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Age-Related Changes in Children's Hedonic Response to Male Body Odor

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Male sweat smells disgusting to many adults, but it is unclear whether children find it so. In Experiment 1A, children (mean age = 8.7 years) and adolescents (*M* = 16.6 years) smelled male sweat and other odors, rated each for liking, and attempted their identification. Only female adolescents disliked male sweat and could identify it. Experiment 1B, using the same procedure, obtained this gender difference in adults (*M* = 26.7 years). In Experiment 2, children (*M* = 8.1 years) and adolescents (*M* = 16.6 years) were cued about the identity of the same odors. Irrespective of gender, adolescents disliked male sweat more than did children. In sum, dislike for the odor of male sweat may be an acquired social response that is based on odor identification.

When adults are confronted with a fecal smell, sweaty feet, or garbage on a hot day, their reaction can be reliably predicted—intense dislike. Predicting children's, infants' or neonates' responses to these same types of odors is considerably more difficult. Many researchers have suggested that there are major developmental changes in hedonic responsiveness to foul odors (e.g., Engen, 1982; Moncrieff, 1966; Rozin, Haidt, & McCauley, 2000). However, the empirical basis for this supposition is not well developed, partly because of difficulties in assessing hedonic responsiveness in young children. This problem is circumvented in the experiments reported here, which examined predicted changes in hedonic responsiveness to male sweat before and after puberty.

Studies of hedonic response to odors in neonates have not provided compelling evidence of innate responding. These studies have typically concentrated on facial expression because other chemosensory stimuli, especially tastes such as quinine, produce a characteristic facial response presumed to be indicative of dislike (Steiner, Glaser, Hawilo, & Berridge, 2001). Historically, olfactory studies using neonates either have been open to alternative interpretations (e.g., nasal irritation as the basis of dislike; Bartoshuk & Beauchamp, 1994) or have failed to observe any similarity to adult hedonic response (e.g., Engen, Lipsitt, & Kaye, 1963). In the most rigorous study to date, Soussignan, Schaal, Marlier, and Jiang (1997) found that neonates' facial responsiveness to odors that adults find pleasant or unpleasant provided few indications of adultlike preferences.

Studies involving preschool-age children have produced inconsistent findings. For example, Peto (1936) and Stein, Ottenberg, and Roulet (1958) found no evidence of dislike for sweat or fecal-type odors (but see Engen, 1974, for a critique of the latter study). Engen (1974), on the other hand, found that children as young as 4 years of age were similar to adults in their rank-order preference for a range of odors. However, the size of the "hedonic interval" between odors increased with age, suggesting that children were more tolerant of malodors than adults. More recently, Schmidt and Beauchamp (1988), using a novel forced-choice procedure, obtained evidence of adultlike hedonic preferences in 3-year-old children. Children were asked to point to one *Sesame Street* character (Big Bird) if they liked the odor and to point to another character (Oscar the Grouch) if they disliked it. These findings have been criticized by Engen and Engen (1997), who questioned whether the children were able to make the link between the *Sesame Street* characters and their own affective reactions.

Data obtained from older children are more consistent. Peto (1936), Stein et al. (1958), and Engen (1974) all reported that by age 7, children's hedonic responses are similar to those of adults. In addition, convergent findings have emerged from conceptually related studies of disgust development in which children's understanding of contamination was assessed. These studies indicated that contamination sensitivity increases markedly from ages 3 to 9 (Fallon, Rozin, & Pliner, 1984; Rozin, Fallon, & Augostoni-Ziskind, 1985). The implication here is that contamination sensitivity and the formation of adultlike hedonic responses to certain odors (especially fecal and body odors) may be related through the ability to comprehend the contaminating nature of the odor's source.

Although there is disagreement about the point in development when adultlike hedonic responses become apparent (e.g., Schmidt, 1990), there is consensus that age-related changes in hedonic response to odors do occur (Engen, 1974; Mennella & Beauchamp, 1991; Rozin et al., 2000). The current series of experiments was designed to determine whether such a change occurs in response to male sweat—an odor that many adults find repellant (Laden, 1988). The rationale for this choice of odor was based on the hypothesis (outlined below) that changes in the hedonic response to sweat may occur relatively late in childhood. This hypothesis

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makes such an investigation especially interesting because it eliminates many of the problems associated with measuring hedonic responses in younger children.

Kirk-Smith and Booth (1987) provided one account of how intense dislikes toward odors may be acquired. It is important to note, however, that their model does not necessarily apply to all malodors. They suggested that two steps are probably required for the development of intense dislike toward an odor. First, an individual must experience the odor. Second, this experience must acquire meaning. An important corollary of this process is that the odor must be *identified* in order for its meaning to be apparent, that is, the person must be able to correctly name or label the odor. Although under naturalistic conditions such a caveat would not be important, when odors are studied in the laboratory, out of context and without accompanying visual cues, they are notoriously hard to identify (Cain, 1982).

The apocrine sweat glands are generally considered to be the major source of odorous sweat (Doty, 1985). Because secretions from the apocrine glands are absent prior to puberty, children's sweat smells relatively benign (Chen & Haviland-Jones, 1999; Shelley, Hurley, & Nichols, 1953). Consequently, children have relatively little exposure to their own odorous sweat prior to puberty. After puberty, sweat, especially in males (Doty, Orndorff, Leyden & Kligman, 1978), starts to smell pungent as a result of bacterial action on the apocrine secretion (Chen & Haviland-Jones, 1999; Shelley et al., 1953). Thus, puberty is likely to be the first time that most individuals routinely encounter this odor on themselves. Because considerable energy is expended on advertising products that mask body odor and because there are widely held beliefs in Western cultures about its negative meaning (Laden, 1988; McBurney, Levine, & Cavanaugh, 1977), the contingencies should thus be set for altering adolescents' reactions to male sweat. Consequently, the odor of male sweat should begin to elicit intense dislike sometime during or after puberty.

Experiment 1A

The main purpose of this first study was to determine if prepubescent children and adolescents (i.e., postpubescent children) differ in their hedonic response to male armpit sweat. Two methods were used to assess hedonic responding: self-report and facial expression. Although the former method has been used successfully with similar age groups (e.g., Soussignan & Schaal, 1996), we included a practice odor and two control odors (butanol, hedonically negative, and caramel, positive) to ensure that participants correctly used the hedonic rating scale. Facial expressions were videotaped to supplement these ratings.

Participants were also asked to identify each odor and rate its intensity. Identification data were collected because failure to label an odor may affect hedonic responding (see the introduction). Females tend to be more accurate in their ability to name odors than are males (Cain, 1982), so roughly equal numbers of males and females were tested. Moreover, participant gender could be an important variable in other ways, especially because male sweat contains putative pheromones (Doty, 1985). Intensity ratings were used to confirm that participants could detect each stimulus and also to replicate previous studies that have found age differences in rated intensity for certain odors (see next paragraph).

