Hormones, Emotional Dispositions, and Aggressive Attributes in Young Adolescents

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SUSMAN, ELIZABETH J.; INOFF-GERMAIN, GALE; NOTTELMANN, EDITHA D.; LORIAUX, D. LYNN; CUTLER, GORDON B., JR.; and CHROUSOS, GEORGE P. *Hormones, Emotional Dispositions, and Aggressive Attributes in Young Adolescents.* CHILD DEVELOPMENT, 1987, **58**, 1114–1134. Relations among hormone levels, emotional dispositions, and aggressive attributes were examined in 56 boys and 52 girls, age 9 to 14 years. The adolescents represented all 5 stages of pubertal development. Serum levels of gonadotropins, gonadal steroids, adrenal androgens, and testosterone-estradiol binding globulin were assessed. Levels of these hormones were related to stage of pubertal development and were assumed to represent relatively stable biological characteristics. The emotional dispositions assessed were adolescent self-reported anger, nervousness, sadness, and impulse control. The aggressive attributes assessed were mother-reported acting out and aggressive behavior problems and rebellious and nasty characteristics. Hormone levels were related to emotional dispositions and aggressive attributes for boys but not for girls. For example, higher levels of androstenedione in boys were related to higher levels of acting-out behavior problems. Level of testosterone-estradiol binding globulin was negatively related to sad affect and acting out behavior.

Puberty is a period of physical development accompanied by dramatic increases in the circulating levels of many hormones (Sizonenko, 1978; Williams, 1981). Puberty also is a period of psychological development characterized by increases in aggressive and rebellious behavior in most cultures (Weisfeld & Berger, 1983). How these two sets of changes relate to each other is the focus of the present study.

At a folk-wisdom level, hormonal changes are associated with behavior change in adolescents. The empirical evidence confirming this link is almost nonexistent. It is known that the rapid hormone changes at puberty include increases in androgens, which are presumed to be linked to aggressive behavior. In many species studied, aggression also increases at puberty, most clearly for males (Weisfeld & Berger, 1983).

The link between androgen levels and aggressive behavior in animals has been found consistently for males and sometimes for females (Bouissou, 1983; Eleftheriou & Sprott, 1975; also see Ellis, 1982). Furthermore, increases in androgen levels in males are implicated in the increases in aggression at puberty. In elegantly designed studies of aggression in mice, Cairns, MacCombie, and Hood (1983) found that at early sexual maturity, aggression began to rise in male mice. In humans, similar but less consistent androgen-aggression relations have been reported in adult males (Mazur & Lamb, 1980) and in late pubertal male adolescents (Olweus, Mattsson, Schalling, & Low, 1980). Females are less frequently studied than males with regard to hormonal influences on aggression.

The extensive animal literature demonstrating the role of hormones in aggression (e.g., Adams, 1983; Bouissou, 1983; Brain, 1977) and the growing psychoneuroendocrinology literature demonstrating the influence of hormones on the behavior of humans (e.g., Rose & Sachar, 1981; Sachar, 1980) provide the basis for the hypothesis that hormone levels are related to aggression in human adolescents. This study simultaneously examines hormone levels, emotions theoretically related to aggression, and aggression in a sample of male and female young adolescents.

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Emotions and aggression.—An unanswered question is, What are the mechanisms whereby the effects of hormones become exhibited in aggressive behavior? One approach to answering this question involves emotional states in the hormone-aggressive behavior pathway. The emotions predisposing adolescents to overt aggressive behavior include rage (Berkowitz, 1964; Fonberg, 1979), sadness (Doering, Brodie, Kraemer, Moos, Becker, & Hamburg, 1975), and fear or anxiety (Bouissou, 1983; Ehrenkranz, Bliss, & Sheard, 1974; Frodi, Macaulay, & Thome, 1977; Leshner, 1983). Fear can have activating as well as inhibitory effects on aggression, depending on the circumstances. Emotions that can have inhibitory or antagonistic effects on the expression of aggression also include happiness or elation (Alpert, Cohen, Shaywitz, & Piccirillo, 1981; Fonberg, 1979). Aggression probably is motivated by multiple emotions that may or may not be experienced consciously by the aggressor.

The mechanisms whereby hormones influence emotions and behavior have been conceptualized in terms of the organizing and activating influences of hormones (Hays, 1981; Phoenix, Goy, Gerall, & Young, 1959; Tieger, 1980). Organizational influences stem from prenatal and perinatal hormone exposure, which affects the structure or functioning of the central nervous system such that development and functioning are altered. Activational influences stem from contemporaneous effects of hormones on behavior. Gonadal steroids are involved prenatally and perinatally in the organization of the central nervous system; during and after puberty, they serve primarily an activating function (Rubin, Reinisch, & Haskett, 1981; Young, Goy, & Phoenix, 1964). The organizing and activating influences of hormones may result in differences among groups, such as those found between the sexes as well as differences among individuals.

The organizing influence of hormones, as reflected in the degree of prenatal and perinatal exposure to gonadal steroids, may sensitize individuals in such a way that they differ with respect to their readiness for certain types of emotional responding (Marcus, Maccoby, Jacklin, & Doering, 1985). Individual differences in early hormone exposure were thought to account for sex differences in frequency, intensity, and age patterns of emotional behaviors, such as girls showing more fearfulness than boys and boys showing more anger and frustration reactions than girls. Links between neonatal hormone levels and predominant mood states in early childhood have been reported (Marcus et al., 1985). In most cases, hormones are presumed to be involved in emotions in children but are not examined.

Hormone links to emotions in adults also have been reported. Although not all the evidence has been consistent, findings indicate hormone links to both emotional states (Bardwick, 1976; de Lignieres & Vincens, 1982; Mazur & Lamb, 1980) and traits (Doering et al., 1975; Houser, 1979). Relations between changes in hormone levels and depression and other affective disorders (e.g., see Anisman & LaPierre, 1982; Puig-Antich, 1986) and premenstrual or menopausal symptoms (e.g., see Bardwick, 1976; de Lignieres & Vincens, 1982; Floody, 1983) also have been examined. Additionally, the bidirectional influence of hormone levels affecting behavior and behavior or experience (e.g., defeat) affecting hormone levels is well recognized in psychobiological research (Leshner, 1983). The pathway involving hormonal influences on behavior was the theoretical focus of this study.

In young adolescents, emotional states may undergo major perturbations as a sequelae of the rise in hormone levels at puberty. The activating influences of hormones may be reflected in the emotions of adolescents because neural tissues are target tissues for some puberty-related hormones. Disturbances in emotions also may reflect disequilibrium in biological processes that may stem from the rapidity of change in hormone levels. In our cross-sectional sample of young adolescents, hormone levels had not yet reached adult levels, even for the adolescents in the later stages of puberty. Therefore, the adolescents still may have been experiencing emotional perturbations related to increases in hormone levels.

