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Aggression, dominance, and affiliation: Their relationships with androgen levels and intelligence in 5-year-old children

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Abstract

This study explores the potential relationship between social behavior (aggression, dominance, and affiliation) and testosterone, androstenedione, and DHEA measurements in 5-year-old children while also analyzing the moderating effect of IQ on the hormone–behavior relationship. 129 healthy normal Iberian children (60 boys and 69 girls) were videotaped in free play interactions in the school playground. Their behavior was then evaluated with particular emphasis on aggression, government, and affiliation. Testosterone, androstenedione, and DHEA levels were measured using an enzyme immunoassay technique in saliva samples. A test (K-BIT) which provides an IQ measurement for children was also administered to subjects. The correlation analysis revealed a positive relationship between the behavioral factor of Provocation and androstenedione in boys, and a regression analysis indicated that this relationship was moderated in a positive direction by the subject's intelligence. In girls, we observed a positive relationship between testosterone and Affectivity, with this relationship being moderated in a negative direction by intelligence.

Keywords: Testosterone; Androstenedione; DHEA; Intelligence; IQ; Aggression; Dominance; Affiliation; Healthy normal Iberian children

Introduction

As highlighted in a recent work by Geary (2006), the evolutionary mechanisms of sexual selection have been used during recent decades to improve our understanding of sexual differences in different species. The basic idea is that the sex that invests less in reproduction (generally males) competes more for access to the other sex, while the sex that invests more in reproduction (generally females) is more selective when choosing a partner.

The action of sex steroids constitutes one of the principal proximal mechanisms for developing sexual dimorphism between males and females, a dimorphism that is at the service of the different means by which each sex increases their biological fitness. The hormones responsible for sexual differentiation in the organism itself are also involved in the sexual dimorphism of behavior (Cohen-Bendahan et al., 2005). In mammals, the development plan means that the genes of sexual chromosomes influence gonadal development, which in turn mediates the development of the genitals while at the same time having an organizational effect on the nervous system, an effect which molds adult sexual behavior (Diamond et al., 1996).

In broad terms, we can divide the action of hormones into organizational and activational effects. Organizational effects structure the nervous system during development, producing permanent changes in the wiring and sensitivity of the brain. Activational effects are transitory changes that, based on circulating hormone levels, modify the activity of the target cells (Cohen-Bendahan et al., 2005; Sisk and Zehr, 2005).

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Many sexual differences become more evident after puberty as a result of the activating and organizational effects of sex steroids (Sisk and Zehr, 2005). However, an organizational influence is already present during early fetal life, organizing the nervous system so that the processing of information for certain aspects with adaptive implications is different for each sex. There are fewer sex differences in behavior in infancy and childhood compared to postpubertally (Geary, 1999). However, because of the early organizational effects of hormones, there may be important sex differences in sensitivity to sex steroids from very early in life. In fact, evidence exists that individuals differ not only in their levels of circulating hormones but also in their sensitivity to them (Cohen-Bendahan et al., 2005). There seems to be a close relationship between sexual differences in the brain and androgen levels (Baron-Cohen et al., 2005). The sexually dimorphic regions of the brain (amygdala, corpus callosum, etc.) contain numerous androgen receptors (AR), and their development may be influenced by androgens during both the fetal phase and later developmental stages.

Studies carried out with clinical populations in humans have found that exposure to high atypical levels of prenatal androgens, such as in the case of females with congenital adrenal hyperplasia (CAH), results in a masculinization of both behavior and cognitive skills (Collaer and Hines, 1995). Furthermore, in healthy populations, inter-individual hormonal variations in prenatal levels of androgens are associated with subsequent sex-typed behavior (Cohen-Bendahan et al., 2005).

Diverse studies have established a link between circulating levels of various androgens (mainly testosterone) and social behavior in humans. In addition to sexual behavior, there are three main types of social behavior for which some link has been established with androgen levels: aggression (Archer, 1991), dominance (Mazur and Booth, 1998), and prosocial behavior (Harris et al., 1996). Current data support a bidirectional model with androgens both influencing and being influenced by social behavior (at least aggression and dominance), although this is not true in all species and seems to be related to the mating system (Wingfield, 2005).

