and Hall, 1993). In the area of olfaction, although there is little evidence of gender differences in absolute olfactory sensitivity *per se*, women tend to outperform men at identifying, naming and discriminating between smells (e.g. Cain, 1982; Oberg *et al.*, 2002; see review by Doty, 1986), and at becoming sensitized to certain odors after extended testing (>5 days) (e.g. Dalton *et al.*, 2002).

With these considerations in mind, we carried out the first study on the combined effect of emotion and personality on olfaction in both men and women. We were interested in the answers to a number of questions. Do emotionally laden odors capture greater attention than neutral odors? Does emotional experience of the observer influence his/her olfactory sensation? Are individuals with certain personality characteristics more likely to be influenced by unpleasant olfactory stimuli than others? Do emotional context and personality interact in biasing perceptions of pleasant and unpleasant odors? Are there any gender differences in processing emotional smells? To address these questions, we measured reaction time and intensity as a function of current emotional state (happy, sad, angry and neutral), personality (neuroticism, anxiety and introversion), the emotional quality of the olfactory stimuli (pleasant, unpleasant and neutral) and gender.

Materials and methods

Subjects

Subjects consisted of 75 young adults (38 male). They were recruited through advertisements posted in local papers and university campuses. Their demographics are presented in Table 1. All reported to have a normal sense of smell, and those reporting to have a cold/allergy were rescheduled and tested after they recovered from the cold/allergy. Pill usage and menstrual cycle phases were assumed to be similarly distributed across the female personality subgroups. The study was approved by the University of Pennsylvania Institutional Review board.

Table 1 Participant demographics

Demographics	Gender		Difference
	Women	Men	
n	37	38	
Mean age (SE) in years	23 (0.77)	24 (0.79)	N.S.
Mean neuroticism (SE)			
High	7.29 (0.44) (*n* = 17)	7.33 (0.39) (*n* = 18)	N.S.
Low	1.65 (0.41) (*n* = 20)	1.95 (0.37) (*n* = 20)	N.S.
Mean anxiety (SE)			
High	20.45 (1.07) (*n* = 20)	21.26 (1.10) (*n* = 19)	N.S.
Low	7.77 (1.16) (*n* = 17)	10.37 (1.10) (*n* = 19)	N.S.
Mean introversion (SE)			
High	7.00 (0.44) (*n* = 17)	7.45 (0.41) (*n* = 20)	N.S.
Low	.85 (0.41) (*n* = 20)	1.94 (0.43) (*n* = 18)	N.S.

Selection of emotion induction material

The video clips were selected with the intention to elicit emotions of happiness, sadness, negativity/hostility and neutrality. The clips were either recommended or chosen based on their use in previous studies (e.g. Gross and Levenson, 1995). Videos of the above emotional categories were each edited into 3.5-min-long segments, and presented to a panel of eight young adult male and female judges. Following each segment, the judges rated their happy, sad, angry/disgust, and neutral feelings in response to the segment on a scale of 0–4 (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely). Segments producing high ratings exclusively in their target emotion were selected. This process yielded a total of 12 video segments for use in this study, consisting of three videos comparable in induction success for each emotion category. The happy segments included slapstick scenes from *There is Something about Mary*, *Waterboy* and *Nutty Professor I*, the sad segments included death and mourning scenes from *Bambi*, *One True Thing* and *The Champ*, and the negativity/hostility-provoking segments included scenes depicting social injustice from *Ghandi*, *Cry Freedom* and *My Bodyguard*.

Measures

Emotional state

Happy, sad, negativity/hostility (angry, disgust), fearful and neutral emotions were each rated on a scale of 0–4 (0 = not at all, 1 = a little, 2 = moderately, 3 = quite a bit, 4 = extremely).

Odor ratings

Olfactory intensity was rated on a scale of 1–9 (from extremely mild to extremely strong).

Personality

Neuroticism, anxiety and introversion were each measured by standardized scales: neuroticism and introversion by the Eysenck Personality Questionnaire Revised—Short (EPQ-RS) (Eysenck and Eysenck, 1994), and anxiety by the Taylor Manifest Anxiety Scale (TMAS) (Taylor, 1953). The EPQ-RS consists of 57 items, each answered on a yes–no basis (e.g. Does your mood often go up and down?). The scores for neuroticism and introversion both range from 0 to 12. Subjects were median split into those scoring either high or low on the trait (see Table 1 for distribution of scores for men and women). The TMAS consists of 50 true–false statements (e.g. I am a very nervous person). Subjects were median split into those scoring either high or low on anxiety. No significant gender difference was found across any of the subgroups of personality ($P > 0.05$).

