AGGRESSIVE BEHAVIOR
Volume 22, pages 321–331 (1996)

Salivary Testosterone and Self-Report Aggressive and Pro-Social Personality Characteristics in Men and Women

Julie Aitken Harris, J. Philippe Rushton, Elizabeth Hampson, and Douglas N. Jackson

Department of Psychology, The University of Western Ontario, London, Ontario, Canada

Measures of salivary testosterone and the personality dimensions of aggression and pro-social behavior were obtained in 306 (155 male and 151 female) university students. Each participant provided two samples of saliva and completed ten self-report personality scales from multiple inventories. A factor analysis of the personality scales produced two factors, an aggression factor and a pro-social behavior factor. Men averaged five times the amount of salivary testosterone as women (99 pg/ml vs. 18.5 pg/ml) and rated themselves as more aggressive and less nurturant. Within each sex, testosterone was positively correlated with aggression and negatively correlated with pro-social personality. Structural equation modelling analyses suggested that a direct effect model best described the relationship between salivary testosterone and the latent personality dimensions of aggression and pro-social behavior. © 1996 Wiley-Liss, Inc.

Key words: testosterone, personality, aggression, empathy, altruism, nurturance

INTRODUCTION

Reviewers are divided on whether there is empirical support for the hypothesis that testosterone contributes to human aggression. Archer [1991, 1994] concluded that several correlational studies favoured this hypothesis. Archer pointed out that the age and sex differences in testosterone and aggression parallel one another, with a curvilinear relation with age in both sexes and with males more aggressive than females at each age. Studies comparing aggressive and non-aggressive groups (e.g., violent vs. non-violent offenders) showed higher testosterone levels in the former for both men and women. Testosterone also showed a small correlation with aggression (and antisocial behavior) in a variety of samples. For example, with 4,462 male military veterans,

Received for publication September 13, 1994; accepted December 21, 1995.

Address reprint requests to J. A. Harris, Department of Psychology, Social Science Centre, The University of Western Ontario, London, Ontario, Canada, N6A 5C2.

Dabbs and Morris [1990] found that serum testosterone predicted a range of antisocial activities including being assaultive towards others. A re-analysis of this data by Booth and Osgood [1993] supported the testosterone-antisocial behavior relationship. Gray et al. [1991] found that testosterone levels were related to aggressive dominance measured by questionnaires in a large community based sample of men.

In a separate review, Albert et al. [1993], however, came to a negative conclusion about the testosterone-aggression relationship. They cited the weakness (and null findings) of several studies, in particular, studies that compared the testosterone levels of aggressive vs. less aggressive individuals. Most of the comparison studies reviewed were based on small samples of men within prisons, categorized by either scores on a self-report hostility measure or from judgments of the severity of the crime committed.

Both Archer [1994] and Albert et al. [1993] concluded that individual differences in aggression were longitudinally stable attributes, rooted in temperament and in early developmental processes. Both reviewers accepted a moderate heritability for aggressive temperament, based on twin studies. Heritability estimates of approximately 50% have been found for the production rate of testosterone in men [Meikle et al., 1987, 1988] as well as for the trait of aggression in both men and women [Rushton et al., 1986].

Subsequent to the reviews by Archer [1991, 1994] and Albert et al. [1993], Van Goozen and colleagues have reported additional experimental evidence for the effects of androgens on aggression. In one study, self-report anger and aggression proneness increased in a group of 22 female-to-male transsexuals after oral administration of androgens [Van Goozen et al., 1994]. In another study, the administration of androgens to a group of 35 female-to-male transsexuals was associated with increased aggression proneness while androgen deprivation in a group of 15 male-to-female transsexuals (by the administration of anti-androgens and oestrogens) decreased anger and aggression proneness [Van Goozen et al., 1995].

The relationship of testosterone to pro-social behavior is almost unknown. Because there is evidence that pro-social behavior is negatively related to antisocial behavior and aggression in both men and women [Julian and McKenry, 1989; Mehrabian and Epstein, 1972; Rushton et al., 1986], it is hypothesized that testosterone may be negatively related to pro-social personality characteristics. Preliminary evidence for this hypothesis was found in a study of women by Baucom et al. [1985] in which testosterone showed a small negative relationship with kindness, having a caring attitude, and being helpful.

