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Prediction of Preschool Aggression from DRD4 Risk, Parental ADHD Symptoms, and Home Chaos

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Abstract This study investigated the influence of a child's DRD4 risk, parental levels of ADHD symptoms, and the interactive influence of these factors on the development of preschool aggression. Additionally, the study investigated the role of home chaos as a mediator between parental ADHD symptoms and child aggression. The sample consisted of 84 4.5-year-old children and their parents. Children were genotyped for the DRD4 polymorphism. ADHD symptoms were self-reported by parents when the child was 2 to 6 months old. Parental reports of home chaos and the child's aggression were collected 4 years later. Child's DRD4 risk and parental ADHD symptoms significantly contributed to the prediction of preschool aggression. However, contrary to our hypotheses, no interactions were found between the child's DRD4 risk and the levels of parental ADHD symptoms. Home chaos played a mediating role in the relation between paternal ADHD symptoms and the child's aggression. The relation between maternal ADHD symptoms and the child's aggression was not significantly mediated through the level of home chaos. The current study emphasizes the importance of longitudinally investigating the contribution of parental ADHD symptoms to child aggression, while also exploring the differential contribution of maternal/paternal inattention and hyperactivity-impulsivity symptoms. Moreover, home chaos was found to be a significant environmental mechanism through which paternal ADHD symptoms affect children's aggression in the preschool years.

Keywords ADHD symptoms · DRD4 · Chaos · Aggression · Preschool

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Early aggressive behaviors in children are associated with negative developmental outcomes. Aggression during childhood has concurrent implications, such as poor social competence and oppositional, anxious, and depressive behaviors (Juliano et al. 2006; Ostrov et al. 2004), as well as long-term implications, such as later aggression and conduct problems (Brame et al. 2001; Crick et al. 2006; Huesmann et al. 2009). For example, high and stable aggressive behaviors in children were found to predict later negative outcomes in early adolescence, such as school failure, peer problems, and delinquency (Campbell et al. 2010). Moreover, this study also indicated that low to moderate levels of reported aggression predict negative outcomes, such as academic and social-functioning difficulties. In fact, the early onset of behavioral problems is a major risk factor for serious conduct problems and antisocial behavior later in adolescence and adulthood (Patterson et al. 1989; Webster-Stratton and Reid 2010).

Considering the negative consequences of preschool aggression, it is important to examine possible genetic and environmental risk factors that may contribute to its development. Genetic studies have shown that dopaminergic genes are associated with behavioral and attentional problems (Bellgrove and Mattingley 2008; Swanson et al. 2007; Young et al. 2002). Furthermore, these genes are also associated with impulsive aggression (Chen et al. 2005); however, the expression of aggression is not solely a function of one neurobiological system. Although there are additional genetic systems that have been found to be involved in aggression, mainly serotonin (Lesch and Merschdorf 2000), in this study we focus on the dopamine genes, as they are also implicated in Attention Deficit-Hyperactivity Disorder (ADHD; Faraone et al. 2005; Swanson et al. 2007; Turic et al. 2010).

Within the dopamine system, one of the most widely studied genes in this context is the dopamine receptor D4 (DRD4). DRD4 has a 48-bp repeat in exon III. The most frequent variant is the 4-repeat allele, and the 7-repeat allele is the next most frequent variant. Previous studies, but not all,

have found an association between the presence of the DRD4 7-repeat allele and ADHD (Faraone et al. 2001; Faraone et al. 2005; Swanson et al. 2000); however, its specific association with aggression is less evident. Molecular genetic studies have found an association between DRD4 and novelty seeking (Benjamin et al. 1996; Ebstein et al. 1996), which is related to aggressive behaviors in children with disruptive behavior disorders (Schmeck and Poustka 2001) and between DRD4 and other behavioral problems (Dmitrieva et al. 2011). Schmidt et al. (2002) have investigated the relation between DRD4 and children's aggression and have shown that children with the long (6–8) repeats of the dopamine receptor D4 (DRD4) were reported by their mothers as having more aggressive behaviors than children with the short (2–5) repeats.

