SEX RELATED FACTORS IN THE PERCEPTION OF THREATENING FACIAL EXPRESSIONS

Lisa M. Goos and Irwin Silverman

ABSTRACT: This study replicated and extended previously reported sex differences involving both viewer and target in the recognition of threatening facial expressions. Based on the assumption that the evolved cognitive mechanisms mediating anger recognition would have been designed by natural selection to operate quickly in the interests of survival, brief tachistoscopic presentation of stimulus photographs was used. Additionally, in contrast to prior published studies, the statistical methods of signal detection research were used to control for the confounding effects of non-random guessing. The main hypothesis, that anger posed by males would be more accurately perceived than anger posed by females, was supported. A secondary hypothesis, that female-posed anger would be more accurately perceived by women than by men, received partial support. Testosterone levels, measured inferentially in terms of diurnal cycles, failed to show the hypothesized positive relationship to accuracy of anger perception.

KEY WORDS: facial expressions; anger; sex differences; evolution.

Long before we began communicating with language, we were communicating with facial expressions. The production and understanding of facial expressions has been found in non-human primates (Chevalier-Skolnikoff, 1973; Andrew, 1963), infants (Johnson & Morton, 1991; Charlesworth & Kreutzer, 1973), deaf and blind people (Eibl-Eibesfelt, 1979) and across cultures (Ekman, 1973), suggesting, as Darwin (1872) first noted, that facial expressions have a biological basis and a long phylogenetic history.

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This work was supported in part by an Ontario Graduate Scholarship to Lisa M. Goos. The authors gratefully acknowledge the assistance of Dr. C. Creelman in evaluating the use of the *d′* statistic.

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Facial Expressions in Threat Displays and Detection

An ethological, adaptionist view of facial expressions suggests that facial displays, like many other types of ritualized signals, are derived from intention movements that precede or form part of more complex behavior patterns (Fridlund, 1994). These displays, therefore, reliably indicate what behavior is to follow (Andrew, 1963; Chevalier-Skolnikoff, 1973; Hinde, 1966). An organism that displays its intentions can modify the behavior of others in the social group without actually having to perform the entire, energetically costly behavior pattern.

As with all communication systems, the form of the message created by the sender evolves in concert with the ability of the recipient to understand the message, each constrained by an energetic cost/benefit relationship. If the signal is too simple or vigilance for it too low, the signal may be missed, energy wasted and neither sender nor receiver would benefit. If the signal is too complex or vigilance too high, too much energy will be used for the benefit gained and the distinction between signal and noise may be lost. Facial expressions represent a cost effective way to communicate our intentions, which is also easily monitored: even expressionless faces attract our attention.

Dangerous situations require fast responses for survival, making the perception and recognition of danger especially important. As social organisms, one of the most common and persistent sources of danger is aggression from other members of the social group. In the case of aggression, baring of the teeth could warn another of impending agonistic attack, giving the recipient the opportunity to change its behavior. By this means, a dangerous attack is avoided and the survivability of both parties is enhanced by the production and subsequent perception of a display (Fridlund, 1994). Many ethologists consider anger to be the emotional correlate to attack aggression (Blanchard & Blanchard, 1984; Dimberg, 1986), a contention supported by the fact that humans and other animals, especially primates, display many of the same facial characteristics during anger and attack aggression (Chevalier-Skolnikoff, 1973). Therefore, angry faces should be processed with the same priority and efficiency as other dangerous environmental stimuli.

Sex Differences in Threat Displays and Detection

In the majority of hominid primates, no consistent sex differences exist in the overall frequency of agonistic interactions (Smuts, 1987). However, the intensity of aggression differs markedly by sex. Aggression between females is fairly common, but rarely results in death or serious injury (Campbell, 1999). Males injure one another more often, and injure each other more severely, including mortally (Archer & Haigh, 1999; Daly & Wilson, 1988; Smuts, 1987).

A pattern in intersexual aggression is also readily discernible. Hominid males are typically larger and stronger than females, making aggression involving a male very dangerous for a female. There is also the additional risk to any offspring she is carrying or caring for. In most species the potential for males to harm infants has been a potent selective force operating on the behavior of females (Smuts, 1987), and females often show extreme vigilance towards males, especially threatening males or those in close proximity to infants (Ransom, 1981).

