

Parenting styles and hormone levels as predictors of physical and indirect aggression in boys and girls

AUTHORS

Eider Pascual-Sagastizabal^a, Aitziber Azurmendi^b, Francisco Braza^c, Ana I. Vergara^d, Jaione Cardas^e, José R. Sánchez-Martín^b.

^a Department of Developmental and Educational Psychology. University of the Basque Country. 48940 Leioa, Spain.

^b Department of Basic Psychological Processes and their Development. Faculty of Psychology. University of the Basque Country. 20018 San Sebastian, Spain.

^c Doñana Biological Station. Spanish Council for Scientific Research (CSIC). 41092 Seville, Spain.

^d Department of Social Psychology and Methodology of the Behavioral Sciences. Faculty of Psychology. University of the Basque Country. 20018 San Sebastian, Spain.

^e Department of Psychology and Pedagogy, The Public University of Navarre, 31006 Pamplona, Spain.

CORRESPONDING AUTHOR

José Ramón SANCHEZ-MARTÍN
Department of Basic Psychological Processes and their Development. Faculty of Psychology. University of the Basque Country. Avda. Tolosa, 70. 20018 San Sebastian, Spain.
Phone. 0034 943 01 5729
Fax: 0034 943 015670
E-mail: joseramon.sanchez@ehu.es

RUNNING TITLE: testosterone, authoritarian and permissive mothers and aggression in children

ABSTRACT

This study examines the relationship between parenting style, androgen levels, and measures of physical and indirect aggression. Peer ratings of aggression were obtained from 159 eight-year-old children (89 boys and 70 girls). Parenting styles (authoritative, authoritarian or permissive) were assessed using the Parenting Styles and Dimensions Questionnaire (PSDQ). Saliva samples were obtained from children and assayed for testosterone and androstenedione concentrations. A regression analysis revealed that high testosterone levels were associated with a higher level of physical aggression in boys with authoritarian mothers. Testosterone was also found to moderate the relationship between father's authoritarian parenting and physical aggression in girls, with both moderate and high levels being significant. In relation to indirect aggression, moderate and high levels of testosterone were associated with higher levels of this type of aggression in girls with permissive mothers. Our results highlight the importance of taking into account the interaction of biological and psychosocial variables when investigating aggressive behavior.

KEY WORDS: testosterone, parenting styles, physical aggression, indirect aggression

INTRODUCTION

Detecting variables which enable us to predict aggressive behavior throughout the human lifecycle is of unquestionable interest. Although family factors have received much attention, there is an increasing interest in using a biosocial perspective, considering the interactive influence of different types of variables (biological and psychosocial) on agonistic behavior (Raine, 2002).

In accordance with this perspective, this study aims to integrate two groups of variables which have traditionally been analyzed separately (parenting styles and hormones), in order to explore the possibility that they act in an interactive manner. From the psychosocial perspective, family context has been the object of intense study in relation to aggressive behavior, with parenting styles being a particularly relevant factor in this sense (Zoccolillo et al., 2005); and from the biological perspective, hormones, especially androgens, have also been the main focus of attention (Archer 2006).

Recently, much emphasis has been placed on the need to explore the different mechanisms underlying diverse types of aggression from both a developmental perspective (Tremblay & Côté, 2005) and in relation to parenting styles (Casas et al., 2006; Kuppens, Grietens, Onghena & Michiels, 2009), as well as in connection with hormones and neurochemicals (Chichinadze, Chichinadze & Lazarashvili, 2011). Our study takes into consideration two types of aggression that involve two clearly distinguishable strategies for coping with conflict, and for which clearly differentiated distal causes have been suggested. Physical aggression is the exertion of physical force against another subject, involving (or not) the use of objects to this end (Tremblay & Nagin, 2005). It also involves the risk of serious injury, which may even threaten the person's physical integrity. It is a type of behavior for which clear sex differences have been found (with men and boys having higher levels than women and girls) and whose ultimate (evolutionary) causes have been linked to the high degree of variability inherent in male than female reproduction, resulting in those emerging victorious from combat having a greater chance of

reproducing (Archer, 2009). Indirect aggression, on the other hand, involves relational actions such as spreading rumors about someone or ganging up on them in order to isolate them socially (Vaillancourt, 2005). This kind of behavior is generally the most commonly used form of aggression among women and girls (Vaillancourt, 2005), and its ultimate causes have been linked to women's need to avoid risky aggressive interactions in order to enhance their own and their offspring's chances of survival (Campbell, 1999).