Regarding environmental risk factors, ineffective parenting practices are known as an important risk factor in preschoolers' early onset of conduct and behavioral problems, before peer relations and academic difficulties become significant (Patterson et al. 1989; Webster-Stratton and Reid 2010). Several studies have shown that parenting difficulties, such as reduced monitoring and inconsistent discipline practices, are associated with children's disruptive behaviors (Campbell et al. 2000; Casas et al. 2006; Yu et al. 2010). Similarly, over-reactivity and harsh parenting are known to be related to child aggression (Campbell et al. 2000; Casas et al. 2006).

Thus, parents with ADHD symptomatology might be a risk factor for the development of aggression in their preschool offspring. These parents might expose their children not only to a genetic risk through the transmission of dopamine genes associated with ADHD, but also to an environmental risk through exposure to a riskier child-rearing environment. Indeed, adults with ADHD describe themselves as having executive function deficits, such as difficulty planning, organizing, and accomplishing goals, as well as difficulty inhibiting and regulating emotions (Biederman et al. 2008). These attentional deficits are known to be stable and to persist over time (Kessler et al. 2010), and they may affect the ability to parent effectively.

The parenting practices of adults with ADHD are still a relatively unexplored area (Johnston et al. 2012). A number of studies have shown that parental ADHD symptoms are likely to be related to poor parenting practices, such as inconsistent, lax parenting, and over-reactivity (Banks et al. 2008; Chronis-Tuscano et al. 2008; Johnston et al. 2012; Mokrova et al. 2010; Murray and Johnston 2006; Weiss et al. 2000). Chen and Johnston (2007) investigated the differential effects of the ADHD subtypes and found that maternal inattention and impulsivity are correlated with the use of inconsistent discipline and that maternal impulsivity is correlated with maternal over-reactivity. Maternal hyperactivity, however, was not significantly correlated with any of the parental behaviors examined; however, the authors did mention that the mothers included in the study had low levels of hyperactivity, which may not have hindered their parenting abilities.

The studies presented thus far have shown that the DRD4 7-repeat allele is a candidate risk-allele for aggression. Likewise, the environmental factors that are linked to child aggression, and which may also be conferred through parental ADHD symptoms, have been discussed. Additionally, there have also been several studies showing an interactive relationship between the DRD4 genetic risk and the environmental factors that may predict childhood aggression. For example, maternal insensitive care was related to children's externalizing problems (DiLalla et al. 2009) and aggressive behavior (Bakermans-Kranenburg and van Ijzendoorn 2006) only in children with the long (6–8) repeats of the DRD4 gene. Similarly, another study found that the DRD4 genetic risk interacts with inconsistent parenting and can predict children's ADHD (especially inattention) and ODD (Oppositional-Defiant Disorder) symptoms (Martel et al. 2011). Additionally, children with the DRD4 7-repeat allele demonstrated lower effortful control (as expressed in their inability to wait during the delay tasks) in the context of high negative parenting, compared to children without this allele (Smith et al. 2012). These findings support a hypothesis that a child's DRD4 genetic risk moderates the relation between parental ADHD symptoms and preschool aggression.

A very relevant environmental factor to consider, while investigating the association between parental ADHD and child's aggression, is the level of home chaos. A chaotic home environment refers to high levels of unpredictability, confusion, and agitation in the home, as well as the lack of daily routines, a sense of disorganization, and time pressures in daily activities (Evans 2006; Matheny 1995; Supplee et al. 2007; Wachs and Evans 2010). Clinical evidence has shown that parents with ADHD have difficulties with the instrumental and organizational tasks of parenting, such as remembering the carpool schedule, preparing morning routines, doing homework with the child, and so forth (Weiss et al. 2000). These day-to-day difficulties may result in a chaotic home environment. Indeed, Valiente et al. (2007) found that parental effortful control, which includes the attention, activation, and inhibition domains relevant for ADHD, was negatively associated with home chaos. In addition, Mokrova et al. (2010) found that home chaos mediated the relation between parental ADHD symptoms and parenting effectiveness.

