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Does the source of an interpersonal odour affect disgust? A disease risk model and its alternatives

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Abstract

Using self-report, this paper explored whether a malodour's source (self, liked person, stranger) influences hedonic responding. In Study 1, participants were presented with vignettes describing various encounters with malodours. Negative affect increased when body malodours emanated from a stranger rather than oneself (the source effect). Study 2 replicated this finding using a smell diary, in which participants recorded their hedonic responses to real odours. Study 3 determined that this source effect was not due to a social status or a halo effect. Study 4 examined the role of exposure and attachment. Exposure, but not attachment, best accounted for the source effect. Study 5 examined whether perceived disease risk varied by source and whether this could account for the source effect. The findings suggested that there are two mechanisms by which disgust responses to malodours can be modulated to reflect the disease risk of their source: implicitly, by mere exposure, and explicitly, by knowledge of risk. In the discussion, we argue that avoiding contact with disease-causing agents is adaptive, and that this is implicitly modulated by exposure, so that the cues for disease emanating from people encountered less frequently are treated with more caution. Copyright © 2005 John Wiley & Sons, Ltd.

INTRODUCTION

The emotion of disgust is characterized by feelings of intense dislike, by a desire to flee the disgust elicitor, and sometimes by a prototypical facial expression (Rozin, Haidt, & McCauley, 2000). Disgust can be elicited by a diverse range of stimuli, including rotting food, vermin, body wastes, gore, and socio-sexual-moral violations (Rozin & Fallon, 1987). Rozin et al. (2000) have proposed that food and its potential contaminants (e.g. body waste) elicit core disgust and that this functions to protect the body from physical harm, especially disease. Although this disease avoidance model has been endorsed by many researchers (e.g. Curtis & Biran, 2001; Royzman & Sabini, 2001), it is not well

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developed. In its simplest form, it may be stated as follows: core disgust stimuli are especially rich sources of pathogens and feeling disgust is an adaptive response to this danger (Curtis & Biran, 2001). One prediction that can be derived from this model is that a relationship should obtain between disease risk and disgust response, namely, the greater the risk, the more intense the response. This hypothesized relationship was explored in the current series of studies.

Body wastes, open wounds, decaying organic matter, vermin, and poor hygiene are all potential sources or vectors of human pathogens. If disgust serves to reduce disease risk, then responses to these types of stimuli (e.g. faeces) should be influenced by their *source* (e.g. you vs. a stranger), to the degree that variations in *source* appear to reflect variations in disease risk. For example, although we might dislike our own waste products, such a response should be considerably more marked towards those of a stranger, primarily because of lack of direct contact with that individual (e.g. are they healthy?) and the consequent heightened risk of infection (hereafter the 'source effect'). On the other hand, with rotting garbage for example, it should make less difference whether it is our own or someone else's, as both constitute a similar though not identical disease risk. Although our principal focus here is in examining an account predicated by a model of disease risk, it is important to note that other models could predict differences of the sort described above. A detailed discussion of these alternatives will be presented later in this paper. Irrespective of the possible theoretical origins of the predicted source effect, it is noteworthy that it has received virtually no attention in the literature (one exception being Curtis, Aunger, & Rabie, 2004).[1] Consequently, the first aim of this paper was to determine whether it actually exists.

At this point, it is important to consider exactly what we mean by disease risk. This turns out to be a complicated issue because in our evolutionary past we did not, as we do now, have a germ theory. Consequently, we have to consider the impact of two separate forms of knowledge about disease risk. The first is our modern and explicit knowledge about disease. For example, in handling someone else's garbage one could not know what was in it (contaminated sharps or used prophylactics?), so a healthy caution might be warranted based upon an explicit awareness of disease risk. The second is whether we have evolved a rough and ready index of disease risk. Such an index could manifest in at least two ways. One is a preparedness to associate certain stimuli with the emotion of disgust (conceptually akin to Seligman, 1970). Those cues being most 'prepared' would, presumably, turn out to be disgust's most potent elicitors, whilst less prepared items would elicit a proportionally smaller response. In this way we might expect that faeces, the archetypal disgust elicitor, would evoke a more potent response than say sweaty bodies or dirty feet, which are primarily 20th century concerns. The other mediator of disease risk may be mere exposure, which is known to reduce negative affect for a range of stimuli (Zajonc, 1968). Thus, exposure to one's own disgust elicitors and those of close kin might act to highlight the foulness of disgust elicitors produced by strangers. However, for mere exposure to function as a proxy indicator of disease risk, the signal produced by different sources of a particular disgust elicitor must be discriminable. Where this is not the case, then exposure could not produce a differential response, and a similar affective experience would arise irrespective of source.

A further issue concerns conflating the signal for disease risk with the actual risk of disease itself (i.e. akin to the miasma theorists of the 19th century) and similarly, conflating the signal for a disgust elicitor with the disgust elicitor itself. For example, one would be at a low risk of catching a faecal borne disease from the smell of faeces, yet most people are disgusted by its smell and may regard it as injurious to health—but the smell is only a signal. Likewise, many Westerner's would find bad breath, dirty feet and sweaty armpits disgusting, yet the risk of disease associated with these smells, and even with the source of these smells, is low. The first point here is simply to recognize that in daily usage,

[1]Using a web-based survey, Curtis et al. asked respondents to select the person with whom they would least like to share a toothbrush. Most, selected individuals who they were not especially familiar with or close to (e.g. 59%—the postman; 24.7% their boss) as opposed to a best friend (1.9%) or a spouse/partner (1.8%).

conflation of the disgust signal with its source is probably routine and a consequence of associative learning during childhood. The second point is that evolution may have left sufficient leeway in what one can associate with the emotion of disgust, so that many more signals now function to elicit this emotion than perhaps a hundred or a hundred-thousand years ago. The third point is that many of the more modern signals for disgust are simply more remote indicators of disease risk. Whilst faeces may contain numerous pathogens such as poliomyelitis, hepatitis, typhoid, salmonella, tetanus, dysentery, cholera, and helminthic and protozoan parasites (Curtis & Biran, 2001; Feachem, Bradley, Garelick, & Mara, 1983), non-faecal body smells, such as dirty feet and sweaty armpits, may be indicative of poor personal hygiene, and thus signal the possible transmission by unwashed hands of faecal pathogens (e.g. Curtis & Biran, 2001; Margolis, Alter, & Hadler, 1997). The risks posed by such transmission should not be underestimated. Dirty hands *can* be fatal.

As the most potent signal for many disgust elicitors is smell, this was chosen as the focus for the present series of studies. Using smell, we then set out to test a number of hypotheses derived from the disease avoidance model of core disgust. Before listing these, we wish to restate the caveat made earlier, that such effects could be predicted by other theoretical accounts than the one selected here. Consequently, this paper pursues two convergent strategies—exploring the validity of the source effect and exploring its cause. To continue, our predictions can be stated thus. First, body odours emanating from a stranger (faecal, sweat, feet) should be regarded as more unpleasant than those from close friends, family or self, as we know little about the disease status of strangers (the source effect). Second, and relatedly, body odours emanating from close friends and family should be more unpleasant than one's own, as again, the risk of disease should be higher from another individual, however close, than from oneself (the source effect). Both these hypotheses may reflect different degrees of exposure to olfactory disgust cues but disease avoidance may be of primary importance only for the first. Third, these two source effects should be most marked for faeces, as this is the richest source of pathogens; likewise, faeces and related odours should evoke the most markedly negative hedonic response. Fourth, an odour's source should have a smaller effect in the case of non-body malodours such as garbage or organic fertilizer. It is likely that the quality of such odours is typically independent of their source, so exposure can not operate differentially to modulate hedonic responding. These possibilities were explored in Study 1.

STUDY 1

The ideal way in which to determine the effect of an odour's source on hedonic responding would be to present real stimuli for participants to sniff, whilst manipulating their beliefs about the source of the odour. It is not readily apparent how one would convince a participant that the faecal smell they were rating was 'their own', unless they were asked to bring a sample along to the laboratory prior to testing. Similar problems are raised with the other body odours. A further issue would be in convincing institutional ethics and biosafety committees that sniffing faecal material, especially from others, carried no risk *even* if it did not (see Lundholm & Rylander, 1980, for example). Thus, there are fairly serious barriers to executing this type of study as a formal experiment. Consequently, vignettes were employed in four of the five studies presented here. A further reason for using this methodology is that it provides a rational first approach to a new research area (see Rozin, 2001). This is especially so here, as there have been relatively few investigations into the social psychology of smell (see Levine & McBurney, 1986).