In general, the parenting styles that have been most frequently linked to aggression are the authoritarian, directive, coercive and uninvolved styles (Hart, Nelson, Robinson, Olsen & McNeilly-Choque, 1998; Nelson, Hart, Yang, Olsen, & Jin, 2006), and to a lesser extent, permissive styles (Underwood, Beron & Rosen, 2009). The authoritarian style is characterized by being demanding and directive, with parents laying down clear rules and exercising very strict control over their child's activities, but not being responsive (Baumrind, 1991). For its part, permissive parenting is characterized by excessive attention to the child's requests (be they reasonable or unreasonable), with parents permitting a high degree of self-regulation and avoiding conflict (Baumrind, 1991; Xu, Farver & Zhang, 2009).

These styles may influence the development of aggressive behavior through their effect on the child's emotional control, modeling behavior and conveying behavioral rules (Lorber & Egeland, 2011). Certain differences do exist in relation to the influence of specific parenting styles on overt and indirect aggression, and the sex of the child in question may also affect this relationship. For instance, Sandstrom (2007) found that the authoritarian style was positively associated with overt aggression in children, especially boys. This author also observed a positive relationship between maternal permissiveness and relational aggression, particularly in girls. Using a longitudinal perspective (from 2 to 8 years of age), Côté, Vaillancourt, Barker, Nagin and Tremblay (2007) identified the predictors of different development trajectories of aggression. Hostile parenting, young motherhood and being a boy were associated with high physical aggression levels.

From a hormonal perspective, androgens (mainly testosterone) are the hormones that have most consistently been linked to aggressive behavior (Chichinadze, Chichinadze & Lazarashvili, 2011; Moya, Serrano & Ramírez, 2010). A positive association has been established between the levels of diverse androgens (above all testosterone) and aggressive behavior in a wide range of species, including humans (Brain, 1977; Trainor, Sisk & Nelson, 2009). Although the majority of studies in this field focusing on humans were carried out with adults and post-pubescent youths, a few studies have found an association between androgens and aggression or externalizing behavior in children (for example, Scerbo & Kolko, 1994; Sánchez-Martín et al., 2000; Azurmendi et al., 2006) and on the whole, the data suggest that these hormones contribute to the development and maintenance of aggression during childhood (Ramirez, 2003).

As stated above, there is a growing interest in exploring the interactive role of social and biological variables in predicting behavioral outcomes. While several authors have pointed out the importance of considering the interaction between temperamental biology-based characteristics and the social and educational context (Bates & Pettit 2007; Rubin, Hastings, Chen, Stewart & McNichol, 1998; Xu et al., 2009), few studies have taken specific physiological measures into consideration at this level. Booth, Johnson, Granger, Crouter & McHale (2003) found that the positive association observed between testosterone levels and risk behaviors in 6-18-year-old children was moderated by the quality of the mother-son and father-son relationship: the higher the quality of the parent-son relationship, the lower the association between testosterone and risk behavior. For their part, Sanchez-Martin et al. (2009) found that the interaction between androgen levels measured in 5-year-old children and parenting styles assessed also at this same age, predicted aggressive behavior at age 6. More specifically, it was observed that in boys with directive mothers, high androstenedione levels were associated with more physical aggression.

This study, which forms part of a broader research project, examines the extent to which parenting styles and androgen levels (testosterone and androstenedione) interact to statistically predict physical and indirect aggression in a cross-sectional study with 8-year-old children. In

accordance with the review of the literature outlined above, we expected that high androgen levels, both testosterone and androstenedione, would be associated with higher levels of aggressive behavior in children whose parents employed parenting styles which have traditionally been linked to aggression (authoritarian and permissive parents).

METHOD

Participants

Participants were 159 eight-year-old children (89 boys and 70 girls) from nine classrooms in four state schools in Guipúzcoa, Spain. The socioeconomic status of the participants in the sample was considered as medium and medium-high, based on our knowledge of the area in which participants live. At the beginning of the academic year, a letter was sent to 201 families providing them with detailed information about the study. The letter also contained a document which they were asked to sign in order to give or refuse their consent to their child participating in the study. Of the 201 families contacted, 165 gave their consent for their child to participate in the study. Finally, for the statistical analyses, the sample group was reduced to 159 due to incomplete data (child being ill on the day of the test, families failing to return their questionnaires, etc.). Although the tests used during this study were not invasive and were all carried out in the school itself, the project was pre-approved by the ethics committee at the institution to which the authors belong.

Measuring aggression

Aggression was assessed using the Direct and Indirect Aggression Scale (DIAS) (Björkqvist & Österman, 1998), a peer-rating measurement instrument for aggressive behavior. Previous studies have shown that this test is a useful instrument for measuring different types of

aggression in young children (Björkqvist et al., 2001; Valles & Knutson, 2008). The Spanish version of the scale (Björkqvist & Österman, 1998) was used. The DIAS is a test containing 24 items in which each child is asked to rate each of their same-sex classmates on a Likert scale (0-4) for behaviors linked to physical aggression (7 items), verbal aggression (5 items) and indirect aggression (12 items). In order to facilitate the collective administration of the test, the questions were asked in table format, thus allowing the participants to assess all their same-sex classmates in every question. The final scores for each scale were obtained by adding together the scores for each item, and then dividing this total by the number of items which made up each scale. Given the study's specific interest in physical and indirect aggression, only those scores for the scales which measure these two types of aggression were used in the analyses. Cronbach's α s were .90 for physical aggression and .94 for indirect aggression.