Home chaos is also associated with negative outcomes for children. Lack of routine and structure were found to be related to externalizing behaviors, such as aggression (Dumas et al. 2005; Supplee et al. 2007; Valiente et al. 2007) and other behavior problems (e.g., emotional problems, conduct problems, and hyperactivity; Pike et al. 2006). Furthermore, home chaos was negatively related to children's self-regulatory skills, which in turn, were positively related to children's externalizing behavior and aggression (Hardaway et al. 2011). A chaotic home environment was also found to be associated with oppositional symptoms, both in children with ADHD as well as

in their siblings without ADHD (Mulligan et al. 2011). Additionally, chaos predicted children's conduct problems above and beyond other factors, such as parenting practices (Coldwell et al. 2006) and housing conditions (e.g., conditions involving hygiene or safety), both concurrently and over time (Deater-Deckard et al. 2009).

Therefore, the aim of the present study was to explore genetic and environmental influences on reported aggressive behavior in 4.5-year-old boys. Specifically, there were two main goals: first, to investigate the contributions of a child's DRD4 risk, parental ADHD symptoms, and the interaction of these factors on the child's aggression; and second, to investigate whether home chaos would play a mediating role in the relation between parental ADHD symptoms and the child's aggression. Based on the literature presented above, we formulated the following uni-directional hypotheses: 1) a child's DRD4 risk and parental ADHD symptoms will be associated with higher levels of childhood aggression; 2) the child's DRD4 risk will moderate the influence of parental ADHD symptoms on the child's aggression; specifically, parental ADHD will have a stronger influence on child aggression in children with the DRD4 7-repeat allele compared to children without it; and 3) home chaos will mediate the relation between parental ADHD and child aggression.

Method

Participants

The sample consisted of 84 4.5-year-old boys (M=4.44, SD=0.16) and their parents, all participants in the Ben-Gurion University Infant Developmental Study (BIDS), a longitudinal study of infants born to fathers with varying levels of ADHD symptomatology. The parents' background information included the mothers' and fathers' age (M=29.7, SD=5.07 and M=33.07, SD=5.6, respectively) and their years of education (M=13.4, SD=2.1 and M=13, SD=2.15, respectively). The participants were recruited from the maternity ward of the Soroka Medical Center, Beer Sheva, Israel. The recruitment was limited to male newborns because externalizing disorders are more prevalent in boys than in girls (Bongers et al. 2003; Juliano et al. 2006). All children were from two-parent families, and parents were either native-born Israelis or immigrants who had studied in Israel and spoke Hebrew.

The research was conducted at Ben-Gurion University and was approved by the Ethics Committee of the Department of Psychology, Ben-Gurion University, Beer Sheva, Israel.

An estimate of the sample size required to ensure that the planned statistical tests (i.e., hierarchical regression analyses) would have adequate power was conducted using a priori power analysis (G*power program; Faul et al. 2009). The analysis was powered to detect a large effect size (f^2=0.35), and the regression analyses were planned to involve a maximum of five predictors, including controlled background variables. According to this power analysis, the minimum number of participants required was 54; thus, our sample size was adequate.

Measures

Child DNA Samples

DNA samples collected from each child were genotyped for the DRD4 polymorphism. Twenty-seven children were coded as having the risk 7-repeat allele and 56 children were coded as having no risk. Collection of DNA from the child was done using soft buccal brushes, which were rubbed approximately 20 times on the inside of each cheek. The brushes were then put into a test tube containing AquaFresh mouthwash. The DNA samples were sent for analysis to the Department of Research, Herzog Hospital, Jerusalem, Israel. The exon III repeat region of the DRD4 receptor was characterized using the PCR amplification procedure. For full details of the procedure see Auerbach et al. (2010). The DRD4 genotype frequencies were in Hardy-Weinberg equilibrium in all subjects. DNA collection was approved by the Helsinki Committee of Soroka Medical Center, Beer Sheva, Israel. Informed consent for taking the DNA samples was given by both parents.