Based on the patterns of aggression described above, we might readily expect sex differences to be involved in the accurate perception of anger. In fact, Rotter and Rotter (1988) showed that both men and women were better at recognizing angry expressions in male faces than in female faces. McAndrew (1986) and Kirouac and Doré (1984) provided evidence that males can correctly identify angry expressions at lower exposure durations than females, and Hagar and Ekman (1979) found that male anger was recognized from greater distances than most other expressions.

The Present Study

The present study attempted to replicate and extend Rotter and Rotter's (1988) findings. Their stimulus materials were used, as well as a modified form of their method. Rotter and Rotter, however, interpreted sex-related differences in the perception of anger in terms of differential learned capacities of males and females to display this emotion. In contrast, the present study emanated from the premise that the influence of sex on the recognition of facial expressions, particularly those signalling threat, is largely a function of differences in perceptual capacities based on evolved adaptive mechanisms.

A test between these interpretations might be based on the extent to which specific sex differences are universal across species and human cultures, but this was beyond the scope of the present study. The present study did include features which might favor the evolutionary view, however. For one, brief tachistoscopic presentations of the stimulus photos were used, based on the notions described above that the evolved cognitive mechanisms mediating anger recognition would have been most effectively designed by natural selection to operate quickly. For another, the relationship of testosterone (T) level to anger recognition was assessed, measured inferentially by time of day of testing. Sex hormone levels have been shown to influence perceptual and cognitive functions of various types (Kimura, 1999) and there has been one reported study (Honk et al., 1999) suggesting that T levels are associated with selective attention to aggressive stimuli.

There was also a methodological aspect by which this investigation differed from Rotter and Rotter's and other reported studies that used forced choice methods to identify facial expressions. Recognition scores for the present study were calculated by the methods of signal detection theory, designed to control for confounding effects of non-random guessing. This seemed particularly salient for anger recognition in that false positive errors, that is, perceiving an expression as anger when it is not, are generally far less costly than the reverse error, particularly in conditions where the consequence of failing to detect a threatening expression would be most dangerous. Thus, we would expect a bias in favor of false positive errors for anger, especially when viewing male posers, which could readily account for prior results.

Our main hypothesis was that, across sex of viewer, anger posed by males would be more accurately perceived than anger posed by females, based on the greater potential danger of male anger to both sexes. A secondary hypothesis was that anger posed by females would be more accurately perceived by female than by male viewers. This was based on the prevalence of female-female competition and the consequent greater likelihood that female anger toward another female, as opposed to female anger toward a male, will result in attack.[1] The lesser vulnerability of males to female aggression also supports this hypothesis. A final hypothesis was that anger perception, overall, would be greater with increased T levels.

Method

Participants

Student volunteers, 58 females and 56 males, were recruited from undergraduate classes at York University. The majority of participants were recruited from the Introductory Psychology Research Participant Pool, and received course credit for their participation. A small fraction (20 males and 11 females) came from other undergraduate psychology classes and were paid $10.00 for their participation. Mean ages in the total sample were 22 for each sex.

Materials

This study used 120 color photos, head shots of volunteers who had posed anger, disgust, fear and sadness. These were part of a sub-sample selected by Rotter and Rotter from a larger pool of photos, based on independent ratings by a panel of judges as to how well the given expression was conveyed. There were more female than male posers in each expression category, a function of the fact that the original sample of posers had a similar imbalance. Seventy-three percent of the posers were in the 18 to 24 year age range and 75% were Caucasian. There were several instances in which the same poser appeared in more than one expression category.

The 120 photos were randomly divided into two sets of 60 each for the two administrations used for comparisons of T levels. Each set contained 15 photos of each expression with the same proportion of female to male posers by expression. Order of presentation of photos for each set was randomized by shuffling all of the photos in a container and drawing them in the blind, one at a time.

