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Hedonic and social determinants of facial displays to odors

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Abstract. The facial responses of seven female subjects were videotaped while they smelled six odors in each of three experimental conditions (spontaneous, posing to real odors and posing to imagined odors). Videotaping was covert in the spontaneous condition and overt in the posed conditions. Raters (N = 65) were shown the videotapes and asked to judge whether the subjects smelled something unpleasant, neutral or pleasant. Raters were correct in only 37% of their judgements when the subjects were not aware of being observed. Raters' accuracy improved significantly when subjects posed to real odors (76% correct) and posed to imagined odors (76% correct). Faces made to unpleasant odors were classified more accurately than those to pleasant odors in all three conditions. These results cannot be accounted for by reflexive-hedonic accounts of odor-related facial expressions.

Introduction

Facial expressions have been widely regarded as a route to a subject's hedonic experience (Fridlund *et al.*, 1987; Tassinary, 1985a,b). There is particular interest in using facial expression to assess emotional response to odors in order to circumvent the difficulty many subjects have in verbalizing their experience of odors, and to avoid the ambiguities of interpreting autonomic measures of emotion. Interest in facial displays to odor has engendered what might be called the 'reflexive-hedonic' interpretation (e.g. Steiner, 1973, 1974, 1976) that holds facial actions to be innate, stereotyped, reflex-like behaviors that serve as an externalized 'readout' of hedonic state. On this account, pleasant odors give rise to positive internal states and thereby evoke smiles, while malodors increase negative hedonic tone and produce expressions of disgust. This account has persisted in the literature despite the fact that demonstrations of 'spontaneous' facial expressions to odor have been uniformly elicited only in situations where the subject knew that facial expression and emotional response were being studied (e.g. Kraut, 1982). In the present experiment, Steiner's reflexive-hedonic view was tested in adult subjects in conditions free of such demand characteristics. Subjects smelled odors while alone, but hedonic evaluations were not requested, and subjects were unaware that their facial expressions were being videotaped. In two subsequent conditions, posed facial expressions were overtly videotaped. Raters then classified videotapes of the subjects' facial behavior. The 'alone' condition assessed the extent of spontaneous expressions, and the 'posed' conditions served to check the experimental technique and to ascertain ceilings in decoding accuracy.

Method

Subjects

Models. Sixteen female undergraduates were recruited from psychology courses for an experiment on 'memory for odors' for which they would be paid $10.00. All were interviewed prior to participation to exclude individuals with head colds or chronic allergies, and those using nasal sprays or psychotropic medication.

Raters. The videotape was viewed by 26 male and 39 female raters ($N = 65$) recruited from the campus community. Raters were paid $3.00 for their participation.

Videotaping of models

The subject was seated in a lounge chair in front of a dummy control panel which housed a hidden video camera. Subjects were videotaped in monochrome. Video frame numbers (Data Systems Design 440-C time number generator) were superimposed on the upper corner of the picture. The camera angle provided a frontal view of the subject from just below her shoulders to just above the top of her head. She was fitted with a lapel microphone, and a rack containing six plastic squeeze bottles was placed across the arms of the chair. The subject was told to hold the bottle with its top at chin level, and squeeze once while taking a single, moderate inhalation. She was then left alone in the room and communication with the experimenters took place over an intercom.

Subjects sampled the odors in each of three experimental conditions, and in two non-taped rating sessions. In Condition 1 the subject was told to sample each bottle to 'familiarize herself' with the odors. Next, in Rating Session 1, she was told to sample each odor again and rate its hedonic value on a rating form. At the end of Rating Session 1 the experimenters entered the room and explained that they wished to repeat this last series of samplings, because 'repeated ratings might have an effect on memory for odors'. The experimenters also explained that they wished to videotape the subject on these trials 'in order to have a record of the experiment'. After the subject agreed and signed a consent form for the videotaping, a dummy video camera was mounted on a tripod in front of her, and she was again left alone in the test room. Rating Session 2 was a repeat of Rating Session 1, and served to accustom the subject to the presence of a camera. In Condition 2 we asked the subject to smell each odor and pantomime with her face her reaction to the odor. In Condition 3 we asked the subject to squeeze a blank bottle and 'pantomime the face that someone would make if she were smelling something extremely unpleasant/unpleasant/slightly unpleasant/neutral/slightly pleasant/pleasant/extremely pleasant'. At the end of the experiment the subject was informed that she had been videotaped covertly in Condition 1, and because of the deception she was given the opportunity to have the videotape erased. All subjects provided written consent for the use of their videotapes. Obtaining *post hoc* consent is standard practice when knowledge of videotaping could alter the behavior of interest. The experimental protocol and the written statements of informed consent and videotaping consent were approved by the University of Pennsylvania Committee on Studies Involving Human Beings.