A number of different models or hypotheses are currently being debated which aim especially to account for the relationship between androgens and the exhibition of aggressive behaviors or behaviors of dominance in humans. Among these, we should highlight the biosocial hypothesis of status (Mazur and Booth, 1998), the challenge hypothesis (for a review, see Archer, 2006), and the multivariate model of association between dominance and testosterone levels proposed by Nyborg (1994, 2004).

Mazur and Booth (1998) have proposed a model for studying the association between testosterone levels and dominance, postulating a bidirectional relationship between the two. Their biosocial status model suggests that high levels of endogen testosterone in men seem to encourage behavior intended to dominate (enhance one's status over) other people. In situations of challenge, testosterone levels rise in an anticipatory manner, while at the same time, an increase in the experience of dominance results in higher testosterone levels.

The challenge hypothesis, originally proposed to account for the association between testosterone and aggression in birds with monogamous mating systems (Wingfield et al., 1990), suggests that aggression and testosterone correlate during moments of social instability or when an individual is challenged by a conspecific. In a recent review on the challenge hypothesis in humans, Archer (2006) concludes that, overall, evidence obtained to date points towards a low (but inconsistent) correlation between aggression and testosterone levels and a higher and more consistent association between dominance and testosterone levels.

Other evidence suggests that low testosterone levels may also be associated with dominance, although of a less aggressive, more formal kind (Dabbs, 1992). The kinds of dominance that involve the use of cognitive skills for establishing social networks or occupational skills are probably associated with these low levels of testosterone. In this sense, Nyborg (1994, 2004) has proposed a multivariate theoretical model of association between testosterone and dominance (the general trait covariance or GTC model) which integrates testosterone, dominance, and intelligence levels. This author proposes that individuals with a high IQ and low testosterone levels may be expected to enjoy a high level of formal dominance and to obtain high status in fields in which analytical capabilities combine favorably with sensitivity. Individuals with a high IQ and high testosterone levels may also be expected to possess formal dominance and high status, although in areas which value a combination of high intelligence, and a certain degree of aggression and insensitivity.

There is another behavioral area, in addition to aggression and dominance, for which certain relationships with androgen levels have also been observed: affiliation and prosocial behavior. Negative correlations between testosterone and prosocial personality have been found in adults. In a study of university students, Harris et al. (1996) found that both men and women showed positive relationships between testosterone and aggression but negative relationships between the same hormone and prosocial personality. A negative correlation was found between testosterone titer and the emission of smiles and pleasantness (Dabbs et al., 1996; Dabbs, 1997).

The majority of studies on the relationship between social behavior and androgen levels have focused on pubertal or postpubertal subjects (especially males), and the few that do focus on prepubertal individuals center their attention on the hormone-aggression and hormone-dominance relationships (for a review of hormones and aggression in childhood and adolescence, see Ramírez, 2003). Some of these studies analyze the relationship between testosterone levels and the exhibition of disruptive or externalizing behaviors (Chance et al., 2000; Maras et al., 2003). With regard to preschool children, only one study has focused on the relationship between testosterone levels and aggressive behavior (Sánchez-Martín et al., 2000). It is important to remember that androgens are at their lowest levels in the preschool period (Forest, 1989), as most circulating androgens in prepubertal children are produced by the adrenal gland. In general, the data suggest that adrenal androgens, which are characteristic of the childhood stage, contribute to initiating and maintaining human aggression (Chance et al., 2000; Sánchez-Martín et al., 2000; Scerbo and Kolko, 1994). In contrast to adolescence, androgen levels in children are relatively stable. Nevertheless, not all studies are consistent, and indeed, Constantino et al. (1993) failed to find any relationship between testosterone levels and aggression in children aged between 4 and 10, while Chance et al. (2000) found an association between testosterone and aggression in 9- to 11-year-old subjects, but not in 5- to 8-year-old children. Further research is required in order to gain a clearer understanding of the relationship between subjects' androgen levels and sociability levels during this development stage. Another interesting aspect of these discoveries is that during childhood, the relationship between androgens and social behavior (aggression, dominance, etc.) is found mainly in boys. Data with postpubertal subjects, however, show an association between testosterone levels and aggression and dominance in young women and adult females that is, on occasions, even stronger than that observed in males (Cashdan, 2003; van Honk et al., 1999; Von der Pahlen et al., 2002). Given that the majority of the studies focusing on prepubertal subjects have been carried out with males, again further research is required with prepubertal girls in order to clarify this question.