Procedure

Sessions for each participant were scheduled on the same day between 8:00 and 9:00 am, representing the high testosterone period, and again between 11:30am and 12:30pm, representing the low testosterone period.[2] Upon entering the laboratory for the first time, participants were told that the purpose of the experiment was to test their ability to identify facial expressions shown very quickly. Following a brief description of the procedure, each participant was given three test trials using photos not contained in the test sets.

The photographic stimuli were presented using a three field Harvard Tachistoscope and a '300' series millisecond timer. A trial consisted of a 2-second pre-stimulus white field with a black 'X', on which participants were instructed to focus; the stimulus photo presented for 30 milliseconds; and a post-stimulus white field presented for 3 seconds. Following this presentation, participants were required to respond verbally as to what expression they believed the face displayed from the choices of anger, disgust, fear and sadness. A verbal prompt reiterating the expression choices was given by the experimenter during the 3-second post-stimulus white field, with the order of the prompt words systematically varied on each trial, until the participant seemed able to remember all four options. In cases where participants expressed indecision about the expression shown, they were encouraged to guess. The order of presentation of the two test sets was counterbalanced across time intervals and viewer sex using an ABBA design.

At the close of testing, one-sample *t*-tests were conducted on accuracy rates across expressions for each time interval, establishing that these were both significantly greater than chance at $p < .001$.

Data Analyses

Individual scores were calculated in terms of proportions rather than frequencies due to unequal Ns for male and female posers, and were derived separately for sex of poser, sex of viewer, time interval and expression. For group comparisons, individual scores were converted into *d′* or Sensitivity scores, which provide proportional estimates of the accuracy of responses in a forced-choice paradigm while correcting for biases based on non-random guessing. The Sensitivity score is recommended by Macmillan and Creelman (1991) as the preferred method for correcting for non-random guessing where the number of response alternatives is greater than two. Sensitivity scores were computed by means of an algebraic algorithm developed by Smith (1982, as cited in Macmillan & Creelman, 1991)[3] and served as the dependent variable in a 2 × 2 × 2 × 4 ANOVA for sex of viewer, sex of poser, time interval, and expression.

Specific hypotheses, tested in terms of various interactions within this ANOVA, were that the expression of anger, solely, will show higher Sensitivity scores:

a. for male posers than female posers across viewers of both sexes, as represented by a 2 × 4 interaction between sex of poser and expression.
b. for female posers by female viewers, as represented by a 2 × 2 × 4 interaction for sex of viewer, sex of poser, and expression, and a 2 × 2 interaction, specifically for anger, for sex of viewer and poser.
c. by viewers of both sexes during the higher T condition compared to the lower T condition, as represented by a significant 2 × 4 interaction between time of testing and expression.

False Alarm rates—that is, proportions of false positive responses—were also tabulated. The principle purpose for this was to ascertain, in the event expected relationships for threat detection were not obtained, whether the findings of prior studies may have been a result of confounds based on over-responding for anger. False alarm rates for all conditions were also evaluated as a potential source of serendipitous information, using a 2 × 2 × 4 ANOVA for sex of viewer, sex of poser, and expression.

Results

False Alarm Rates

The overall data for false alarm rates are shown in Figure 1. There was a main effect of expression (F (3, 110) = 109.04, $p < .001$), with sadness and disgust generating the most false alarms, followed by anger and fear, respectively. Simple effects, measured by *t*-tests for paired samples, indicated false alarm rates were significantly different between expressions ($p < .05$), with the exception of disgust vs. sadness ($p = .88$). There was