Odor presentation and rating

Each 250-ml polypropylene bottle contained 20 ml of solution. Two bottles (blanks) contained only mineral oil. The others contained the odor of cloves (1.0% eugenol), roses (0.125% phenylethyl alcohol), urine (0.5% butyric acid) and rancid sweat (0.05% isovaleric acid) each in a mineral oil diluent. Order of presentation of the odors was incompletely counterbalanced across conditions (D'Amato, 1970). The subject indicated over the microphone when she had finished smelling each odor, and the experimenter held the interstimulus interval to at least 20 s.

Subjects rated each odor by marking on a 178-mm line scale with end points labeled 'extremely unpleasant' and 'extremely pleasant', and a mid-point labeled 'neutral'. These were converted to hedonic scores (range -89 to $+89$) by measuring the distance to the subject's mark from the scale mid-point.

Construction of composite videotape

From a total of 16 subjects we selected seven who showed no paradoxical response to the test odors, i.e. who rated cloves and rose positively, urine and rancid sweat negatively and blanks approximately neutral. Their facial responses were assembled on a composite videotape, on which each subject is seen smelling six bottles in each of three experimental conditions, yielding 126 facial response trials. These trials were incompletely counterbalanced across model, odor type and experimental condition. Each trial began just as the subject started to squeeze a bottle. Four seconds of a computer-generated numeral were followed by 3 s of facial response, then by 8 s of blank screen to allow raters to record their judgements. Total running time of the tape was 31.5 min.

Rating of model videotape

The videotape was shown to groups of 2–20 raters at a time. They scored each numbered trial on single response sheets, bound together into booklets. On each trial raters were asked: 'Did her face move after she squeezed the bottle? (circle yes or no)' and 'Did she smell something pleasant, neutral, or unpleasant (circle one)'. Raters were asked to list their age, sex, handedness, and to rate their mood on a line scale (from 'worst possible' to 'best possible').

Results

Hedonic ratings of odors by models

The videotaped models rated each odor once in Rating Session 1 and once again in Rating Session 2. In Rating Session 1 the unpleasant, neutral and pleasant odors were rated -64 ± 24, 0 ± 2, and 53 ± 25 mm, respectively ($M \pm$ SD) on the 178 mm line scale. In Rating Session 2 the corresponding ratings were -70 ± 18, 0 ± 2, and 57 ± 25 mm on the same scale. An absence of overlapping hedonic values for odor types for any model in either rating session suggests an unambiguous differentiation of the odor types. Because models were selected for non-paradoxical response to the odors, no model gave a negative score to a pleasant odor, nor a positive score to an unpleasant odor.

Raters' classification of facial displays

An accuracy score was calculated as the percentage of correct judgements in answer to the question 'Did she smell something pleasant, neutral or unpleasant?' Accuracy scores were analyzed by a $3 \times 3 \times 7$ ANOVA (Condition $\times$ Odor Type $\times$ Model) with repeated measures on all factors. Odor type was obtained by combining the pairs of pleasant, unpleasant and neutral odors. To mitigate effects of possible ANOVA violations of variance–covariance matrix homogeneity or compound symmetry (Huynh and

Table I. Classification accuracy and facial movement scores ($M \pm$ SE) for condition and odor type*

	Accuracy (%)	Facial movement (%)
Condition		
1 Unposed	39 ± 1^a	43 ± 1^a
2 Posed real	76 ± 1^b	79 ± 1^b
3 Posed imagined	76 ± 1^b	85 ± 1^c
Odor type		
Pleasant	52 ± 1^a	69 ± 1^a
Unpleasant	73 ± 1^b	81 ± 1^b
Neutral	65 ± 1^c	56 ± 1^c

*Within each factor different superscripts indicate significant differences ($P < 0.0001$) across conditions.