The present study investigated more fully the relation between circulating testosterone and self-report aggressive and pro-social personality characteristics in a group of healthy men and women. A wide variety of paper and pencil tests was used, from which reliable composite measures of personality were derived. The effects of seasonal and diurnal variations in testosterone were also controlled.

METHOD

Subjects

Subjects were 306 university students, both undergraduate (recruited through a first year Psychology subject pool and participating in order to partially fulfill course requirements) and graduate (volunteers). Of these, 155 were men (age range: 19–36 years, $M = 21.6$) and 151 were women (age range: 19–49 years, $M = 22.4$). All subjects were

asked prior to testing to participate only if they were not taking medication. Women were asked not to participate if they were on oral contraceptives.

Procedure

In both men and women, testosterone displays a circadian rhythm, with concentrations highest in the morning and lowest in the evening [Riad-Fahmy et al., Walker, 1983; Dabbs, 1990b]. Therefore, time of day of saliva sampling was held constant for all subjects. Although the relationship within women is not known, within men, testosterone has also been found to be lowest in the spring and highest in the fall and early winter months [Dabbs, 1990a; Reinberg and Lagoguey, 1978]. Therefore it was essential that all subjects be tested within the shortest time span possible.

In women, testosterone secretion also varies with the menstrual cycle. A slight rise in plasma testosterone occurs around mid-cycle in ovulating women [Bancroft et al., 1980]. The effect of the menstrual cycle on salivary testosterone is reported to be considerably smaller than the influence of the circadian rhythm [Dabbs and de La Rue, 1991]. Dabbs and de La Rue [1991] found an 80% change in testosterone levels over a day, by comparing morning saliva samples to evening samples, compared to a 12% change in testosterone levels over the course of the menstrual cycle in women. In the present study, phase of cycle at time of testing was random. Because oral contraceptives can suppress endogenous testosterone production [Alexander et al., 1990], and because some contraceptive compounds have androgenic effects themselves, women on oral contraceptives were specifically excluded.

Testing was conducted in small groups over the course of three months (January to March, 1993). All subjects began the test session at 09.00 hr and all had completed the session by 11.00 hr. During testing, subjects were instructed as to how and when saliva samples would be taken. Participants then completed a brief information sheet which inquired as to whether they were taking any medications (including birth control pills). Following this, the personality scales described below were administered.

Personality Scales

In order to assess the multiple dimensions within the aggression and pro-social personality domains, subscales of various inventories were incorporated into a test battery. The first scale completed was the Self-Report Altruism Scale [Rushton et al., 1981]. This scale is comprised of 20 items such as, "I have offered to help a handicapped or elderly stranger across the street," responded to using a 5-point scale (ranging from: 1, Never to 5, Very Often). The second set of questionnaires consisted of the four subscales from The Aggression Questionnaire [Buss and Perry, 1992]. These scales include a seven item anger scale (item example: "I have trouble controlling my temper"), an eight item hostility scale (item example: "I am sometimes eaten up with jealousy"), a nine item physical aggression scale (item example: "If somebody hits me, I hit back"), and a five item verbal aggression scale (item example: "I often find myself disagreeing with people"). For these four subscales subjects responded using a 5-point scale (ranging from 1, extremely uncharacteristic of me to 5, extremely characteristic of me).

The third scale completed was the Emotional Empathy Scale [Mehrabian and Epstein, 1972], consisting of 33 items, such as, "I become nervous if others around me seem to be nervous," with responses ranging from +4, very strong agreement to –4, very strong disagreement. Subjects then completed the Personality Research Form (PRF) nurturance

scale [Jackson, 1984], consisting of 16 items in which a subject responds true or false to statements such as, "I often take people under my wing." The fifth questionnaire was the Interpersonal Behavior Survey (IBS) aggression scale [as cited in Rushton et al., 1986]. This scale includes 23 items, responded to in a true or false manner (item example: "A person who says something stupid deserves to be put down").

The next two scales completed were the Nonverbal Personality Questionnaire (NPQ) aggression scale and the NPQ nurturance scale [Paunonen and Jackson, 1988]. Each scale consists of eight pictorial items (such as a stick person yelling at a police officer for receiving a ticket for the aggression scale, or visiting an individual in the hospital for the nurturance scale), responded to in a 7-point format ranging from 1, extremely unlikely that I would perform this type of behavior to 7, extremely likely that I would perform this type of behavior.