For this peer rating technique, children rated their same-sex classmates, and analyses were performed separately for boys and girls. This segregation is due to the sex segregation that is typical of free play behavior at this age (Maccoby, 1998; Strayer & Santos, 1996). School-aged children tend to establish sex-based play and friendship groups: the majority of boys play and relate to other boys, while girls tend to do so with other girls. For this reason, it is logical to refrain from asking boys about girls or vice versa, since this may result in a rating error due to ignorance or prejudices that children of this age may have in relation to members of the opposite sex.

Measuring parenting styles

Parenting styles were assessed using the Parenting Styles and Dimensions Questionnaire, a test which evaluates authoritative, authoritarian and permissive parenting styles (Robinson, Mandlco, Olsen & Hart, 2001). The questionnaire consists of 62 items grouped into three primary scales (authoritative, authoritarian and permissive) and 11 secondary sub-scales (warmth and involvement; reasoning/induction; democratic participation; good

nature/easygoing; verbal hostility; corporal punishment; nonreasoning/punitive strategies; directiveness; lack of follow-through; ignoring misbehavior and self-confidence). Responses are given on a Likert-type scale, ranging from 0 (never) to 4 (always), and assess the frequency with which parents engage in certain behaviors in relation to their child. In order to obtain the scale for our sample, a factorial analysis was conducted which revealed that the items of the questionnaire were grouped into three main factors, which coincided with the three primary scales proposed by the authors (authoritative, authoritarian and permissive) for both the mother and the father. The authoritative factor consisted of the subscales warmth and involvement, reasoning/induction; democratic participation; and good nature/easygoing. The authoritarian factor consisted of the subscales verbal hostility; corporal punishment; nonreasoning/punitive strategies; and directiveness. Finally, the permissive factor was consisted of the subscales lack of follow-through; ignoring misbehavior; and self-confidence. The reliability scores obtained in our sample for authoritative, authoritarian and permissive styles were $\alpha = .86$; $\alpha = .63$ and $\alpha = .67$ (respectively).

Determining androgen levels in saliva

Two saliva samples for each child were collected at the same time of day (0900h to 0915h) on two separate occasions separated by 6 weeks. Participants were asked to deposit their saliva in a biological test tube. To facilitate salivation, each child was given a sweet and told they could only eat it once enough saliva had been collected. Upon arrival at the laboratory, each subject's sample was stored in two different tubes (one for testosterone and the other for androstenedione). The samples were frozen and stored in the laboratory at -80° C until subsequent analysis using an ELISA technique (Salimetrics, State College, USA), with each sample being analyzed in duplicate. For testosterone, the average intra-assay coefficient of variation (CV) was 6.7%, and the average inter-assay CV was 14.05%. For androstenedione, the intra and inter-assay CVs were 7.5% and 8.5% respectively. For all analyses, we averaged

testosterone and androstenedione concentrations from the two collection periods. The values obtained 6 weeks apart were significantly correlated with each other for both hormones (testosterone: for boys $r = .560$, $p = .0001$ and for girls $r = .611$, $p = .0001$; androstenedione: for boys $r = .301$, $p = .006$ and for girls $r = .272$, $p = .027$).

Study procedures

Data were collected during the second half of the school year to ensure that social relationships between participants were well established. Parents were sent a questionnaire designed to measure both maternal and paternal parenting styles. Finally, two saliva samples were collected at a 6 week interval, in order to establish a baseline for each child's hormonal levels.

Statistical analysis

All the variables were transformed into Z scores in order to cancel the effect of the range disparity problems. Since they did not have a normal distribution, physical aggression, indirect aggression, hormone levels and parental styles were normalized using the Bloom transformation, which is the most common inverse normal transformation (Maritz, 1982).

The test used to measure aggressive behavior (DIAS) is a peer-rating test which is usually administered separately for each sex. In other words, boys only rate the other boys in their class, and girls only rate other girls. Given the nature of the study's dependent variable, it seemed logical to maintain this distinction between boys and girls when conducting the statistical analyses.

The relations between the different variables considered in the study were examined using a sex-based Pearson correlation coefficient. Based on the correlations obtained, and with the aim of analyzing the potential predictive role played by parenting styles, hormone levels and their

interaction, regression analyses were conducted taking the different types of aggressive behavior (physical and indirect) as dependent variables. All the variables introduced in the regression models were continuous. To assess the significant interactions (parenting styles x hormone levels), we conducted simple slopes tests one standard deviation above and below the mean, following the approach outlined in Hayes & Matthes, (2009). All the analyses were carried out using the SPSS 15.0 statistical package.