Three other odors were used in the study: female sweat (to complement male sweat); androstenone (a putative human pheromone); and pentadecalactone (a synthetic musk). Children are more sensitive to androstenone than are adolescents (Dorries, Schmidt, Beauchamp, & Wysocki, 1989; Schmidt & Beauchamp, 1988), so this odor was included to check that participants were correctly using the intensity rating scales. Musk was included because it falls within the same general class as androstenone and sweat. Thus, responses to this odor might also vary by age and/or gender.

Method

Participants

Forty-nine children (mean age = 8.69 years, *SD* = 0.71, range = 8–11 years) and 35 adolescents (mean age = 16.62 years, *SD* = 0.49, range = 16–17 years) participated. The child sample was composed of 23 boys (mean age = 8.78 years, *SD* = 0.80) and 26 girls (mean age = 8.62 years, *SD* = 0.64). These children were from two elementary schools in Sydney, Australia. The adolescents were recruited from two high schools and came from the same suburbs as the children. There were 19 male adolescents (mean age = 16.72 years, *SD* = 0.46) and 16 female adolescents (mean age = 16.50 years, *SD* = 0.52). As in all of the studies reported here, the majority of the participants were middle-class Caucasians.

Materials

Seven odors were used: adult male sweat, adult female sweat, androstenone, butanol, pentadecalactone (musk), caramel, and cherry (the "practice" odor). Two samples of each odor were prepared, and these were alternated during testing. Adult male sweat was collected using a method derived from McBurney et al. (1977). Three male donors (ages 21, 23, and 36 years) wore close-fitting, new T-shirts for 48 hr. Prior to wearing their T-shirts, the donors were instructed to refrain from eating spiced food, garlic, and onion and to avoid wearing any perfumes. Directly before the start of sweat collection, the donors showered and washed with an unscented soap. The T-shirts were then worn continuously for 48 hr, and during this period, donors engaged in at least 1 hr of vigorous exercise. After the donors removed their T-shirts, the shirts'armpits were immediately cut out and refrigerated. Three shirt armpits (one from each donor) were then placed, loosely rolled, inside an opaque plastic squeeze bottle with a sealable spout. The other three shirt armpits were likewise placed in a second bottle. Each bottle was labeled with a code number for identification purposes, as were all the other odors. An identical procedure was followed in collecting adult female sweat from three donors (ages 21, 22, and 39 years). Androstenone (5-alpha-Androst-16-en-3-one; Sigma Chemical Co., Inc., Sydney, Australia) was analyzed by gas chromatography/mass spectroscopy to confirm its purity. It was then dissolved in light white mineral oil (Sigma Chemical) at a concentration of 1 mg/ml of oil. Musk (w-Pentadecalactone; Aldrich Chemical Co., Inc., Sydney, Australia) was also dissolved in light white mineral oil at a concentration of 50 mg/ml of oil. Butanol (1-Butanol; Sigma Chemical) was dissolved in the same way at a concentration of 2×10^{-3} ml/ml of oil; caramel (Dragoco Ltd., Sydney, Australia, No. 9/013999) and cherry (Quest International Ltd., Sydney, Australia, No. DC12790) were similarly dissolved at concentrations of 40 mg/ml of oil. These concentrations were selected to be above threshold. For each odorant, 10 ml of the oil–chemical mixtures was pipetted onto two balls of cotton inside an opaque plastic squeeze bottle.

Procedure

Written consent was obtained from the parents of all participants. In addition, oral consent was provided by the children, and written consent was obtained from the adolescents. Participants were individually tested in a room at the school, separate from their regular classrooms. Two adults (the experimenter and a research assistant) were always present during testing because of child protection requirements. Each participant was seated at a table, facing an unconcealed video camera. The session began with the collection of biographical information. The experimenter then showed participants how to smell the practice odor (cherry) by placing the spout of the bottle 3–5 cm below the nose and squeezing the bottle while sniffing. Participants were then given the practice odor to smell and were asked to hand it back if they spent more than 5 s sniffing it. The research assistant videotaped participants, from the shoulders up, as they smelled each odor. All participants were told that the videotapes would later be used to check that they had followed the correct sniffing procedure. Having smelled the odor, participants rated their hedonic response (i.e., "What do you think of this smell?") using a 5-point scale with an added visual component to assist comprehension. The available responses were *I dislike it a lot* (2 black circles), *I dislike it a bit* (1 black circle), *unsure* (1 gray square), *I like it a bit* (1 white circle), and *I like it a lot* (2 white circles). Intensity ratings (i.e., "How much does it smell?") were then obtained in a similar manner. The response options were *no smell* (1 white square), *a little* (1 black square), *quite a bit* (2 black squares), *a lot* (3 black squares), and *heaps* (a colloquialism for the largest amount possible—4 black squares). The experimenter explained that this question referred to the strength of the odor. Finally, participants were asked, "What do you think it smells of?" If no answer was provided within 15 s, the experimenter gave the following verbal prompt: "You can guess if you want." If a response was not given after a further 10 s, then *no response* was recorded.

Although the experimenter talked participants through each step of the practice trial, for subsequent odors, the adolescents read and completed all three questions by themselves. Children were also allowed to read the questions and response options, but the experimenter verbally presented them as well. A 90-s interval separated each odor, and presentation order was partially counterbalanced. Presentation order was yoked between the adolescent and child groups such that the first participant in each age group had the same presentation order. Testing took approximately 15 min for each participant.

Coding and Reliabilities

In the identification task, correct responses received a score of 3, near misses, a score of 2, and incorrect or no responses, a score of 1. A second coder independently scored 35% of the data set. Both coders, used in all of the studies here, had been repeatedly exposed to the test odors and knew the formal name for each one (i.e., those names listed under *Materials*). The formal name and the common name were synonymous for certain odors (e.g., caramel, sweat [note that participants just used the term *sweat* and rarely specified the gender of its source], and musk). However, for butanol and androstenone, a correct response was based on the most similar source objects (e.g., marker pen for butanol; dirty clothes for androstenone). The appropriateness of these similar sources was left to the discretion of the coder. The coders were blind to participants' age and gender. For male sweat, interrater agreement was high (91%; Cohen's $\kappa =$ .84, $p < .01$). Agreement was also high (84%–97%) for the remaining odors (kappas ranged from .60 to .95, all $ps < .01$).