Testosterone Sampling

Saliva samples provide an accurate and reliable measure of the biologically active component of testosterone. Salivary testosterone consists essentially of the unbound portion of serum testosterone, since testosterone bound to sex hormone binding globulin does not pass through the salivary glands. Unbound testosterone is considered to be the bio-available fraction and represents approximately 2 to 3% of the total circulating testosterone [Pardridge and Demers, 1991]. Salivary testosterone correlations with free testosterone in serum have been reported to fall between .93 [Navarro et al., 1986] and .97 [Vittek et al., 1985], for men and mixed-sex samples. Correlations of .80 and above have been reported in women [Smith et al., 1979].

In the present study, subjects provided two saliva samples, one at 09.00 hr and one at 10.30 hr, to yield a more reliable measure of the individual's testosterone concentration. Saliva was stimulated by providing subjects with Trident fruit flavoured sugar free gum to chew, a method which has been shown to not alter measured testosterone concentrations. Saliva samples were collected in 16 × 100 mm polystyrene tubes pretreated with sodium azide. All saliva samples remained at room temperature for a period of 24 hr, and were then frozen at –20°C before being assayed.

Prior to assay, samples were thawed and centrifuged at 3000 rpm, then submitted to a double ether extraction procedure. Testosterone assays were then completed using a commercially available Coat-a-Count ^{125}I radioimmunoassay (RIA) kit [Diagnostic Products, Los Angeles, CA] altered for use with saliva. All samples were assayed in duplicate, and the amount of testosterone was expressed in pg/ml.

RESULTS

Personality Inventories

Table I lists the means and standard deviations for men, women, and the total sample, for each of the scales. Also listed in Table I are the F-ratios for sex differences based on an analysis of variance. Men were found to score significantly higher than women on the NPQ aggression scale, the IBS aggression scale, and the physical aggression scale. Women, in turn, scored significantly higher on the NPQ nurturance scale, the PRF nurturance scale, and the empathy scale. Each scale was assessed for internal reliability and all were found to be within acceptable range. The internal consistency alpha values can be found in Table I.

TABLE I. Means, Standard Deviations, Sex Differences, and Coefficient Alpha for Scales

Scale (Alpha)	Males (*N*=155) Mean	Males (*N*=155) SD	Females (*N*=151) Mean	Females (*N*=151) SD	Total sample (*N*=306) Mean	Total sample (*N*=306) SD	ANOVA *F* (1, 304)
Altruism (.79)	54.4	8.8	53.3	8.9	53.9	8.8	1.28
Physical aggression (.70)	23.5	6.3	19.3	4.9	21.5	6.0	42.87*
Verbal aggression (.75)	15.4	3.8	14.5	3.8	15.0	3.8	4.31
Anger (.83)	16.5	5.9	16.7	5.4	16.6	5.7	0.08
Hostility (.68)	21.5	4.9	21.7	5.5	21.6	5.2	0.14
Empathy (.86)	22.6	23.4	51.7	21.2	37.0	26.6	130.27*
PRF Nurturance (.70)	9.3	2.9	11.9	2.6	10.6	3.0	70.89*
IBS Aggression (.74)	9.9	3.8	7.3	3.7	8.6	3.9	34.62*
NPQ Aggression (.78)	24.6	8.4	18.7	8.0	21.7	8.7	38.46*
NPQ Nurturance (.82)	38.0	7.8	44.1	6.8	41.0	7.9	53.76*

*$P < .001$.

Interrelations Among Scales

The personality scales were intercorrelated within each sex and were factor analyzed using principal components. Within each sex, Kaiser's measure of sampling adequacy was within acceptable range (men's *KMO* = .76; women's *KMO* = .81), suggesting that the variables were suitable for factor analysis. Two factors were retained for interpretation for each sex based on an examination of the scree distribution and the magnitude of the eigenvalues. For the men, the two extracted factors accounted for 60.6% of the variance. For the women, the two factors extracted accounted for 55.7% of the variance. Table II presents the varimax rotated factor loadings for the variables for each factor within each sex. Factor I was defined as an aggression factor and Factor II as a pro-social factor for both men and women.