Olfactory Stimuli

Three types of suprathreshold olfactory stimuli were used: pleasant, unpleasant, and neutral. The pleasant odorant was a lemon/orange scent (96+% mixture of *cis* and *trans*, purchased from Sigma-Aldrich, 50% diluted in filtered mineral oil), the unpleasant, a fecal odor (0.05% of 3-methylindole diluted in propylene glycol) and the neutral, rubbing alcohol (5% isopropyl alcohol diluted in propylene glycol). The selection of the pleasant and neutral odorants was established from prior studies (Cain and Johnson, 1978). The unpleasant odorant is almost universally regarded as unpleasant, and described as a stench in the material safety data sheet (Physical and Theoretical Chemistry Laboratory, Oxford University, UK). The concentrations of the odorants were determined by a panel of four judges to be of comparable intensity based on agreements on pairwise comparisons. This ensured that the intensities were approximately the same.

Procedure

In a double-blind study, subjects were tested individually in a sound-proof, temperature-, air flow- and humidity-controlled environmental chamber. They were told:

> We are interested in studying how people respond to various visual and olfactory stimuli. You will watch a short video segment, and when it is over, complete a few questions on what the segment made you feel. Following this, you will pause for five seconds and concentrate on evaluating the intensity of the air quality in this room. In all, you will watch a total of 12 video segments, and will repeat the above steps following each segment. At any point during the experiment, a particular smell other than the room air will be introduced in the room. The smell will be perceptible to most people. You may or may not like the way it smells. As soon as you detect its presence, please ring this bell, and fill out a questionnaire about its strength, and what it smells like. Only one smell is introduced at any one point in time. The smells introduced at different points in time may or may not vary in type, intensity, and/or pleasantness.

Throughout the experiment, there was a constant flow of room air towards the nasal regions of the subject via tubings on top of a television set 51 cm away from the subject. Each subject watched in a counterbalanced order a series of 12 video clips intended to produce happiness, sadness, negativity/hostility and neutrality, with each clip lasting 3.5 min. A blocked design was used in which three videos of the same emotional content (e.g. all comedies) were presented consecutively, each followed by the presentation of one of the three suprathreshold odorants. (To reduce possible habituation, each video segment was followed by a different smell.) For example, subjects watched three comedies in a row, the first followed by a pleasant smell, the second by an unpleasant smell and the third by a neutral smell. Each odor presentation and judgement was separated from the next by >5 mins. Odorants were delivered in a counterbalanced fashion for each participant, and in a semi-counterbalanced fashion across participants. The odorant was always delivered after the subject completed the mood questionnaire, and the delivery was terminated once the subject rang the bell to indicate the detection of the smell. The average duration of an odorant presentation was 6.54 ± 2.24 s (mean ± SD). Reaction times to odorants were recorded as fractions of a second on a stopwatch, and defined as the lapse of time (in s) between the release of the odorant and when the subject rang the bell.

Data Analyses

To examine the effectiveness of the emotion induction methods, self-reported emotions following each video segment were subjected to repeated-measures analyses of variance (ANOVAs) with emotion (four measures: happiness, sadness, negativity/hostility, neutrality), odorant (three measures: pleasant, unpleasant, neutral) and video (four measures: comedy, tragedy, anger, neutrality) as the within-subjects factors, and gender and personality respectively as between-subjects factors.

To examine differences in olfactory intensity and reaction time (log transformed), repeated-measures ANOVAs were first conducted with emotional state (four measures) and odorant (three measures) as within-subjects factors, and gender and personality as between-subjects factors. In addition, given that affective information is processed differently from neutral information (e.g. Derryberry, 1991; Rogers and Revelle, 1998; Vuilleumier and Schwartz, 2001; Anderson *et al.*, 2003), it would be instructive to determine if subjects responded to olfactory information differently depending on whether they were in an emotional or a neutral mood state. To this end, we conducted repeated-measures ANOVAs with