In this study, four aspects of emotion were examined: anger, nervousness, sadness, and impulsivity. These aspects of emotion are referred to as "emotional dispositions." Rather than describing specific emotional states, they describe traits or dimensions of behavior similar to temperament or the behaviors examined in the Stanford Longitudinal Study (Maccoby, Doering, Jacklin, & Kraemer, 1979; Marcus et al., 1985). Impulsivity is not usually labeled an emotion, but it is considered to reflect characteristics of temperament. Impulsivity also is thought to link hormones and aggression (Olweus et al., 1980; Schlain, 1976).

While hormones may affect both positive and negative emotions, it is negative emotions that are implicated in aggression. If negative emotions are expressed in behavior, they are likely to be expressed as irritability, talking back, or some other similar negative attribute. It is this form of aggression that was investigated in the present study. Irritability and rebellious behaviors are more likely expressions of aggression in normal adolescents than physical attack. As in the case of emotions, the measures of aggression describe traits. They are referred to as "aggressive attributes."

We examined relations among (*a*) hormones and emotional dispositions, (*b*) hormones and aggressive attributes, and (*c*) hormones and emotional dispositions together and aggressive attributes. If the activational influences of hormones at puberty are reflected in emotional dispositions and emotional dispositions are reflected in aggressive attributes, then prediction of aggressive attribute scores should be improved by using both hormones and emotional dispositions, rather than hormones alone.

Sex differences.—Sex differences in the expression of aggression are reported for most species, but the degree and pattern of differences depend on the species and type of aggression being considered (Cummings, Hollenbeck, Iannotti, Radke-Yarrow, & Zahn-Waxler, 1986; Floody, 1983; Frodi et al., 1977). The most marked sex differences are seen in rank-related aggression (Brain, 1977). In most species, males tend to be more aggressive than females (Maccoby & Jacklin, 1974, 1980). Sex differences in socialization practices (Friedman, Richart, & Vande Wiele, 1974) and, as mentioned earlier, the organizing and activating influences of hormones (Gandelman, 1980; Hays, 1981; Tieger, 1980; van de Poll, Smeets, & van der Zwan, 1982) are viewed as important factors in sex differences in the expression of aggression.

State versus trait characteristics.—In addition to short-term variations within individuals, hormone levels also vary across individuals. In adolescents, a major source of the variation in hormone levels across individuals is associated with stage of pubertal development. The hormones examined in this study correlate with stage of pubertal development using Tanner criteria (Marshall & Tanner, 1969, 1970). Therefore, for adolescents progressing through puberty, the hormone levels represent the hormone analogue of psychological traits. In this study, individual differences in hormone levels were examined in relation to individual differences in typical or average behavior, that is, to psychological traits. The traits were the emotional dispositions and aggressive attributes. For human males, individual differences in testosterone level have related to the traits of aggressiveness, assertiveness, and impulsiveness, especially where provocation and threat were involved (Doering et al., 1975; Ehrenkranz et al., 1974; Houser, 1979; Mattsson, Schalling, Olweus, Low, & Svensson, 1980; Olweus et al., 1980; Persky, Smith, & Basu, 1971; Scaramella & Brown, 1978). Thus, in this study, both the hormone and behavior measures were assumed to assess traits.

Hormone-behavior specificity.—The literature on aggression provides few empirical findings relevant to developing hypotheses about which particular hormones should be related to aggression in healthy human young adolescents under normal conditions. In the Olweus et al. study (1980), testosterone levels related to certain aspects of aggression in adolescent males in the later stages of puberty. Hormone-aggression findings generally are based on studies of experimentally induced changes in hormone level (e.g., Bouissou, 1983), pathological conditions (Hines, 1982; Kelly, 1981; Siris, Siris, Van Kammen, Docherty, Alexander, & Bunney, 1980), unusual or prison samples (e.g., Ehrenkranz et al., 1974; Mattsson et al., 1980), or infrahumans (e.g., Bouissou, 1983; Rose, Bernstein, Gordon, & Lindsley, 1978). Whether these findings can be generalized to normal adolescents of both sexes is an open question.

The groups of hormones examined in this study were: gonadotropins (luteinizing hormone and follicle stimulating hormone), gonadal steroids (testosterone and estradiol), and adrenal androgens (dehydroepiandrosterone, dehydroepiandrosterone sulphate, and androstenedione). Testosterone-estradiol binding globulin also was measured. These hormones were chosen because of their contribution to sexual development (Sizonenko, 1978; Williams, 1981) and because of assumed links between sexual maturation and aggression (Cairns et al., 1983). Along with testosterone, it was hypothesized that higher levels of adrenal androgens would be related to higher levels of aggression. The adrenal glands are a major source of androgens during early puberty for boys and girls and throughout puberty for girls. It also was hypothesized that estrogen would be negatively related to aggression. Estrogen may inhibit aggression, especially in females. Estrogen levels are high during ovulation and pregnancy (Fregly

& Luttge, 1982), periods of the reproductive cycle during which aggression may be antithetical to species survival. Gonadotropins were included as measures to provide preliminary findings on their relation to emotions and aggression (see Lloyd, 1975; Rubin et al., 1981). To summarize, our hypothesis was that hormone levels, particularly androgen levels, would be positively related to negative emotional dispositions and aggressive attributes.

Method

Participants

Ten- to 14-year-old boys ($N = 56$) and 9–14-year-old girls ($N = 52$) and their parents were the participants in the study. The adolescents were assessed three times on both biological and psychological measures at 6-month intervals over 1 year. Information provided by the adolescents and their mothers at the first time of assessment was used in this report. Adolescents at all five stages of pubertal development, based on Tanner criteria (Marshall & Tanner, 1969, 1970), were included in the sample. There were at least seven adolescents of each sex at each stage of pubertal development. The wider age range of girls was necessary in order to include girls in all five stages of pubertal development. The adolescents were from intact families, although the parents were not necessarily the biological parents. The majority of the families were middle to upper middle class (Hollingshead, 1975).

Recruitment of participants was done mainly through notices distributed at churches, health clinics, community centers, and parent-teacher association and scout troop meetings. Families who contacted the project laboratory were sent a written explanation of the study. The project staff then contacted the family to determine if the family wished to participate. If the decision was positive, two appointments were scheduled: (*a*) a 4-hour visit for mother, father, and adolescent at a home-like laboratory, where most of the behavioral data were collected, and (*b*) a 2-hour visit for the adolescent and one parent at an outpatient clinic in a research hospital, where the biological data were collected. Mother and adolescent also made mood ratings at home during the week following the laboratory and clinic visits.