Table II. Percentage of facial responses within each odor type classified by raters as unpleasant (UP), neutral (N), or pleasant (P)

	Condition 1 *Spontaneous*	Condition 2 *Posed to real*	Condition 3 *Posed to imagined*
Unpleasant odor			
Classified UP	39	89	92
Classified N	59	5	4
Classified P	2	6	4
Neutral odors			
Classified UP	21	18	15
Classified N	70	66	56
Classified P	9	16	29
Pleasant odors			
Classified UP	12	10	5
Classified N	81	18	19
Classified P	7	72	76

Table III. Percentage of unpleasant (UP), neutral (N), and pleasant (P) odor trials rated as showing facial movement

Odor type	Condition 1	Condition 2	Condition 3
UP	48	98	98
N	47	52	68
P	33	86	88

Feldt, 1970) conservative epsilon-adjusted F-ratios (Geisser and Greenhouse, 1958) were used throughout. *Post hoc* comparisons were done with Scheffé tests.

All main effects and interactions of the ANOVA were significant at the $P < 0.005$ level or better. Facial responses were classified more accurately in Condition 2 (pose to real odor) than in Condition 1 (spontaneous) ($P < 0.0001$), and in Condition 3 (pose to imagined odor) than in Condition 1 ($P < 0.0001$). Conditions 2 and 3 did not differ ($P > 0.05$) (Scheffé tests, Table I).

Unpleasant odor trials were more accurately classified than pleasant ($P < 0.0001$) and neutral ones ($P < 0.0001$), and neutral odor trials were more accurately classified than pleasant ones ($P < 0.0001$) (Scheffé tests, Table I). A majority of raters had higher accuracy scores for unpleasant than for pleasant odor trials (97, 75 and 83% of raters in Conditions 1, 2 and 3, respectively). This asymmetry in rating accuracy can also be seen in that in Condition 1 only 7% of positive odor trials were correctly classified, while 39% of negative odor and 70% of neutral odor trials were correct (Table II). In Conditions 2 and 3 accurate classification for negative and positive odor trials increased substantially whereas accuracy for neutral trials declined (Table II).

In Condition 1, the low accuracy on positive odor trials was evident for all models (only one of seven had a rate greater than 8%). Similarly, the high accuracy for neutral odor trials was apparent for most models (neutral odor trials were the most accurate category for all but model 7). However, the majority of Condition 1 trials were classified as 'neutral' regardless of odor type (Table II). Thus the high accuracy for neutral trials may not reflect specific detection of neutral responses as much as a bias to rate Condition 1 trials neutral.

Variation among models was evident in the significant interaction terms involving models. There was a main effect of model, but this must be interpreted in light of significant interaction of model with condition and odor type. Still, for every model accuracy was higher in both Conditions 2 and 3 than in Condition 1. Differences in accuracy between Conditions 2 and 3 varied with the model, i.e. some models were more accurately classified when posing to real odors, other when posing to imagined odors.

Qualitative examination of the videotape suggested that in Condition 1 models displayed little facial movement. This 'poker face' may have been interpreted by raters as a neutral response, a possibility borne out by analysis of the facial movement data.

Raters' judgements of facial movement

Affirmative responses to the question 'Did her face move?' were expressed as a percentage of all responses (Table III). In the 3 × 3 × 7 ANOVA (Condition × Odor Type × Model) all main effects and interactions were significant at $P < 0.0001$. As before, conservative epsilon-adjusted F-ratios were used throughout.

Raters perceived facial movements significantly less often in Condition 1 than in either Condition 2 ($P < 0.0001$) or Condition 3 ($P < 0.0001$). There was more facial movement in Condition 3 than in Condition 2 ($P < 0.0001$) (Scheffé tests, Table I).