Conners Adult ADHD Rating Scale (CAARS)

The CAARS assesses ADHD symptoms and associated behavior in adults using a 4-point Likert scale ranging from 0 = *not at all/never* to 3 = *very much/very frequently* (Conners et al. 1999). The long self-report version (CAARS-S:L) was used in this study. The CAARS-S:L consists of 66 items and 8 subscales. The scales used for this report were the DSM-Inattentive (9 items, range: 0–27), the DSM-Hyperactive (9 items, range: 0–27), and the total DSM-ADHD (18 items, range: 0–54). Each parent completed the questionnaire when their child was 2 to 6 months of age. The Cronbach alphas for the mothers' and the fathers' reports respectively were 0.80/0.76 for the DSM-Inattentive subscale and 0.79/0.78 for the DSM-Hyperactive-Impulsive subscale. The Cronbach alpha for the DSM-ADHD subscale was 0.87 for both parents.

Confusion, Hubbub, and Order Scale (CHAOS)

The short version of the CHAOS contains six items ("We are usually able to stay on top of things") anchored on a 5-point scale ranging from 1 = *extremely untrue* to 5 = *extremely true* (Matheny 1995; Petrill et al. 2004). Preliminary analysis revealed that one of the items was not correlated with the others

("There is usually a television turned on somewhere in our home"); therefore, it was excluded from the statistical analyses. The questionnaire was completed separately by both parents when their child was 4.5 years old. Since the mothers' and the fathers' ratings were significantly correlated (r=0.36, p<0.01), they were combined to create a single summed score for each child that was used in the statistical analyses (range: 10–50). The Cronbach alpha for the CHAOS was 0.69, which is similar to internal consistencies found in other studies using the short version of the CHAOS (Coldwell et al. 2006; Pike et al. 2006).

Child Behavior Checklist (CBCL)

The CBCL is a parent-report questionnaire assessing childhood behavioral problems. Behavior is rated using a 3-point scale ranging from 0 = *not true* to 2 = *very true or often true* (Achenbach 1992). This study used the 19-item Aggressive Behavior subscale of the CBCL. The questionnaire was completed separately by both parents when the child was 4.5 years old. Since the mothers' and the fathers' ratings were significantly correlated (r=0.56, p<0.001), they were combined to create a single summed score for each child that was used in the statistical analyses (range: 0–76). The Cronbach alpha for the CBCL was 0.82.

Data Analysis

The first analyses examined the intercorrelations among the study variables using Pearson and point biserial correlations; then several sets of hierarchical regression analyses were performed. Given the directional nature of the hypotheses, one-tailed tests of significance were reported. These regression analyses were run controlling for parents' age and years of education. Analyses concerning parental ADHD included separate analyses for inattention and hyperactivity-impulsivity symptoms, as well as for the parents' total ADHD symptom score.

The first set of regression analyses included the child's DRD4 risk and maternal ADHD contributions to aggression. The second set included the child's DRD4 risk and paternal ADHD contributions to aggression. Another set of regression analyses were performed to examine home chaos mediation of the relations between parental ADHD symptoms and the child's aggression. Separate analyses were run for maternal and paternal mediation models, controlling for DRD4 risk and parents' age and education. The mediation assessments were performed according to Baron and Kenny's (1986) recommended steps: First, confirm that the independent variable (i.e., parental ADHD) is a significant predictor of the dependent variable (i.e., child's aggression); second, confirm that the independent variable (i.e., parental ADHD) is a significant predictor of the mediator (i.e., home chaos); and third, confirm that the mediator (i.e., home chaos) is a significant predictor of the dependent variable (i.e., child's aggression), in the presence of the independent variable (i.e., parental ADHD). Assessing mediation also requires a reduction in the contribution of the independent variable to the dependent variable when the mediator is included in the regression analysis, compared to its contribution without it (Baron and Kenny 1986). The significance of these models was tested with the Sobel test (Sobel 1982).