Participants' videotaped facial expressions were examined for each odor. The videotapes were coded without sound. Participants displayed little emotion, so their responses were categorized as either positive/neutral or negative. A second coder independently rated 35% of the participants. Both coders were naïve about the aims of the study and the contents of the squeeze bottles and coded participants' facial expressions in all of the experiments reported here. For male sweat, there was 79% agreement between the two coders (phi coefficient = .52, $p < .01$). For the remaining odors, interrater agreement was satisfactory (76%–100%; phi coefficients ranged from .42 to 1.00, all $ps < .05$).

Data Analysis

Data in all experiments were principally analyzed by odor type. All of the data met the assumptions for parametric testing, so the hedonic, intensity, and identification responses were each analyzed using factorial analyses of variance (ANOVAs) with age and gender as between-subjects factors. Significant interactions were examined with simple effects analyses.

Results

Participant Factors

In this experiment and all the experiments reported here, neither having a cold at the time of testing nor participant ethnicity influenced hedonic or intensity ratings.

Rating Scale Responses and Odor Identification as a Function of Age and Gender

Male sweat. Mean hedonic, intensity, and identification (naming) responses for male sweat are presented in Figure 1. Hedonic ratings differed as a function of age, $F(1, 80) = 10.59$, $p < .01$, but there was also a significant Age $\times$ Gender interaction, $F(1, 80) = 5.45$, $p < .05$. Simple effects analyses revealed that female adolescents ($M = -1.69$) rated the odor as more unpleasant than did female children ($M = -0.42$), $F(1, 80) = 15.22$, $p < .001$ (effect size, $r^2_{pb} = .29$), but there was no significant difference between younger ($M = -0.74$) and older ($M = -0.95$) males. Among the adolescents, females disliked the smell of male sweat more than did males, $F(1, 80) = 4.58$, $p < .05$ (effect size, $r^2_{pb} =$ .16). There was no gender difference in children's hedonic ratings.

Analysis of the odor intensity ratings revealed a significant Age $\times$ Gender interaction, $F(1, 80) = 4.45$, $p < .05$, but no main

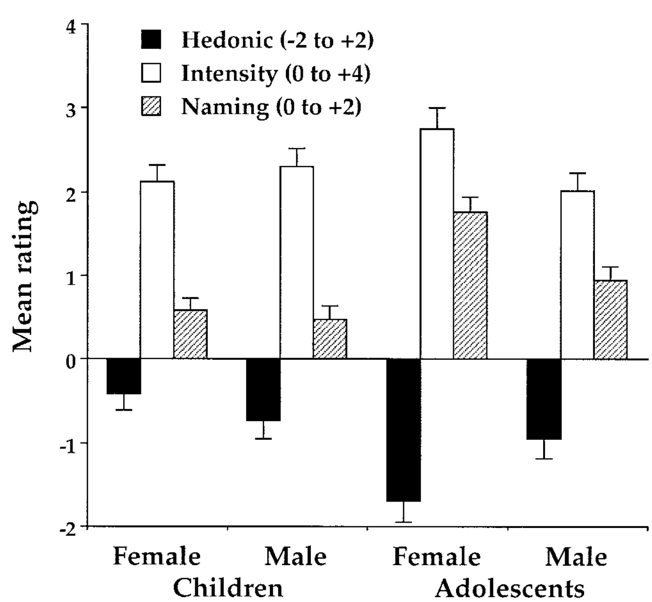

Figure 1. Mean ratings by age and gender for male sweat in Experiment 1A. Note that hedonic ratings range from –2 to +2, intensity ratings from 0 to +4, and identification ratings from 0 to +2. Vertical lines depict standard errors of the means.

effect of age or gender. The overall pattern of responding closely resembled that of the hedonic data (see Figure 1). Adolescent females ($M = 2.75$) gave higher intensity ratings for this odor than did both their male age-mates ($M = 2.00$), $F(1, 80) = 4.85$, $p < .05$ (effect size, $r^2_{pb} = .14$), and the younger females ($M = 2.12$), $F(1, 80) = 4.44$, $p < .05$ (effect size, $r^2_{pb} = .10$). These latter two groups were similar to the male children ($M = 2.30$) in their intensity ratings. The relationship between hedonic and intensity ratings was also explored. There was a significant relationship for adolescents, $r(33) = -.78$, $p < .01$, but not for children, $r(47) = -.22$, $p > .05$, and the adolescent correlation was significantly larger, $Z = 3.57$, $p < .01$.

Participants' ability to identify the odor as sweat also resembled the hedonic response pattern (see Figure 1). There were significant main effects for age, $F(1, 80) = 27.35$, $p < .01$, and gender, $F(1, 80) = 8.24$, $p < .01$, along with an Age × Gender interaction, $F(1, 80) = 5.03$, $p < .05$. Simple effects analyses indicated that female adolescents ($M = 2.75$) outperformed female children ($M = 1.58$), $F(1, 80) = 27.26$, $p < .01$ (effect size, $r^2_{pb} = .47$). Likewise, male adolescents ($M = 1.95$) outperformed male children ($M = 1.48$), $F(1, 80) = 4.58$, $p < .05$ (effect size, $r^2_{pb} = .09$). Female adolescents were also better able to identify the odor than were their male age-mates, $F(1, 80) = 11.19$, $p < .01$ (effect size, $r^2_{pb} = .24$), but there was no gender difference in the younger age group.

There was a significant correlation between identification score and hedonic rating in the adolescent group, $r(33) = -.83$, $p < .01$, which did not differ by gender (male $r = -.85$, female $r = -.55$). Thus, hedonic ratings became more negative as adolescents' ability to identify the odor increased. This correlation only approached significance in children, $r(47) = -.25$, $p = .08$, where it also did not differ by gender (male $r = -.25$, female $r = -.28$). Overall, the relationship between identification and hedonic rating was significantly smaller in the children than in the adolescents ($Z = 4.05$, $p < .01$). The relationship between identification and hedonic response was also examined across the whole data set. For participants correctly identifying the odor as sweat, hedonic ratings were most negative ($M = -1.67$), and they were significantly more negative than the ratings of participants who showed only partial identification ($M = -1.04$), $t(46) = 2.58$, $p < .05$. However, for those unable to identify the odor, hedonic ratings were effectively neutral ($M = -0.22$) and differed significantly from those of the partial identification group, $t(58) = 3.13$, $p < .01$.

Female sweat. There was a significant Age × Gender interaction in hedonic response to female sweat, $F(1, 80) = 9.95$, $p < .01$. Simple effects analyses revealed that adolescent females ($M = -0.88$) disliked this odor more than did the younger females ($M = -0.08$), $F(1, 80) = 8.42$, $p < .01$ (effect size, $r^2_{pb} = .18$). In addition, there was a significant gender difference in the younger age group such that males ($M = -0.78$) rated the odor as more unpleasant than did females, $F(1, 80) = 8.11$, $p < .01$ (effect size, $r^2_{pb} = .15$). There were no significant effects related to age or gender for intensity judgments and identification ability, nor was there any hedonic difference between those who identified this odor as sweat ($M = -0.86$) and the 14 participants who partially identified it ($M = -0.80$). However, together, these participants disliked the odor significantly more ($M = -0.83$) than did the 59 participants who could not identify it ($M = -0.36$), $t(81) = 2.20$, $p < .05$.