RESULTS

Correlation analysis

The analysis of the sex-based correlations observed between the different variables studied is shown in Table 1. Firstly, we should stress that it is mainly parenting styles (rather than hormones) that are directly related to aggressive behavior. In this sense, it is worth highlighting that, for boys, mother's and father's authoritarian parenting was found to correlate positively with physical aggression. No parental style correlated with indirect aggression in boys. For girls, father's and mother's authoritarian parenting and mother's permissive parenting were found to correlate positively with physical aggression. Also in girls, father's authoritarian and mother's permissive parenting were found to correlate positively with indirect aggression.

Interaction between parenting styles and hormone levels on aggression

In order to assess the interaction between parenting style and hormone levels in aggression, a number of regression analyses were conducted¹. First, physical or indirect aggression were introduced as dependent variables and parenting styles, hormones and their interactions (parenting style x hormone) were introduced as predictors. Next, with the aim of improving the model, interactions that were not significant were removed from the model. Given the lack of statistically significant differences between the two models (original and simplified), the most parsimonious option which explained the highest percentage of variance was chosen in each case (Cohen, Cohen, West & Aiken, 2003). The general regression models obtained for physical aggression in boys ($R^2 = .13$; $F = 2.377$; $p = .043$) (Table 2) and in girls ($R^2 = .401$; $F = 4.604$; $p = .001$) (Table 3), and for indirect aggression in girls ($R^2 = .383$; $F = 5.446$; $p = .0001$) (Table 4) were significant.

To analyze the significant interactions, simple slope tests were conducted as described above. Thus, with the aim of analyzing the interaction between having an authoritarian mother and testosterone in boys, the pick-a-point approach was used, estimating the effects at low (one SD below the mean), moderate (simple mean) and high (one SD above the mean) values of testosterone. The visual plot of the interaction is shown in Figure 1. As you can see, the moderator effect of testosterone was deemed to be statistically significant when its values were one standard deviation above the mean. The simple slopes between authoritarian mother scores and physical aggression are $b = -.1520$ ($p = .409$) for low testosterone (-1 SD), $b = .0926$ ($p = .473$) for mean testosterone and $b = .3372$ ($p = .05$) for high testosterone (+1 SD). Using the Johnson-Neyman technique, we observed that the range of testosterone values in which having an authoritarian mother has a statistically significant effect was over 0.96.

¹ For all the models, we tested the multiple regression assumption of multicollinearity for all the predictors and their interactions. The tolerance values obtained were adequate and oscillated between .50 and .80, with VIF values of 1.20 and 1.80.

The pick-a-point approach was again used to analyze the interaction between having an authoritarian father and testosterone in girls, estimating the effects at low (one SD below the mean), moderate (simple mean) and high (one SD above the mean) values of testosterone. The visual plot of the interaction is shown in Figure 2. The moderator effect of testosterone was deemed to be statistically significant when its values were on the mean or were over one standard deviation above the mean. The simple slopes between authoritarian father scores and physical aggression are $b = -.9391$ ($p = .774$) for low testosterone (-1 SD), $b = -.0029$ ($p = .044$) for mean testosterone and $b = .9332$ ($p = .001$) for high testosterone (+1 SD). Using the Johnson-Neyman technique, we observed that the range of testosterone values in which having an authoritarian father has a statistically significant effect was over $-.0225$.

Finally, with the aim of analyzing the interaction between having a permissive mother and testosterone in girls, the pick-a-point approach was used once more, estimating the effects at low (one SD below the mean), moderate (simple mean) and high (one SD above the mean) values of testosterone. The visual plot of the interaction is shown in Figure 3. As you can see, the moderator effect of testosterone was deemed to be statistically significant when its values were on the mean or were over one standard deviation above the mean. The simple slopes between permissive mother scores and indirect aggression are $b = -.1024$ ($p = .628$) for low testosterone (-1 SD), $b = .3552$ ($p = .016$) for mean testosterone and $b = .8128$ ($p = .001$) for high testosterone (+1 SD). Using the Johnson-Neyman technique, we observed that the range of testosterone values in which having a permissive mother has a statistically significant effect was over -0.1455 .

DISCUSSION

The results of the study suggest that it is worthwhile exploring the interactive role of psychosocial and biological variables when attempting to explain aggressive behavior (biosocial or biopsychosocial perspective). Specifically, we found that testosterone moderates the association between authoritarian and permissive parenting and physical and indirect aggression (respectively). Testosterone was found to moderate the association between authoritarian parenting and physical aggression. In boys, high testosterone levels strengthen the positive association between mother's authoritarian parenting and physical aggression. In girls, testosterone, at moderate and high levels, was found to moderate the association between father's authoritarian parenting and physical aggression. There are several possible explanations for these interaction effects.