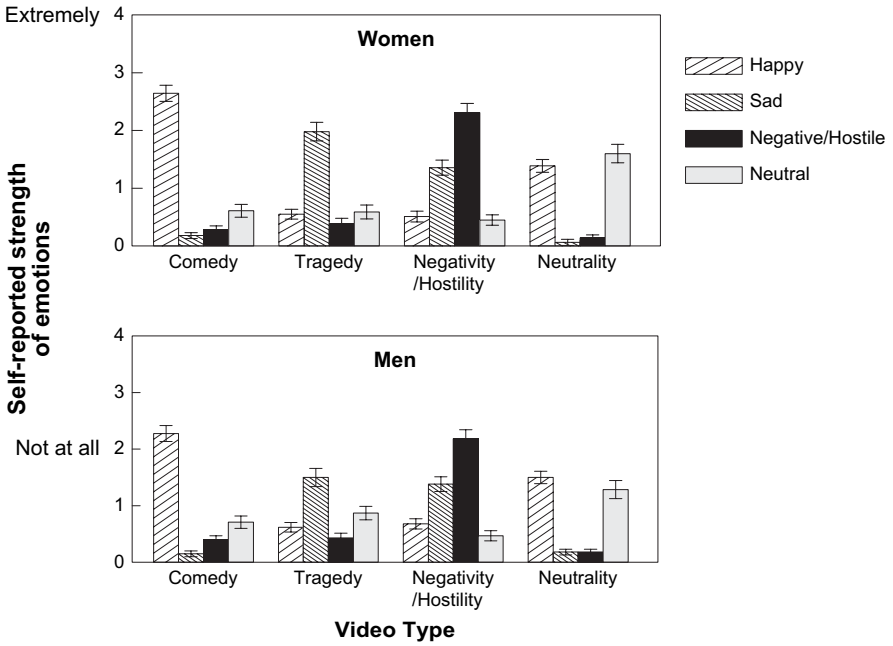

Figure 1 Average strength of emotion for women and men reported as a function of video type (bars represent SE).

emotion (two measures: emotional versus neutral) and odorant (two measures: emotionally valenced versus neutral) as the within-subjects factor; here, we derived the emotional-state variable by taking the average of happiness, sadness and negativity/hostility, and derived the emotionally valenced odorant variable by taking the average of the pleasant and the unpleasant odorants.

No main effect of gender was found on either intensity or reaction time. Gender differences were observed as four-way interactions in both reaction time ($P = 0.06$) and olfactory intensity ($P = 0.007$). As a result, men and women were analyzed separately in subsequent repeated measures ANOVAs on olfactory intensity and reaction time. In addition, our initial match of olfactory intensity was only approximate. The finer difference in intensities was determined using all 75 judges. The unpleasant odorant was found to be stronger than the pleasant or neutral odorant. All subsequent analyses on reaction time were conducted using the intensity of the unpleasant (or the emotionally valenced) odorant as a covariate.

No significant main or interaction effect involving introversion was found in any of the above analyses ($P > 0.05$). Results on introversion will thus not be presented.

Where multiple comparisons were involved in *post hoc* analyses, the P-values reported were based on Bonferroni-adjusted degrees of freedom.

Results

Emotion Induction Manipulation Check

As shown in Figure 1, emotion induction was equally successful in men and women. Both men and women reported greater happiness in response to the comedy, sadness to the tragedy, negativity/hostility to the anger-provoking segments, and neutrality and happiness to the neutral segments. Self reports of happiness were expected during the neutral videos, as previous research (Cacioppo and Gardner, 1999) has revealed a tendency for people to report feeling positive when they are feeling neutral. There was a gender by mood induction interaction effect [$F(4.95,361.66) = 3.35$, $P = 0.006$]. Follow-up analysis showed that the sadness reported by women during the tragedy was higher than that reported by men [3.96 versus 3.00, SE = 0.32 versus31, $F(1,73) = 4.76$, $P = 0.032$]. No other gender difference was found. Emotion induction was the same across odor conditions [$F(10.54,2198.80) = 0.80$, $P > 0.05$]. We found no main effect in gender or personality.

Intensity

A main effect of intensity was found for odorants for both men and women. Both men and women perceived the unpleasant odorant stronger than either the pleasant (M = 6.39 versus 5.56, SE = 0.33 versus 0.23, $P = 0.004$ for women; M = 6.42 versus 5.48, SE = 0.21 versus 0.22, $P < 0.0001$ for men) or the neutral (M = 6.39 versus 4.97, SE = 0.33 versus 0.23, $P < 0.0001$ for women; M = 6.42 versus 5.22, SE = 0.21 versus 0.25, $P < 0.0001$ for men), although the latter two did not differ ($P > 0.05$). We found no main effect of personality on olfactory intensity.