Procedure

Behavioral measures.—The adolescent, mother, and father were given a battery of standardized tests and interviews to assess various aspects of the adolescent's social, emotional, and cognitive development as well as family relationships. Measures for the present analyses were selected from the larger battery of tests based on the following criteria: (1) The measures had to be relevant to the theoretical perspective of the study. For the emotional dispositions, the following variables were included: (*a*) angry mood (angry-friendly), (*b*) anxious or fearful mood (nervous-calm), (*c*) sad mood (happy-sad and emotional tone), and (*d*) impulse control, which could affect whether or not aggressive tendencies are expressed as aggressive behavior. For the aggressive attributes, variables tapping delinquent (acting out), aggressive, rebellious, and "nasty" behavior were included. (2) The measures needed to be limited in number. The hormone levels, emotional dispositions, and aggressive attributes were analyzed using multiple regression. Therefore, the total number of variables selected was limited to take into account constraints related to number of variables and number of participants.

Angry-friendly, nervous-calm, and happy-sad.—The adolescents were instructed to complete a series of self-ratings at home at the end of every day for 5 consecutive days during the week following the laboratory and clinic visits. These self-ratings included angry-friendly, nervous-calm, and happy-sad. Ratings were made using five-point scales. Scores of 5 represented feeling very friendly to others, feeling very calm, and feeling very sad, respectively. For example, for angry-friendly, 1 = very angry, 2 = angry, 3 = neither angry nor friendly, 4 = friendly, and 5 = very friendly. Scores used in analyses are comprised of means across 5 days of self-ratings.

Stabilities for each of these ratings were assessed by correlating the mean of the scores for the odd days (days 1, 3, and 5) with the mean of the scores for the even days (days 2 and 4). For angry-friendly, nervous-calm, and happy-sad, the respective r's were .55, $p \leq .001$, .55, $p \leq .001$, and .33, $p \leq .05$, for boys and .32, $p \leq .05$, .26, $p \leq .10$, and .48, $p \leq .001$, for girls. Because these self-ratings reflected emotions, it was expected that there would be considerable day-to-day variability. The stability coefficients supported this expectation. In addition to intraindividual variability in emotions, there also was interindividual variability in emotions, which was reflected in the mean scores across 5 days of self ratings. Thus, means for angry-friendly, nervous-calm, and happy-sad were used as indices of emotional dispositions.

Emotional tone and impulse control.—Emotional tone and impulse control are subscales from the Offer Self-Image Questionnaire for Adolescents (Offer, Ostrov, & Howard, 1977). Wording of the items was modified for use with younger adolescents. Statements were rated by the adolescent on a six-point scale (1 = describes me very well; 6 = describes me not at all). Cronbach's alphas for the emotional tone and impulse control subscales, based on this sample, were .81 and .65, respectively. Examples of items from the emotional tone subscale are: "Most of the time I am happy" (negative weight) and "I often feel sad." Examples of items from the impulse control subscale are: "I rarely lose my temper (rarely get mad)" (negative weight) and "I get wild if I don't get my way." High scores on emotional tone indicate high levels of sadness. High scores on impulse control indicate problems with impulse control. The Offer Self-Image Questionnaire has been used on more than 120 samples, including younger and older teenagers. It differentiates among groups of normal, delinquent, and psychiatrically disturbed youths (Offer, Ostrov, & Howard, 1984).

Delinquent and aggressive.—The delinquent and aggressive measures are two subscales from the Child Behavior Checklist (CBC) (Achenbach & Edelbrock, 1979). The CBC consists of 113 behavior problems rated on a scale of 0 (not true of my child) to 2 (very true or often true of my child). The items are grouped into nine subscales for boys and eight subscales for girls. Mothers completed the checklist during the evening visit to the laboratory. While these two subscales do not include exactly the same items for boys and girls, they are very similar for both sexes. Examples of items (common to boys and girls) on the delinquent subscale are: disobeys at school, lies and cheats, steals at home, steals outside the home, and poor schoolwork. Examples of items (common to boys and girls) on the aggressive subscale are: argues, demands attention, sulks, stubborn, cruel to others, temper tantrums, and threatens people.

The CBC is a widely used instrument for which reliability and validity data are available (see Achenbach & Edelbrock, 1983). One-week test-retest reliabilities for the delinquent and aggressive subscales have ranged from .94 to .97 and .87 to .95, respectively. These subscales are highly correlated with scales from other instruments assessing similar dimensions. Ninety-eight percent of the items on the scale differentiate clinically referred from nonreferred but demographically similar children. (While the CBC subscale aggressive was actually labelled "aggressive," the variables delinquent, rebellious, and nasty also were assumed to index aspects of aggression.)

Rebellious.—The mother of each adolescent was instructed to rate her child on 28 items at the end of every day for 5 consecutive days during the week following the laboratory and clinic visits. The items consisted of adjectives (or verbs) that have been used in mood and behavior checklists and rating scales with established reliability and validity (e.g., the Multiple Affect Adjective Check List; Zuckerman & Lubin, 1965). The items were chosen on the basis of hypothesized relevance to emotional states and behaviors of adolescents. Mothers were instructed to rate each item on a seven-point scale (1 = not at all; 7 = very much) in terms of how it described their adolescent's mood or behavior that day. Mean scores across the 5 days of ratings were used in a varimax rotation of a principal components factor analysis. The rebellious attribute is the second of four factors derived from this analysis. High-loading items (with loadings given in parentheses) on the rebellious factor are: rebellious (.88), talks back (.88), sulks (.68), irritable (.64), irresponsible (.52), agreeable (−.52), cries (.51), and assertive (.51). Initial factor analyses were done separately for boys and girls. A four-factor solution identified in these analyses was highly similar for boys and girls. Factor scores used in the regression analyses reported here are based on the combined sample. The factor replicated across two independent samples: The correlation for the factor loadings for boys and girls was $r = .88$. Thus, the rebellious factor was viewed as representing a reliable structure.

Nasty.—Mothers rated their adolescents on 20 items modified from the Adolescent Q-Set (Block, 1971). The ratings were made during the evening visit to the laboratory. Using a seven-point scale (1 = not at all true; 7 = extremely true), each mother rated the degree to which each of the items was descriptive of her adolescent. The nasty attribute measure was the first of two factors derived from a varimax rotation of a principal components analysis. High-loading variables (with factor loadings given in parentheses) on the nasty factor are: tries to see how much he/she can get away with (.75), blames others for things (.71), tries to take advantage of others (.69), is jealous of others (.67), is stubborn (.65), is moody (.63), gets upset when he/she has to

wait for things (.62), is obedient and well-behaved (−.58), and gets upset even at unimportant things (.57). Initial factor analyses were done separately for boys and girls. A two-factor solution in these analyses was highly similar for boys and girls. Factor scores used in the regression analyses are based on the combined sample. The factor replicated across two independent samples: The correlation for the factor loadings for boys and girls was $r = .89$. Thus, the nasty factor was viewed as representing a reliable structure.