Firstly, it has been suggested that authoritarian and coercive parenting styles have an activating effect on children at both a physiological and psychological level, affecting their emotional control and heightening their levels of rage and hostility (Hart et al., 1998; Underwood, Beron & Rosen, 2009). Moreover, it has also been suggested that more coercive and controlling styles establish a rigid structure which does not allow children to exercise self-control and limits their opportunities for gaining experience with positive social skills that will enable them to resolve conflicts (Casas et al., 2006; Kuppens et al., 2009; Rubin et al., 1998). Indeed, some authors argue that authoritarian parenting may be interpreted by the child as a form of rejection, something which may increase hostility; at the same time, the assertive power techniques associated with this parenting style may constitute a model followed by the child in interactions with their peers (Casas et al., 2006; Nelson et al., 2006). If, to these potential effects of the authoritarian parenting style, we add the well-documented positive association between testosterone and aggression in children (Archer, 2006; Sanchez-Martin et al., 2011), the result is an interactive effect of both types of influence which predict an increase in physical aggression levels, as indeed was observed in our study.

A second line of argument claims that the relationship between parenting styles and children's behavior is bidirectional, and that children who have behavioral problems may affect the way in which their parents deal with them (Hart et al., 1998; Xu et al., 2009). Thus, a problematic child will provoke a parental response which in turn engenders an increase in disruptive behavior. If this were the case, high testosterone levels in aggressive children with authoritarian parents may foster the emergence of higher levels of physical aggression, which in turn may trigger an even more authoritarian response from parents. This would also be consistent with our results, although a longitudinal study is required to determine whether or not this interpretation is correct. Furthermore, it is important to consider the bidirectional nature of the relationship between aggression, testosterone levels, and parenting. Specifically, heightened aggressive behavior can modulate both testosterone concentrations and influence parental behavior.

A third explanation for our results is more speculative, although no less plausible, and is related to the dominance hypothesis proposed by Grant (1990). This hypothesis suggests that both the mother's parenting style and the sex of the child are related to levels of maternal testosterone (probably around the time of pregnancy). Indeed, diverse evidence exists which shows that dominant females of numerous species tend to produce a higher number of male offspring than their subordinate counterparts (Clutton-Brock, Albon & Guinness, 1984). Given the design of our study, we are unable to confirm whether or not Grant's maternal dominance hypothesis plays a role in our results, but it is tempting to suggest that the boys in our sample who have more authoritarian (dominant) mothers are more physically aggressive either because they have inherited androgen levels associated with higher levels of dominance or because their hormone levels have been influenced by maternal levels through other pathways. The majority of studies on the heritability of testosterone levels have been conducted with adolescents and adults, and have found a genetic contribution to inter-individual variability in testosterone levels that varies in accordance with age (Hoekstra, Bartels & Boomsma, 2006; Bogaert et al., 2008). The only studies on this question carried out with prepubescent subjects found that it was environmental factors that best explained inter-individual variability in testosterone levels (Sakai, Baker,

Jacklin, Shulman, 1991; Caramaschi, Petittclerc, Boivin, Tremblay, 2012). These environmental factors include maternal hormone levels.

In specific terms, we found that in boys with authoritarian mothers, high testosterone levels predict an increase in physical aggression levels. Sanchez-Martin et al. (2009) found that in 5-year-old boys with directive mothers, high androstenedione levels predicted higher physical aggression levels at age 6, suggesting the possibility that, in accordance with Grant's hypothesis, mothers with a more dominant style may have more male children and that in these boys, high androgen levels may increase physical aggression and dominance behavior. Applying this approach to our results is indeed speculative, but it is consistent with the ultimate causes proposed for physical aggression in males, in the sense that it fosters greater reproductive success given the higher degree of reproductive variability among male mammals. This study, which was conducted with 8-year-old children, confirms the predictor role of the interaction between a domineering maternal style and androgen levels for physical aggression in boys.

Another relevant result of this study is that related to indirect aggression. For this type of aggression, we found that testosterone moderates the association between mother's permissive parenting and indirect aggression in girls, with moderate and high levels of testosterone strengthening the positive association between mother's permissive parenting and this type of behavior. It has been suggested that indulgent parents may lack the skills required to control their children's behavior, something which may result in behavioral problems such as aggression (Xu et al., 2009). Moreover, Sandstrom (2007) found a differential association between maternal permissiveness and the level of relational aggression in girls. This author suggests that girls with an "entitled or selfish orientation", fostered by maternal permissiveness, may perhaps have more conflicts with peers than their male counterparts with the same orientation, which seems to be more consistent with what is culturally expected of boys (Sandstrom, 2007). It has also been suggested that mothers may have a different reaction to aggression in sons than to aggression in daughters (Sandstrom, 2007). In our case, it may be that mothers react differently to physical aggression in sons (becoming more authoritarian) than