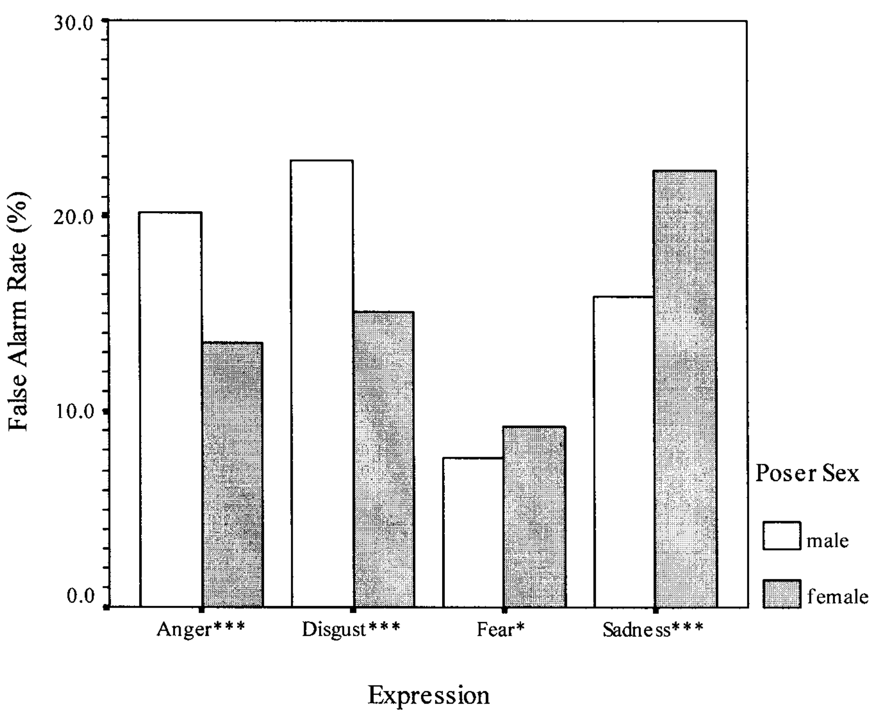


Figure 1. Mean false alarm rate for each expression compared by poser sex. Significant differences are indicated by *$p < 0.05$, and ***$p < 0.000$.

also a main effect of sex of poser (F (1, 112) = 43.21, $p < .001$), with male posers evoking more errors across expressions than females. This, however, was attributable to a significant interaction between sex of poser and expression (F (3, 110) = 45.39, $p < .001$). Male posers yielded more false positive errors for anger and disgust; female posers generated more false positive errors for fear and sadness. Simple effects between sexes in terms of t-tests were significant at $p < .001$ for anger ($t(113) = 7.71$), disgust ($t(113) = 8.25$) and sadness ($t(113) = -7.36$), and at $p < .05$ for fear ($t(113) = -2.29$). There were no significant findings regarding sex of viewer.

Hypothesis 1

The hypothesized 2 × 4 interaction for poser sex and expression was present (F (3, 110) = 20.624, $p < .001$) and is shown in Figure 2. Sensi-

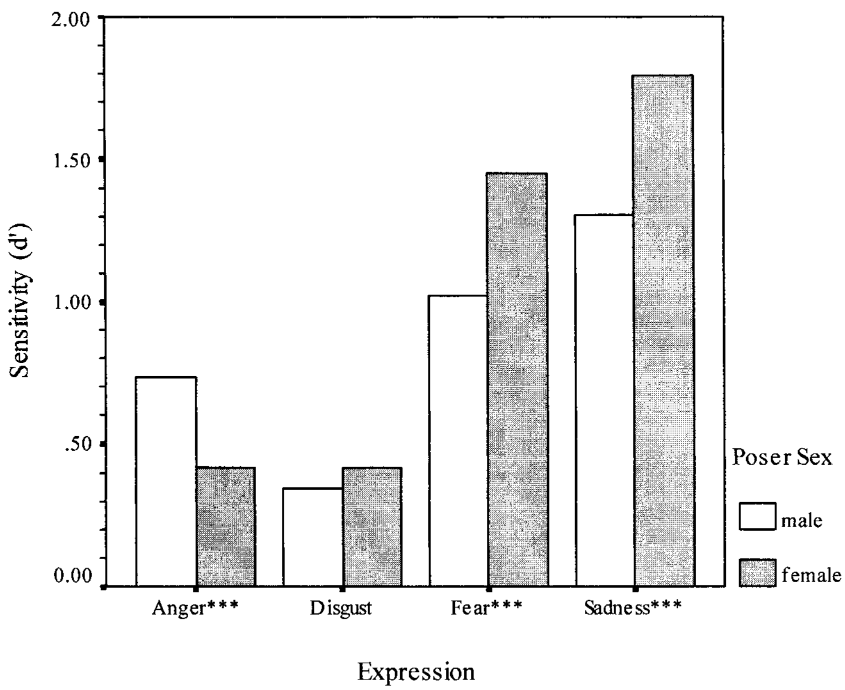


Figure 2. Mean sensitivity (d') for each expression compared by poser sex. Significant differences are indicated by ***$p < 0.001$.