Testosterone Measures

Due to the number of samples, assays were performed using three different RIA kits, to which samples were assigned randomly. For the three assays, the sensitivity was 5 pg

TABLE II. Rotated Factors and Factor Loadings for Males and Females

Scale	Males (*N*=155) Factor I	Males (*N*=155) Factor II	Females (*N*=151) Factor I	Females (*N*=151) Factor II
Altruism	–.01	.73	–.07	.34
Physical aggression	.85	–.10	.77	–.23
Verbal aggression	.71	.01	.67	–.09
Anger	.88	.05	.87	.02
Hostility	.55	.07	.67	–.06
Empathy	–.01	.69	.00	.76
PRF Nurturance	–.13	.82	–.12	.82
IBS Aggression	.65	–.48	.71	–.29
NPQ Aggression	.77	–.28	.61	–.53
NPQ Nurturance	–.03	.85	–.28	.75

or less for detecting testosterone. The average intra-assay coefficient of variation (CV) was 5.7%. Non-specific binding was approximately 1% for the three assays.

Based on the self report information, ten women were found to be taking oral contraceptives despite our attempt to solicit only women not on oral contraceptives for the study. These women were eliminated from analyses of the testosterone data. Based on these analyses, men were found to have an average salivary testosterone concentration of 99.07 pg/ml (SD = 31.9), approximately five times greater than was found for the women (M = 18.54 pg/ml, SD = 8.4). The mean value obtained for men falls around the midpoint of the testosterone range identified by Read [1993] as acceptable. The same kit was used for the women, and the values obtained compare favourably with those of Gould, Turkes, and Gaskell [1986] who used a gas chromatography-mass spectrometry technique.

T-tests were calculated within each sex for the two testosterone samples. As expected, the 09.00 hr testosterone concentration was significantly higher than the 10.30 hr concentration for both men ($t(154) = 14.41$, $P < .001$) and women ($t(140) = 13.35$, $P < .001$), reflecting the diurnal variation in testosterone levels. In addition to the time of day samples were collected, sex differences in when subjects were tested were examined, since data collection was conducted over 3 months. An analysis of variance revealed that women were tested significantly later into the year than were men ($F(1,304) = 24.8$, $P < .001$).

Analysis of variance of testosterone (based on an average of the 09.00 hr and 10.30 hr samples) across the 3 months of testing was also examined. A significant main effect for men was found across month of testing ($F(2,152) = 9.18$, $P < .001$) but this was found to be non-significant for the women ($F(2,138) = 0.85$, $P > .05$). Post hoc analyses, using Tukey's q-statistic, of the significant main effect found for men, revealed that testosterone concentrations in February (M = 108.08 pg/ml) were not significantly different from those in March (M = 114.96 pg/ml, $q(1,152) = -2.83$, $P > .05$), and that the February and March levels combined (M = 111.73 pg/ml) were significantly higher than the January (M = 91.14 pg/ml) levels ($q(1,152) = -6.96$, $P < .01$ and $q(1,152) = -9.79$, $P < .01$, respectively). As mentioned previously, ideally all participants would have been tested on the same day. Unfortunately this was not possible in the present study, and therefore day of testing was treated as a covariate and statistically removed in subsequent analyses relating testosterone to the personality measures. The zero-order correlations between testosterone and the personality scales within each sex were also computed, partialling out the effects of age, and the combined effects of age and day of testing. These partial correlations were found to not be different from the correlations with date of testing alone partialled out.

Testosterone and Personality Scales

To assess the relationship between testosterone and personality, canonical correlations were computed within each sex on those scales that comprised the two extracted factors. For men and women, two canonical correlations were computed to assess the relationship between a linear aggregate of the scales constituting a factor with the two testosterone samples and tested for significance using Pillais' multivariate test [Knapp, 1978]. As stated previously, the two factors extracted were defined as an aggression factor and a pro-social factor. For both men and women, the two canonical correlations were found to be significant. Men's testosterone levels correlated .36 ($P < .001$) with

the aggression factor scales and .44 ($P < .001$) with the pro-social factor scales. Women's testosterone levels correlated .41 ($P < .001$) with the aggression scales and .29 ($P < .01$) with the pro-social scales.