to indirect aggression in daughters (becoming more permissive). Indirect aggression involves the use of more elaborate and cognitively sophisticated strategies than those employed in physical aggression and has been considered a less intense, low-risk type of aggression, albeit a highly effective one in the competition for resources, with clear advantages from an adaptive point of view (Bjorkqvist, 1994; Campbell, 1999). The finding that testosterone increases indirect aggression in girls with permissive mothers may constitute an underlying mechanism of a strategy designed to control available resources through this type of aggression. Although Sanchez-Martin et al. (2009) failed to find that a permissive mother x androgen level interaction at age 5 predicted indirect aggression at age 6, this does not imply any contradiction with the results of the present study, obtained with 8-year-old children, since in order to employ this type of aggression effectively, children require cognitive skills that are more developed at age 8 than at age 6. Indeed, it has been observed that the use of indirect aggression increases with age, and is more prevalent during adolescence than during previous stages (Bjorkqvist, Lagerspetz & Kaukiainen, 1992; Owens 1996; Vaillancourt, 2005).

In summary, the findings presented here may help improve our understanding of the psychobiological mechanisms underpinning different types of aggressive behavior in children. These findings are novel given the scarcity of studies with children examining the interaction between endogenous hormones and parenting styles. In relation to the limitations of our study, it should be noted that the absence of a longitudinal design prevents us from confirming some of the interpretations proposed for our results. Also, a larger sample group would have lent our analyses greater explanatory power. Future work may wish to build upon the present findings by examining emotional and cognitive variables (i.e. anger, empathy, etc.) that may ultimately underlie the effects observed in the current study.

ACKNOWLEDGEMENTS

This study was supported by a grant provided by the Ministry of Science and Innovation (PSI2010-1750) and funding provided by the Basque Country Government (GIC07/19-IT-238-07; BFI 08.111). We would like to express our gratitude to the teaching staff, parents and children of the participating schools.

REFERENCES

- Archer, J. (2006). Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neuroscience Biobehavioral Review*, 30, 319-345. doi:10.1016/j.neubiorev.2004.12.007
- Archer, J. (2009). Does sexual selection explain human sex differences in aggression? *Behavioral and Brain Sciences*, 32, 249-311. doi:10.1017/S0140525X09990951
- Azurmendi, A., Braza, F., Garcia, A., Braza, P., Munoz, J.M. & Sanchez-Martin, J.R., 2006. Aggression, dominance, and affiliation: Their relationships with androgen levels and intelligence in 5-year-old children. *Hormones and Behavior*, 50, 132-140. doi:10.1016/j.yhbeh.2006.02.004
- Baumrind, D. (1991). The influence of parenting style on adolescent competence and substance use. *Journal of Early Adolescence*, 11, 56-95. doi:10.1177/0272431691111004
- Bates, J.E. & Pettit, G.S. (2007). Temperament, parenting and socialization, In J.E. Grusec & P.D. Hastings (Eds.). *Handbook of socialization: Theory and Research* (pp. 153-180). New York: The Guilford.
- Björkqvist, K. (1994). Sex-differences in physical, verbal, and indirect aggression: A review of recent research. *Sex Roles* 30, 177-188. doi:10.1007/BF01420988
- Björkqvist, K., Lagerspetz, K.M.J. & Kaukiainen, A. (1992). Do girls manipulate and boys fight? Developmental trends in regard to direct and indirect aggression. *Aggressive Behavior* 18, 117-127. doi:10.1002/1098-2337(1992)18:2%3C117::AID-AB2480180205%3E3.0.CO;2-3
- Björkqvist, K. & Österman, K. (1998). *Scales for research on interpersonal relations*. Abo Academy University, Pro Facultate
- Björkqvist, K., Österman, K., Lagerspetz, K.M.J., Landau, S.F., Caprara, G.V. & Fraczek, A. (2001). Aggression, victimization, and sociometric status: Findings from Finland, Israel, Italy and Poland. In J. Martin-Ramirez & D.S. Richardson (Eds.). *Cross-cultural approaches to research on aggression and reconciliation* (pp. 111-119). Huntington, NY: Nova Science Publishers,
- Bogaert, V. Taes, Y., Konings, P., Van Steen, K., De Bacquer, D. Goemaere, S., Zmierzczak, H., Crabbe, P., Kaufman, J.M. (2008). Heritability of blood concentrations of sex-steroids in relation to body composition in young adult male siblings. *Clinical Endocrinology*, 69, 129-135. doi:10.1111/j.1365-2265.2008.03173.x