Biological measures.—The biological measures were obtained during a 2-hour visit at an outpatient clinic. The clinic visit was scheduled within a mean number of 2.3 days from the behavioral measures assessment. The biological measures were obtained by a pediatric nurse practitioner or by an endocrinologist. For this report, pubertal stage was based on genital development for boys and breast development for girls (Marshall & Tanner, 1969, 1970). Interexaminer agreement for pubertal stage for boys and girls was $r = .99$ and 1.00, respectively.

Hormone levels may exhibit many types of variation that are relevant to the interpretation of findings: (1) diurnal variations, (2) minute-to-minute fluctuations because of the pulsatile release of some hormones, (3) variations related to stress responses to the experimental situation, (4) variations with age, (5) variations because of illness or other unusual circumstances such as pregnancy, (6) variations related to the menstrual cycle, and (7) other interindividual variations related to constitutional or genetic characteristics.

To minimize the effects of diurnal variations, blood samples were collected between the hours of 8:00 and 10:00 A.M. To minimize the effects of minute-to-minute fluctuations due to pulsatile release of hormones, three blood samples were drawn at 0, 20, and 40 min. Mean values for the three samples were used in statistical analyses. One sample of testosterone-estradiol binding globulin was obtained at Time 0 only. There were significant differences among the three samples for only one measure—testosterone in boys. Testosterone level decreased across the three samples, but the post hoc tests were not significant. Use of the mean hormone levels based on three samples also minimized the effects of stress on our results. Adolescents may vary in the timing of their physiological stress responses to the phlebotomy procedure. Some adolescents may have heightened physiological responses prior to the venipuncture as a result of anticipatory anxiety. Others may not respond until they actually experience the venipuncture itself. Therefore, no one sample was viewed, a priori, as more reliable than any other sample.

Hormones also vary with age as a result of timing and rate of maturation. The decision regarding whether or not to control for age in statistical analyses was complicated by the fact that developmental phenomena are of interest in this study. For that reason, statistical analyses were done controlling for age as well as without controlling for age. Variations in hormone levels due to unusual circumstances such as illness or disease were minimized by excluding adolescents with a history of major health problems that could have affected hormone levels (e.g., adolescents with diabetes). The adolescents had no known chronic illnesses or major health problems at the time of study.

Menstrual cycle–related variations in hormone levels in females were not controlled in this study. In the sample of 52 girls, 34 (65%) were premenarcheal and 18 (35%) were menarcheal. The probability of a regular cycle of increases and decreases in hormone levels related to ovulation varies with gynecological age (duration of time since first menses) (Vihko & Apter, 1980). However, menarche does not absolutely differentiate girls who show hormone cycles from those who do not. Menarche merely is the culmination of a long series of endocrine changes that are occurring at least 2 years prior to menarche (Apter & Vihko, 1985). Thus, variations in hormone levels in both the premenarcheal and menarcheal girls may introduce error in the data to an unknown extent.

Finally, no attempts were made to control for interindividual variations related to constitutional or genetic characteristics.

Radioimmunoassays were performed according to the following techniques: luteinizing hormone (Odell, Ross, & Rayford, 1967); follicle stimulating hormone (Cargille & Rayford, 1970); testosterone (Nieschlag & Loriaux, 1972); estradiol (Abraham, Buster, Lucas, Corrales, & Teller, 1972); and dehydroepiandrosterone, dehydroepiandrosterone sulfate, and androstenedione (Cutler, Glenn, Bush, Hodgen, Graham, & Loriaux, 1978). Testosterone-estradiol binding globulin, a glycoprotein produced by the liver that serves in binding and transporting gonadal steroids, was measured by a competitive binding assay (Dunn, Nisula, & Rodbard, 1981). The serum concentrations of this glycoprotein change

during puberty in boys (Cunningham, Loughlin, Culliton, & McKenna, 1984). Testosterone-estradiol binding globulin influences the fraction of testosterone that is free (unbound) and active. Findings involving testosterone-estradiol binding globulin indirectly may provide information about the effects of free testosterone. The testosterone to estradiol ratio also was computed and used in the analyses. Interassay and intraassay coefficients of variation and assay detection limits appear elsewhere (Nottelmann et al. 1987b).

Results

Mean Levels and Sex Differences

Behavioral measures.—Means and standard deviations for the behavioral variables for boys and girls appear in the top half of Table 1. Analysis of variance for sex differences was conducted for seven of the nine behavioral variables. There were no significant mean level differences between boys and girls. The two Child Behavior Checklist subscales, delinquent and aggressive behavior problems, are highly similar for boys and girls, but some of the items are different for the sexes. Therefore, tests for sex differences were not conducted for these two variables.

Hormone levels.—Means and standard deviations for the hormone levels for boys and girls appear in the bottom half of Table 1. The means and standard deviations by pubertal stage appear elsewhere (Nottelmann et al., 1987b). Analysis of variance for sex differences was conducted for the nine hormone measures (see Table 1). Boys were significantly higher than girls for level of testosterone, the testosterone to estradiol ratio, and dehydroepiandrosterone sulphate. Girls were significantly higher than boys for level of luteinizing hormone, follicle stimulating hormone, estradiol, and androstenedione. There were no significant group differences between boys and girls for dehydroepiandrosterone or testosterone-estradiol binding globulin.

Intercorrelations

Behavioral variables.—Intercorrelations among the behavioral measures for boys and girls appear in Table 2. In general, the behav-

TABLE 1

MEANS, STANDARD DEVIATIONS, AND *F* RATIOS FOR SEX DIFFERENCES FOR BEHAVIORAL MEASURES AND HORMONE LEVELS FOR BOYS AND GIRLS

	Boys			Girls			
	$\bar{X}$	SD	*N*	$\bar{X}$	SD	*N*	*F*
Behavioral measures:							
Angry-friendly	3.50	.61	52	3.50	.64	49	.00
Nervous-calm	3.51	.68	52	3.29	.67	48	2.84
Happy-sad	2.17	.40	53	2.15	.67	49	.02
Emotional tone	2.22	.68	55	2.22	.73	52	.00
Impulse control	2.86	.68	55	2.91	.57	52	.12
Delinquent	57.80	4.05	55	58.33	4.73	52	...
Aggressive	58.65	6.17	55	58.50	5.86	52	...
Rebellious	−.11	.86	53	.12	1.13	48	1.31
Nasty	−.04	1.11	56	.05	.88	52	.22
Hormone levels:							
LH (mIU/ml)	5.66	3.74	54	7.58	5.68	51	4.26*
FSH (mIU/ml)	6.97	4.74	54	9.12	4.98	51	5.16*
T (ng/dl)	214.65	204.35	55	19.25	9.24	52	47.43***
E_2 (pg/ml)	12.79	8.19	48	44.99	49.61	50	19.70***
T/E_2 (ng/l)	158.10	142.95	48	9.01	8.64	50	54.21***
TeBG (ug/dl)	1.91	1.29	42	1.87	1.16	34	.02
DHEA (ng/dl)	256.01	139.86	54	240.48	162.46	50	.27
DHEAS (ug/dl)	104.57	51.08	55	71.98	41.79	52	12.96***
Δ4-A (ng/dl)	62.27	41.14	52	87.18	54.25	51	6.91**