Testosterone Models

One means of assessing the potential directional effects of testosterone on personality is through the use of structural equation modelling analyses [Dabbs, 1992; Olweus, 1986]. Two possible models were tested within each sex using LISREL 7 [Jöreskog and Sörbom, 1989], a method that assesses the overall fit of the data to the constraints imposed by the model through maximum likelihood estimations of the model parameters. Model 1 tested whether the latent variable testosterone, defined by the combined 09.00 hr and 10.30 hr samples, correlated with the two latent personality variables, defined by those personality scales that constituted the aggression and pro-social factors, by designating all three latent variables as exogenous (ksi), which by definition, can only correlate with other exogenous variables and not directly affect each other. Model 2 assessed whether testosterone had a direct effect on the personality dimensions by designating the testosterone variable as an exogenous (causal) variable and the aggression and pro-social variables as endogenous (eta) variables, that can either be caused by an exogenous variable or correlate with, or directly effect, another endogenous variable, but can not affect an exogenous variable.

Therefore, Model 1 (correlational model) and Model 2 (direct effect model) were tested to determine which model better fit the data. Both of the models were generated using first order partial correlations, within each sex, with day of testing as a covariate. In addition, all possible model differences were tested using a nested chi-square design in which the chi-square values, and their corresponding degrees of freedom, for the two models are subtracted from each other and tested for significance based on the new degree(s) of freedom [Hayduk, 1987], and based on a conservative significance level so as not to capitalize on chance.

Within men, Model 1 (X^2 (51) = 158.08) and Model 2 (X^2 (49) = 109.35) yielded a significant nested chi-square (X^2_{nested} (2) = 48.73, $P < .01$), such that Model 2 resulted in a better fit to the data set. A non-significant nested chi-square was found for the women (X^2_{nested} (9) = 0.01, $P > .01$) between Model 1 (X^2 (51) = 116.05) and Model 2 (X^2 (42) = 116.04). Because the difference between the two models for women was non-significant, either model could be considered to fit the data, creating a conceptual or theoretical issue rather than a statistical one [Dillon and Goldstein, 1984]. Therefore, to allow for comparisons between men and women, Model 2 was chosen for further analyses.

To test whether Model 2 differed between men and women, a nested chi-square test was calculated. A non-significant nested chi-square was found between men and women (X^2_{nested} (7) = 6.69, $P > .01$). Therefore, men and women were combined, and two models were tested for the combined data. Again, Model 1 tested the possibility that testosterone correlated with the two latent variables, aggression and pro-social behavior, and Model 2 tested, as described above, for a direct relationship between testosterone and the two latent personality variables. A significant nested chi-square was found between these two models (X^2_{nested} (3) = 56.16, $P < .01$), with Model 2, the direct effect model, (X^2 (44) = 123.68) being significantly better than Model 1, the correlational model (X^2 (47) = 179.84).

To further assess whether the sex combined Model 2 was significantly different from

either Model 2 for the men, or Model 2 for the women, two nested chi-square tests were calculated. These tests were performed to determine whether there was any discrepancy between the sex combined model and the models from each sex independently. Non-significant nested chi-square tests were found between the combined Model 2 and Model 2 for the men (X^2_{nested} (5) = 14.33, $P > .01$), and between the combined Model 2 and Model 2 for the women (X^2_{nested} (2) = 7.64, $P > .01$). Based on the above results, the combined Model 2 was considered to be the best fit, representing models for both men and women. Following from this, the overall fit of Model 2, based on the total sample, was then assessed.

Of the methods that have been suggested to assess the overall fit of a model based on correlational data, four were chosen to evaluate the combined direct effect model: chi-square per degree of freedom test; a standardized chi-square test; the goodness of fit index; and the value of the residuals [Bentler, 1980; Bollen, 1989; Jöreskog and Sörbom, 1989; La Da and Tanaka, 1989; Wheaton et al., 1977]. The fact that the chi-square per degree of freedom and the standardized chi-square tests, when applied to the combined direct effect model, each yielded a non-significant value (X^2 (1) = 2.81, $P > .05$, X^2 (9) = 8.49, $P > .05$, respectively), suggested an acceptable fit of the model. Although the goodness of fit index [Jöreskog and Sörbom, 1989] does not have an associated significance test [Cliff, 1987], the obtained value of .94 (where 1.0 represents perfect fit) was judged to be acceptable. Finally, the fitted residuals of the combined direct effect model proved to be close to zero, with the largest root mean square of .04, again supporting the acceptability of the model.