tivity scores for anger were higher for male than female posers ($t(113) = 5.42$, $p < .001$), and this pattern was not present for any other expression. In fact, there was a main effect of poser sex across expressions favoring females ($F\ (1, 112) = 32.07$, $p < .001$). Fear ($t(113) = -5.89$) and sadness ($t(113) = -5.23$) both showed higher Sensitivity scores for female posers at $p < .001$, respectively, while male and female poser scores for disgust were virtually identical ($t(113) = .93$).

Hypothesis 2

Neither the $2 \times 2 \times 4$ interaction for sex of poser, sex of viewer and expression, nor the 2×2 interaction for sex of viewer and sex of poser for anger were significant. As predicted, however, female viewers showed significantly more sensitivity than males to females posing anger ($F\ (1, 112) = 5.19$, $p < .05$), (see Figure 3) while this difference did not reach or approach significance for male posers. Though unanticipated by the hypotheses, the same trend occurred for sadness; female viewers were significantly more sensitive than their male counterparts to female posers ($F\ (1, 112) = 6.24$, $p < .05$), while the same difference for male posers did not reach or approach significance.

Hypothesis 3

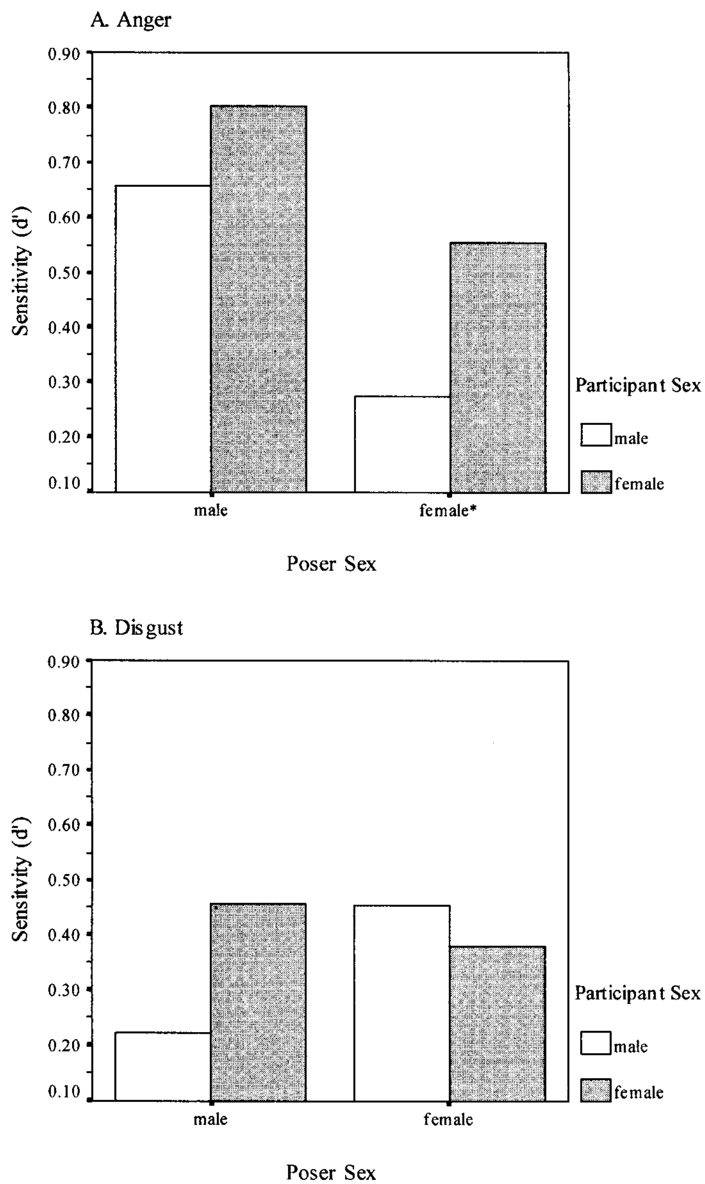
The predicted interaction for time and expression was not obtained, nor were anger recognition scores greater during the period of higher T levels.