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulphate, Δ4-A = androstenedione.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

TABLE 2

INTERCORRELATIONS OF BEHAVIORAL MEASURES FOR BOYS AND GIRLS

	1	2	3	4	5	6	7	8	9
1. Angry-friendly		.59***	−.48***	−.28	−.15	.03	.06	−.09	.19
2. Nervous-calm	.41**		−.20	−.28	−.14	−.06	−.08	−.12	.01
3. Happy-sad	−.39**	−.08		.28	.35**	.04	.15	.16	.10
4. Emotional tone	−.24	−.07	.14		.57***	−.07	.00	.02	.01
5. Impulse control	−.21	−.17	.10	.60***		.02	.15	.03	.05
6. Delinquent	−.24	−.38**	.04	.20	.30*		.70***	.45***	.49***
7. Aggressive	−.12	−.20	−.13	.07	.27*	.61***		.62***	.72***
8. Rebellious	−.16	.13	.24	.06	.00	−.05	.14		.56***
9. Nasty	−.22	−.21	−.01	.07	.23	.56***	.65***	.27*	

NOTE.—The correlation coefficients below the diagonal are for boys; those above the diagonal are for girls. *N*'s range from 52 to 56 for boys and from 47 to 52 for girls.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

ioral measures showed only minimal to moderate intercorrelations. The strongest relations were among the measures of aggression, although, even there, there was considerable independence of each measure.

Hormone levels.—Intercorrelations of the hormone levels for boys and girls appear in Table 3. There were moderate to high intercorrelations among the hormone levels.

Correlations with Age

Behavioral measures.—Only one of the behavioral measures was significantly correlated with age, emotional tone ($r = .36$, $p \leq .01$), for males only. High scores on emotional tone denote sad affect.

Hormone levels.—For boys, there were significant positive correlations between age and luteinizing hormone ($r = .46$, $p \leq .001$), follicle stimulating hormone ($r = .40$, $p \leq .01$), testosterone ($r = .54$, $p \leq .001$), the testosterone to estradiol ratio ($r = .56$, $p \leq .001$), dehydroepiandrosterone ($r = .29$, $p \leq .05$), and androstenedione ($r = .32$, $p \leq .05$). There was a significant negative correlation between age and testosterone-estradiol binding globulin ($r = -.40$, $p \leq .01$). Estradiol and dehydroepiandrosterone sulphate were not significantly correlated with age. For girls, there were significant positive correlations between age and luteinizing hormone ($r = .52$, $p \leq .001$), follicle stimulating hormone ($r = .40$, $p \leq .01$), testosterone ($r = .56$, $p \leq .001$), estradiol ($r = .52$, $p \leq .001$), dehydroepiandrosterone ($r = .40$, $p \leq .01$), dehydroepiandrosterone sulphate ($r = .53$, $p \leq .001$), and androstenedione ($r = .65$, $p \leq .001$). There was a significant negative correlation between age and the testosterone to estradiol ratio ($r = -.44$, $p \leq .001$). Testosterone-estradiol binding globulin was not significantly correlated with age.

Regression Analyses

Findings are reported for three separate sets of regression analyses: (*a*) the hormones as predictors of emotional dispositions, (*b*) the hormones as predictors of aggressive attributes, and (*c*) both hormones and emotional dispositions as predictors of aggressive attributes. In the reporting of findings, the terms predictor, dependent variable, and independent variable are used for their statistical meaning and not to imply causality. The zero-order correlations between the hormones and the behavioral variables appear in Table 4.

Both the hormones and the emotional dispositions were entered into the regression equations as sets of independent variables. The hormones were entered as a set into the regression equations because they appear to act in synchrony in bringing about maturation during puberty. The exact mechanisms regulating pituitary, gonadal, and adrenal functioning and, thus, the relative levels of these hormones under various circumstances are currently being examined extensively. What is known is that some combination of these hormones is responsible for normal pubertal maturation. Therefore, the set of hormones was entered into regression equations. There was only a moderate degree of multicollinearity among the hormones.

The emotional dispositions also were entered as a set into the regression equations because they were assumed collectively to reflect important aspects of the emotional development of adolescents. By treating the hormones or the behaviors as sets in terms of how they relate to the dependent variables, the set is effectively reduced to a single variable (Cohen & Cohen, 1975). In each multiple regression analysis, the overall F test for each equation is tested for its statistical significance. The individual variables within the set also are tested for their significance by a standard t test, such that the partial contribution of each individual independent variable is assessed (Cohen & Cohen, 1975). The partial contribution of each individual independent variable to the overall result is reflected in its beta weight. In the analyses reported here, all significant results are reported, but findings involving significant betas should be interpreted with caution if the overall F is not also significant.

Hormones and emotional dispositions.—The hormone values (luteinizing hormone, follicle stimulating hormone, testosterone, estradiol, the testosterone to estradiol ratio, testosterone-estradiol binding globulin, dehydroepiandrosterone, dehydroepiandrosterone sulphate, and androstenedione) were entered into the regression equations as a set of independent variables with adolescent emotional dispositions as the dependent variables (angry-friendly, nervous-calm, happy-sad, emotional tone, and impulse control). For each dependent variable, the betas and overall R, R^2, and F ratio appear in Table 5. The findings shown are for boys only. There were no significant findings for girls.

Emotional tone was the only emotional disposition that was related to chronological age. Therefore, for multiple regression to emotional tone, age was entered into the equation first, so as to control for the relation between age and emotional tone before the

TABLE 3

INTERCORRELATIONS OF HORMONE LEVELS AND PUBERTAL STAGE FOR BOYS AND GIRLS

	LH	FSH	T	E_2	T/E_2	TeBG	DHEA	DHEAS	Δ4-A	Pubertal Stage
LH		.63***	.47***	.49***	−.32*	−.16	.24	.41**	.57***	.56***
FSH	.51***		.47***	.20	−.20	−.23	.22	.26	.39**	.34*
T	.61***	.60***		.43**	−.08	.25	.29*	.42**	.62***	.48***
E_2	.41**	.43**	.63***		−.51***	.16	.33*	.35**	.76***	.55***
T/E_2	.41**	.44**	.68***	.01		−.07	−.21	−.21	−.38**	−.47***
TeBG	−.31*	−.30*	−.45**	−.35*	−.34*		−.02	−.23	.03	.02
DHEA	.26	.39**	.39**	.26	.31*	−.31*		.53***	.60***	.37**
DHEAS	.14	.20	.13	.16	−.01	−.25	.59***		.57***	.46***
Δ4-A	.27	.42**	.50***	.49***	.41**	−.36*	.56***	.31*		.61***
Pubertal stage[a]	.60***	.53***	.82***	.46***	.69***	−.57***	.38**	.14	.53***	

SOURCE.—Nottelmann et al., 1987b.