A main effect of intensity was also found for emotional state in men. Overall, men perceived odorants stronger in an emotional than a neutral state [5.79 versus 5.47, SE = 0.19 versus 0.23, $F(1,37) = 4.43$, $P = 0.042$]. Subsequent

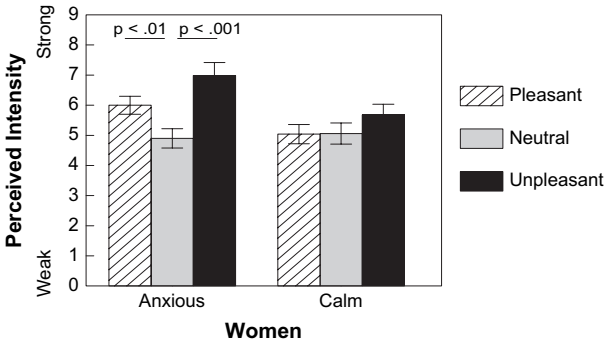

Figure 2 Intensity for anxious versus calm women as a function of odor type (bars represent SE).

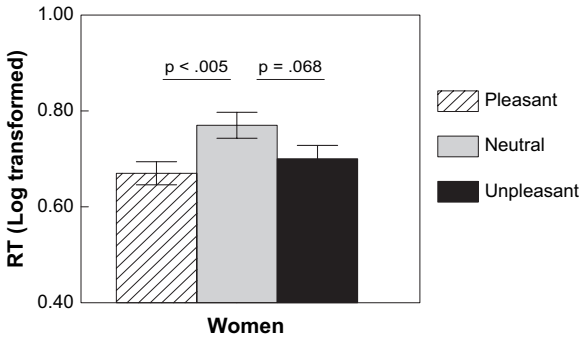

Figure 3 Average reaction time for women as a function of odor type (bars represent SE).

comparisons between each emotional and the neutral state showed that the same holds for the happy versus neutral state (5.93 versus 5.47, SE = 0.23 versus 0.23, $P = 0.05$) and, to a less extent, sadness versus neutral state (5.76 versus 5.47, SE = 0.21 versus 0.23, $P = 0.11$). In the case of the negativity/hostility versus neutral state, the effect also applies though, here, the unpleasant odorant was rated more intense in an emotional than a neutral state (6.74 versus 5.84, SE = 0.25 versus 0.36, $P = 0.010$).

No such effect was found in women ($P > 0.05$). Finally, we identified an interaction effect between personality and emotional odorants in women [$F(1.74,61) = 4.44$, $P = 0.020$]. As shown in Figure 2, women high in trait anxiety perceived emotionally valenced odorants stronger than the neutral odorant [6.00 and 6.99 versus 4.90, SE = 0.25, 0.35 versus 0.27, for pleasant, unpleasant and neutral respectively, $P = 0.005$ and 0.0001, $F(2,18) = 15.91$, $P < 0.0001$]. Women low in anxiety did not [$F(2,15) = 1.38$, $P > 0.05$]. No personality by intensity effect was found in men ($P > 0.05$).

Reaction Time

We found that the emotional content of the odorant had a main effect on reaction time for women but not men, as shown in Figure 3. Women responded to the pleasant odorant faster than the neutral odorant (0.67 versus 0.77, SE = 0.024 versus 0.027, $P = 0.005$), and to the unpleasant odorant marginally faster than the neutral one (0.70 versus 0.77, SE = 0.028 versus 0.027, $P = 0.068$). Men also responded to the affectively valenced odorants faster than the neutral one but the effect disappeared after olfactory intensity was controlled for. We found that neither personality nor current emotional state had any main effect on reaction time.

We also found an odor by personality effect in men [$F(1,35) = 9.09$ and 11.74, $P = 0.005$ and 0.002 respectively for neuroticism and anxiety] but not women. Both neurotic and anxious men perceived emotionally valenced odorants faster than the neutral one (0.78 versus 0.90, SE = 0.025 versus 0.44, $P = 0.002$ for neuroticism, and 0.76 versus 0.89, SE = 0.03 versus 0.04, $P = 0.001$ for anxiety), whereas stable and calm men perceived them equally fast (0.76 versus 0.75, SE = 0.034 versus 0.032, $P > 0.05$ for stable men, and 0.78 versus 0.76, SE = 0.031 versus 0.032, $P > 0.05$ for calm men). The reaction time for anxious versus calm men by the emotional content of the odorants is shown in Figure 4.