Androstenone. Although there were no significant differences in hedonic response to androstenone, children rated this odor as stronger smelling ($M = 2.49$) than did adolescents ($M = 1.40$), $F(1, 80) = 24.27$, $p < .01$ (effect size, $r^2_{pb} = .23$). Identification ability did not differ as a function of age or gender. Sixteen participants fully ($n = 2$) or partially ($n = 14$) identified this odor. Together, they rated it as more unpleasant ($M = -1.25$) than did the 68 participants who could not identify it ($M = -0.53$), $t(82) = 2.73$, $p < .01$.

Pentadecalactone (musk). No significant differences emerged in participants' hedonic ratings for musk. However, as with androstenone, children ($M = 2.08$) rated musk as significantly stronger smelling than did the adolescents ($M = 1.54$), $F(1, 80) = 6.48$, $p < .05$ (effect size, $r^2_{pb} = .07$). For odor identification, female participants ($M = 1.26$) demonstrated a slight advantage over male participants ($M = 1.09$), $F(1, 80) = 4.37$, $p < .05$ (effect size, $r^2_{pb} = .05$). Fifteen participants were able to partially identify this odor and rated it as significantly more pleasant ($M = 0.13$) than did the 69 participants who could not identify it ($M = -0.54$), $t(82) = 2.18$, $p < .05$.

Butanol. No significant differences were found in hedonic ratings for butanol. Children ($M = 2.45$) rated this odor as more intense than did adolescents ($M = 2.06$), $F(1, 80) = 3.98$, $p = .05$ (effect size, $r^2_{pb} = .05$). Adolescents ($M = 1.60$) were slightly better at identifying the odor than were children ($M = 1.33$), $F(1, 80) = 4.44$, $p < .05$ (effect size, $r^2_{pb} = .05$). There was no significant relationship between identification and hedonic rating.

Caramel. Females ($M = 1.33$) rated caramel as somewhat more pleasant smelling than did males ($M = 0.76$), $F(1, 80) = 5.27$, $p < .05$ (effect size, $r^2_{pb} = .06$). Intensity ratings did not differ significantly between groups, although there was a tendency for higher ratings among children. Females ($M = 2.09$) were better at identifying this odor than were males ($M = 1.69$), $F(1, 80) = 11.49$, $p < .01$ (effect size, $r^2_{pb} = .12$). There was no significant difference between the hedonic ratings of the 11 participants who fully identified caramel ($M = 1.46$) and those of the 53 participants who only partially identified it ($M = 1.19$). However, as a group, they liked the odor more than did the 20 participants who could not identify it ($M = 0.45$), $t(82) = 3.05$, $p < .01$.

Facial Responses

The facial expression data were less informative than the self-report data. A series of logistic regression analyses was conducted to determine whether participant age, gender, or both were related to the facial ratings (i.e., positive/neutral vs. negative) for each odor. These analyses did not reveal any significant effects (all ps $> .05$). For comparison with facial ratings, participants' hedonic ratings for each odor were also collapsed into the same two categories. The phi coefficient was then used to determine whether self-report ratings were related to participants' facial responses. There was a significant relationship for male sweat ($\phi = .26$, $p < .05$) but not for any other odor (all ps $> .05$).

Discussion

Our main aim in Experiment 1A was to determine whether adolescents (a postpubescent group) and children (a prepubescent group) would differ in their hedonic response to the smell of adult male sweat. The prediction that they would was only partially confirmed in that there was a significant gender difference, with an age effect evident among the female participants but not the male participants. The validity of this result is reinforced by a number of other findings. First, the pattern of hedonic responses for the control odors, butanol (negative) and caramel (positive), suggests that participants used the rating scale appropriately. In addition, the data revealed previously observed age-specific patterns of responding, with higher intensity ratings for androstenone in children than in adolescents (Dorries et al., 1989; Schmidt & Beauchamp, 1988). Finally, there was a tendency for a female advantage in identifying the odors. This finding is consistent with previous research (Cain, 1982) and is possibly the result of better retention of odor names among female participants (Dempsey & Stevenson, 2002).

Indeed, superior female identification ability may partly account for why male adolescents rated male sweat as less unpleasant than did their female counterparts. This explanation is best illustrated by the strong relationship between identification and hedonic response to male sweat in this age group. Moreover, when data from the whole sample are considered, those participants who were unable to identify the odor were relatively *indifferent* to the smell of male sweat (i.e., rated the odor as neither pleasant nor unpleasant). The importance of odor identification is further bolstered by the general finding that identification was meaningfully associated with hedonic response to some of the other odors used here. That is, when an odor was identified as something with a positive meaning (e.g., caramel or musk [perfume]), hedonic ratings were also more positive. Likewise, for androstenone and female sweat, identification of the odor as something negative (i.e., dirty clothes or sweat) was associated with more negative evaluations. This latter finding is intriguing because if labeling was responsible for hedonic responding, then why should female and male sweat differ? Because male sweat smells both stronger and different from female sweat (see the introduction), it may be more routinely associated with the label *sweat*. Thus, the significantly higher rate of identification of male sweat as *sweat*, in comparison to female sweat, $t(82) = 4.93$, $p < .01$, might explain participants' greater dislike for the smell of male sweat. Because all of these findings pointed to an important relationship between odor identification and hedonic response, we conducted two further experiments to explore this effect.

Experiment 1B

The purpose of Experiment 1B was to establish whether an adult sample would show a gender difference in hedonic response to male sweat. Several studies have demonstrated that the ability to identify odors progressively improves until a peak is reached in the 30s and early 40s (Cain et al., 1995; De Wijk & Cain, 1994). So an older sample might not show such a pronounced gender difference in their ability to identify male sweat. Consequently, there might be a smaller difference between adult males and females in their hedonic ratings for this odor.

Method

Participants

Thirty students from Macquarie University participated in this study and received either course credit or a $10 payment. Fifteen of these students were male (mean age = 26.47 years, $SD = 3.60$), and 15 were female (mean age = 26.93 years, $SD = 3.99$). The male and female groups had the same age range (24–37 years), and there was no significant difference in mean age between the groups.

Materials and Procedure

Test odors were prepared in a manner identical to that in Experiment 1A, with the only difference being that one of the original male donors was unavailable for sweat collection. A 32-year-old male donor replaced the 23-year-old male used in the previous study. All other odors were prepared in the manner described for Experiment 1A. The procedure was identical to that used for the adolescent sample in Experiment 1A.