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulphate, Δ4-A = androstenedione. Correlations below the diagonal are for boys; correlations above the diagonal are for girls. *N*'s range from 42 to 55 for boys and 34 to 52 for girls.

[a] Pubertal stage is represented by genital development for boys and breast development for girls.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

TABLE 4

ZERO-ORDER CORRELATIONS OF BEHAVIORAL MEASURES WITH HORMONE LEVELS

BEHAVIORAL MEASURES	HORMONES								
	LH	FSH	T	E_2	T/E_2	TeBG	DHEA	DHEAS	Δ4-A
Boys:									
Angry-friendly	−.06	.05	−.05	−.04	−.07	.08	−.20	−.08	−.16
Nervous-calm	.25	−.05	.10	.25	−.09	−.17	−.07	−.14	−.01
Happy-sad	.17	.12	.13	.32*	−.07	−.15	.35**	.22	.23
Emotional tone	.06	.18	−.07	.11	−.13	−.31*	.10	.03	.28*
Impulse control	−.11	.06	−.13	−.04	−.10	−.26	.19	−.05	.20
Delinquent	.01	.17	.10	−.11	.22	−.21	.19	−.02	.41**
Aggressive	−.08	−.07	.06	−.12	.15	−.21	.06	−.12	.16
Rebellious	.32*	−.15	−.01	.03	−.04	−.24	.28*	.22	−.03
Nasty	.01	−.21	.02	−.15	.10	−.06	.02	−.14	.15
Girls:									
Angry-friendly	.06	−.18	.08	.17	.09	.24	−.01	.17	.08
Nervous-calm	.22	−.04	.18	.08	.14	.20	−.01	.29*	.12
Happy-sad	.19	.21	.02	.17	−.22	−.06	.13	−.01	.10
Emotional tone	.16	.20	.02	.13	−.09	.15	.10	−.15	.14
Impulse control	.27*	.29*	−.05	.15	−.26	−.17	.09	.06	.21
Delinquent	−.08	−.02	−.15	.00	−.04	.07	−.11	−.17	−.11
Aggressive	−.03	−.05	−.21	−.10	.04	−.01	−.26	−.33*	−.22
Rebellious	−.13	−.14	−.27	−.09	−.01	−.08	−.20	−.24	−.20
Nasty	−.26	−.28*	−.19	−.14	.14	.18	−.12	−.34**	−.27*

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulfate, Δ4-A = androstenedione. For boys, *N*'s range from 40 to 55; for girls, *N*'s range from 30 to 52.

* $p \leq .05$.

** $p \leq .01$.

TABLE 5

MULTIPLE REGRESSION OF HORMONE LEVELS TO EMOTIONAL DISPOSITIONS FOR BOYS: BETA WEIGHT FOR EACH HORMONE MEASURE, MULTIPLE R, R^2, AND F RATIO

EMOTIONAL DISPOSITIONS	HORMONES												
	AGE	LH	FSH	T	E_2	T/E_2	TeBG	DHEA	DHEAS	Δ4-A	R	R^2	F^a
Angry-friendly	...	−.09	.22	.06	−.01	−.03	.03	−.22	.06	−.12	.28	.08	.25
Nervous-calm	...	.34	−.23	−.04	.21	−.17	−.20	.04	−.23	−.04	.47	.22	.87
Happy-sad	...	.14	−.07	−.27	.37	−.03	−.03	.39	−.03	−.03	.48	.23	.88
Emotional tone	.59***	.02	.28	−.15	−.40	−.82**	−.35*	−.04	−.23	.54**	.77	.59	3.74**
Impulse control	...	−.04	.20	.08	−.53	−.65	−.45*	.35	−.46*	.40	.62	.38	1.87

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulfate, Δ4-A = androstenedione. Results presented are for boys only. There were no significant findings for girls.

[a] *Df*'s were 9,27 for all measures except emotional tone, for which *df* was 10,26.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

relation between the set of hormones and emotional tone was assessed. Higher emotional tone, indicating sad affect, was related to older age. The set of hormones was significantly related to emotional tone. Higher emotional tone was related to lower testosterone to estradiol ratios, lower levels of testosterone-estradiol binding globulin, and higher levels of androstenedione. Difficulty with impulse control also was related to lower levels of testosterone-estradiol binding globulin and lower levels of dehydroepiandrosterone sulphate, but the overall F was not significant.

Hormones and aggressive attributes.—The same hormones were entered into the regression equations as a set of independent variables with aggressive attributes as the dependent variables (delinquent, aggressive, rebellious, and nasty behavior). For each independent variable, the betas and overall R, R^2, and F ratio appear in Table 6. These results are for boys only. The set of hormones was significantly related to delinquent and rebellious behavior problems. There were no significant findings for girls. Higher scores on delinquent behavior problems were related to lower levels of estradiol and higher levels of androstenedione. Higher scores on the rebellious attribute were related to higher levels of luteinizing hormone, lower levels of follicle stimulating hormone, and higher levels of dehydroepiandrosterone. Higher scores on the nasty factor also were related to higher levels of androstenedione, but the overall F was not significant.

Hormones, emotional dispositions, and the aggressive attributes.—The hormones were entered into the regression equations as a set, followed by the emotional dispositions as a second set of independent variables predicting the aggressive attributes. The hormones were entered into the equation first because they were assumed to be causally prior to the emotional dispositions and aggressive attributes. Emotional dispositions and aggressive behaviors also may affect hormone levels. However, it is unlikely that emotions and aggressive behaviors are totally responsible for the rapid increases in hormones during puberty, and that changes in the emotions and behavior of adolescents during puberty are totally unaffected by these hormone changes. Emotional dispositions were entered into the regression equations second. Therefore, the variance accounted for by emotional dispositions is the increment that is added after controlling for the variance accounted for by the hormones.

For each dependent variable, the betas and overall R, R^2, and F ratio appear in Table 7. The findings shown are for boys only. There were no significant findings for girls. Hormones and emotional dispositions, jointly, were significantly related to delinquent behavior problems in boys. For delinquent behavior problems, three additional single hormones and one emotional disposition became significant when the emotional dispositions were added to the equation. Higher scores on delinquent behavior problems were related to lower testosterone to estradiol ratios, lower levels of testosterone-estradiol binding globulin, lower levels of dehydroepiandrosterone sulphate, and lower levels of calm disposition (higher nervousness), in addition to lower levels of estradiol and higher levels of androstenedione. Further, the multiple R for delinquent behavior problems increased from .66 to .76 as a function of adding the emotional dispositions to the regression equation. The overall F for rebellious attributes became nonsignificant when the additional variables were added. Similarly, the betas for follicle stimulating hormone and dehydroepiandrosterone in predicting rebellious attributes became nonsignificant.