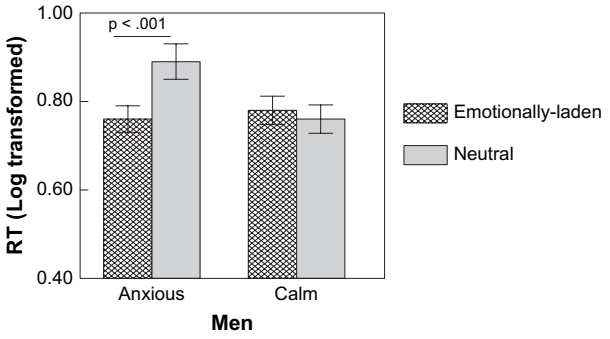

Figure 4 Average reaction time for anxious versus calm men as a function of emotional content of the odors (bars represent SE).

Discussion

Based on our results, a number of observations can be made. First, regardless of emotional state or personality, women responded to the emotionally valenced (i.e. pleasant) odorant faster than the neutral one. This shows that women attend faster to olfactory stimuli that contain greater informational value. Our result is analogous to prior studies using visual stimuli (e.g. Rogers and Revelle, 1998; Schupp *et al.*, 2000).

Second, we found that the emotional states of the observers augmented the perceived intensity of the odorants for men (but not for women). Men perceived greater olfactory intensity in emotional states than they did in neutral states, regardless of the valence of the olfactory stimuli. This effect is reminiscent of the observation that emotions augment intensity in taste and audition (Dess and Edelheit, 1998), and in smell (Bensafi *et al.*, 2004).

We found that personality did not directly influence olfactory experiences. However neuroticism and anxiety did modulate olfactory intensity and reaction times. Women high in trait anxiety perceived the emotionally valenced odorants as stronger compared to the neutral one. Similarly, men high in neuroticism or anxiety detected the emotionally valenced odorants faster compared with the neutral one. Thus, neurotic/anxious individuals were more responsive to both pleasant and unpleasant odorants. Previous studies showed that people high in neuroticism demonstrated faster P300 latency, suggesting that they were faster at evaluating information (Pritchard, 1989; Stelmack *et al.*, 1993). Here our findings on intensity and reaction time together suggest that, in the area of olfaction, heightened emotional reactivity predispose neurotic and anxious individuals to respond more selectively to emotional odors. Interestingly, compared with stable and calm men, neurotic and anxious men in our study did not differ in the speed in which they responded to emotionally laden odorants but did (i.e. responded slower) to the neutral odorant. In this particular case, the difference could have been driven by a slower response on the part of neurotic and anxious men to the neutral stimuli. If so, this would be consistent with the hypothesis proposed by Stelmack *et al.* (1993), which we have modified for our setting, that high neurotics exhibit a behavioral excitation to the emotional and an inhibition to the neutral stimuli. The fact remains that calm men in our present study did not differentially respond to the emotional versus neutral odorants whereas anxious men did. Consistent with previous studies (e.g. Koelega, 1994; Pause *et al.*, 1998; Larsson *et al.*, 2000), introversion–extraversion did not affect olfactory perception.

Some of the aforementioned results also highlight gender differences. Women did not perceive odors any stronger in emotional over neutral states. Particularly, we found that only men perceived smell intensity change as a result of being in either an emotional or neutral state. This effect of emotional state is to be contrasted with women's superior olfactory sensitivity in identifying, discriminating and naming smells (see review by Doty, 1986). This is one of the few effects in olfaction where a gender difference is tilted towards men, and is certainly worthy of further study.

Summary and conclusions

We produced emotions of happiness, sadness, negativity/hostility and neutrality using video clips, and exposed subjects to one of three suprathreshold odorants—pleasant, unpleasant and neutral—following each emotion. We examined the extent to which emotional state and neuroticism and anxiety impact the perception of olfactory stimuli, specifically intensity and response time.

We found that women reacted faster to emotionally valenced smells than to the neutral smell. In addition, emotional states augmented the intensity of odorants for men. Finally, we found that personality did not directly influence olfactory experience but did modulate the reaction time and the olfactory intensity depending on the emotional tone of the smells.

To summarize, our findings suggest that emotionally valenced olfactory stimuli heighten the attention, especially among emotionally labile individuals, and that current emotional state influences olfactory perception in men.

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