There is also evidence to suggest that the data gained from observing behavior enable the establishment of a more consistent relationship between androgen levels and aggressive behavior and dominance than data gained from self-reports, as shown by the meta-analyses carried out by Archer et al. (2005) and Book et al. (2001). It is for this reason that we decided to study the relationship between diverse androgen levels and social behavior, understood in a broad sense of the term (aggression, government or leadership, and affiliation) in 5-year-old children, using systematic observation of subjects' interaction behavior with their peers in free play contexts.

The study presented in this paper forms part of a wider project which aims to explore, from a biopsychosocial perspective, the influence of diverse factors (family, cognition, endocrine parameters, etc.) on young children's social adjustment to their social environment (peers). The study specifically explores the relationship between social behavior and testosterone, DHEA, and androstenedione measurements and the potential moderating effect of IQ on this hormone–behavior relationship.

In our case, we will focus our observations on the behaviors of aggression, government or leadership and affiliation. Both from a functional and descriptive point of view, which constitute the two main channels for operationalizing behavior in systematic observation (Lehner, 1996; Martín and Bateson, 1986), we believe this taxonomy of behavior to be appropriate for the objectives of the present study. These broad behavioral categories are appropriate from a functional point of view since they group together behavioral traits located in the same functional area. Furthermore, from a descriptive perspective, they encompass practically all the behavioral traits that may be described in the social interaction of preschool children (Carreras et al., 2001).

Moreover, from a psychobiological point of view, we have already, in the introductory section, alluded to different explanatory models of the relationship between hormones and behavior, from which it can be deduced that a closer association between aggressive type behaviors and androgen levels is more likely than between non-aggressive dominance behaviors and androgens (Archer, 2006; Nyborg, 2004). It is for this reason that we aim to pay specific attention to this kind of behavior. The third functional behavioral category we have selected (affiliation) has, as stated earlier, a number of antecedents in adults, particularly as regards their relationship with hormones, and constitutes an interesting counterpoint for study (with regard to aggressive and dominant behaviors) within the field of children's behavior.

Material and methods

Subjects

The subjects were 129 preschool children (60 boys and 69 girls) from eight classrooms in three public schools in San Sebastian, Urnieta, and Puerto Real (Spain). The mean age of the sample was 5 years 5 months for boys and 5 years 4 months for girls, with the same range of 5 years 0 months to 5 years 11 months for both sexes. The socioeconomic status of subjects in the sample was medium and medium–high. The children's parents had been fully informed of the study and had given their consent.

Social behavior

Subjects' social interactions with their peers were videotaped daily from November to June between 10:00 and 10:30 h in a free play context in the school playground. Focal sampling and continuous recording were used through three video cameras (Sony SSC/C 370P Sony Electronics, Barcelona, Spain). Each subject was filmed for 2 min on a rota basis throughout the school year, with no subject being filmed again until all the other subjects on the list had been filmed. Subsequently, the central minute of the recording was analyzed in order to contextualize the subject's behavior. This procedure was carried out with 15 recordings per subject, with a total of 15 min finally being assessed for each child. The taped behavior was evaluated by two pairs of observers using Observer 4.1 behavior analysis software (Noldus IT, Wageningen, The Netherlands). The inter-observer reliability for behavioral categories was computed as Cohen's Kappa, obtaining an inter-observer reliability level of $r = 0.80$.

The behavioral categories selected (see Table 1) were based on those used by the authors in previous research studies (Braza et al., 1994, Sánchez-Martín et al., 2000). Nevertheless, we previously reviewed those lists made by other authors, especially those studies more closely related to the behavior of preschool children (Blurton Jones, 1972; Branningan and Humphries, 1972; McGrew, 1972; Smith and Connolly, 1972). The behavioral guidelines considered were grouped into three main categories: aggression, government, and affiliation. The observers recorded the number of times subjects engaged in each of the behaviors during the observation period, and the rate (mean times per minute) was used for the statistical processing of the data thus obtained.