Results

Table 1 presents the descriptive statistics for the study measures. Pearson correlations among the study variables revealed that the child's level of aggression was significantly related to the mother's and the father's level of inattention symptoms (r=0.30, p<0.01 and r=0.22, p<0.05, respectively) and also to their total ADHD score (r=0.32, p<0.01 and r=0.24, p<0.05, respectively). As for parental hyperactivity-impulsivity scores, correlations with the child's aggression were significant for the mothers (r=0.29, p<0.01) and marginal for the fathers (r=0.20, p<0.1). The child's level of aggression was also related to the level of chaos in the home (r=0.38, p>0.001). The correlation between the child's DRD4 risk gene, which is a dichotomous variable, and the child's level of aggression was calculated with point biserial correlations indicating those variables are significantly correlated (r=0.22, p<0.05; see Table 2).

Tables 3 and 4 present the regression analyses used to examine the study's hypotheses. According to the first hypothesis, the results indicated that the child's DRD4 risk significantly, although moderately, contributed to the child's aggression (β=0.21, p<0.05 for mothers' and fathers' models). Children with the DRD4 7-repeat allele have significantly higher levels of reported aggression than children without this risk allele.

Table 1 Means and standard deviations of study variables

	Inattention	Hyperactivity-impulsivity	Total ADHD	Child aggression	Home chaos
Mother	5.23 (4.00)	6.89 (4.41)	12.13 (7.66)	12.39 (6.56)	8.8 (2.55)
Father	6.33 (4.06)	8.78 (4.74)	15.12 (7.86)	12.01 (6.78)	9.21 (2.97)
Sum of Parental Mean Ratings				24.4 (11.76)	18.01 (4.57)

Standard deviations are presented in parentheses

Table 2 Pearson and point biserial correlations

		2	3	4	5	6	7	8	9
1	Child Aggression	0.38***	0.30**	0.29**	0.32**	0.22*	0.20†	0.24*	0.22*
2	Home Chaos		0.26*	0.17	0.23*	0.35**	0.25*	0.33**	0.06
3	Mother Inattention			0.65***	0.90***	0.21†	0.08	0.16	−0.01
4	Mother Hyperactivity-Impulsivity				0.91***	0.17	0.00	0.09	−0.01
5	Mother ADHD					0.21†	0.04	0.13	−0.01
6	Father Inattention						0.59***	0.87***	−0.02
7	Father Hyperactivity-Impulsivity							0.90***	−0.08
8	Father ADHD								−0.06
9	Child DRD4 Risk								

Pearson correlations are presented for the continuous variables: aggression, chaos, and parental ADHD levels; point biserial correlations are presented for the dichotomous DRD4 risk only. †$p<0.1$

*$p<0.05$, **$p<0.01$, ***$p<0.001$

The results also confirmed the hypothesized association between maternal and paternal levels of ADHD symptoms and the child's aggression ($\beta=0.31$, $p<0.01$ and $\beta=0.20$, $p<0.05$, respectively). For the mothers, both inattention and hyperactivity-impulsivity levels contributed significantly to this prediction ($\beta=0.27$, $p<0.01$ and $\beta=0.30$, $p<0.01$, respectively). As for the fathers, inattention levels contributed significantly to the prediction of the child's level of aggression ($\beta=0.18$, $p<0.05$), whereas for hyperactivity, the results were borderline ($\beta=0.17$, $p=0.05$). Contrary to our hypothesis, no interactions were found between the child's DRD4 risk and maternal or paternal levels of total ADHD symptoms score ($\beta=0.08$, $p=$n.s. and $\beta=-0.08$, $p=$n.s., respectively).

One of the explanations tested for the significant contribution of parental ADHD symptoms to the child's aggression was the mediation of home chaos. Examining Baron and Kenny's first step for mediation (i.e., analyzing whether parental total ADHD as well as inattention/hyperactivity-impulsivity symptoms are significantly associated with child aggression), was confirmed for all of the mediation models examined (see Figs. 1, 2, 3, 4 and 5). However, to fully assess mediation there is still a need to apply Baron and Kenny's second and third steps.