Therefore, based on the above results, Model 2, the direct effect model for men and women combined, was considered the better of the two models in fitting the data set. A third model, in which the two personality dimensions were combined into one aggression—pro-social variable, was found to not fit the data as well as the model in which aggression and pro-social personality dimensions are treated separately, suggesting that the two personality dimensions are best represented as separate variables. Figure 1 illustrates the best fitting model. All of the weights in the model were significant (based on obtained t-values [Jöreskog and Sörbom, 1989], as well as controlling for Type I error rates, by setting the significance criteria at $P < .01$). As shown in Figure 1, aggression is negatively correlated with the pro-social personality dimension and testosterone has a positive and direct relationship with aggression and a negative direct relationship with pro-social personality of almost equal magnitude.

DISCUSSION

The present study investigated between and within sex relationships between the sex hormone testosterone and the personality dimensions of aggression and nurturance based on self-report measures. Personality scales were factor analyzed, within each sex, producing two factors, an aggression factor and a pro-social factor. When the scales that defined the two factors were combined, based on commonalities, to form two new latent variables, moderate relationships between testosterone and the latent variables emerged. A possible direct effect relationship between testosterone and the aggression and pro-social latent variables was then tested. Based on the results of the model analyses, the direct effect model was found to have a better fit with the data than the correlational model for men. For women, no difference was found in terms of model fit for the

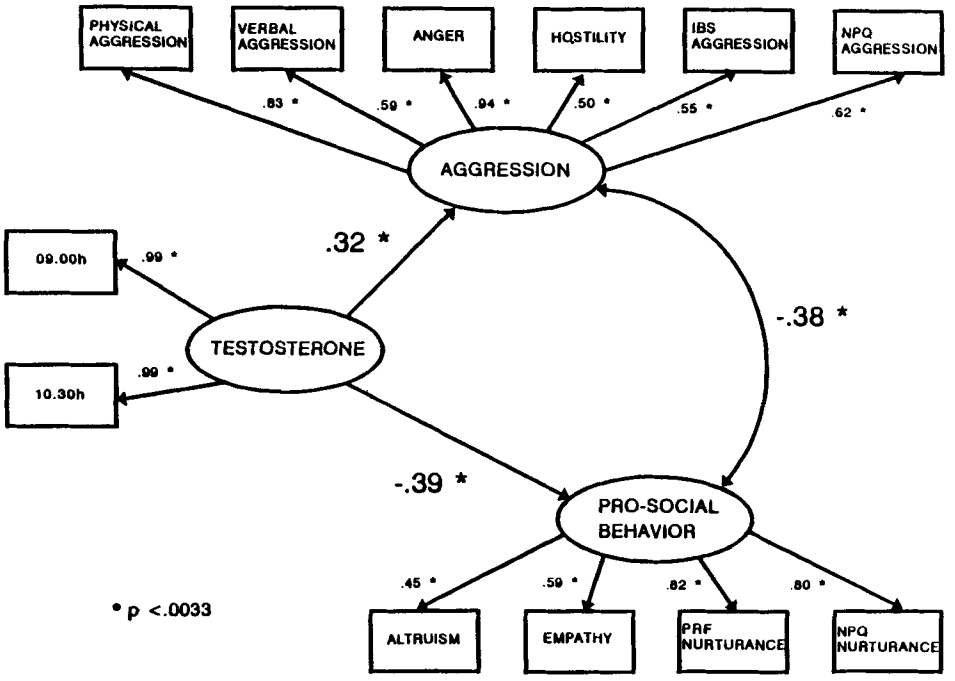

Fig. 1. Direct effect model of testosterone, aggression, and pro-social personality for males and females combined.

two models tested. The results suggested that for both men and women, testosterone had a positive relationship with aggression and a negative relationship with pro-social personality.

Consistent with previous literature on sex differences in social behavior [Eagly et al., 1991], men scored higher on the aggression scales and women scored higher on the nurturing and empathetic dimensions. No sex differences were found for the measure of altruism.

A noteworthy result of the structural model analysis was the lack of major sex differences in the relation of the two latent personality dimensions to testosterone, such that the overall structure between testosterone, aggression, and the pro-social personality scales was found to be not statistically different for each sex. This result must be interpreted cautiously, since there was no difference between the direct effect model and the correlational model when women alone were examined.

Phase of menstrual cycle was not explicitly controlled in this study due to practical limitations. In a study of this size, the resulting slight increase in salivary testosterone variability in women is not a serious concern [Dabbs and de La Rue, 1991]. Relationships between testosterone and the pro-social and aggressiveness measures in women were significant and, as noted above, resembled the relationships found in men. Nevertheless, future studies should ideally take menstrual cycle variability into account.