Although the use of vignettes bypasses the problems described above, it raises new ones about validity. For this reason, two approaches were adopted to establish validity in Study 1. The first was

based on replicating results obtained from experimental studies and the second on obtaining correlational validity with an established instrument. Turning to the first approach, several studies of odour hedonics have revealed that the context in which they are smelled (alone vs. with an experimenter) and the type of response measured (facial expression vs. self-report) produce relatively large differences in outcome. Studies which directly compare an alone vs. with an experimenter condition, reveal fewer facial signs of emotion when accompanied than when alone (Kraut, 1982; Soussignan & Schaal, 1996). In addition, when an unpleasant and a pleasant odour are compared, the effect size is considerably greater when the dependent variable is self-report rather than facial expression (Janke & Kaufmann, 1994; Soussignan & Schaal, 1996). For this reason, we included two dependent variables for each vignette: how the participant would feel (degree of positive or negative affect) and what they would show or display (degree of expressed disgust or delight). We expected that 'display' ratings (being equivalent to facial expression) would consistently be rated as a less potent medium of disgust than 'feel' ratings (i.e. negative affect). In addition, we expected that the presence or absence of an odour's source (being somewhat equivalent to presence or absence of the experimenter) would impact primarily on display ratings, by muting responses when the odour's source was present. Reproducing these effects constituted our first line of validity checks. However, we wish to stress that this is a rather novel way of ensuring validity, as we can not be sure of the extent to which participants normally have access to these facets of their behaviour and thus whether they can be imagined under self-report conditions. Rozin, Haidt, McCauley, Dunlop, and Ashmore (1999) recently demonstrated that behavioural tests of disgust sensitivity are moderately correlated with responses to the Disgust Sensitivity Questionnaire (DSQ; Haidt, McCauley, & Rozin, 1994). Given the established validity of the DSQ, our participants completed this scale to establish correlational validity with their vignette responses. Two types of relationships were expected to emerge. First, the disgust scale should correlate with vignette ratings, as variation in these ratings should, to some extent, be accounted for by individual differences in disgust sensitivity. Second, such correlations should be more robust between felt responses and disgust sensitivity, than for displayed emotion and disgust sensitivity, due to the greater situational constraints that govern display.

Method

Participants

One hundred and eighty five students from Macquarie University participated in the study, with some receiving course credit for their involvement. The majority of participants, as in all the studies reported here, were middle-class Caucasians (see Table 1 for more details).

Procedure

Vignettes describing specific odour scenarios were created and systematically varied with respect to the odour's source. Three sources were used. First, the participant themselves, that is, 'self'. Second, 'stranger', namely a person unknown to the participant. This individual was an electrician in the faecal vignettes, a plumber in the foot odour vignettes, a delivery driver in the fertilizer vignettes and identified simply as a 'stranger' in the sweat, flatulence and garbage vignettes. The third source was someone with very close emotional ties to the participant. This latter category required careful definition at the start of the questionnaire. Participants were asked to select the 'person you most like and care for' (i.e. your 'chosen person'). They were then asked to think of this person whenever

Table 1. The characteristics of participants in Study 1 and Study 3

Variable	Study 1 $n = (\%)$	Study 3 $n = (\%)$
Participants	180 (100.0)	95 (100.0)
Gender*		
Male	53 (29.4)	45 (47.4)
Female	127 (70.6)	49 (51.6)
Age*		
16–35	136 (75.6)	86 (90.5)
36–55	38 (21.1)	6 (6.3)
56+	6 (3.3)	2 (2.1)
Relationship to their chosen person		
Sexual partner	107 (59.4)	48 (50.5)
Family member	41 (22.8)	30 (31.6)
Friend	32 (17.8)	17 (17.9)
Proximity to their chosen person		
Live with them	104 (57.8)	32 (33.7)
Do not live with them	76 (42.2)	63 (66.3)

*One participant from Study 3 had missing data.

'chosen person' was mentioned. The relationship of the participant to their 'chosen person' and whether they were currently living with them was also recorded.

Manipulation of odour source in each vignette was achieved by substitution. For example, in the vignette concerning smelly feet, source was changed by appropriately substituting the italicized text: 'You have new carpet and so you [*take off your shoes by the door.*][*ask your chosen person*][*ask the plumber you have hired*] to leave their shoes by the door. As [*you*] [*they*] remove [*your*] [*their*] shoes you notice [*your*] [*their*] feet smell strongly'. A second manipulation was also performed to assess the extent to which responses were affected by the presence of the odour source in each vignette. In this case, the vignettes retained a common source (e.g. 'chosen person') but varied their presence. For example—'Your chosen person has just used the toilet. You walk in as they are washing their hands. You notice they have made a strong faecal smell' (i.e. source present) vs. 'Your chosen person uses the toilet and returns to the living room. You then go to use the toilet. As you shut the door, you notice they have made a strong faecal smell' (i.e. source absent).

Each participant was exposed to three basic types of vignette: one using a faecal odour, one using another body odour, and a third using a non-body foul odour. Thus, with the three (source) by two (source present/absent) manipulations, each participant received 18 vignettes in total. Pilot testing revealed that participants became fatigued when all odour types were included in a single questionnaire. Hence, two separate versions of the questionnaire were employed. These varied in the specific odour types featured, but were identical in all other respects. Version A featured faecal, foot and organic fertilizer odours ('blood and bone'—which smells of rotting flesh), whereas Version B used flatulence, armpit sweat and garbage odours. After reading each vignette, participants were asked to make two types of rating. The first asked 'In this situation, how much would you like or dislike the smell?'. This 'felt' response was rated on an 11-point scale (−5: Dislike Extremely through to +5: Like Extremely). Participants were then asked 'In this situation, what response to the smell would you show?'. This 'shown' or public response was also rated on an 11-point scale (−5: Extreme disgust through to +5: Extreme delight). After completing both ratings for each of the 18 vignettes, participants reported their gender and age, rated how good they thought their sense of smell was and how frequently they were exposed to foul odours. They then completed the 32-item DSQ (see Haidt et al., 1994). The vignette ratings and the questionnaire were completed in either group settings or individually. Method of

completion was identified on the questionnaire and there were no differences in the data between methods. The data from five participants were removed prior to analysis. Two of these failed to complete the questionnaire and the other three reported having either a bad or absent sense of smell.

Results

Participant Characteristics

Ninety-one participants received Version A and 89 Version B of the questionnaire. Chi-squared analyses revealed no significant difference between groups on any characteristic. Table 1 shows these characteristics collapsed across groups.

Are there Source Effects?

Figure 1 presents participants' felt and shown hedonic ratings for each test 'odour' in each vignette. Source effects were most evident for faeces, feet, flatulence and sweat, somewhat for garbage and not at all for organic fertilizer. These impressions were confirmed statistically. Paired *t*-tests were performed between sources, for each odour type. The dependent variable in each case was the felt hedonic ratings, collapsed across person present/absent.

In Version A, participants rated their own faecal odour as less unpleasant than that of their chosen person, $t(90) = 5.67$, $p < 0.001$. In turn, faecal odours were rated as less unpleasant when they were associated with the chosen person rather than a stranger, $t(90) = 8.16$, $p < 0.001$. For foot malodour, participants again judged their own smell as less unpleasant than that of their chosen person, $t(90) = 2.40$, $p < 0.02$. Again, the chosen person's foot malodour was judged less offensive than that of a stranger, $t(90) = 6.58$, $p < 0.001$. For organic fertilizer, participants' ratings did not significantly differ by source (both ts < 1.4).

Version B ratings were examined in the same way. Participants rated flatulence as least unpleasant when it came from themselves, when compared to their chosen person, $t(88) = 7.10$, $p < 0.001$. Flatulence from strangers was rated as more unpleasant than that of the chosen person, $t(88) = 7.94$, $p < 0.001$. A different pattern emerged for sweat, where ratings were similar for self and chosen person ($t < 1$). This may be one case where the relationship to the chosen person influences ratings. Thus, we separately compared self and chosen person when the latter was a sexual partner versus a family member. When the chosen person was a family member, the difference score was negative ($n = 17$; mean difference $= -1.2$), indicating that the chosen person's sweat was rated as more unpleasant than that of the self. However, when the chosen person was a sexual partner, the chosen person's sweat was judged as more pleasant than self ($n = 57$; mean difference $= 0.7$). Although these two responses significantly differed, $t(72) = 2.00$, $p < 0.05$, a stranger's sweat was still rated as less pleasant than that of the chosen person, $t(88) = 8.87$, $p < 0.001$. Finally, for garbage, participants' felt dislike ratings were *lower* for their chosen person than themselves, $t(88) = 4.16$, $p < 0.001$. A stranger's garbage was rated as more unpleasant than that of the chosen person, $t(88) = 6.58$, $p < 0.001$, and themselves, $t(88) = 3.21$, $p < 0.002$.

Do Source Effects Differ between Odours?

In comparing the size of the source effect between different odours, faecal odours appear to show the largest effects (self vs. stranger), followed by non-faecal body odours and non-body foul odours (see

Figure 1). These impressions were tested and confirmed by contrasting the difference between self and stranger for one odour type with that of another. As above, felt dislike ratings were the primary focus, collapsed across person present/absent.

The difference between self and stranger was larger for faeces than for fertilizer, $t(90) = 8.99$, $p < 0.001$; larger for feet than for fertilizer, $t(90) = 5.22$, $p < 0.001$; and larger for faeces than for feet, $t(90) = 4.74$, $p < 0.001$. In Version B, the difference between self and stranger was larger for flatulence than garbage, $t(88) = 11.22$, $p < 0.001$; larger for sweat than garbage, $t(88) = 6.96$, $p < 0.001$; and larger for flatulence than for sweat, $t(88) = 3.37$, $p < 0.001$.

Were the Odours Judged Equally Unpleasant?

To assess this, the odour from the stranger vignettes, collapsed across person present/absent for actual felt rating were employed. The stranger ratings were chosen because we thought these likely represented the hedonic response free of any hypothesized exposure effect. For Version A, there were significant differences between ratings for faeces ($M = 4.1$), feet ($M = 3.4$) and organic fertilizer ($M = 2.2$; all $t(90)$s > 7.33). For Version B, there were also significant differences between ratings for flatulence ($M = 4.3$), sweat ($M = 3.8$) and garbage ($M = 3.4$; all $t(88)$s > 3.54). On this basis, faecal odours were the most unpleasant, followed by body odours and foul non-body odours.