Other Findings

There was a main effect of expression ($F\ (3, 110) = 81.13$, $p < .001$), across all conditions, whereby sadness was correctly perceived most often, followed by fear, anger and disgust, respectively. In terms of simple effects, *t*-tests for paired samples indicated that all expressions were significantly different from all others at $p < .01$.

There were no main effects either for viewer sex or for times, the latter suggesting an absence of practice effects for the test.

The correlation between overall Sensitivity scores between times was .420 ($p < .001$), indicating a moderate degree of reliability.


A. Anger
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Sensitivity (d')
male
female*
Poser Sex
Participant Sex
male
female
B. Disgust
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Sensitivity (d')
male
female
Poser Sex
Participant Sex
male
female

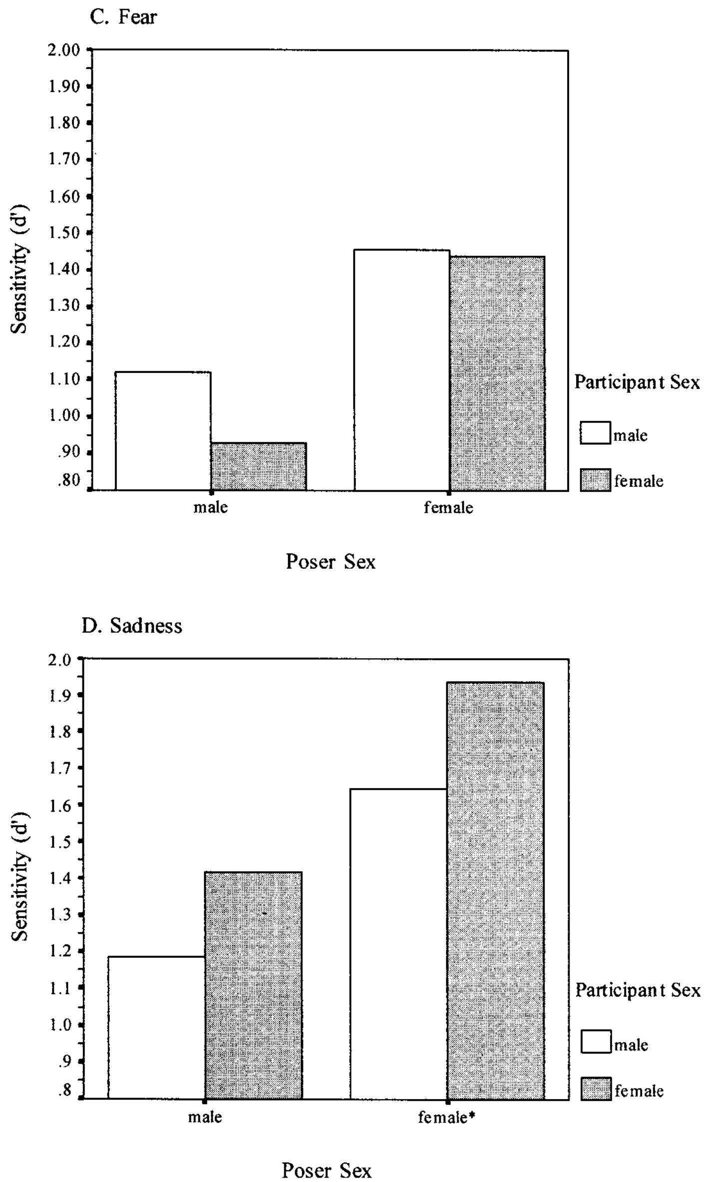


Figure 3. Sensitivity (d') for each poser sex, comparing results for each participant sex, for each expression. Significant differences are indicated by *($p < 0.05$).