This type of classification therefore enables us to group behaviors located within the same functional field in each separate category: aggressive behaviors seem to be used for disputing resources and increasing individuals' possibilities of accessing them (Archer, 1988); non-aggressive dominance behaviors serve to direct the behavior of other subjects with the aim of facilitating the achievement of objectives through a strategy that involves less risk than aggressive confrontation (Muñoz et al., 2004) and finally, affiliative behaviors enable the subject to establish support and social cohesion networks whose adaptive value in the field of reciprocity is undeniable (Strayer et al., 1985). Diverse studies have found that these behavioral categories constitute relevant spheres of social relations in preschool children and infants (Carreras et al., 2001; Gauthier and Jacques, 1985; Montagner, 1988; Muñoz et al., 2004; Strayer et al., 1985).

Table 1
Catalogue of behaviors

Aggression	Compete for resources	To take an object away, try to take an object away, stop another taking an object away
	Verbal aggression	To threaten, dispute
	Physical aggression	To push, hit, shake, spit
	Non aggressive reaction	To cover oneself, move away, cry … after being physically or verbally assaulted
	Annoy	To interrupt or upset others' activities
	Receive aggression	To be assaulted (physically or verbally) by another
Government	Order	To give orders, direct movement, redirect, coax
	Obey	To follow orders, follow movement, allow redirection
	Organize	To organize an activity (sort into teams for a game of football, etc.)
	Receive an order	To receive an order
Affiliation	Share resources	To give, offer, exchange or show objects
	Social contact	To laugh, converse, accompany one another, signal and respond to signals
	Affection	To hug, caress, put your arm round someone's shoulder, hold hands
	Receive affection	To be hugged, caressed or kissed
	Physical help	To help and neaten up others
	Receive help	To be helped, neatened up

We opted for the term Government in consideration of the fact that the type of behaviors considered here, and generally described under the title dominance, encompass, in our inventory, a wide range of behaviors belonging to the dominance–subordination axis, rather than dominance alone. Furthermore, there is usually a certain degree of overlap between what is understood by aggression and what by dominance. In our case, we have included in this category behaviors which involve directing the behavior of others using non-aggressive strategies and behaviors which involve being directed and organized by others and which seem to make an important contribution to social interaction with peers (Muñoz et al., 2004).

Given the limitations imposed by behavioral observation with regard to the size of what is considered a manageable sample, within the selected categories or contexts, we have opted for more compact variables in order to be able to carry out statistical analyses without violating the demands of the said analyses. In order to achieve this degree of compactness, what we have done is look for proximity between the traits of a certain context, with the aim of identifying factors that unite traits and are located within a single function field, thereby rendering them useful for the purposes of the research project. To this end, we have opted for an analysis of principal components that we believe is suitable for the objectives of the study.

The fact that we do not use the broad behavioral categories as units for analysis is related to the fact that the ethogram used encompasses a diversity of behavioral traits that contribute important nuances to our objectives at a qualitative level between the factors. Thus, for example, in the field of aggression, we find that the items that make up this category may be either active or passive in nature (attack versus being attacked) or may even involve a certain behavioral gradient (non-aggressive behaviors, provocations, aggression). We therefore believe it is important to explore their grouping through a specific principal component analysis.

Measurement of intelligence

The Kaufman Brief Intelligence Test, K-BIT (Kaufman and Kaufman, 1994); Spanish adaptation by TEA ediciones, 2000) was used to evaluate overall IQ through the combination of the measurements obtained in two subscales: Vocabulary and Matrices. These subtests reflect, respectively, crystallized intelligence (ability to use information that has already been learned) and fluid intelligence (type of intelligence influenced by neurological development and not affected by learning), skills that have previously been used in the study of relationships between hormones, cognition, and behavior (Azurmendi et al., 2005; Kutlu et al., 2001; Reuter et al., 2003; Tan and Tan, 1998). Overall IQ is the sum of the score obtained in the two aforementioned subtests and was the intelligence measurement used in this study. The tests were administered by qualified, trained researchers in a room adjacent to the classroom in each of the schools and lasted approximately 25 min.

Determination of salivary hormone levels

Testosterone, DHEA, and androstenedione concentrations in saliva reflect those in the free (non-protein bound) fraction of plasma (Granger et al., 1999a; Navarro et al., 1986; Otten et al., 1983; Riad-Fahmy et al., 1982; Vittek et al., 1985; Young et al., 1988), and subjects provide saliva more willingly than serum, meaning that samples can be collected without medical help. Salivary hormone measurement, therefore, provides a reliable, non-intrusive method of determining hormone titer.