Validity

As noted earlier, previous laboratory-based research has suggested that larger hedonic effects are obtained when the dependent variable is self-report rather than facial expression. This was explored here by simply testing for a main effect of rating type (felt vs. shown) across all conditions (and both versions). Overall, the mean for all felt ratings was -3.0, whereas for shown ratings it was -1.9. This difference was significant, $t(178) = 19.98$, $p < 0.001$. In at least two previous studies, the presence of an experimenter led to reduced facial expressiveness. This was explored here by comparing display (shown) ratings when either the chosen person or a stranger was present and when they were absent, across odour type (and both versions). When either the chosen person or stranger was present, ratings of displayed emotion were reduced ($M = -1.8$) compared to when they were absent ($M = -2.1$), $t(178) = 5.00$, $p < 0.001$.

The relationship between disgust sensitivity scores and each of the 36 hedonic ratings (shown and felt by version) were examined using Pearson correlation coefficients. The median correlation for Version A was -0.29 (range 0.01 to -0.43) and for Version B, -0.35 (range -0.13 to -0.50), both of which were significant ($p < 0.05$). Overall (i.e. versions combined), correlations were stronger between disgust sensitivity and felt ratings (median $r = -0.33$) than with shown ratings (median $r = -0.28$; Wilcoxon test, $Z = 2.63$, $p < 0.01$). In addition, correlations between vignette ratings and disgust sensitivity were greater when the participant was the odour source (median $r = -0.36$), rather than chosen person (median $r = -0.29$) or stranger (median $r = -0.26$), Friedman test $= 12.17$, $p < 0.05$.

Discussion

Study 1 set out to explore a number of predictions derived from the disease avoidance model of core disgust. It was predicted that variations in disease risk, produced by changing an 'odour's' source and

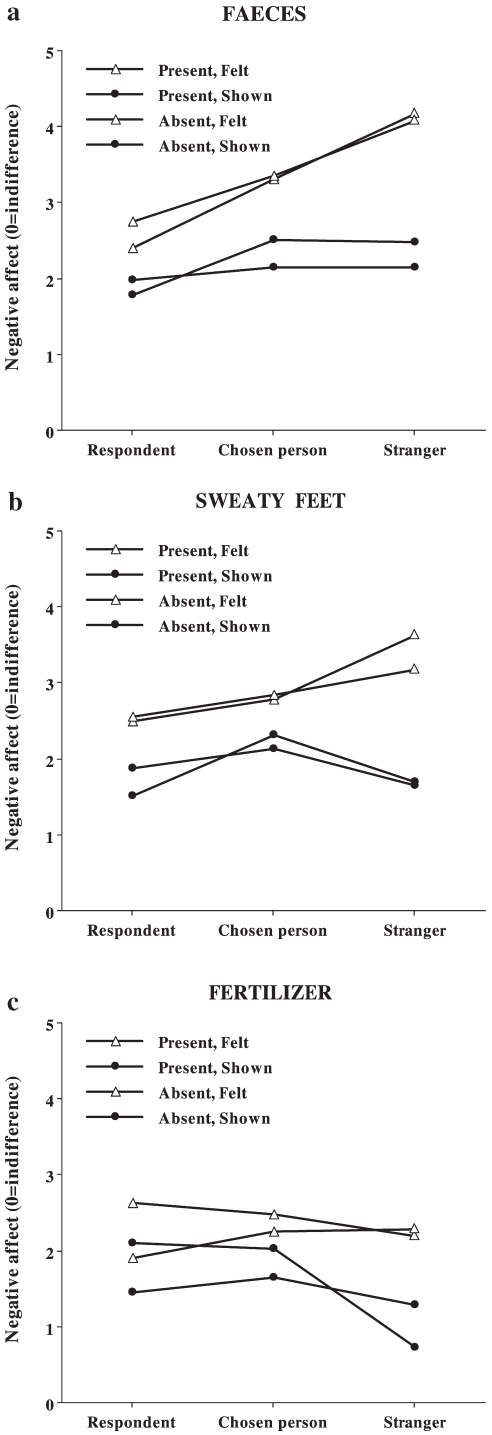

Figure 1. Mean ratings of felt dislike and 'shown disgust' (i.e. what the participant predicts they would show) for (a) faeces, (b) feet and (c) fertilizer, when the source of the odour was either present or absent for Version A of the questionnaire.

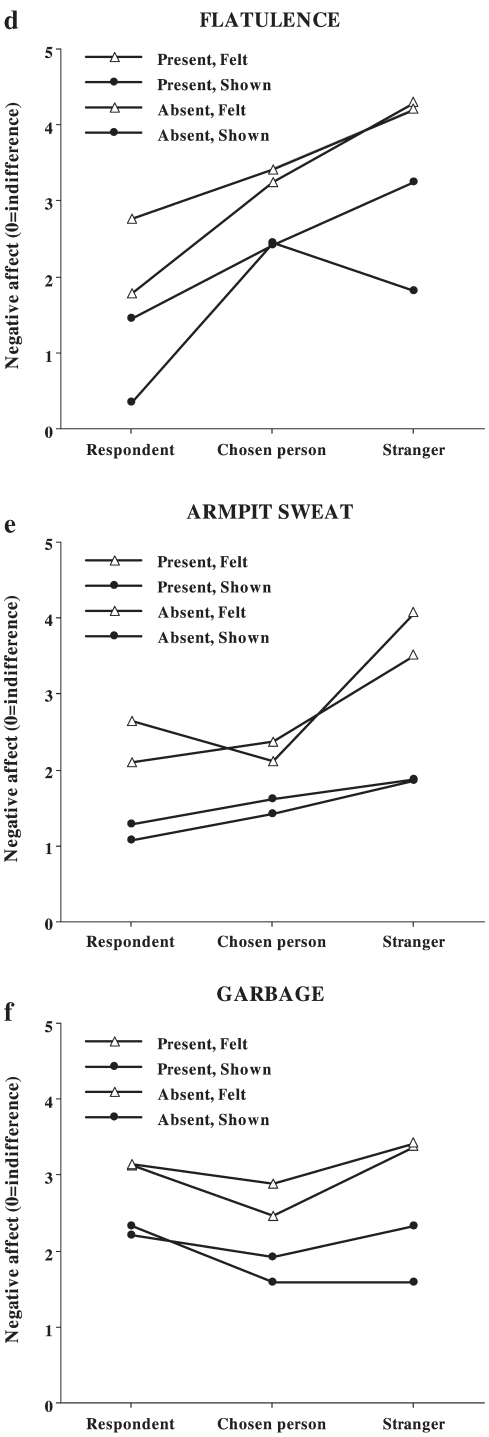

Figure 1. (Continued) Mean ratings of felt dislike and 'shown disgust' (as above) for (d) flatulence, (e) armpit sweat and (f) garbage, when the source of the odour was either present or absent for version B of the questionnaire (Study 1)

type, should influence participants' judged hedonic response. The results were highly consistent with these predictions. For faecal 'odours', where pathogen risk should increase from self to stranger, response strength also increased. A similar effect was observed for non-faecal body 'odours', although, in accordance with disease risk, it was significantly smaller. For foul non-body 'odours', where pathogen risk should be broadly equal regardless of 'odour' source, there was no source effect in one case (organic fertilizer) and only a small effect in the other (garbage). One criticism that can be made of such self-report data is that they do not reflect how participants would normally behave, that is, the source effect may represent some artifact of the procedure. In an attempt to address this issue we conducted a second study.

STUDY 2

Study 1 indicated that hedonic responses, especially to body malodours, can be influenced by their source. Although this study evidenced good validity, demonstrating a source effect using real odours would be far more compelling. For reasons discussed in the Introduction, a laboratory-based approach to this problem was not a viable option. A more acceptable compromise, however, was to ask volunteers to record their hedonic reactions to malodours as they encountered them in their day to day life. This type of diary-based approach has not previously been applied to olfactory tasks, but should be well suited, given that participants simply need to record their hedonic response to an odour when they encounter it. As the study was anonymous and only volunteers were used, it was anticipated that this should encourage frank responding. Our basic question then, was whether or not we could still obtain a source effect under conditions where hedonic ratings were made soon after the real odours were actually encountered outside of the laboratory.

Method

Participants

Thirty-three diary kits were distributed to members of the Macquarie University community who had contacted the researchers in response to various advertisements. Sixteen complete diaries were returned. Of these 16, seven participants were aged between 16 and 25, three between 36 and 45, five between 46 and 55 and one was over 66. Five participants were male and 11 were female.

Procedure

Over 5 days, participants were asked to record anew, each day, their first encounter with any of 22 listed odours. These remained the same across the study and were: [*Outside the home smells*] After rain smell, body odour (other person), cigarette smoke (other person), flatulence (other person), garbage (other person), hot bread, breath (other person), toilet at work or university after use—faecal smell (other person) and vehicle fumes; [*Inside the home smells*] body odour (other person), body odour (self), coffee, flatulence (other person), flatulence (self), frying onions, Parmesan cheese, perfume/deodourant (other person), perfume/deodourant (self), shoes after being worn (other person), shoes after being worn (self), toilet after use—faecal smell (other person) and toilet after use—faecal smell (self). At least three ratings were completed whenever an odour was initially encountered on a day. First, an 11-point hedonic scale (Dislike extremely [−5], Indifferent [0] and Like extremely [5]). Second, a Yes/No forced-choice response as to whether the odour was disgusting. Third, a Yes/No forced-choice response as to whether these two preceding ratings had been made within 5 min of

smelling the odour. In addition, for all odours whose source was a third party (e.g. flatulence [other person]), the participant was asked to indicate whether or not they knew the person (yes or no). Only minimal biographical data were collected (age by band and gender), so that the participant could not be identified. Completed responses were mailed back to the investigators and no incentive was offered for participation.