Coding and Reliabilities

The identification task was coded as in Experiment 1A. The second coder independently scored 40% of the data set. Interrater agreement was 100% for male sweat. Agreement was high (83%–100%) for the remaining odors (kappas ranged from .66 to 1.00, all *p*s $< .01$). Participants' facial expressions were coded using the same procedure as in Experiment 1A. The second coder independently rated 35% of the participants. For male sweat, there was 82% agreement ($\phi = .62$, $p < .05$). For the remaining odors, acceptable interrater agreement was obtained only for caramel (91%) and female sweat (82%).

Results

Male Sweat

Figure 2 presents the hedonic, intensity, and identification data for male sweat. Adult females ($M = -1.60$) rated the male sweat as more unpleasant smelling than did the adult males ($M = -1.07$), $t(28) = 2.03$, $p = .05$ (effect size, $r_{\text{pb}}^2 = .13$). To determine whether this pattern of responding was similar to that obtained for adolescents in Experiment 1A, we conducted a two-way ANOVA with age group (adolescent vs. adult) and gender as between-subjects factors. This comparison was based on the assumption that conditions and stimuli were largely identical in the two experiments. The analysis revealed a significant main effect of gender, $F(1, 61) = 10.23$, $p < .01$ (effect size, $r_{\text{pb}}^2 = .14$), with females rating the odor as more unpleasant. Most important, however, there were no age effects (*F*s < 1).

Although adult females ($M = 2.53$) rated the male sweat odor as more intense smelling than did males ($M = 1.93$), this difference failed to reach significance, $t(28) = 1.52$, $p > .05$. Once again, we used a factorial ANOVA to determine whether this response pattern differed from that of the adolescents in Experiment 1A. This analysis revealed a main effect of gender, $F(1, 61) = 7.26$, $p < .01$ (effect size, $r_{\text{pb}}^2 = .10$), but no age-related effects (*F*s $<$ 1). As in Experiment 1A, there was a significant correlation between intensity and hedonic ratings, $r(28) = -.48$, $p < .01$.

The identification data (see Figure 2) suggested that adult females were better at identifying odors than were adult males, but this difference did not reach significance, $t(28) = 1.13$, $p > .05$. Once again, an ANOVA was used to explore whether age (ado-

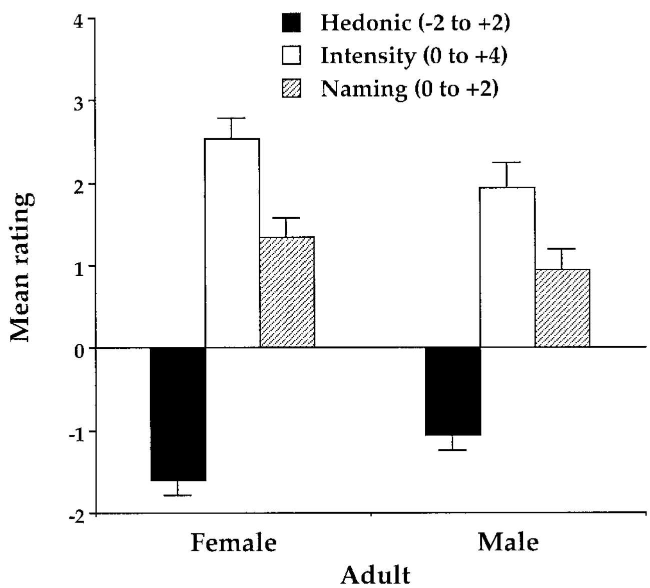

Figure 2. Mean ratings by gender for male sweat in Experiment 1B. Note that hedonic ratings range from –2 to +2, intensity ratings from 0 to +4, and identification ratings from 0 to +2. Vertical lines depict standard errors of the means.

lescents vs. adults) influenced identification ability. There was a main effect of gender, $F(1, 61) = 8.03$, $p < .01$ (effect size, $r^2_{pb} = .11$), but no significant age effects (Fs < 1). The hedonic response of participants who could fully ($n = 16$) or partially ($n = 2$) identify the odor ($M = -1.44$) was significantly more negative than that of the 12 who could not identify it ($M = -1.0$), $t(28) = 2.08$, $p < .05$.

Female Sweat

Adult females ($M = -0.67$) rated this odor as significantly less pleasant than did the male participants ($M = -0.13$), $t(28) = 2.14$, $p < .05$ (effect size, $r^2_{pb} = .14$). There were no significant differences between adult males and females in their intensity ratings or identification ability (all ps $> .05$). Four participants partially or fully identified female sweat, and they disliked it ($M = -1.25$) more than did those who were unable to identify the odor ($M = -0.27$), $t(28) = 2.81$, $p < .01$.

Other Odors

There were no gender differences in hedonic or intensity ratings for androstenone, musk, butanol, and caramel (all ps $> .05$). In addition, males and females were similar in their ability to identify these four odors (all ps $> .05$). For musk and butanol, identification was not related to hedonic ratings. For androstenone, 8 participants were either fully ($n = 5$) or partially ($n = 3$) able to identify the odor, and together they disliked it more ($M = -1.63$) than did the 22 participants who could not name it ($M = -0.41$), $t(28) = 3.24$, $p < .01$. For caramel, hedonic ratings for the 4 participants who fully identified the odor ($M = 1.50$) did not differ from those of the 21 participants who partially identified it ($M = 1.33$). As a group, they liked the caramel odor more than did the 5 participants who could not identify it ($M = -0.20$), $t(28) = 4.42$, $p < .01$.

Facial Responses

As in Experiment 1A, the facial expression data were less informative than self-reported hedonic response. Chi-square analyses revealed no gender differences (all ps $> .05$), and phi coefficients revealed no relationship between facial and hedonic ratings.

Discussion

In Experiment 1B, we examined whether gender differences in hedonic response to male sweat would be evident in adulthood. Adult females disliked male sweat more than the adult males did, and this gender effect (effect size, $r^2_{pb} = .13$) was nearly identical to that obtained for the adolescents in Experiment 1A (effect size, $r^2_{pb} = .16$). Although there was no significant gender difference in adults' ability to identify male sweat, their means did not differ significantly from those of adolescents in Experiment 1A. In addition, relationships emerged between identification and hedonic responding that were similar to those observed in Experiment 1A. Together, these results suggest some degree of continuity from adolescence to adulthood in hedonic response to male sweat and that differences between males and females may be explained, in part, by differences in identification ability. The role of identification was explored more directly in Experiment 2.