Facial movement was perceived more often in unpleasant odor trials than in those with pleasant odors ($P < 0.0001$), which in turn had more movement than those with neutral odors ($P < 0.0001$) (Scheffé tests, Table I).

Facial movement ratings varied significantly as a function of classification in all three experimental conditions (dependent χ^2 tests of contingency were computed for each condition; $P < 0.001$ in each; Table IV). Facial movement was overwhelmingly (73–98%) associated with pleasant and unpleasant ratings. In contrast, an absence of facial movement was associated with neutral ratings (76, 58 and 49% of neutral trials in Conditions 1, 2 and 3, respectively). As most subjects made few facial movements when unobserved, neutral accuracy scores were particularly inflated in Condition 1.

Given that facial movements were more frequent in Conditions 2 and 3, it makes sense that the association with movement scores for pleasant and unpleasant odor faces increased in those conditions as well. However, there was a good deal of heterogeneity among models in the degree to which they moved their face in response to neutral odors. This may be because some models actively portrayed an attitude of indifference (facial

Table IV. Number of trials rated unpleasant (UP), neutral (N), or pleasant (P) arranged by raters' judgements of facial movement (M) or nonmovement (NM)[a]

Classified	Condition 1		Condition 2		Condition 3	
	M	NM	M	NM	M	NM
UP	588	70	1035	33	956	23
N	457	1450	337	467	387	365
P	120	45	779	79	963	36

[a]Condition 1, $\chi^2(128, N = 2730) = 921$, 935 and 860 for conditions 1, 2 and 3, respectively. $P < 0.001$ in each condition.

and shoulder shrugs, etc.) while others maintained a poker face seemingly characteristic of neutral responses in the spontaneous, unobserved Condition 1.

Covariates of rater accuracy

No effects were found for age, sex, handedness or mood of raters on accuracy in rating facial responses.

Discussion

Raters were unable to interpret faces made spontaneously to unpleasant and pleasant odors. A high apparent accuracy (70%) for spontaneous faces to neutral odor reflected a low frequency of spontaneous facial movement, together with a bias to judge non-moving faces as neutral. We also observed a decoding asymmetry between unpleasant (39% accuracy) and pleasant (7%) odor faces. In contrast, faces posed to real and imagined odors were readily interpretable by people viewing videotapes. Raters accurately assigned the categories of unpleasant, neutral and pleasant to posed faces; accuracy was less for faces made to pleasant than to unpleasant odors. This result indicates that the failure of raters to distinguish accurately among faces made spontaneously was not due to the experimental technique employed.

Our own observations revealed that only a few subjects displayed disgust faces to unpleasant odors, while no subject spontaneously smiled to an odor she found pleasant. Posed displays included smiles and raised eyebrows for pleasant odors, and disgust faces for unpleasant odors. Odorless air elicited neutral poker faces or facial shrugs.

It is possible that our pleasant odors were not strong enough to elicit identifiable spontaneous facial displays. However, other evidence makes this explanation unlikely. Tassinary (1985a) analyzed facial action units (Ekman and Friesen, 1978) of subjects covertly videotaped during odor inhalation. Strong unpleasant odors produced twice as many action units as weak unpleasant odors, while no intensity related difference was found for pleasant odors. Additionally, Steiner (1979) has anecdotally reported that faces made by infants to pleasant odors are less intense than those to unpleasant odors. Together, these results suggest that the decoding asymmetry in Condition 1 is the result of a real difference in facial response.

It is also possible that there were reflexive facial movements during Condition 1, but that they were not large enough to be visible. Perhaps they could be revealed electromyographically (Fridlund and Izard, 1983). If 'naso-facial' reflexes are part of the human communicatory repertoire as Steiner maintains, then their display must be substantially enhanced when the subject is aware of being observed. But this weaker form of the reflexive-hedonic hypothesis then becomes virtually indistinguishable from a communicatory interpretation, because on both accounts full-blown displays would only be seen in the presence of others.

The strong form of the reflexive-hedonic view holds that facial responses to odor are innate, reflex-like, readouts of hedonic state (Steiner, 1973, 1974, 1976). Its corollary is that facial movement indicates a hedonic response, while non-movement implies neutral affect. This is the prevalent view of the lay public, and it is one held by many psychologists as well. Indeed, the results of the present study suggest that our raters implicitly subscribed to this view. However, our results also indicate that this view is incorrect.