Analysis

Because many participants had missing data (i.e. not everyone encountered every type of odour on every day), key scores were assembled by averaging responses both across the 5 days of data collection and across selected odour types. Three types of scores were produced. First, *Self Ratings*, composed of body odour (self), flatulence (self), shoes after being worn (self) and toilet after use (self). Second, *Other person ratings (External)*, composed of body odour, flatulence, breath and toilet. Third, *Other person ratings (Internal)* composed of body odour, flatulence, shoes and toilet. These three scores were generated for hedonic ratings, disgust responses and time of rating. Because the averaging process effectively rendered the disgust and time scores as continuous variables and these data met assumptions necessary for parametric testing, all data were analysed using paired *t*-tests.

Results and Discussion

Participants varied in their propensity to report smelling different odours, with a mean number of 10.5 of the 22 odours that could be reported per day ($SD = 6.6$). Body odours coming from the self (self ratings) were judged as being significantly less unpleasant ($M = -1.7$) than those from other people, both within the home ($M = -2.8$, $t(14) = 4.08$, $p < 0.001$; one participant reported no odours for other people within their home), and outside of the home ($M = -2.6$), $t(15) = 2.62$, $p < 0.02$. There was no significant difference between the inside and outside home ratings ($t < 1$). This may have been because the majority of the outside home body odours arose from people the participant knew.

Participants' disgust ratings revealed similar findings. Body odours coming from the self were judged as being less disgusting ($M = 1.5$) than those from other people within the home ($M = 1.2$), $t(14) = 2.90$, $p < 0.02$, but only approached significance for those outside of it ($M = 1.3$), $t(15) = 1.69$. Participants' ratings of time delay were also examined. When the odours were smelled within the home, there was no difference in the speed with which ratings were entered into the diary for their own odours ($M = 1.3$) versus those from other people ($M = 1.3$). Outside the home, however, participants took longer to record other people's odours than they did for their own odours at home ($M = 1.4$), $t(15) = 2.51$, $p < 0.025$).

Under naturalistic conditions, where ratings are made soon after the event, participants still judge their own body odours as being less foul and disgusting than those of other people. In so far as the diary reports are accurate, and there is no obvious reason why participants should fabricate responses, people do appear to be less disgusted by their own body odours than those of other people. The following studies explored why this might be so.

STUDY 3

The aim of Study 3 was to replicate the source effect reported in Study 1 using a different population but with a similar procedure (vignettes varying odour [faecal, perfume and fertilizer] and source [self,

chosen person, neighbour, architect and electrician]) and more importantly, evaluate whether the source effect results from the influence of social status and/or a halo effect. In Study 1 the stranger, when identified, was drawn from a lower socio-economic group than the largely white, middle-class student body that completed the questionnaire. It is conceivable that the potency of the stranger manipulation arose not from the fact that the target was a stranger, but from the fact that they were in a lower socio-economic group. This type of effect was discussed extensively in George Orwell's novel *The Road to Wigan Pier* (Secker & Warburg, London, 1937) in which he critically examined his own class prejudices. To quote, he ascribed these feelings to the fact that 'the lower classes smell' (see pp. 129–132). Such social status effects, applied to smell, have not been formally studied, but they might account for a significant proportion of the source effect if the stranger is perceived as having a low socio-economic status (SES). To test this, we provided stranger vignettes for both a low and a high SES group (electricians vs. architects) and later had participants rate the salary, education and prestige of both these occupations plus those of their chosen person and their next door neighbour, both of whom featured in the vignettes described in the procedure below. In essence, if SES is important, then a much larger source effect should be obtained for the electrician vignette than for the architect vignette relative to self. Likewise, the magnitude of the source effect for chosen person, neighbour, architect and electrican might also be mediated by SES.

The second account is that the less negative ratings for malodours emanating from loved ones, are due to a halo effect. Because respondents love their chosen person, this might influence their ratings in a positive way, such that in general, this person is judged less negatively (or more positively) than people they know less well or not at all. To test this possibility, we asked participants to evaluate a new set of vignettes, in which the target odour was hedonically positive—perfume. Clearly, there is no disease risk associated with perfume, however, mere exposure may act to moderate people's responses to any odour, good or bad. Thus, when the chosen person is a sexual partner, the perfume might be encountered more frequently because of intimate contact, relative to when the chosen person is a blood relative. Consequently, the exposure account predicts a differential response, as was observed for the sweat odour vignette in Study 1. In contrast, the halo account predicts an equal response in both cases, because the chosen person is the one to whom the respondent is most emotionally attached. It is important to note, however, that for faecal odours, both exposure and halo accounts predict the same outcome, because exposure levels should be more similar across the two types of chosen person.

Method

Participants

Ninety-five students from Macquarie University participated in the study, with some receiving course credit for their involvement (see Table 1 for more details).

Procedure

Vignettes describing specific odour scenarios were created and systematically varied with respect to the odour's source. Five sources were used: self and chosen person as described for Study 1, neighbour, electrician, and architect. Three types of vignette were completed for each source, using the person-absent condition: faecal smell after using the toilet, organic fertilizer on a garden, and the lingering smell of the person's perfume. After establishing the identity of the chosen person and whether they lived with them, the 15 vignettes were presented in two random orders (one the reverse of the other;

there was no effect of order). Each vignette was rated using the hedonic scale described for Study 1 (felt response, 11-point hedonic rating). These were followed by biographical data (age, gender, sense of smell) as described for Study 1. The perceived social status of the four non-self odour sources was established using three questions for each: earnings (6-point scale of income bins), highest level of education achieved (5-point scale by outcome achieved), and the prestige of the occupation (5-point scale from 'Not at all prestigious' to 'Extremely prestigious'). This was then followed by the DSQ.

Results

Is there a Source Effect?

Mean responses for each odour type and source are illustrated in Figure 2. It is readily apparent that hedonic responses differed by odour source. For faecal odours, the most acceptable was one's own smell, which was significantly different from that of the chosen person ($t(94) = 3.00$, $p < 0.005$), which significantly differed from ones neighbour ($t(94) = 4.11$, $p < 0.001$), which in turn differed from that of the architect ($t(94) = 2.04$, $p < 0.05$). The latter did not, however, differ from the electrician. For the organic fertilizer vignettes, the lowest ratings were for self and chosen person and these did not differ significantly ($t = 1.22$). However, fertilizer smell from the chosen person's garden was judged to smell more acceptable than that of the neighbour's ($t(93) = 4.45$, $p < 0.001$), which did not differ from the architect's or electrician's. For perfume, the highest ratings were obtained for self and chosen person and these did not significantly differ. However, the chosen person's perfume was more acceptable than that of the neighbour ($t(93) = 9.19$, $p < 0.001$); the neighbour's perfume was more acceptable than the architect's ($t(94) = 3.64$, $p < 0.001$); and the architect's was more acceptable than the electrician's ($t(94) = 2.71$, $p < 0.01$).

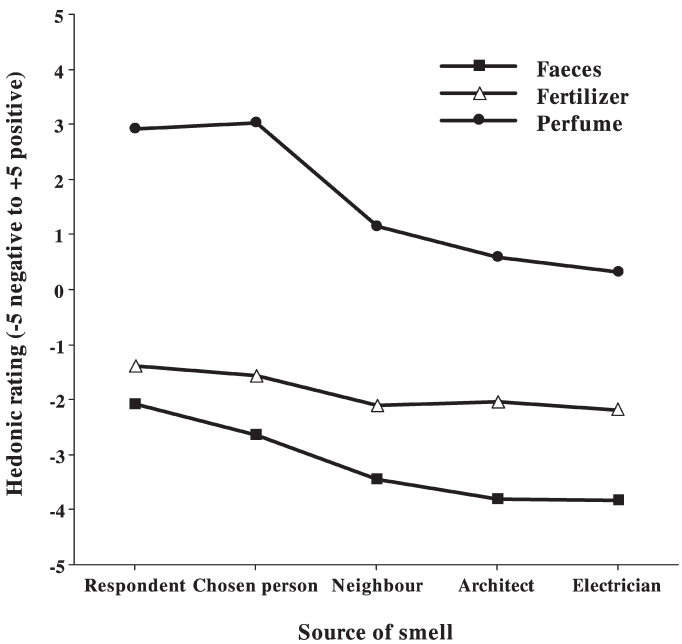

Figure 2. Mean hedonic ratings for faeces, fertilizer and perfume, by odour source (Study 3)

Halo Effect

Forty-seven participants selected their partner as their chosen person, whilst 30 selected family members, principally parents ($n = 23$). The remainder selected friends, and although these were excluded from this analysis, it is worthwhile noting that they gave identical means for the perfume of self and chosen person, but showed a source effect for faecal odours. Participants' perfume and faecal odour ratings were analysed using a three-way analysis of variance (ANOVA), with Chosen person (relative or partner) as a between-participants factor and two within-participant variables, Odour type (perfume and faecal) and Source (self and chosen person). Of central interest was the three-way interaction between Chosen person, Source and Odour type ($F(1, 75) = 6.22$, $p < 0.025$), which is illustrated in Figure 3. It is readily apparent that both groups show a source effect for faeces, but that each shows the opposite pattern for perfume. When the chosen person is the partner, the partner's perfume is judged to smell nicer than one's own. When the parent is the chosen person, one's own perfume is judged to smell nicer than one's parents. If the strong emotional attachment dictated responses toward one's chosen person (i.e. the halo effect), this would not predict a difference. Effects were also obtained for Source and Chosen person ($F(1, 75) = 10.54$, $p < 0.01$) and Odour type ($F(1, 75) = 409.15$, $p < 0.001$), but as these are subsumed under the three-way interaction described above, they are of little interest.