We collected two saliva samples per subject, gathered during the administration of the intelligence test and behavioral observation (both at the same time, 09:00 h, with an interval of 3 weeks) in order to obtain a base line for androgen levels in each subject. Saliva samples were taken by passive drool into a plastic cup. Samples were frozen and stored in the laboratory at −80°C until analysis.

On the day of the analysis, the samples were centrifuged at 3000 rpm for 15 min to remove mucins. Both samples for each duplicate test were used in the analyses. The average of the duplicate tests was used in the analyses. All samples were assayed using an enzyme immunoassay kit (Salimetrics, State College, USA, for testosterone and DHEA; Dia.Metra, Foligno, Italy, for androstenedione). For testosterone, the average intra-assay coefficient of variation (CV) was 6.7% (26.3 pg/ml), and the average inter-assay CV was 9.6% (13.1 pg/ml). For DHEA, the average intra-assay CV was 6.8% (88.9 pg/ml), and the average inter-assay CV was 8.4% (67.8 pg/ml). For androstenedione, the intra- and inter-assays CVs were 5.6% and 3.4% respectively. The sensitivities of the kits were as follows: testosterone, <1.5% pg/ml; DHEA, 10 pg/ml; androstenedione, 5 pg/ml.

The two values of each hormone were averaged, as they were correlated (testosterone: $r = 0.722$, $P < 0.01$; DHEA: $r = 0.309$, $P < 0.05$; androstenedione: $r = 0.500$, $P < 0.01$), with the result being a single score for each hormone in each subject.

Statistical analysis

In the first place, we calculated the principal components of behavioral patterns, using a factor analysis with varimax rotation for each of the three behavioral categories (aggression, government, and affiliation). The solution obtained for the aggression category was a three-factor solution. The first factor consisted of the items significantly involving 'non-aggressive reaction' (0.87) and 'receive aggression' (0.84) and was called 'Victimization'; the second factor encompassed the 'compete for resources' (0.77), 'verbal aggression' (0.77), and 'physical aggression' (0.60) items and was called 'Offensiveness'; and the third factor consisted of the 'annoy' item (0.96) and was called 'Provocation'. The solution obtained for the government category was a two-solution factor. The first factor consisted of the items significantly involving 'obey' (0.73) and 'receive an order' (0.88) and was called 'Subordination'; and the second factor encompassed the 'order' (0.74) and 'organize' (0.76) items and was called 'Dominance'. And finally, the solution obtained for the affiliation category was a three-factor solution. The first factor consisted of the items significantly involving the 'share resources' (0.88) and 'social contact' (0.78) items and was called 'Linking'; the second factor encompassed the 'physical help' (0.82) and 'receive help' (0.60) items and was called 'Prosociality'; and the third factor consisted of the 'affection' (0.65) and 'receive affection' (0.85) items and was called 'Affectivity'.

The differences between the sexes in terms of their social behavior measurements were analyzed by means of a one-way ANOVA. The relationships between the scores for social behavior and the hormone levels were examined using Pearson's correlation coefficient and the Bonferroni correction.

Finally, a multiple regression analysis (stepwise) was carried out, using the hormonal and intelligence measurements as independent variables and each of the social behavior factors as dependent variables. This analysis enabled us to determine the impact of hormones and intelligence on the social behavior observed.

Results

Gender differences in social behavior, hormonal measurements, and intelligence

No significant gender differences were found for intelligence measurements. In the case of hormones, gender differences were only found for DHEA, with girls having higher DHEA levels than boys ($F = 6.359$; $P = 0.002$).

In the case of behavior, the only gender difference found was in the Prosociality behavioral factor, with girls engaging in this type of behavior more often than boys ($F = 6.208$; $P = 0.014$).

Despite failing to find many gender differences with regard to behavior, we nevertheless opted to consider the analyses of the hormone–behavior relationship separately for boys and girls, bearing in mind that other studies which also failed to find substantial differences with regard to behavior in this age group did find a specific hormone–behavior relationship for each sex (Sánchez-Martín et al., 2000).

Relationships between behavioral factors and hormonal measurements

As a first approximation, all correlations between behavioral factors and hormone measurements were based on combined data for both boys and girls. Thus, after applying the Bonferroni correction, a significant positive correlation was found between the Affectivity behavioral factor and testosterone ($r = 0.277$, $P < 0.01$).