Age, Hormones, Emotional Dispositions, and Aggressive Attributes

As mentioned previously, age was correlated with only one behavioral variable, emotional tone. For the regression analysis predicting to emotional tone, age was entered first into the equation, and the beta for age was significant. Although age was not related to the other behavioral variables, age was related to most hormone levels. Therefore, the relations between hormones and the other behavioral variables were examined when age was controlled for by entering it first into the regression equations. Analyses parallel to those described above were conducted. Including age in the regression equations did not affect the pattern of findings.

Pubertal stage.—For boys, pubertal stage was significantly related to luteinizing hormone, follicle stimulating hormone, testosterone, estradiol, the testosterone to estradiol ratio, testosterone-estradiol binding globulin (negative relation), dehydroepiandrosterone, and androstenedione (see Table 3). Pubertal stage did not relate to dehydroepiandrosterone sulphate. For girls, pubertal stage was significantly related to luteinizing hormone, follicle stimulating hormone, testosterone, estradiol, the testosterone to estradiol ratio (negative relation), dehydroepiandrosterone, dehydroepiandrosterone sulphate, and an-

TABLE 6

MULTIPLE REGRESSION OF HORMONE LEVELS TO AGGRESSIVE ATTRIBUTES FOR BOYS: BETA WEIGHT FOR EACH HORMONE MEASURE, MULTIPLE R, R^2, AND F RATIO

AGGRESSIVE ATTRIBUTES	HORMONES									R	R^2	F^a
	LH	FSH	T	E_2	T/E_2	TeBG	DHEA	DHEAS	Δ4-A			
Delinquent	−.02	.19	.56	−.95***	−.64	−.25	.03	−.30	.77**	.66	.43	2.28*
Aggressive	−.11	−.11	.60	−.67	−.44	−.31	.09	−.31	.37	.49	.24	.93
Rebellious	.57**	−.44*	−.38	.14	.04	−.25	.46*	−.00	−.23	.67	.45	2.44*
Nasty	.15	−.36	.65	−.73	−.53	−.14	.07	−.30	.51*	.53	.28	1.16

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulfate, Δ4-A = androstenedione. Results are for boys only. There were no significant findings for girls.

[a] *Df*'s were 9,27.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

TABLE 7

MULTIPLE REGRESSION OF HORMONE LEVELS AND EMOTIONAL DISPOSITIONS TO AGGRESSIVE ATTRIBUTES FOR BOYS

AGGRESSIVE ATTRIBUTES	HORMONES								
	LH	FSH	T	E_2	T/E_2	TeBG	DHEA	DHEAS	Δ4-A
Delinquent	.15	.16	.52	−.95**	−.85*	−.44*	.06	−.46*	.86**
Aggressive	.04	−.15	.50	−.56	−.54	−.42	.12	−.38	.41
Rebellious	.57*	−.43	−.35	.07	−.03	−.30	.48	−.06	−.21
Nasty	.28	−.41	.60	−.65	−.59	−.21	.05	−.35	.52

	EMOTIONAL DISPOSITIONS							
	Angry-Friendly	Nervous-Calm	Happy-Sad	Emotional Tone	Impulse Control	R	R^2	F^a
Delinquent	−.04	−.43*	−.02	−.19	−.04	.76	.58	2.21*
Aggressive	−.01	−.30	−.16	−.19	.11	.57	.33	.76
Rebellious	−.01	−.06	.06	.04	−.13	.68	.46	1.35
Nasty	−.03	−.31	−.03	−.14	.11	.61	.37	.93

NOTE.—LH = luteinizing hormone, FSH = follicle stimulating hormone, T = testosterone, E_2 = estradiol, T/E_2 = testosterone to estradiol ratio, TeBG = testosterone-estradiol binding globulin, DHEA = dehydroepiandrosterone, DHEAS = dehydroepiandrosterone sulfate, Δ4-A = androstenedione. Results are for boys only. There were no significant findings for girls.

[a] *Df*'s were 14,22.

* $p \leq .05$.

** $p \leq .01$.

*** $p \leq .001$.

drostenedione. Pubertal stage did not relate to testosterone-estradiol binding globulin.

To determine whether the relations among hormone levels, emotional dispositions, and aggressive attributes were changed by including pubertal stage in the equation, the following regression analyses were conducted: (*a*) The hormones as a set were entered into the equation first, followed by pubertal stage, in predicting each of the emotional dispositions and aggressive attributes. (*b*) The hormones as a set were entered into the equation first, followed by pubertal stage, followed by the emotional dispositions as a set, in predicting each of the aggressive attributes. (*c*) Pubertal stage was entered into the equation first, followed by the emotional dispositions as a set, in predicting each of the aggressive attributes. In all cases, entering pubertal stage into the equations did not change the previous results.

Discussion

Hormone levels were related to both emotional dispositions and aggressive attributes for boys, but not for girls. For the emotional dispositions, the strongest relations were between hormones and sad affect (based on the emotional tone subscale) and anxious affect. For the aggressive attributes, the strongest relations were between hormones and delinquent (acting-out) and rebellious behavior.

Our expectations regarding specific hormone-behavior relations were confirmed in some cases but not in others. The expectation that serum testosterone levels (which include bound and unbound testosterone) would be related to negative emotional dispositions and aggressive attributes was not supported directly. Olweus et al. (1980) reported associations between testosterone and a specific type of aggression, response to provocation and threat and lack of frustration tolerance. Testosterone was not associated with many of the items that also were expected to index aggressive behavior. Our sample of adolescents differed from the Olweus et al. sample. While the Olweus et al. sample was limited to male adolescents in the later stages of puberty, adolescents from each of the five pubertal stages were included in our sample. Thus, the testosterone levels in the Olweus et al. adolescents were likely to be close to reaching adult levels for many of the adolescents, while the testosterone levels in our adolescents had not yet reached adult levels for the majority of adolescents.

Although testosterone levels and aggression were not directly related, there was some evidence linking testosterone and emotional dispositions and aggressive attributes in males. The level of testosterone-estradiol binding globulin, a carrier protein which serves in binding and transporting of gonadal steroids, was negatively related to sad affect. Furthermore, when both hormones and emotional dispositions were used to predict aggressive attributes, testosterone-estradiol binding globulin level was negatively related to delinquent behavior problems. As total testosterone and testosterone-estradiol binding globulin are negatively correlated, these relations between testosterone-estradiol binding globulin in males and the behavioral variables are consistent with our prediction for total testosterone. The pattern of findings for adrenal androgens, androstenedione and, to a lesser degree, dehydroepiandrosterone, in males, was consistent with what was expected for androgens of gonadal origin. Higher levels were related to sad affect and delinquent and rebellious behavior problems. Higher levels of adrenal androgens and higher degrees of negative behavior is a pattern that we have identified in other aspects of our larger study (Nottelmann et al., 1987a). While little is known about the influences of adrenal androgens on behavior, it may be speculated that their effects parallel those of androgens of gonadal origin.