Social Status

As indicated in the preceding analysis, and as can be seen in Figure 2, the magnitude of the source effect for the architect and electrician were the same and did not significantly differ. However, there

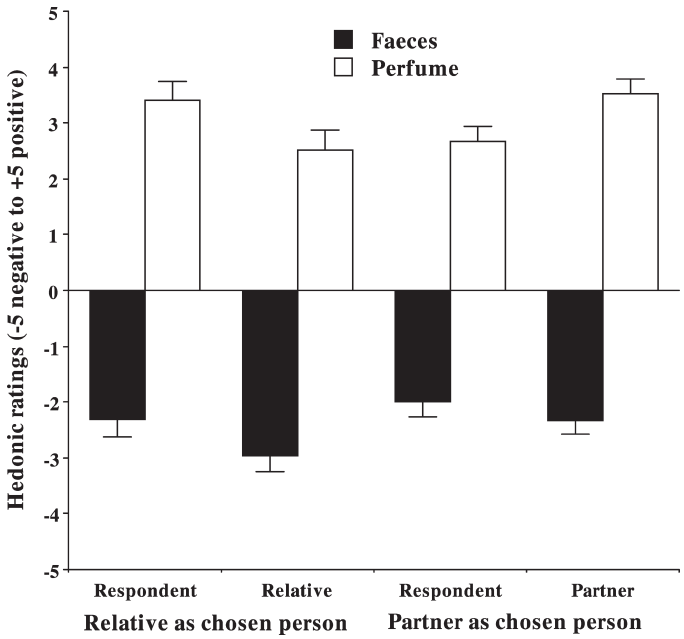

Figure 3. Mean hedonic ratings (and standard error) for faeces and perfume, by whether the chosen person was a sexual partner or a family member (Study 3)

were very large differences in judged social status (collapsing across income, education and prestige) between these two occupations ($t(93) = 21.07$, $p < 0.001$), clearly indicating that participants believed that an architect had the higher SES (architect mean = 12.6/16 vs. electrician mean = 8.5/16). By the same token, the chosen person was judged significantly poorer in SES terms (mean = 8.8/16) relative to the architect ($t(92) = 12.34$, $p < 0.001$) and to the neighbour ($t(92) = 2.47$, $p < 0.025$; mean for the neighbour = 9.7/16), yet in each of these instances too, the chosen person was regarded as more fragrant.

There were, however, some limited effects of social status that were most readily apparent by comparing the vignette responses for the architect and the electrician. The difference in hedonic ratings for perfume significantly correlated with the difference in reported social status for these occupations (Pearson's $r(93) = 0.36$, $p < 0.001$), as did their difference in social status with the difference in hedonic ratings for faeces (Pearson's $r(93) = 0.28$, $p < 0.01$). The same trend was apparent for organic fertilizer ($r(93) = 0.17$). Thus, when both persons were unknown, social status influenced ratings in a positive manner, but there was no evidence that social status could explain the large difference in response between self and these sources, as both received similar ratings for faeces, the key comparison.

Validity

We also assessed whether the DSQ was related to the faecal ratings given in the various scenarios. The largest correlation was for self and disgust sensitivity ($r(95) = -0.33$, $p < 0.01$) and only one other was significant, neighbour and disgust sensitivity ($r(95) = -0.25$, $p < 0.02$). In these two cases, greater disgust sensitivity was associated with more aversive responses. For the other sources, all were negatively correlated, but none reached significance. The magnitude of the source effect was also correlated with disgust sensitivity. Larger source effects tended to co-occur with larger disgust sensitivity ratings for self vs. chosen person ($r(95) = 0.28$, $p < 0.01$), self vs. electrician ($r(95) = 0.21$, $p < 0.05$), and self vs. architect ($r(95) = 0.21$, $p < 0.05$), but not for self vs. neighbour. Thus, participants' responses were, at least in part, related to an independently validated measure of disgust.

Discussion

Although we successfully demonstrated the source effect, there was no evidence that it resulted from either a halo effect or the social status of the stranger. The halo effect could not account for differences in perfume evaluations between partners and family members. Because these persons were identified by the respective participants as the person they most liked and cared for, the halo effect should have operated equally in both groups, but it did not. Rather, the results are more consistent with the effects of mere exposure, which is likely to produce greater exposure to some of your partner's odours, such as their body odour and their perfume. Evidence consistent with this was also observed in Study 1 (sweat data) and the putative effects of exposure are tested more explicitly in Study 4. The other account explored here was that the low SES of the stranger in Study 1 conflated SES and strangerness. This was directly tested here by comparing architects with electricians, two occupations which the participants judged to be significantly different in terms of SES. Despite a large SES difference, the size of the source effect between them, for faeces, was statistically identical. Nonetheless, our procedure was sensitive enough to pick up some small effects of SES, in that for perfume and faeces, and possibly too for fertilizer, there was a tendency to show a smaller difference in hedonic ratings between these two occupations when SES was also judged to be closer.

STUDY 4

Studies 1, 2 and 3 all demonstrate that the source of a malodour, especially when it is a faecal or other body odour, can influence participants' hedonic ratings. The explanation that we have consistently identified as being important, is that participants come to know the various smells of their own body and those close to them, and that this process of exposure acts to reduce disliking—the mere exposure effect (Bornstein, 1989; Zajonc, 1968). This account relies upon body odours being distinguishable and to some degree, consistent. Currently, both of these issues can only be addressed for human sweat, as data are simply not available for other foul odours. For sweat, there are differences between individuals (Kalmus, 1955) which appear to be based on genetic variation, dietary differences, and personal hygiene (Porter, Balogh, Cernoch, & Franchi, 1986; Shelley, Hurley, & Nichols, 1953; Wallace, 1977). Individuals are able to distinguish between the body odours of different people (Schleidt, Hold, & Attili, 1981) and identify sweat odours of their kin (Porter et al., 1986). Most importantly, when making blind odour ratings, participants tend to judge their own sweat as smelling more pleasant than that of a stranger (McBurney, Levine, & Cavanaugh, 1977). Thus, in principal at least, it may be possible for mere exposure to underlie the source effect.

One problem with this explanation is that greater exposure is likely to occur towards people that one likes (i.e. oneself, partner, family), thus exposure is confounded with attachment or liking towards the source—the halo effect. In this study we control for this possible confound by examining whether *degree* of attachment to the odour source or *degree* of exposure to its malodours, better predicts the source effect. We explored this in a rather novel way by studying dog owners and their pets, as we expected considerable variation in the degree of attachment between an owner and their pet and in the degree to which the owner looked after the physical needs of their dog, including clearing up its faeces (i.e. exposure). Consequently, we examined two issues. First, do dog owners demonstrate a source effect—that is, do they rate their own dog's malodours as being less unpleasant than those produced by someone else's dog. Second, does their attachment to their pet or their degree of exposure to its body products, best predict (1) hedonic response to their dog's faeces (measured using vignettes) and/or (2) the magnitude of the source effect (i.e. the difference between hedonic ratings of their own dog and another person's dog faeces).

Method

Participants

Sixty-three dog owners (26 male and 37 female) all members of the Macquarie University community, volunteered to participate in this study. Forty five were aged between 16–25, 14 between 36–55 and four were over 56. Forty eight currently had just one dog, 15 had two or more, and 45 had previously owned dogs prior to their current one. Twenty three had kept dogs for under 5 years, 12 for between 5–9 years, 10 for 10–20 years and 18 for more than 20 years.

Procedure

The questionnaire was divided into four parts. The first collected biographical details about participants, their dog and their history of dog ownership. If a participant owned two or more dogs, they were asked to focus their subsequent responses consistently on one of their animals. The second

part of the questionnaire collected information about the participant's role in the physical care of their dog. This consisted of seven questions concerning, feeding, washing, walking, cleaning up, and attending to the medical needs of their dog. For each question, participants were asked how frequently they dealt with that aspect of their dog's care, by selecting one of the following responses: Always, Mostly, Sometimes, or Never. Each of the seven items was scored 0 (Never) to 3 (Always) and scores were combined to provide a proxy measure of exposure to the various odours produced by their dog (hereafter the Exposure score). The third part of the questionnaire collected information about the participant's degree of emotional attachment to their dog. This consisted of evaluating (Agree, Unsure, Disagree) the following eight statements: I feel that my dog is 'part of the family'; I celebrate my dog's birthday; I include my dog in Xmas celebrations; I let my dog sleep on my bed; I let my dog lick my face; I greet my dog when I get home; I feel my dog is irreplaceable; and If my dog passed away, I would feel as sad as if a close friend had died. After scoring each item (Agree = 2, Unsure = 1, Disagree = 0), responses were summed to produce a scale reflecting participants' emotional attachment to their dog (hereafter the Attachment score).