Tables 2 and 3 show the correlations between the scores obtained in the behavior factors and the separate hormone measurements for boys and girls, respectively. The correlations between hormonal measurements and IQ failed to give any significant results for either girls or boys.

Table 2
Correlations between behavioral factors and hormonal measurements in boys, using the Pearson correlations coefficient

	Testosterone	DHEA	Androstenedione
Aggression			
Victimization	$r = -0.123$	$r = -0.047$	$r = -0.322$ *
Offensiveness	$r = -0.013$	$r = 0.086$	$r = -0.034$
Provocation	$r = 0.162$	$r = 0.141$	$r = 0.378$ **
Government			
Subordination	$r = -0.041$	$r = -0.249$	$r = -0.089$
Dominance	$r = 0.106$	$r = 0.003$	$r = -0.198$
Affiliation			
Linking	$r = -0.104$	$r = 0.136$	$r = 0.186$
Prosociality	$r = 0.138$	$r = 0.300$	$r = 0.221$
Affectivity	$r = 0.030$	$r = 0.070$	$r = 0.139$

* $P < 0.05$.
** $P < 0.01$.

Table 3
Correlations between behavioral factors and hormonal measurements in girls, using the Pearson correlations coefficient

	Testosterone	DHEA	Androstenedione
Aggression			
Victimization	$r = 0.038$	$r = 0.041$	$r = -0.080$
Offensiveness	$r = 0.123$	$r = 0.179$	$r = -0.177$
Provocation	$r = -0.080$	$r = 0.097$	$r = 0.049$
Government			
Subordination	$r = -0.102$	$r = -0.143$	$r = -0.182$
Dominance	$r = 0.133$	$r = 0.026$	$r = -0.094$
Affiliation			
Linking	$r = -0.034$	$r = -0.049$	$r = 0.121$
Prosociality	$r = -0.186$	$r = -0.060$	$r = -0.033$
Affectivity	$r = 0.453$ *	$r = 0.153$	$r = 0.106$

* $P < 0.001$.

Intelligence as a moderator of hormone–behavior relationships

In order to analyze the question of whether or not intelligence acts as a moderator of hormone–behavior relationships, several regression analyses were performed taking into consideration only those variables that presented significant effects in the results shown in Tables 2 and 3. In each regression, a behavioral factor was entered as a dependent variable, and a hormone and IQ were used, along with the interaction between the two (hormone*IQ), as predictors. In this way, a regression analysis was performed for each social behavior (Provocation, Victimization, and Affectivity). In each regression, only one hormone, IQ, and the interaction between the two were predictors (Table 4). Subsequently, in the cases in which the variable assessing interaction was significant, the association between hormones and behavior factors was examined by means of a single regression analysis for the two intelligence levels—low and high (see Table 5).

Discussion

Gender differences

Our study failed to find any gender differences with regard to IQ, a finding consistent with that observed by other authors who also failed to find sexual differences in IQ or who found only weak differences (Collaer and Hines, 1995; Halpern and LaMay, 2000; Kaufman, 1990). As regards hormone levels, we failed to find any gender differences between testosterone and androstenedione. Other studies have also failed to find gender differences in relation to testosterone and androstenedione levels (Cortés-Blanco et al., 2000; Strong and Dabbs, 2000) in children. Nevertheless, gender differences were found with regard to DHEA levels, with those levels being significantly higher in girls than in boys. This finding coincides that recorded by Granger et al. (1999b), who found higher DHEA levels in 8-year-old girls than in boys of the same age.

With regard to behavior, we found a significant difference in the behavioral factor of Prosociality, in favor of girls. This result

Table 4
Multiple regression analysis (stepwise) of the androgen, IQ measurements and their interaction (androgen*IQ) for different behavioral factors

Gender group	Dependent	Predictors	β	t	P	R^2	df
Boys							
	Victimization	Androstenedione	−0.331	−2.581	0.013 *	0.110	55
		IQ	−0.006	−0.048	0.962		
		Androstenedione*IQ	−0.060	−0.154	0.878		
	Provocation	Androstenedione	−0.155	−0.412	0.682		
		IQ	0.056	0.444	0.659		
		Androstenedione*IQ	0.414	3.340	0.002 **	0.171	55
Girls							
	Affectivity	Testosterone	1.800	3.542	0.001 **	0.200	66
		IQ	0.308	1.448	0.153		
		Testosterone*IQ	−1.384	−2.723	0.008 **	0.283	66