Experiment 2

In this final study, we used the same odors and age groups that were used in Experiment 1A, but the crucial difference was that participants were explicitly cued about the real nature of some of the odors. If ability to identify an odor is important in dictating hedonic responding, then cuing participants as to an odor's nature should reduce or eliminate any hedonic response difference resulting from this factor. The experimental procedure was redesigned so that several cues were now available. These included (a) detailing how each smell came from one person's clothes, (b) rephrasing the questions to remind participants that each odor came from a person, (c) asking participants whether they would sit next to "someone who smelled like this," and (d) having the experimenter say "Here is the next person's smell" as each odor was presented.

One problem was encountered during pilot testing. When children were asked to identify each odor, some suggested that the bottles contained dirty underwear—an observation that was impossible to refute because odor identity was never disclosed. We feared that leaving such comments uncorrected might result in many upset parents and that word might rapidly spread around the school. For this reason, we chose not to measure identification ability but instead had participants rate their familiarity with each odor.

Method

Participants

Thirty-seven children (mean age = 8.08 years, $SD = 0.43$, range = 7–9 years) and 36 adolescents (mean age = 16.64 years, $SD = 0.49$, range =

16–17 years) from Sydney, Australia, participated in this experiment. Sixteen boys (mean age = 8.25 years, *SD* = 0.45) and 21 girls (mean age = 7.95 years, *SD* = 0.38) were recruited from three elementary schools. Nineteen male adolescents (mean age = 16.63 years, *SD* = 0.50) and 17 female adolescents (mean age = 16.65 years, *SD* = 0.49) were drawn from four high schools in the same neighborhood.

Materials

The odor stimuli were the same as those used in Experiment 1B because the two experiments were run concurrently. Other materials were identical to those in Experiment 1A.

Procedure

The procedure was identical to that of Experiment 1A except as detailed below. Prior to the practice odor, the following instructions were read aloud verbatim by the experimenter: "We are going to ask you to smell a few things today. Each one of these smells [points to all the bottles] comes from people's clothes. What we do is get people to wear something for a while, then they give it to us, and we cut it up and put the bits in a bottle for you to smell. So each bottle is like one person's smell." As the experimenter recited this information, she showed the participant a new T-shirt, which had a 10 × 10 cm section cut out from the bottom left-hand corner. The experimenter rolled up the piece of T-shirt and placed it inside a bottle that was visually identical to the test bottles. Child participants were then immediately asked "So what's in each of these bottles?" to ensure that they had understood the information. This question was repeated at the end of the odor-sniffing phase. Most participants gave a correct response (i.e., people's clothes) to this initial question, and only 1 child needed the information repeated. All children (except 1 who was mistakenly not asked) gave correct responses to the question at the end of the sniffing trials.

As in the other two experiments, participants were shown how to smell the practice odor (cherry) and were given a maximum of 5 s to sniff the contents of the bottle. Participants were then asked, "Would you sit near someone who smelled like this?" A 3-point response scale was used, with an added visual component to assist comprehension. The available responses were *I would not sit near them* (two neutral faces spaced 3.5 cm apart), *unsure* (a gray square), and *I would sit near them* (two neutral faces 0.1 cm apart). This question was included primarily to reinforce the idea that the odors were derived from people's clothing. Hedonic and intensity ratings were then obtained with procedures identical to those in the other two experiments. Finally, participants were asked, "Have you ever smelled anything like this before?" The response options were *yes*, *unsure*, and *no*. After completing the practice phase, participants were given the first test odor. As the experimenter handed it over, she said, "This is the first person's smell." This format was adopted throughout to further ensure that participants did not forget the origins of each odor.

Coding and Reliabilities

Participants' videotaped facial expressions were examined with the same procedure used in Experiments 1A and 1B. A second coder independently rated 35% of the participants. For male sweat, there was 81% agreement between the coders, and the phi coefficient was .61 ($p < .01$). Interrater agreement ranged from 73% to 92% for the other odors, with phi coefficients ranging from .68 to .75 (all *p*s < .01), except for musk and caramel, which were not significant.

Results

Male Sweat

Figure 3 provides a summary of the "sit near," hedonic, intensity, and familiarity responses for male sweat. Adolescents (*M* = −1.50) rated the male sweat as more unpleasant smelling than did the child participants (*M* = −0.73), $F(1, 69) = 10.28$, $p < .01$ (effect size $r^2_{pb} = .13$). Unlike in Experiment 1A, there was no significant Age × Gender interaction ($F < 1$). An additional ANOVA was used to compare adolescent hedonic responses in this experiment with those in Experiment 1A. There were no main effects for gender or experiment (Experiment 1A vs. Experiment 2), but the analysis revealed a significant interaction between these two factors, $F(1, 67) = 4.00$, $p < .05$. This reconfirmed the existence of an adolescent gender difference in Experiment 1A and its absence in Experiment 2. A comparable analysis for child participants across both experiments revealed no effect of cuing on hedonic ratings.

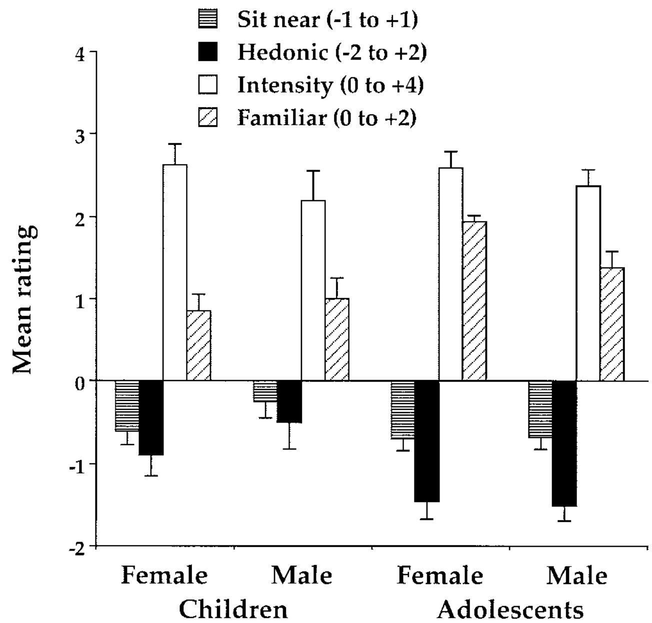

Figure 3. Mean ratings by age and gender for male sweat in Experiment 2. Note that "sit near" ratings range from –1 to +1, hedonic ratings from –2 to +2, intensity ratings from 0 to +4, and familiarity ratings from 0 to +2. Vertical lines depict standard errors of the means.