The final part of the questionnaire involved evaluating four vignettes. The order of the vignettes was counterbalanced across participants. Two of the vignettes involved the participant's dog: (1) faeces from their dog got on their shoe and (2) they had to clear up their dog's faeces from their back yard. The other two vignettes were identical except that faeces from 'someone else's dog' was substituted in each vignette. After reading a vignette, participants were asked how they thought the smell would make them feel. They rated their responses on five 7-point category scales (Would not feel sick to Would feel very sick; Would not feel disgusted to Would feel very disgusted; Would feel indifferent to Would find the smell very bad; Would tolerate the smell to Would find the smell intolerable; and Would not make me angry to Would make me very angry). For each of the four vignettes, scores for these different rating scales were all highly correlated, rs > 0.60. Thus, a combined score was used in all the analyses. After a participant had completed each vignette, they were asked whether or not the scenario had ever actually happened to them (Yes, Unsure, No). Finally, participants completed the 32-item DSQ (Haidt et al., 1994). All the questionnaires were completed individually.

Results

Do Dog Owners Demonstrate a Source Effect?

Figure 4 illustrates participants' hedonic ratings for each of the four vignettes (your dog/shoe, your dog/yard, someone else's dog/shoe, someone else's dog/yard). A two-way repeated measures ANOVA, with odour source (participant's vs. someone else's dog) and vignette type (shoe vs. yard) was employed. The ANOVA revealed a main effect of odour source, $F(1, 56) = 76.26$, $MSE = 1.09$, $p < 0.001$ (three cases had missing data), indicating that, overall, participants rated the smell of someone else's dog's faeces as more repellant than that of their own dog. There was also a main effect of vignette type, $F(1, 56) = 18.97$, $MSE = 0.53$, $p < 0.001$, with participants reporting that, regardless of the odour's source, the shoe scenario was worse than the yard scenario. The two main effects interacted, $F(1, 56) = 28.44$, $MSE = 0.43$, $p < 0.001$. Figure 4 suggests that the source effect was larger in the yard than in the shoe scenario. Nonetheless, a post-hoc paired t-test indicated that the shoe scenario source effect was still significant, $t(60) = 5.08$, $p < 0.001$.

The effect of having actually experienced the scenarios was explored by repeating the ANOVA described above, but now including Experience as a between-participant factor. Participants were classified on the basis of whether they had experienced all of the vignettes ($n = 22$) vs. only some or none ($n = 38$). The ANOVA revealed no interaction between Experience and any variable. Apart from

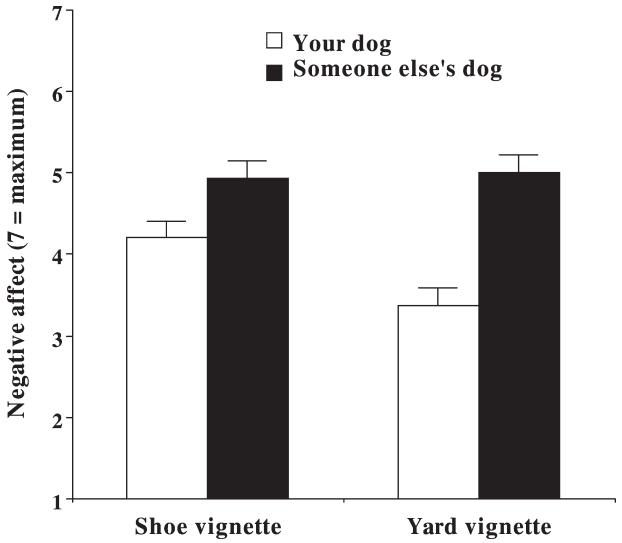

Figure 4. Mean hedonic ratings (and standard error) for each of the dog vignettes (Study 4)

main effects of odour source and vignette type, and their interaction (see above), the only other effect was that of Experience, $F(1, 58) = 4.71$, $MSE = 8.81$, $p < 0.05$. This main effect suggested that when the vignettes had actually been experienced, less negative ratings were produced overall (mean difference = 0.9).

Exploring the Exposure Account of the Source Effect

There was considerable variation in the degree to which participants cared for the physical needs of their dog (possible range = 0–21; observed range = 0–21; $M = 10.6$; $SD = 5.9$) and also in their degree of emotional attachment to their pet (possible range = 0–16; observed range = 2–16; $M = 11.1$; $SD = 3.6$). This variability allowed us to explore the relationships between each of these two measures and (1) expected hedonic response to the faecal odour of one's own dog (mean across both vignette types) and (2) the mean difference between responses to one's own dog and that of someone else (across both vignette types).

The scores from both vignettes concerning the participants' dog were highly correlated, $r(57) = 0.80$, $p < 0.001$, so they were collapsed and the product correlated with the Exposure and Attachment variables. There were significant negative correlations between participants' reported hedonic response to their own dog's faeces and both their Exposure, $r(57) = -0.54$, $p < 0.001$, and their Attachment scores, $r(57) = -0.35$, $p < 0.01$. That is, greater exposure and/or attachment was associated with more positive responses to their dog's faeces. Attachment and Exposure scores were also significantly correlated, $r(57) = 0.33$, $p < 0.01$. Partial correlations revealed that the relationship between Attachment and hedonic response, controlling for Exposure, was not significant, $r(57) = -0.21$, but the effects of Exposure were sustained when variation in Attachment was partialled out, $r(57) = -0.48$, $p < 0.001$.

An alternate approach is to determine the relationships between the magnitude of the source effect (someone else's dog minus your dog) and the Exposure and Attachment variables. Although Exposure was significantly related to the magnitude of the source effect, $r(57) = 0.41$, $p < 0.001$, Attachment was not, $r(57) = 0.18$. Not surprisingly, partialling out Attachment had no effect on the relationship

between Exposure and the magnitude of the source effect, $r(57) = 0.38$, $p < 0.005$, and partialling out Exposure on the Attachment-source effect correlation also made little difference, $r(57) = 0.06$. Finally, disgust sensitivity was not significantly correlated with either the Attachment, $r(57) = 0.05$, or Exposure scores, $r(57) = 0.01$.

The data from this study afford two additional tests of the Exposure account. First, if a participant currently owns more than one dog, then they should (on average) be exposed to more faecal odours. Consequently, one might expect a greater degree of tolerance for these smells in multiple rather than single dog owners. This was confirmed by using the number of dogs owned (one vs. more than one) as the independent variable, with mean hedonic rating from the vignettes involving their own dog as the dependent variable. An independent *t*-test revealed that multiple dog owners reported less offence to their dog's faecal odour ($M = 3.0$) than single dog owners ($M = 4.1$), $t(59) = 2.17$, $p < 0.025$, one-tailed.

A further test of the exposure account is provided by the length of time that participants reported owning dogs. To test this, participants were classified into those who had owned dogs for more than 20 years versus those who had owned them for less. This classification was chosen to maximize the chance of observing an effect. An independent *t*-test revealed a significant effect of length of ownership, $t(59) = 1.72$, $p < 0.05$, one-tailed, with long-term dog owners reporting less offence to their dog's faecal odour ($M = 3.2$) than short-term owners ($M = 4.0$).

Validity

Validity was explored by examining correlations with the DSQ. There was a significant association (i.e. $p < 0.05$) between each of the four vignette scores and disgust sensitivity—your dog-yard, $r(57) = 0.37$; your dog-shoe, $r(57) = 0.43$; someone else's dog-yard, $r(57) = 0.63$; and someone else's dog-shoe, $r(57) = 0.62$. Thus, higher levels of reported dislike for dog faecal odours were associated with higher levels of reported disgust sensitivity.

Discussion

Study 4 examined two questions. First, could a source effect be obtained with dog owners' reactions to their pet's faecal odours. Second, could this source effect be accounted for by participants' attachment to their pet, or by exposure to their dog's malodours. The results suggested that a source effect was evident in this group, with participants' rating the smell of their own dog's faeces as being less unpleasant than that of someone else's dog. In addition, the results indicated that exposure to one's own dog malodours, provides a better explanation of the source effect than attachment.

STUDY 5

So far, we have not assessed whether participants believe that when the source of a disgust elicitor is a stranger, this poses a greater health hazard than when the source is the self. Study 5 explored this by examining the basic source effect for self versus a new next door neighbour, in which the neighbour visits to introduce themselves and uses the toilet (vs. you using the toilet) and in which the new neighbour's garbage bin is inadvertently knocked over (vs. you knocking over your own garbage). The proxy cues for the disgust elicitors were the smell of faeces and the smell of garbage. In each case, after making their hedonic ratings for each of these four scenarios, participants were asked about likelihood of engaging in three hygiene-related behaviours. For the faecal scenarios, these were

cleaning any part of the toilet before using it, avoiding touching any part of the toilet whilst using it, and hand cleaning after use. For the garbage scenarios, which involved accidentally knocking over a garbage bin when parking your car and then having to pick up bags of garbage, the questions were: would you avoid touching the garbage bags (i.e. wear gloves), would you wash the parts of your car that came in contact with garbage, and after clearing it up, what hand washing behaviour would be engaged in. Scores were then derived for hygiene-related behaviour and for hedonic responses to these hypothetical scenarios. Finally, in each scenario, participants were asked an open-ended question about why they would engage in any of these particular behaviours. The aim here was to see whether a concern about germs motivated any of these behaviours. In summary, there are two key questions that we set out to answer. First, whether hygiene-related behaviour would parallel the source effect and second, whether hygiene-related behaviour (and disgust sensitivity) would predict the magnitude of the source effect. These questions should answer two outstanding issues in relation to the disease hypothesis, the extent to which it is explicit and the extent to which greater disease risk is associated with those less well known to you.