Although LISREL can identify potential causal relationships among variables, it must be stressed that the data analyzed here were fundamentally correlational in nature. No

actual manipulation of testosterone was carried out. This study does not reveal whether it is testosterone, or some metabolite of testosterone that is important in mediating these relationships, nor can it distinguish between long-term effects of the hormone and more immediate effects of circulating androgen. The results support a multifactorial view of aggression, and should not be interpreted as suggesting that testosterone is the only variable influencing human aggression and pro-social behavior. Clearly the expression of these behaviors is also influenced by prior learning and other developmental influences.

To conclude, the present study supports prior findings that testosterone is positively related to aggression in both men and women [Archer, 1991; Ehlers et al., 1980; but see Gladue, 1991, who found a negative correlation between testosterone and aggression in women], and extends the literature by suggesting that testosterone is negatively related to pro-social personality dimensions in men and women. Studying how testosterone is related to overt behavior will be a challenge for future research, as will how hormonal factors might influence personality development in combination with societal influences.

REFERENCES

Albert DJ, Walsh ML, Jonik RH (1993): Aggression in humans: What is its biological foundation? Neuroscience and Biobehavioral Reviews 17:405–425.

Alexander GM, Sherwin BB, Bancroft J, Davidson DW (1990): Testosterone and sexual behavior in oral contraceptive users and nonusers: A prospective study. Hormones and Behavior 24:388–402.

Archer J (1991): The influence of testosterone on human aggression. British Journal of Psychology 82:1–28.

Archer J (1994): Testosterone and aggression. In Hillbrand M, Pallone NJ (eds): "The Psychobiology of Aggression." New York: Haworth Press, pp 3–35.

Bancroft J, Davidson DW, Warner P, Tyrer G (1980): Androgens and sexual behavior in women using oral contraceptives. Clinical Endocrinology 12:327–340.

Baucom DH, Besch PK, Callahan S (1985): Relation between testosterone concentration, sex role identity, and personality among females. Journal of Personality and Social Psychology 48:1218–1226.

Bentler PM (1980): Multivariate analysis with latent variables: Causal modelling. Annual Review of Psychology 31:419–456.

Bollen KA (1989): "Structural Equations With Latent Variables." New York: John Wiley & Sons.

Booth A, Osgood DW (1993): The influence of testosterone on deviance in adulthood: Assessing and explaining the relationship. Criminology 31:93–117.

Buss AH, Perry M (1992): The aggression questionnaire. Journal of Personality and Social Psychology 63:452–459.

Cliff N (1987): "Analyzing Multivariate Data." San Diego, CA: Harcourt Brace Jovanovich.

Dabbs JM, Jr (1990a): Age and seasonal variation in serum testosterone concentration among men. Chronobiology International 7:245–249.

Dabbs JM Jr (1990b): Salivary testosterone measurement: Reliability across hours, days, and weeks. Physiology and Behavior 48:83–86.

Dabbs JM Jr (1992): Testosterone and occupational achievement. Social Forces 70:813–824.

Dabbs JM Jr, de La Rue D (1991): Salivary testosterone measurements among women: Relative magnitude of circadian and menstrual cycles. Hormone Research 35:182–184.

Dabbs JM Jr, Morris R (1990): Testosterone, social class, and antisocial behavior in a sample of 4,462 men. Psychological Science 1:209–211.

Dillon WR, Goldstein M (1984): "Multivariate Analysis: Methods and Applications." New York: John Wiley & Sons.

Eagly AH (1995): The science of comparing women and men. American Psychologist 50:145–158.

Eagly AH, Wood W (1991): Explaining sex differences in social behavior: A meta-analytic perspective. Personality and Social Psychology Bulletin 17:306–315.

Ehlers CL, Richler KC, Hovey JE (1980): A possible relationship between plasma testosterone and aggressive behavior in a female outpatient population. In Girgis M, Kiloh LG (eds): "Limbic Epilepsy and the Dyscontrol Syndrome." New York: Elsevier/North-Holland Biomedical Press, pp 183–194.

Gladue BA (1991): Aggressive behavioral characteristics, hormones, and sexual orientation in men and women. Aggressive Behavior 17:313–326.