Discussion

The false alarm data of the present study, particularly the interaction between sex of poser and expression, have important methodological implications. There were significant differences between male and female posers for all four expressions, with male posers generating higher false alarm rates for anger and disgust and female posers yielding higher rates for fear and sadness. These findings appear to have a rational basis in that they reflect conventional views regarding sex differences in the frequency of expression of specific emotions. We might intuit that most people believe that males are more likely to show anger and disgust while females tend more to show sadness and fear, and these preconceptions appeared to influence their guesses. Thus, when controls for non-random guessing are not employed in facial expression recognition studies, spurious results may readily occur.

Non-random false alarm rates could have produced the data anticipated by Hypothesis 1, but the prediction was nevertheless supported with this factor controlled. Viewers of both sexes more often correctly identified anger when posed by males than females, and this difference did not occur for any of the other three expressions.

The data for Hypothesis 2 were equivocal. Neither the three-way interaction for poser sex, viewer sex and expression, nor the embedded interaction of poser sex and viewer sex for anger, were significant. On the other hand, female viewers were significantly more accurate than their male counterparts in their recognition of female posed anger, while a parallel difference for male posed anger did not reach or approach significance. The same trend, however, was observed for sadness as for anger. Female viewers, compared to male viewers, showed significantly higher scores for female posers, while this difference did not reach or approach significance for male posers.

This trend for sadness was not anticipated by the hypothesis but may also be accounted for in terms of adaptive, evolved mechanisms. Anthropological studies of primitive cultures have found sadness to be a cue for the strengthening of social support for the sad individual (Tousignant, 1984; Tousignant & Maldonado, 1989), and recent studies have shown that women tend more than men to seek social support from other women when dealing with stress (Taylor et al., in press). Additionally, studies of the proxemic behavior of individuals perceiving expressions of happiness or sadness have demonstrated that while men were more comfortable being closer to others expressing happiness, women were equally comfortable when close to others showing happy or sad expressions (Mandal & Maitra, 1985).

The hypothesis that Sensitivity scores for anger would vary with testosterone levels was not confirmed, possibly due to shortcomings in the inferential method used.

The question remains as to the extent to which present and previous findings involving sex differences in facial expression recognition are based on differential capacities for accurate display or accurate perception of specific expressions. The latter explanation is rendered more parsimonious by two aspects of the present data. First, false positive perceptions were consistent with conventional wisdom about the likelihood of attributing particular expressions to men or women. Additionally, male and female viewers showed predictably different Sensitivity scores to the same stimuli.

The differential roles played by innate, evolved mechanisms as distinct from socialization variables also remain at issue. The hypotheses of the present study involving sensitivity to anger by sex of poser and viewer were derived from evolutionary theory, although they could be attributed as well to experience gained in learning to stay out of harm's way. It is considered that the use of conditions of very brief exposure provided some additional credence to the concept of an instinctive basis for facial expression recognition. The hypothesis regarding sex hormone correlates was not supported, however direct blood or salivary measures of T levels may be more reliable. Other measures of biological bases underlying anger recognition may also bear on these interpretations and, in this vein, recent fMRI and pharmacological studies have shown that angry facial expressions are processed in parts of the brain distinct from the areas used to process non-threatening facial expressions (Blair, Morris, Frith, Perrett, & Dolan, 1999; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998; Blair & Curran, 1999). Finally, as previously noted, studies directed toward establishing the universality or lack thereof of the relevant sex differences would probably provide the most apt test between the evolutionary and socialization perspectives.

Notes

1. As contemporary support for this contention, recent data from the National Crime victimization survey in the U.S. revealed that 75% of violent crimes committed by females are simple assaults on other females (*AP*, December 6, 1999).
2. Testosterone levels show a circadian rhythm, varying by as much as 80% over the course

of the day (Dabbs & de LaRue, 1991). Concentrations are highest in the morning and lowest in the evening, with the greatest change taking place over the course of the morning (Dabbs, 1990).

3. $d' = K_M \ln [(M - 1)P_c / (1 - P_c)]$ where $K_M = 0.86 - 0.085 \ln (M - 1)$, M = the # of alternative, P_c = proportion correct.

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