Method

Participants

Ninety nine students from Macquarie University, 18 male and 81 female, participated in the study, with some receiving course credit for their involvement. Eighty nine were aged between 16–35 years and 10 between 36–55.

Procedure

Four vignettes were created, two concerning faeces and two concerning garbage. The first asked participants to rate their hedonic reaction to generating a strong faecal smell at home after using their toilet. Hedonic ratings were collected as in Study 3. This was followed by three hygiene-related behaviour questions. The first asked 'Would you normally clean *any part* of your toilet, *before* using it?, responses ranged from 'No, I would not' (1), 'Unsure' (2) to 'Definitely Would' (5). The second asked 'Would you normally avoid touching *any part* of your toilet, *whilst* using it?' and the same scale was used again. The third asked 'In this situation, would you clean your hands more carefully than normal *after* using your toilet?'. The same response scale was used again. If participants responded to any of the hygiene questions with a score of 3–5 ('Possibly would', 'Probably would' or 'Definitely would') they were then asked why they would engage in this (or these) behaviours. The second vignette asked participants the same questions. The third vignette concerned accidentally knocking over your own garbage bin when parking and spilling bags of rubbish over your car and the road. Participants were also told that whilst clearing the bags up, they would experience a strong smell of garbage. Again, participants made an hedonic evaluation of the smell and then proceeded to answer three hygiene-related questions. First they were asked 'Whilst clearing up the garbage bags, would you avoid touching any part of them (e.g. use gloves)'. The response scale was the same as described for the previous vignettes. The second question asked 'After clearing up the garbage bags, would you wash the parts of your car where the garbage fell?'. The same scale was used for this and the third question which asked 'After clearing up the garbage bags, would you clean your hands more carefully than normal?'. The same question regarding motivation for any hygiene-related behaviour was then elicited. The fourth vignette used the same basic design and questions, except this time it was the

neighbour's garbage bin that was knocked over. All participants then completed age, gender and sense of smell biographical questions followed by the DSQ.

Results

As illustrated in Figure 5, hedonic ratings increased for both the faecal and garbage vignettes, from self to stranger. Both these changes were significant ($t(98) = 11.27$, $p < 0.001$; $t(98) = 5.06$, $p < 0.001$, respectively) and the magnitude of the source effect was greater for the faecal scenario ($t(98) = 8.16$, $p < 0.001$). For the composite hygiene behaviour score (see Figure 5), this too increased in both the faecal ($t(98) = 3.43$, $p < 0.001$) and garbage scenarios ($t(98) = 5.30$, $p < 0.001$), but importantly, there was no significant difference in the degree of change between these two conditions ($t < 1$). That is, the extent to which the hedonic ratings changed between the two odour cues by source, appeared to exceed the extent to which hygiene-related behaviours changed, and this difference was significant ($t(98) = 3.60$, $p < 0.001$). The import of these findings is that whilst 'explicit' hygiene-related behaviour increased uniformly from self to neighbour, irrespective of disgust elicitor, hedonic changes were significantly greater for the faecal vignettes.

To explore the degree to which hygiene behaviour and disgust sensitivity predicted changes in hedonic ratings, two regression analyses were carried out. For the first, the dependent variable was change in hedonic ratings from self to neighbour for the faecal vignette, with the predictor variables being changes in hygiene-related behaviour and disgust sensitivity. The model failed to significantly predict changes in hedonic ratings ($R^2 = 0.02$), however, the semi-partial correlation coefficients revealed a marginally significant effect of disgust sensitivity. For garbage, the same type of regression analysis was conducted with a very different outcome. Here, the overall model was significant ($R^2 = 0.15$; $F(2, 96) = 9.53$, $p < 0.001$) and hygiene-related behaviour was the only significant predictor (squared semi-partial correlation coefficient = 0.15). Thus, whilst changes in 'explicit' hygiene-related behaviour significantly predicted changes in hedonic ratings for the garbage source effect, such ratings were not able to predict similar changes for the faecal source effect.

Finally, a germ-based explanation for any hygiene-related behaviour was scored (responses classed as such included; infection, bacteria, disease, avoiding getting sick, sanitary reasons, etc). For the self-faecal vignette, of the 85/99 participants who reported a hygiene behaviour, 51 (60%) reported a germ-related reason. For the neighbour-faecal vignette, of the 82/99 participants who reported a hygiene behaviour, 52 (63%) reported a germ-related reason. For the self-garbage vignette, 96/99 participants who reported a hygiene behaviour, 65 (68%) reported a germ-related reason. For the neighbour-garbage vignette, of the 95/99 participants who reported a hygiene behaviour, 62 (65%) gave a germ-related reason.

Validity

As in Study 1, we assessed whether disgust sensitivity was related to the ratings given in the various scenarios. Participants' hedonic ratings for both faeces and garbage were all significantly correlated with their disgust sensitivity score (self faeces $r(99) = -0.34$; neighbour faeces $r(99) = -0.38$; self garbage $r(99) = -0.32$; neighbour garbage $r(99) = -0.46$; $p < 0.05$ in all cases). For the hygiene behaviour score, ratings for three out of the four vignettes were significantly correlated (self faeces $r(99) = 0.13$ $p > 0.05$; neighbour faeces $r(99) = 0.24$; self garbage $r(99) = 0.33$; neighbour garbage $r(99) = 0.40$). Thus, disgust sensitivity was predictive of both the degree of disgust felt towards the various scenarios and the degree of hygiene related-behaviour that the respondent claimed they would engage in.

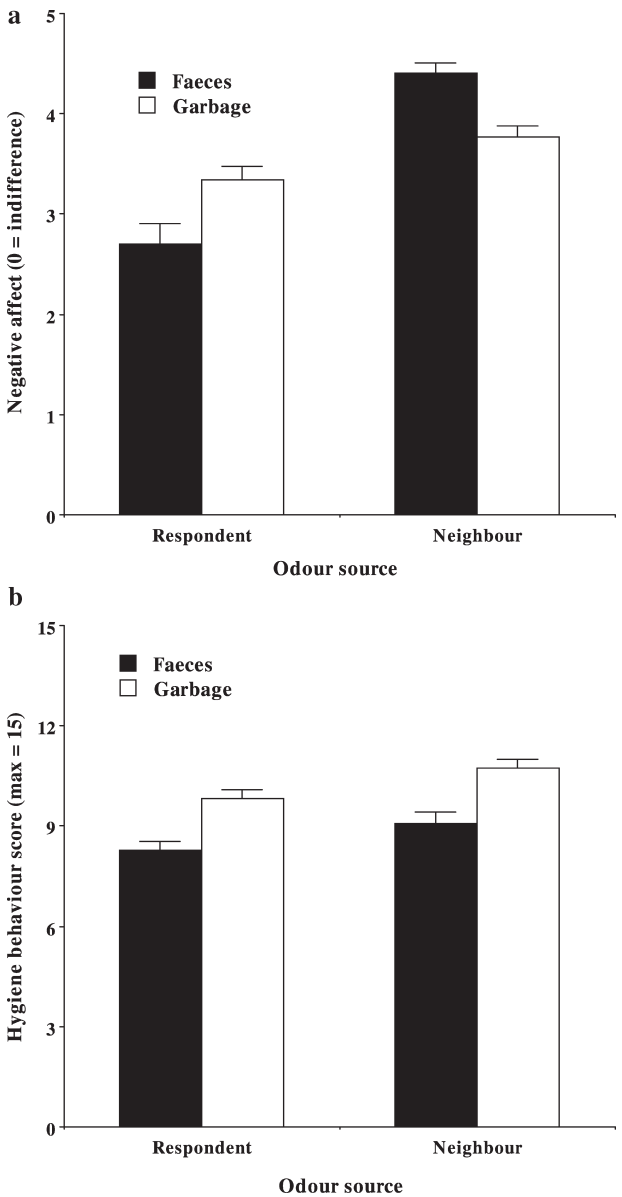

Figure 5. (a) Mean hedonic ratings (and standard error) and (b) mean hygiene behaviour ratings (and standard error) for the faeces and garbage vignettes by odour source (Study 5)

Discussion

Participants' perception of disease risk, as assessed by the hygiene-related behaviours they would reportedly engage in, revealed that risk assessments do increase when the source of an odour (and thus its associated disgust elicitor) is produced by someone other than self. However, this explicit knowledge clearly does not account for the source effect for the faecal odour, but does account for some of the variance in the source effect for the garbage odour. Obviously, in these vignettes, contact

with the disgust elicitor was far more direct for garbage, than for faeces, nonetheless, the key conclusions are based upon the degree of change within each scenario as source varied from self to neighbour. Consequently, any absolute differences in response should not affect our conclusions.

As we suggested in the Introduction, there are at least two ways in which one might gauge disease risk. The first is simply based upon explicit knowledge, and this clearly does appear to be the case, at least for the garbage vignette described here. Under these conditions, participants' hedonic ratings appeared to change in concert with changes in hygiene-related behaviour, and much of the change in hygiene-related behaviour is directly explained by participants as a desire to avoid getting sick. The second method of gauging disease risk has to be inferred. Although the previous study (Study 4) revealed that exposure could account for changes in the magnitude of the source effect for reactions to dog faeces, supporting a role for exposure in these effects, we can only suggest that this mechanism functions as a proxy measure of disease risk. It is plausible, of course, that reductions in negative hedonic responses are just an incidental consequence of exposure and that they have some other (or no) adaptive value and we shall explore this theme further in the General Discussion.