* $P < 0.05$.
** $P < 0.01$.

coincides with existing literature on the subject, with Eisenberg and Fabes (1998) describing a meta-analysis that found modest gender differences in prosocial behavior in favor of girls. This association has been linked to the fact that girls are more empathic than boys (Hoffman, 1977). The general pattern suggests that empathy in human females is mainly directed towards their friends and family (Baumeister and Sommer, 1997), which is consistent with the peer context in which our observations were carried out.

Relationship between hormone levels and behavior (aggression, government, and affiliation)

As mentioned in the Introduction, the majority of studies focusing on relationships between hormones and aggression, dominance and prosocial behavior have been carried out with adults and young pubertal and postpubertal individuals. The fact that relationships have been observed between androgen levels and these types of behaviors during the preschool period, during which the levels of these hormones are at their lowest point ever, is undoubtedly a relevant piece of data. This serves to confirm the idea that these androgen–behavior relationships do not only occur as the result of the activating effects of adolescence.

One aspect of our results that is particularly worth noting is a gender-based difference in the hormones found to be related to behavior. In the case of boys, it is androstenedione which is associated with different behaviors, while in girls, it is testosterone that seems to determine the hormone–behavior relationship.

Table 5
Regression slopes (beta coefficient) depicting the association between hormonal measurements and behavioral factors at different levels of IQ

Gender groups	Dependent	Predictor	Levels of IQ	
			Low	High
Boys	Provocation	Androstenedione	0.341	0.444 *
Girls	Affectivity	Testosterone	0.549 **	0.137

* $P < 0.05$.
** $P < 0.001$.

As regards aggression, the only relationship we found with androgen levels were observed in boys and involved androstenedione. On the one hand, we found a positive relationship between androstenedione and the behavior of Provocation and, on the other, a negative relationship between this same hormone and the behavior of Victimization. It therefore seems that boys with higher levels of this androgen tend to engage more in this type of aggression (Provocation) and, consistently, are less likely to be the object of peer aggression. In a previous study, the research team that carried out this work found a positive association between testosterone measurements and aggression in preschool boys (Sánchez-Martín et al., 2000). The fact that this relationship was not found in the present study may be due to, among other reasons, the different catalogue of behaviors used in this study; the different observation context, since in this study the children were observed in the school playground (whereas in the previous one, they were observed in the classroom itself, which may foster friction and challenges between subjects); the different age of the individuals observed (they were slightly younger in the previous study); or the inconsistency mentioned above regarding the testosterone–aggression association; etc. In this study, as indicated above, we found an association between Provocation, a behavior that may perhaps be considered as a prelude to aggressive interaction, and androstenedione. This finding supports the need to consider the relationship between other androgens (apart from testosterone) and aggression, particularly during early childhood when the influence of adrenal hormones seems to be relevant. If in accordance with the challenge hypothesis, the androgen–aggression association is linked to a specific life history (which has repercussions on the individual's reproduction and parenting strategies), then the said association may appear early on in the subject's ontogenetic development (Archer, 2006). Our data support this hypothesis. Our results coincide also with those obtained by Susman et al. (1987) who, in a sample of boys and girls aged 9 to 14, found that high levels of acting out behavior were associated with high levels of androstenedione in boys. For their part, in a sample of boys aged between 8 and 12, Van Goozen et al. (1998) found a positive, marginally significant relationship between androstenedione measurements and behavioral disorders (antisocial, aggressive, etc.). Furthermore, Nottelmann et al. (1987) found a positive association between androstenedione levels and psychosocial adjustment problems in a sample of boys and girls aged between 9 and 14. Based on the data found by Inoff-Germain et al. (1988) that showed a positive relationship between the expression of anger and androstenedione measurements in girls, Ramírez (2003) suggests that adrenal androgens such as androstenedione (a major source of adrenal androgens in females) may play a role in female aggression. Our data fail to support this hypothesis in preschool girls, although they do support it in preschool boys.