- Booth, A., Johnson, D.R., Granger, D.A., Crouter, A.C. & McHale, S. (2003). Testosterone and child and adolescent adjustment: The moderating role of parent-child relationships. *Developmental Psychology*, 39, 85-98. doi:10.1037/0012-1649.39.1.85
- Brain, P.F. (1977). *Hormones and Agression*. Montreal: Eden Press.
- Caramaschi, D., Booij, L., Petitelerc, A., Boivin, M., Tremblay, R.E. (2012). Genetic and environmental contributions to saliva testosterone levels in male and female infant twins. *Psychoneuroendocrinology*, 37, 1954-1959. doi:10.1016/j.psyneuen.2012.04.008
- Campbell, A. (1999). Staying alive: Evolution, culture, and women's intrasexual aggression. *Behavioral and Brain Sciences* 22, 203-252. doi:10.1017/S0140525X99001818
- Casas, J.F., Weigel, S.M., Crick, N.R., Ostrov, J.M., Woods, K.E., Yeh, E.A.J. & Huddleston-Casas, C.A. (2006). Early parenting and children's relational and physical aggression in the preschool and home contexts. *Journal of Applied Developmental Psychology* 27, 209-227. doi:10.1016/j.appdev.2006.02.003
- Clutton-Brock, T.H., Albon, S.D. & Guinness, F.E. (1984). Maternal dominance, breeding success and birth sex-ratios in red deer. *Nature*, 308, 358-360. doi:10.1038/308358a0
- Cohen, J., Cohen, P., West, S.G. & Aiken, L.S. (2003). *Applied multiple regression: Correlation analysis for the behavioral sciences* (3rd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Côté, S., Vaillancourt, T., Barker, E.D., Nagin, D. & Tremblay, R.E. (2007). The joint development of physical and indirect aggression: predictors of continuity and change during childhood. *Development and Psychopathology*, 19, 37-55. doi:10.10170S0954579407070034
- Chichinadze, K., Chichinadze, N. & Lazarashvili, A. (2011). Hormonal and neurochemical mechanisms of aggression and a new classification of aggressive behavior. *Aggression and Violent Behavior*, 16, 461-471. doi:10.1016/j.avb.2011.03.002
- Grant, V.J. (1990). Maternal personality and sex of infant. *British Journal of Medical Psychology*, 63, 261-266. doi:10.1111/j.2044-8341.1990.tb01618.x
- Hart, C.H., Nelson, D.A., Robinson, C.C., Olsen, S.F. & McNeilly-Choque, M.K. (1998). Overt and relational aggression in russian nursery-school-age children: Parenting style and marital linkages. *Developmental Psychology*, 34, 687-697. doi:10.1037/0012-1649.34.4.687

- Hayes, A.F., Matthes, J. (2009). Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. *Behavior Research Methods*, 41, 924-936. doi:10.3758/BRM.41.3.924
- Hoekstra, R.A., Bartels, M., Boomsma, D.I. (2006). Heritability of testosterone levels in 12-year-old twins and its relation to pubertal development. *Twin Research Human Genetics*, 9, 558-565. doi:10.1375/twin.9.4.558
- Kuppens, S., Grietens, H., Onghena, P. & Michiels, D. (2009). Associations between parental control and children's overt and relational aggression. *British Journal of Developmental Psychology*, 27, 607-623. doi:10.1348/026151008X345591
- Lorber, M.F. & Egeland, B. (2011). Parenting and infant difficulty: Testing a mutual exacerbation hypothesis to predict early onset conduct problems. *Child Development*, 82, 2006-2020. doi:10.1111/j.1467-8624.2011.01652.x
- Maccoby, E.E. (1998). *The two sexes: Growing up apart, coming together*. Cambridge, MA: Belknap Press.
- Maritz, J.S. (1982). *Distribution free statistical methods*. London: Chapman and Hall.
- Moya, L., Serrano, M.A. & Ramirez, J.M. (2010). Interacción testosterona y agresión: evolución y estado actual de la cuestión. In L. Moya (Ed.). *Psicobiología de la violencia* (pp. 123-139). Madrid: Pirámide.
- Nelson, D.A., Hart, C.H., Yang, C.M., Olsen, J.A. & Jin, S.H. (2006). Aversive parenting in China: Associations with child physical and relational aggression. *Child Development*, 77, 554-572. doi:10.1111/j.1467-8624.2006.00890.x
- Owens, L.D. (1996). Sticks and stones and sugar and spice: Girls' and boys' aggression in schools. *Australian Journal of Guidance and Counseling*, 6, 45-55.
- Raine, A. (2002). Biosocial studies of antisocial and violent behavior in children and adults. *Journal of Abnormal Child Psychology*, 30, 311-326. doi:10.1023/A:1015754122318
- Ramirez, J. (2003). Hormones and aggression in childhood and adolescence. *Aggression and Violent Behavior*, 8, 621-644. doi:10.1016/S1359-1789(02)00102-7
- Robinson, C.C., Mandleco, B., Olsen, S.F. & Hart, C.H. (2001). Parenting Styles and Dimensions Questionnaire (PSDQ), In B.F. Touliatos, B.F. Perlmuter & G.W. Holden (Eds.). *Handbook of family measurements techniques* (pp. 188-189). Thousand Oaks: Sage Publications.