GENERAL DISCUSSION

This series of studies had two basic aims. First, to establish whether source effects occur and second, to establish what mechanism might underlie them. In respect to the second aim, we were also interested in establishing whether a disease avoidance model might provide an overarching explanation. Before turning to the question of what might explain the source effect, it is worthwhile evaluating how robust the evidence for it is. First, the source effect was obtained on five occasions, using different populations and research designs. Second, the source effect was obtained even when participants made ratings under conditions which might be expected to eliminate it. Namely, when completing the diaries, participants may have felt less able to rate their housemates, friends, family or lover, as smelling less pleasant than themselves. Third, unexpected findings emerged which were entirely consistent with the existence of the source effect, notably the influence of *who* the chosen person was on odours such as sweat and perfume. Fourth, anecdotal reports of source effects in the literature (e.g. (Classen, 1992, p. 135; Jones, 2000, p. 61; Largey & Watson, 1972, p. 1022) and the one finding reported in a web-based survey by Curtis et al. (2004), the *only* available data prior to this study, tend to favour their existence, rather than their non-existence (Royzman & Sabini, 2001, p. 49). In sum, the pattern of results obtained here are confirmatory and lend support to the basic notion that for primarily interpersonal odours, especially faeces, one's own odours smell less offensive than those from other people.

The first key question here is what accounts for the source effect. In Study 3, we explored whether social class and/or a halo effect might produce alterations in hedonic responding, thus generating a source effect. Although social class clearly exerted some influence on participants' hedonic responses, the strongest evidence against it was the equally large source effect for two 'strangers', an architect and an electrician, who significantly differed in social class. An explanation based upon a halo effect also appeared unlikely. Participants were asked to select the person they most liked and cared for, thus we can reasonably argue that the chosen person should exhibit a similar sized halo effect, irrespective of whom that chosen person is (i.e. partner, parent, etc). Contrary to this expectation, when the chosen person was a parent, this person's perfume was rated as *less* pleasant than that of the self, but when the chosen person was a partner, their perfume was rated as *more* pleasant than for self. Thus, the direction of the source effect differed depending on the specific relationship between the respondent and their chosen person, even though this was the person they most liked and cared for. It is interesting to note

the parallel situation observed here for the sweat odour vignette in Study 1. These findings suggest that neither social class nor the halo effect can adequately explain the source effect.

The observation in Study 3 that the source effect for faeces was the same irrespective of whether the source was the respondents' partner or parent and the findings described above for perfume (Study 3) and sweat (Study 1) suggest a different mechanism. Participants are presumably exposed to their own odours more than those of their immediate family, with relatively little exposure to the odours of strangers. In particular, differences in exposure will occur if the chosen person is sexually intimate with the respondent, as this will result in far greater exposure to certain classes of odour, especially sweat and possibly perfume as well. On this basis, exposure might produce the source effect, as greater exposure acts to reduce negative affect, thus greater exposure to sweat and perfume from a sexually intimate chosen person will lead to different outcomes—like those we observed—when contrasted to a non-sexually intimate relationship, such as that between a respondent and their parent.

The effects of exposure were tested more directly in Study 4, taking into account the possible confound between greater exposure towards, and greater liking for, the malodour's source. The results revealed that the source effect, at least in respect to dogs and their owners, could be well predicted by the exposure of their owner to their dog's malodours, but could not be well explained by their degree of attachment to their pet. Moreover, the exposure account received further confirmation from the unexpected finding that ownership of multiple dogs (i.e. more exposure) and ownership of dogs for longer periods of time (i.e. more exposure) were related to a less potent response to their dog's faecal odour. Although we could only infer that exposure might be responsible for the source effect in general and the particular effects observed for sweat in Study 1 and perfume in Study 3, taken together, these findings are all consistent with the hypothesis that differential exposure to malodours can reduce the degree of negative hedonic responding.

The assumption underlying this series of studies is that disease avoidance might modulate disgust through the operation of two mechanisms. An evolutionary mechanism that requires no knowledge of germ theory, in conjunction with a modern and quite explicit knowledge of the risks posed by the source of particular malodours. This was examined in Study 5, in which participants were asked to evaluate the hygiene-related behaviours that they might perform in four different scenarios. When a malodour was generated directly or indirectly by someone other than themselves, respondents reported that they would engage in more hygiene related-behaviours, confirming our general assumption that disease risk is perceived as higher when a disgust elicitor is generated by someone other than self. However, changes in hygiene-related behaviours could not explain the greater magnitude of the source effect for faeces—crucially, these changes were uncorrelated. For the garbage odour, on the other hand, changes in hygiene-related behaviours predicted some of the variability in changes in hedonic ratings from self to stranger. We would argue that this reflects the operation of two mechanisms, one based upon exposure and the other based upon explicit knowledge of disease risk. Thus, our central thesis is that both of these mechanisms operate to modulate responding to the cues produced by core disgust elicitors and that the magnitude of the disgust that is felt is adjusted in accordance with the disease risk posed.

Needless to say, this is just one potential interpretation of the data and it relies on two assumptions. The first, is that any changes in hedonic responding, induced by exposure, truly serve as proxy measures of disease risk. Second, that mere exposure can produce the reductions in negative affect for olfactory cues that we argue it can. We deal with each of these issues in turn. Why would it be advantageous to adjust the magnitude of disgust relative to its source? Obviously, one possibility is the risk of disease, but this is by no means the only possibility. For example, to become sexually intimate with someone means high level exposure to many of that person's intimate odours, some of which would probably be judged as unpleasant if they were encountered in a

non-sexually intimate acquaintance. Thus, a reduction in disgust could assist the formation of sexual bonds, mediated through neural changes resulting from exposure, sexual arousal or romantic love (see for example, Kalogerakis, 1963). Similarly, group cohesion might be strengthened by a repulsion to the odours of non-group members, resulting from exposure-based tolerance to the odours of in-group members. Interestingly, Kurzban and Leary (2001) have made a strikingly similar argument from a different perspective, in that they suggest that stigmatization of out-groups owes its *origins* to the avoidance of communicable diseases. Returning to the core argument, neither of these possibilities—sex or groups—are mutually exclusive and neither necessarily need any mention of disease.

So what, then, favours a disease-based explanation for an exposure-mediated source effect? The first point in favour is that disease risk must vary between self and other. This is appreciated by participants (re Study 5) and by logic, as the health status of a stranger can not be known. In fact, there is a growing recognition that humans may be especially sensitive to cues such as symmetry and unblemished skin, so as to avoid mating with individuals who carry pathogens (e.g. Gangestad & Buss, 1993). As a system designed to avoid disease is likely to be overly sensitive, it would appear eminently reasonable (biologically speaking) to treat strangers with caution. The second point in favour is that disease risk is, arguably, already calibrated into the way in which we selectively respond to some stimuli (e.g. faeces) with a greater disgust response than to others (e.g. dirty bodies). Sweat may be unpleasant, even disgusting, but most people would probably prefer to touch a sweaty armpit than a piece of faeces and this is reflected in the ratings which participants give to the malodours emanating from these sources (see Study 1, p. 7). Thus, the system itself already reflects a degree of calibration that is grossly sensitive to disease risk and as we argued earlier, this may result from a preparedness to associate the emotional response of disgust preferentially with certain cues. On this basis, the notion of modulating disease risk on-line, does not appear far fetched. The third point is that there is considerable evidence that animals show sensitivity to disease risk and clearly this occurs in the absence of any explicit knowledge about germs or disease. Many ungulates avoid grazing in areas which have been contaminated by faeces and in horses and sheep, it appears that it is the odour of faecal material which leads to this avoidance behaviour (Cooper, Gordon, & Pike, 2000; Odberg & Francis-Smith, 1977). If animals do avoid disease vectors, and the evidence offered by Hart (1990) is extensive and compelling, it should be no surprise to find the same types of mechanism operating in ourselves. In sum, we would argue that mere exposure underpins the source effect, and that this is an evolutionary adaptation to sensitize the organism to high disease risks.

But could mere exposure function in the way that we have suggested? To do so, exposure to a novel smell would have to result in a positive change in affect (i.e. a reduction of negative affect or an increase in positive affect) and the target odour would have to be discriminable. The latter issue was discussed earlier and the data, albeit limited, do indeed suggest that many of the malodours that show a source effect, notably sweat, do differ between individuals. There is also evidence favouring a mere exposure effect for odours too. We do know that familiar odours are regarded as smelling more pleasant than unfamiliar ones, suggesting a role for exposure (e.g. Engen & Ross, 1973) and that exposure to an unpleasant odour can reduce its degree of unpleasantness (Cain & Johnson, 1978). In addition, there is plenty of evidence that retronasally experienced odours in food, come to be more preferred with exposure (e.g. Pliner, 1982), lending support to the notion that exposure can produce the effects that we suggest here.

In sum, this paper provides strong, but preliminary evidence, that people respond differently to odours that emanate from themselves, than they do to odours coming from other people. This source effect appears to be mediated by exposure and this appears to occur because exposure allows a tacit form of disease risk modulation, thus serving to maximize disgust responses to odours emanating from the most potentially pathogenic sources—strangers.

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