In relation to Government behavior, in the present study, we failed to find any significant association between this behavior and androgen levels in either of the two sexes. Although a number of studies have found a relationship between androgen levels (mainly testosterone) and dominance measurements, practically all these works focused on pubertal and postpubertal individuals. Some studies have found a positive association between testosterone levels and dominance in women (van Honk et al., 2001; Cashdan, 1995). In men, when dominance is based on the use of aggressive strategies, a positive relationship has been found between testosterone levels and the said behavior (Mazur and Booth, 1998). However, when the dominance indicator is occupational status, the relationship with androgen levels is negative (Dabbs et al., 1998). The fact that, in our case, we failed to find any significant relationship between Government behaviors and androgen levels may be due to the fact that the behavioral factors included in this category do not involve the use of aggressive strategies. During the preschool stage, hierarchical status still depends to a large extent on the use of aggressive behavior (in combination with affiliative behaviors) (Montagner, 1988; Restoin et al., 1985). Thus, our results support the hypothesis that androgen levels are associated more with aggressive behaviors than with non-aggressive ones, at least during this development stage.

As for affiliation, we found a positive hormone–behavior relationship only in girls. Thus, testosterone was found to have a positive relationship with the Affectivity factor (with this hormone accounting for up to 20% of the variance in this behavior) in girls. Montagner (1988) and Restoin et al. (1985) both described social behavior profiles in preschool children based on systematic observation, finding that leaders demonstrated a combination of (aggressive) dominance behaviors associated with affiliative behaviors; it is probably this mixture that gives them the edge over their peers. It is possible that a mechanism of this nature underlies the results found in our study.

Intelligence as a moderator of the hormone–behavior relationship

When analyzing the predictive capacity of hormones and IQ with regard to different behaviors, the first thing to highlight is that if we consider only the independent contribution of hormones and intelligence to various behaviors (without taking the contribution of their interaction into account), then it is only hormones that have a predictive effect on behavior, with no such effect being observed in any case for intelligence considered independently. Thus, we observed that, in the case of boys, androstenedione accounts for 11% of the variance in the Victimization behavioral factor. In girls, testosterone accounts for up to 20% of the variance in the Affectivity behavioral factor. The fact that IQ alone has no predictive effect means that it does not mediate the hormone–behavior relationship. And the fact that the hormone–intelligence interaction variable does have a predictive value implies that intelligence moderates this hormone–behavior relationship in some cases.

When we took into account the effect of the hormone–intelligence interaction and therefore the potential moderating effect of this on the hormone–behavior relationship, we found that, in boys, intelligence moderates the androstenedione–Provocation relationship. We found that in boys with a high IQ, androstenedione is a predictor for Provocation behavior. The model proposed by Nyborg (1994, 2004) predicts that low testosterone levels associated with a high IQ would be related to measurements of non-aggressive dominance, but that the association between high testosterone levels and a high IQ could be related to moderately aggressive forms of dominance (that could be valuable in certain contexts). In a sample of subjects aged between 5 and 11 with behavioral disorders, Chance et al. (2000) found that in boys with a low IQ, testosterone measurements correlated positively with aggression and withdrawal. In our case, in a sample with no specific behavioral disorder problems, we observed a positive association between androstenedione measurements and a mild form of aggression (Provocation), with this effect being moderated by IQ: in boys with a high IQ, androstenedione is a better predictor of this type of aggressive behavior; this coincides with that proposed by Nyborg (1994, 2004) with regard to testosterone. In girls, intelligence moderates the testosterone–Affectivity relationship in that it is for girls with a low IQ that testosterone is a good predictor for Affectivity behavior.

The data obtained in our study indicate that there are sex-specific relationships between androgens and behavior in preschool children. Specifically, androstenedione is positively correlated with a mild form of aggression (Provocation) in boys, and this relationship is moderated by intelligence. In contrast, among girls, androstenedione does not relate to aggression, and instead, testosterone relates to Affectivity, with this relationship also being moderated by intelligence. In short, for boys of high IQ, more circulating androstenedione correlates ($P < 0.05$) with more provocational behavior, but there is no such correlation between androstenedione and behavior in girls of either high or low IQ. For girls of low IQ, more circulating testosterone correlates very strongly ($P < 0.001$) with Affectivity, but there is no such correlation between testosterone and behavior in boys of either high or low IQ, nor for girls of high IQ.

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