We found minimal spontaneous facial movement to odors (Condition 1). This is difficult to reconcile with a reflexive-hedonic model. Due to release from cultural display rules (Ekman and Friesen, 1971; Fridlund *et al.*, 1987) people should, if anything, be freer in their expression of 'reflexive' behaviors (e.g. belches) when in private. Our observation of an asymmetry in the decoding of facial response to pleasant and unpleasant odors is neither predicted nor accounted for by a reflexive-hedonic view. If a common pathway serves naso-facial reflexes (Steiner, 1979) there is little reason to expect greater facial expression to unpleasant odor.

In fact, close scrutiny of the reflexive-hedonic position reveals critical flaws in both its empirical support and its theoretical claims.

First, there is little empirical support for the reflexive-hedonic view, despite its popularity. Perhaps the most frequently cited experiment is described only in a conference discussion (Steiner, 1974), a meeting abstract (Steiner and Finnegan, 1975) and two reviews (Steiner, 1977, 1979). Steiner reports that normal neonates exhibit innate, stimulus-dependent, stereotypic and reflex-like facial responses to both positive and negative odor. A similar claim for the odor-specific facial response of blind adolescents is made in an abstract (Steiner, 1976) and a review (Steiner, 1979). A similar interpretation is given to odor-related facial expression in patients with Usher's syndrome (Steiner and Abraham, 1978), a disease characterized by congenital hearing loss and severe and progressive visual impairment. As neither quantitative results nor customary statistical analyses are provided in any of these publications, Steiner's data must be considered anecdotal. None of these findings has, to our knowledge, been replicated in an independent laboratory.

Second, in his theorizing Steiner appears to have conflated two very different concepts: behavioral reflexes and ritualized behaviors. Behavioral reflexes (e.g. sneezing) are automatic and their display is independent of the history, knowledge or social context of the actor. Ritualized behaviors (see Smith, 1977) are also 'automatic' (stereotypic around a modal pattern), but this does not imply that they are reflexes. In neither the ethological sense (e.g. avian precopulatory displays) nor in the sociological sense (e.g. baptism) is it implied that ritualized behavior is contextually invariant. The present results suggest that while faces made in response to odor are certainly not reflexive, they are perhaps informative, and are almost certainly ritualized.

One facial display to odor — sneezing — may indeed qualify as a reflex. However, sneezing is not usually regarded as a communicative behavior or an expression of hedonic state. Although it can occur in response to odors (especially those with trigeminal irritant properties such as pepper) it can also occur in the presence of allergens, head colds and champagne bubbles. We would not be surprised if other facial displays to odor prove to have an ontogenetic origin in a neonatal reflex. We do claim, however, that like other reflexive behaviors once freely expressed in childhood, facial displays to odors come under increasing inhibitory control as we grow older, i.e. they become socialized (Cole, 1985). This socialization process may begin early, since babies as young as 36 h are able to discriminate and imitate adult facial expressions (Field *et al.*, 1982). Thus, if there is a neonatal naso-facial reflex, it is likely to disappear more quickly than other neonatal reflexes such as grasping and rooting.

Finally, the notion of a 'communicative reflex' is, from an evolutionary viewpoint, a *non sequitur*. What would be the adaptive utility of an involuntary, unmodulated communication of hedonic state, especially one that occurred in private as well as in public? Natural selection favors the attenuation of involuntary, reflexive facial behavior for a variety of reasons including deception, economy and privacy (Krebs and Dawkins, 1984; Smith, 1977).

It would be a mistake to regard facial expression as a royal road to the hedonics of olfaction. Facial expression may reflect the social circumstances in which they are embedded as much as the odor to which they are ostensibly a response. All subjects could pose highly recognizable facial expressions to real or imagined odors. These poses, we believe, are commentaries on ongoing interactions, not unlike the 'emblematic' faces made to films, audio tracks, etc. They corroborate the view that the primary display role of the face is paralinguistic rather than emotional (Fridlund and Gilbert, 1985).

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