The findings relating specific hormones and emotional dispositions and aggressive attributes should be interpreted with caution. Two factors should be considered. First, the significant beta weights may be affected by the nature of the distribution of each hormone and behavioral variable in the equation. Therefore, the significant betas may reflect random rather than true associations between specific hormones and specific emotional dispositions and aggressive attributes. Thus, a conservative interpretation of our findings is that some linear combination of hormones relates to emotional dispositions and aggressive attributes in boys. Second, a particular relation cannot be interpreted as meaning that that specific hormone is the active metabolic ingredient associated with an emotion or behavior. The hormones that we measured are metabolized into other substances which may, in turn, act on neural tissue. For instance, testosterone may be aromatized into estradiol. Estradiol is generally hypothesized to be the active metabolic substance affecting central nervous system functioning, which in turn may influence the expression of aggression (Clark & Nowell, 1979). Experimental

studies or experiments in nature (e.g., with hypogonadal males) are the preferred method for determining the causal role of specific hormones on behavior.

The assumption that emotional states are involved in the hormone-aggressive behavior pathway received only moderate support. The addition of emotional dispositions to the hormones in the regression equations improved the multiple *R* of the hormones in predicting delinquent behavior problems in boys so as to account for an additional 15% of the variance. In the case of rebellious attributes, the multiple *R* became nonsignificant when additional variables were added to the equation.

Nervous-calm, an index of anxiety, was the emotional disposition significantly related to delinquent behavior problems in the regression equation in which both hormones and emotions were entered. Higher anxiety was related to more delinquent behavior problems in boys. The role of fear or anxiety in mediating the expression of aggressive behavior has been examined in animals and, to a lesser extent, in humans (Ehrenkranz et al., 1974; Frodi et al., 1977). Determining the specific mechanisms whereby anxiety affects aggression is complicated by the fact that anxiety may have inhibitory as well as activating effects on the expression of aggression. As with the other relations, our cross-sectional findings do not allow us to assign a causal link between anxiety and aggression.

Sad affect also was related to hormone levels. These findings are consistent with research on the psychoneuroendocrinology of emotions in adults. Disturbances in hypothalamic-pituitary-adrenal (Chrousos, Schuermeyer, Oldfield, Doppman, Schulte, Gold, & Loriaux, 1985; Gold & Chrousos, 1985) and hypothalamic-pituitary-gonadal (Rubinow, Roy-Byrne, & Hoban, 1985) axes functioning have been reported in individuals with clinical depression. The findings relating sad affect to specific hormones among boys should be interpreted with caution for the reasons mentioned earlier. However, the question of whether changes in hormone levels are causal factors in the appearance of depressive symptoms in adolescents is an important one. Kandel and Davies (1986) reported that feelings of dysphoria in adolescence predicted similar feelings in adulthood as well as use of habit-forming substances and problems in peer and family relationships. A question for future research is whether the degree of sensitivity to changes in hormones during puberty, when hormone changes are most dramatic, predicts affective disorders or other emotional characteristics later in the lifespan.

Pubertal stage did not relate to the emotional dispositions or the aggressive attributes. Similarly, Olweus and colleagues (1980) failed to find relations between pubertal stage and aggression. Pubertal stage was related to cognitive abilities as well as characteristics of parent-child interactions in previous studies of adolescents (Steinberg, 1981; Steinberg & Hill, 1978). In recent studies, external indices of pubertal status generally have not related to many behaviors during adolescence. When such relations are found, they tend to be small in number and inconsistent across domains of behavior (Susman et al., in press).

The complete absence of relations between hormone level and both emotional dispositions and aggressive attributes for girls was striking. One explanation for this lack of findings involves the error introduced by menstrual cycle–related variations in hormone levels. While only 35% of the girls had reached menarche, these girls were in various phases of the menstrual cycle when they participated in the study. Considerable controversy exists in the literature regarding the validity and reliability of relations between phase of the menstrual cycle and behavioral variability (Rubinow & Roy-Byrne, 1984). If phase of the menstrual cycle influences emotions and aggression, then our findings might have been influenced to an unknown extent by the variations in behavior related to phase of the menstrual cycle. Hormone-level variability even in the girls who were premenarcheal also may have affected our findings to an unknown extent. For example, level of follicle stimulating hormone shows an increase in girls as young as 7 (see Apter & Vihko, 1985, for a comprehensive longitudinal study of hormone level variations in 7–17-year-old girls).

The possibility that error is introduced by menstrual cycle–related variations in hormone levels did not negate the value of measuring hormone levels in girls. Correlations between hormone levels and pubertal stage were similar in boys and girls in this study. Furthermore, in other aspects of our larger study, hormone levels were related to behavioral measures in our sample of girls. For example, girls who were earlier maturers based on hormone levels were found to be higher on sad affect and to spend less time with peers than did later maturers (Susman et al., 1985). However, relations between hor-

mones and behaviors were much stronger and more consistent for boys than for girls for the behaviors that we have examined. The less consistent pattern of findings for girls is also consistent with previous studies by other investigators. Marcus and colleagues (1985) found many of the correlations between neonatal sex steroid levels and behavior in early childhood for girls to be lower and nonsignificant or opposite in sign from the correlations for boys.

Our aggressive attributes failed to discriminate between males and females in level of aggression. There were no differences between males and females on rebellious and nasty attributes, the two attributes for which we could test for sex differences. Males generally are reported to be more aggressive than females (Maccoby & Jacklin, 1980), although sex differences in aggression tend to be greater in younger rather than in older children (Hyde, 1984). Females can be highly aggressive under certain circumstances, for example, those involving defense of one's young (Rose, Bernstein, Gordon, & Catlin, 1974) or those in which aggression is positively sanctioned. For many species, hormonal abnormalities or treatments also can increase aggressive behavior in females (Floody, 1983). In addition to there being no mean level difference between boys and girls on the behavioral measures, the behavioral measures were not related to hormone levels in females. Thus, we are unable to discern whether the measures were inadequate to assess aggression in females or whether aggression in females is unaffected by changes in hormone levels at puberty. It may be that levels of aggressive behavior and dominance shown by females are influenced more by social interactions and relationships than by hormonal changes (Floody, 1983; Marcus et al., 1985). Thus, males and females could show comparable overall levels of aggression but have different correlates of aggression.

In conclusion, relations between hormones and some emotional dispositions and aggressive attributes were found for boys but not for girls. This pattern of findings indicates that puberty-related hormone changes may not be as important in the development of aggression in adolescents as previously speculated. These findings, including the lack of findings for girls, need to be replicated, and future studies need to be extended to include other age groups. The influences of culture, family, and peers as moderators of hormone-aggression links also remain to be explored. Nevertheless, hormones responsible for physical and sexual development during puberty were related to emotions and the expression of aggression in early adolescent boys. These findings suggest the need for consideration of hormonal processes in future studies of the behavioral development of adolescents.

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