Intensity ratings for male sweat did not vary as a function of age or gender. As in the other two experiments, there was a significant correlation between intensity and hedonic ratings, $r(71) = -.47$, $p < .01$. In this experiment, however, we were able to explore whether the variation in intensity ratings was primarily responsible for the age difference in hedonic response. This could not be explored in Experiment 1A because there was a significant inequality across the two age groups in the relationship between intensity and hedonic response. The hedonic ANOVA was repeated with intensity ratings entered as a covariate. This analysis revealed a main effect of age, $F(1, 68) = 7.79$, $p < .01$, with no other effects. Thus, even after we controlled for the perceived strength of the odor (i.e., assuming that it did not represent hedonic "leakage"), children and adolescents still differed in their hedonic response.

The fact that the male sweat samples were not identical in Experiments 1A and 2 might have accounted for the differences in adolescents' hedonic ratings in these studies. Therefore, we examined intensity ratings for the adolescents to determine whether there was a difference between the two studies in the perceived strength of the sweat samples. There were no significant effects involving the experiment variable (Experiment 1A vs. Experiment 2), which suggested that the strength of the male sweat was roughly equivalent across experiments (both *p*s $> .05$). However, there was a main effect of gender, $F(1, 67) = 5.40$, $p < .05$ (effect size $r^2_{pb} = .07$). Thus, regardless of experimental design and sweat sample, adolescent females rated male sweat as stronger smelling than did their male age-mates. A similar analysis was conducted to compare children's intensity ratings across the two studies. There were no significant gender or experiment effects.

Adolescents ($M = 1.64$) rated themselves as more familiar with the male sweat odor than did children ($M = 0.92$), $F(1, 69) = 14.95$, $p < .01$ (effect size $r^2_{pb} = .17$). There was a significant correlation between odor familiarity and hedonic response, $r(71) = -.25$, $p < .05$, but the size of this effect was much smaller than the identification–hedonic response relationship observed in Experiment 1A. All participants indicated a general reluctance to sit next to someone who smelled like this, but there were no significant effects involving age or gender.

Female Sweat

There were no significant differences in hedonic, intensity, and "sit next to" ratings for female sweat. However, adolescents ($M = 1.03$) were more familiar with this odor than were children ($M = 0.59$), $F(1, 69) = 5.65$, $p < .05$ (effect size $r^2_{pb} = .07$).

Androstenone

There were no age or gender differences in hedonic ratings for androstenone. As in Experiment 1A, children ($M = 2.51$) rated this odor as more intense than did adolescent participants ($M = 1.92$), $F(1, 69) = 5.69$, $p < .05$ (effect size $r^2_{pb} = .07$). Adolescents ($M = 1.28$) were somewhat more familiar with this odor than were children ($M = 0.89$), $F(1, 69) = 3.92$, $p = .05$ (effect size $r^2_{pb} = .05$). Finally, in comparison to adolescents ($M = -0.08$), children reported a marked reluctance to sit next to someone who smelled like androstenone ($M = -0.68$), $F(1, 69) = 11.53$, $p < .01$ (effect size $r^2_{pb} = .14$).

Pentadecalactone (Musk)

There were no age or gender differences in hedonic ratings for musk. However, as in Experiment 1A, children ($M = 2.22$) gave this odor significantly higher intensity ratings than did adolescents ($M = 1.64$), $F(1, 69) = 6.79$, $p < .05$ (effect size $r^2_{pb} = .09$). There were no significant effects for any of the other rating scales.

Butanol

No significant age or gender differences were found in hedonic ratings for butanol. Once again, children ($M = 3.11$) gave higher intensity ratings to this odor than did adolescents ($M = 2.36$), $F(1, 69) = 10.93$, $p < .01$ (effect size $r^2_{pb} = .13$). Adolescents ($M = 1.17$) were somewhat more familiar with the odor than children were ($M = 0.70$), $F(1, 69) = 3.89$, $p = .05$ (effect size $r^2_{pb} = .05$). Finally, children ($M = -0.11$) were more reluctant to sit next to someone smelling of butanol than were adolescents ($M = 0.25$), $F(1, 69) = 4.54$, $p < .05$ (effect size $r^2_{pb} = .06$).

Caramel

There were no age or gender differences in hedonic response to caramel. There were higher intensity ratings in the younger ($M = 2.73$) than in the older ($M = 1.97$) age group, $F(1, 69) = 11.94$, $p < .01$ (effect size $r^2_{pb} = .14$). Females ($M = 1.61$) were more familiar with the caramel odor than were males ($M = 1.23$), $F(1, 69) = 4.95$, $p < .05$ (effect size $r^2_{pb} = .07$). Children ($M = 0.35$) were less willing than adolescents were ($M = 0.69$) to sit next to someone smelling of caramel, $F(1, 69) = 4.41$, $p < .05$ (effect size $r^2_{pb} = .06$).

Facial Responses

Despite participants' being cued about the nature of the odors, facial responses were still largely neutral and less informative than self-report ratings. We used the same analysis strategy as in Experiment 1A and found no significant age or gender effects for any odor. For relationships between hedonic and facial ratings, only that for caramel was significant ($\phi = .33$, $p < .01$).

Discussion

In this final experiment, participants were told that the odors were derived from used clothing. Under these conditions, male adolescents indicated that they strongly disliked the smell of male sweat. More important, their hedonic responses did not differ from those of female adolescents. In addition, adolescent males in Experiment 1A found this odor less unpleasant than did those in the present study. It could be argued that this latter finding was due to some difference in the male sweat samples used in these studies (i.e., one of the original three male sweat donors was replaced in Experiment 2). However, such an explanation seems unlikely given that there was no difference across the two studies in adolescents' intensity ratings for this odor. Instead, the findings suggest that the cuing procedure eliminated the difference in hedonic responding between adolescent males and females, a result originally attributed to differential rates of identification.

Interestingly enough, cuing children about the nature of the male sweat odor appeared to have relatively little effect. Children rated this odor as being less unpleasant than did the adolescents, and their hedonic ratings were similar to those obtained from children in Experiment 1A. The absence of any cuing effect in this younger age group may be explained in a number of ways. For instance, (a) children might simply require more explicit cues (e.g., being told that the smells came from people's bodies as opposed to clothes); (b) they may not yet associate the odor of male sweat with its name; (c) this link may already be established, but the name and odor may not yet have acquired a negative meaning; or (d) children may not have had sufficient prior exposure to this odor, especially from their own bodies. The last possibility is supported by the significantly lower familiarity ratings obtained for male sweat in children. Thus, children may have had less opportunity to learn the identity of the odor and/or its negative meaning. This situation may change markedly when they reach puberty and start to produce this odor themselves.

Despite the procedural change, data from the other odors in this experiment were broadly similar to the data obtained in Experiment 1A. So even with a tendency for children to give higher intensity ratings to these other odors, there were no age differences in hedonic responses.