Gould VJ, Turkes AO, Gaskell SJ (1986): Gas chromatography-mass spectrometric analysis of salivary testosterone with reference to diethylstilboestrol-treated prostatic cancer patients. Journal of Steroid Biochemistry 24:563–567.

Gray A, Jackson DN, McKinlay JB (1991): The relation between dominance, anger, and hormones in normally aging men: Results from the Massachusetts male aging study. Psychosomatic Medicine 53:375–385.

Hayduk LA (1987): "Structural Equation Modelling With LISREL: Essentials and Advances." Baltimore, MD: Johns Hopkins University Press.

Jackson DN (1984): "Personality Research Form Manual" (2nd ed) Port Huron, MI: Sigma Assessment Systems.

Jöreskog KG, Sörbom D (1989): "LISREL 7 User's Reference Guide." Mooresville, IN: Scientific Software.

Julian T, McKenry PC (1989): Relationship of testosterone to men's family functioning at mid-life: A research note. Aggressive Behavior 15:281–289.

Knapp TR (1978): Canonical correlation analysis: A general parametric significance-testing system. Psychological Bulletin 85:410–416.

La Da TJ, Tanaka JS (1989): Influence of sample size, estimation method, and model specification on goodness-of-fit assessments in structural equation models. Journal of Applied Psychology 74:625–635.

Mehrabian A, Epstein N (1972): A measure of emotional empathy. Journal of Personality 40:525–543.

Meikle AW, Bishop DT, Stringham JD, West DW (1987): Quantitating genetic and nongenetic factors that determine plasma sex steroid variation in normal male twins. Metabolism 35:1090–1095.

Meikle AW, Stringham JD, Bishop DT, West DW (1987): Quantitating genetic and nongenetic factors influencing androgen production and clearance rates in men. Journal of Clinical Endocrinology and Metabolism 67:104–109.

Navarro MA, Juan L, Bounin MR (1986): Salivary testosterone: Relationship to total and free testosterone in serum. Clinical Chemistry 32:231–232.

Olweus D (1986): Aggression and hormones: Behavioral relationship with testosterone and adrenaline. In Olweus D, Block J, Radke-Yarros M (eds): "Development of Antisocial and Prosocial Behavior." Orlando, FL: Academic Press, pp 51–72.

Pardridge WM, Demers LM (1991): Bioavailable testosterone in salivary glands. Clinical Chemistry 37:139–140.

Paunonen SV, Jackson DN (1988): "Nonverbal Personality Questionnaire." London: University of Western Ontario.

Read GF (1993): Status report on measurement of salivary estrogens and androgens. Annals of the New York Academy of Sciences 694:146–160.

Reinberg A, Lagoguey M (1978): Circadian and cirannual rhythms in sexual activity and plasma hormones (FSH, LH, Testosterone) of five human males. Archives of Sexual Behavior 7:13–30.

Riad-Fahmy D, Read GF, Walker RF (1983): Salivary steroid assays for assessing variation in endocrine activity. Journal of Steroid Biochemistry 19:265–272.

Rushton JP, Chrisjohn RD, Fekken GC (1981): The altruistic personality and the self-report altruism scale. Personality and Individual Differences 2:293–302.

Rushton JP, Fulker DW, Neale MC, Nias DKB, Eysenck HJ (1986): Altruism and aggression: The heritability of individual differences. Journal of Personality and Social Psychology 50:1192–1198.

Smith RG, Besch PK, Dill B, Buttram VC (1979): Saliva as a matrix for measuring free androgens: Comparison with serum androgens in polycystic ovarian disease. Fertility and Sterility 31:513–517.

Van Goozen S, Cohen-Kettenis PT, Gooren LJG, Frijda N, Van de Poll N (1995): Gender differences in behavior: Activating effects of cross-sex hormones. Psychoneuroendocrinology 20:343–363.

Van Goozen S, Frijda N, Van de Poll N (1994): Anger and aggression in women: Influence of sports choice and testosterone administration. Aggressive Behavior 20:213–222.

Vittek J, L'Hommedieu DG, Gordon GG, Rappaport SC, Southren AL (1985): Direct radioimmunoassay (RIA) of salivary testosterone: Correlation with free and total serum testosterone. Life Sciences 37:711–716.

Wheaton B, Muthen B, Alwin DF, Summers GF (1977): Assessing reliability and stability in panel models. In Heise DR (ed): "Sociological Methodology." San Francisco, CA: Jossey-Bass, pp 84–136.