- Rubin, K.H., Hastings, P., Chen, X.Y., Stewart, S. & McNichol, K. (1998). Intrapersonal and maternal correlates of aggression, conflict, and externalizing problems in toddlers. *Child Development, 69*, 1614-1629. doi:10.2307/1132135
- Sakai, L.M., Baker, L.A., Jacklin, C.N., Shulman, I. (1991). Sex steroids at birth: genetic and environmental variation and covariation. *Developmental Psychobiology, 24*, 559-570. doi:10.1002/dev.420240804
- Sanchez-Martin, J.R., Azurmendi, A., Pascual-Sagastizabal, E., Cardas, J., Braza, F., Braza, P., Carreras, M.R. & Munoz, J.M. (2011). Androgen levels and anger and impulsivity measures as predictors of physical, verbal and indirect aggression in boys and girls. *Psychoneuroendocrinology, 36*, 750-760. doi:10.1016/j.psyneuen.2010.10.011
- Sanchez-Martin, J.R., Azurmendi Imaz, A., Fano Ardanaz, E., Braza Lloret, F., Munoz Sanchez, J.M. & Carreras de Alba, M.R. (2009). Androgen levels, parenting styles and aggressive behavior in 5-6-year-old boys and girls. *Psicothema 21*, 57-62.
- Sánchez-Martín, J.R., Fano, E., Ahedo, L., Cardas, J., Brain, P.F. & Azpíroz, A. (2000). Relating testosterone levels and free play social behavior in male and female preschool children. *Psychoneuroendocrinology 25*, 773-783. doi:10.1016/S0306-4530(00)00025-1
- Sandstrom, M.J. (2007). A link between mothers' disciplinary strategies and children's relational aggression. *British Journal of Developmental Psychology, 25*, 399-407. doi:10.1348/026151006X158753
- Scerbo, A. & Kolko, D.J. (1994). Salivary testosterone and cortisol in disruptive children: Relationship to aggressive, hyperactive, and internalizing behaviors. *Journal of The American Academy of Child and Adolescent Psychiatry, 33*, 1174-1184. doi:10.1097/00004583-199410000-00013
- Strayer, F.F. & Santos, A.J. (1996). Affiliative structures in preschool peer groups. *Social Development, 5*, 117-130. doi:10.1111/j.1467-9507.1996.tb00075.x
- Trainor, B.C., Sisk, C.L. & Nelson, R.J. (2009). Hormones and the development and expression of aggressive behavior. In D. Pfaff, A. Etge, S. Fahrback & R. Rubin (Eds.). *Hormones, brain and behavior* (pp. 167-203). San Diego: Academic Press/Elsevier.
- Tremblay, R.E. & Côté, S. (2005). The developmental origins of aggression: Where are we going? In R.E. Tremblay, W.W. Hartup & J. Archer (Eds.). *Developmental origins of aggression* (pp. 447-464). New York: The Guilford Press.

Tremblay, R.E. & Nagin, D.S. (2005). The developmental origins of physical aggression in humans. In R.E. Tremblay, W.W. Hartup & J. Archer (Eds.). *Developmental origins of aggression* (pp. 83-106). New York: The Guilford Press

Underwood, M.K., Beron, K.J. & Rosen, L.H. (2009). Continuity and change in social and physical aggression from middle childhood through early adolescence. *Aggressive Behavior*, 35, 357-375. doi: 10.1002/ab.20313

Vaillancourt, T. (2005). Indirect aggression among humans. Social construct or evolutionary adaptation?, In R.E. Tremblay, W.W. Hartup & J. Archer (Eds.). *Developmental origins of aggression* (pp. 158-177). New York: The Guildfor Press.

Valles, N.L. & Knutson, J.F. (2008). Contingent responses of mothers and peers to indirect and direct aggression in preschool and school-aged children. *Aggressive Behavior*, 34, 497-510. doi: 10.1002/ab.20268

Xu, Y., Farver, J.A., M. & Zhang, Z. (2009). Temperament, harsh and indulgent parenting, and chinese children's proactive and reactive aggression. *Child Development*, 80, 244-258. doi:10.1111/j.1467-8624.2008.01257.x

Zoccolillo, M., Romano, E., Joubert, D., Mazzarello, T., Coté, S., Boivin, M. et al., (2005). The intergenerational transmission of aggression and antisocial behavior. In R.E. Tremblay, W.W. Hartup, J. Archer (Eds.), *Developmental origins of aggression* (pp. 353-375). New York: The Guilford Press.