General Discussion

Certain odors, such as male sweat, are intensely disliked or found disgusting by the majority of adults. How these odors come to induce such a reaction has been ascribed to developmental changes in affective response (Engen, 1982; Rozin et al., 2000). Thus, as children mature, more adultlike hedonic responses are thought to emerge. In the experiments reported here, we set out to test this account by determining whether prepubescent children, postpubescent adolescents, and adults differed in their hedonic responses to the smell of male sweat. When no cues were provided about the identity of the odors (Experiments 1A and 1B), male and female children, adolescent males, and adult males all disliked male sweat to a similar extent. Adolescent and adult females were the only groups to intensely dislike this odor and were also more able to correctly identify it. In Experiment 2, odor identity was cued by telling participants that each smell was obtained from "used clothing." Under these conditions, both male and female adolescents intensely disliked the smell of male sweat. Cuing, however, had no overt effect on children. They rated male sweat as less unpleasant than did the adolescents and also reported that they were less familiar with this odor. Taken together, these results support the claim that developmental changes in hedonic responsiveness to odors can occur. The results are also consistent with a model of olfactory hedonics in which the acquisition of meaning is important to the development of intense dislikes.

Before turning to discuss the mechanistic implications of these findings, it is important that we establish that the difference in hedonic response between children and adolescents is valid rather than a methodological artifact. There was no evidence that the age effect was due to children being unable to understand the hedonic rating scales or use them appropriately. For instance, both age groups rated butanol as unpleasant and caramel as pleasant. In addition, for most odors in Experiments 1A (4 out of 6) and 2 (5 out of 6), there were no hedonic differences between adolescents and children. This finding suggests that differences in hedonic response to male sweat were not a consequence of any systematic response bias in either group. A further consideration is whether the age effect in hedonic responding is due to differences in odor sensitivity. For example, maybe the adolescents perceived male sweat as a particularly strong odor and this influenced their hedonic ratings. The hedonic response to male sweat was indeed correlated with rated intensity in Experiments 1A and 2, a finding consistent with the results of previous studies (e.g., Doty et al., 1978). However, Experiment 2 offered an opportunity to explore the influence of intensity, and when it was used as a covariate, there was still a significant difference in hedonic responses by age. Thus, it appears unlikely that differences in sensitivity to the smell of male sweat could account for our findings. A further issue is whether a more direct manipulation of odor identity would have produced results similar to those obtained in Experiment 2. Although their results are not directly analogous, Herz and Clef (2001) observed that with adults, labeling the smell of iso-valeric acid as either Parmesan cheese or vomit had a profound effect on the hedonic rating this odor received. Clearly, a participant has to *know* what Parmesan cheese and vomit are for this manipulation to be successful. Likewise, if children are told "this is sweat" but are not party to what *sweat* means, then labeling should not affect responding. Although the studies here suggest such an outcome, it remains to be directly addressed.

In the current experiments, our interpretation of the data derived in part from the model outlined by Kirk-Smith and Booth (1987). According to this model, the development of extreme dislike for an odor may depend on both the individual's being exposed to the odor and the odor's acquiring a negative meaning. Thus, in the present context, differences in the stimulus (i.e., child sweat being relatively odorless and bacterial action making male sweat more pungent than female sweat) provide the first step in this process. The key exposure to male sweat probably then occurs in males largely through their own sweat and in females through incidental or intimate exposure to males. During this period, both male and female adolescents also are probably learning an association, primarily between the label *sweat* and the pungent odor of male sweat. This learning is presumably accompanied by the formation of negative attitudes to body odor from peers, parents, and the media (see McBurney et al., 1977). The result of this process is that by late adolescence, certain body odors (e.g., from strangers) in certain circumstances (e.g., exposure on public transport) come to invoke intense dislike. Finally, in an experimental context (e.g., Experiments 1A and 1B), gender differences in the hedonic response to male sweat emerge as the result of better odor identification among females, an ability that has been linked to their enhanced retention of odor names (Dempsey & Stevenson, 2002).

Needless to say, the current experiments cannot rule out other possibilities, such as maturational changes in hedonic perception that are independent of any social process. Nonetheless, the findings reported here are generally supportive of Kirk-Smith and Booth's (1987) model, most notably, the relationship between identification and the demonstration of intense dislike. This support emerges from several lines of evidence: (a) the strong correlation between hedonic ratings and identification in adolescents and the finding that, overall, in Experiment 1A, inability to identify male sweat was associated with hedonic indifference to its smell; (b) the greater ability of adolescents, compared with children, to identify male sweat; (c) the extant literature that suggests a female advantage in identification (Cain, 1982); (d) the preservation of the gender difference in hedonic ratings into adulthood, suggesting that superior female identification ability is not specific to one age range; (e) the loss of this gender difference when adolescents were cued about the identity of the odors; and (f) the findings in Experiments 1A and 1B indicating that identification can appropriately enhance both positive and negative hedonic responses to odors other than male sweat.

If the ability to correctly identify male sweat underpins the intense dislike or disgust reported by adolescent and adult participants, then the question arises as to whether this dislike represents an actual change in affect upon identification of the odor or a change in knowledge that includes a propensity to report more negative affect than might actually be felt (i.e., who would want to be thought of as liking male sweat?). The only data here that seem to bear on this question are the videotapes of participants' facial expressions as they sniffed each odor. Across all three experiments, the majority of participants showed little or no discernible facial response to the odors. One interpretation of these findings is that participants did not actually feel intense dislike for male sweat and that their reported dislike was simply a socially acceptable response. However, there is considerable evidence that facial expressions can be carefully controlled (Jancke & Kaufmann, 1994; Kraut, 1982; Soussignan & Schaal, 1996). Thus, like self-reports, facial data may not always be a reliable indicator of felt dislike or disgust. Of course, in the final analysis, it is conceivable that individuals start by responding in a socially acceptable way, with little expressed dislike, and that this way of responding eventually becomes internalized.

In the introduction, we noted that sensitivity to contamination may be a prerequisite for the formation of intense olfactory dislikes. The fact that this sensitivity occurs somewhere between the 3rd and 7th years suggests that intense olfactory dislikes should emerge around the same time, which does appear to be broadly true. Moreover, the odors that are most disliked by adults also tend to be those that are the most contaminating—notably, feces, dirty bodies, urine, vomit, and rotting organic matter. Consequently, we argue that the development of intense olfactory dislikes depends on an awareness of the potential for contamination and that it is for this reason that intense olfactory dislikes are formed at this time or, as in the experiments reported here, somewhat later.

In conclusion, this study is the first to demonstrate differential hedonic responsiveness to the smell of male sweat between pre- and postpubescent participants. The findings are consistent with the argument that intense dislike for the odor of male sweat is probably an acquired social response and that this judgment is based, at least in part, on the ability to identify the odor. In other words, if one does not know that one is smelling sweat, one will not necessarily report extreme dislike or disgust.

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