As for the mothers, the level of ADHD symptoms contributed significantly to the level of home chaos ($\beta=0.19$, $p<0.05$). Additionally, entering home chaos into the regression

Table 3 Prediction of child's aggression from child's DRD4 risk and maternal ADHD symptoms

		Maternal inattention				Maternal hyperactivity-impulsivity				Maternal total ADHD score			
	Variable	β	R^2	F	Sig. F Change	β	R^2	F	Sig. F Change	β	R^2	F	Sig. F Change
Step 1	Age	−0.25*	0.06	2.70	0.04	−0.25*	0.06	2.70	0.04	−0.25*	0.06	2.70	0.04
	Years of of education	0.02				0.02				0.02			
Step 2	Age	−0.23*	0.10	3.10*	0.03	−0.23*	0.10	3.10*	0.03	−0.23*	0.10	3.10*	0.03
	Years of of education	0.02				0.02				0.02			
	C DRD4 risk	0.20*				0.20*				0.20*			
Step 3	Age	−0.18	0.17	4.05**	0.007	−0.24*	0.19	4.63**	0.003	−0.20*	0.20	4.79***	0.002
	Years of of education	−0.01				−0.01				−0.02			
	C DRD4 risk	0.21*				0.20*				0.21*			
	ADHD	0.26**				0.30**				0.31**			
Step 4	Age	−0.19	0.17	3.26**	0.31	−0.25*	0.20	3.85**	0.19	−0.21*	0.20	3.92**	0.23
	Years of of education	−0.01				−0.01				−0.02			
	C DRD4 risk	0.21*				0.21*				0.21*			
	ADHD	0.25*				0.27**				0.28**			
	C DRD4 risk x ADHD	0.05				0.09				0.08			

C Child

*$p<0.05$, **$p<0.01$,***$p<0.001$

Table 4 Prediction of child's aggression from child's DRD4 risk and paternal ADHD symptoms

		Paternal inattention				Paternal hyperactivity-impulsivity				Paternal total ADHD score			
	Variable	β	R^2	F	Sig. F Change	β	R^2	F	Sig. F Change	β	R^2	F	Sig. F Change
Step 1	Age	−0.29**	0.12	5.67	0.0003	−0.29**	0.12	5.67	0.0003	−0.29**	0.12	5.67	0.0003
	Years of of education	0.19				0.19				0.19			
Step 2	Age	−0.28**	0.16	5.08**	0.003	−0.28**	0.16	5.08**	0.003	−0.28**	0.16	5.08**	0.003
	Years of of education	0.17				0.17				0.17			
	C DRD4 risk	0.19*				0.19*				0.19*			
Step 3	Age	−0.26**	0.19	4.67**	0.04	−0.25**	0.19	4.56**	0.05	−0.25**	0.20	4.84***	0.03
	Years of of education	0.15				0.16				0.15			
	C DRD4 risk	0.20*				0.21*				0.21*			
	ADHD	0.18*				0.17				0.20*			
Step 4	Age	−0.26**	0.19	3.69**	0.44	−0.25**	0.21	4.08**	0.09	−0.25**	0.20	3.97**	0.22
	Years of of education	0.15				0.19				0.16			
	C DRD4 risk	0.20*				0.21*				0.21*			
	ADHD	0.18*				0.21*				0.21*			
	C DRD4 risk x ADHD	0.001				−0.14				−0.08			

C Child

*$p<0.05$, **$p<0.01$,***$p<0.001$

model, while controlling for maternal ADHD symptoms, revealed that home chaos contributed significantly to the child's aggression ($\beta=0.33$, $p<0.01$). The contribution of maternal ADHD to the child's aggression was reduced, although it remained significant ($\beta=0.25$, $p<0.05$). Analyzing whether this reduction was significant revealed a nonsignificant Sobel test statistic ($Z=1.46$, $p<0.1$; Fig. 1).

Investigation of this mediation model for maternal inattention and hyperactivity-impulsivity separately indicated that only maternal inattention symptoms contributed to the level of home chaos ($\beta=0.21$, $p<0.05$), whereas hyperactivity-impulsivity did not ($\beta=0.13$, p=n.s.). Thus, further examination of the mediation model was conducted only for maternal inattention. Entering home chaos into the regression model, while controlling for maternal inattention symptoms, indicated that home chaos contributed significantly to the child's aggression ($\beta=0.33$, $p<0.01$). The contribution of maternal inattention symptoms was reduced, although it remained significant ($\beta=0.21$, $p<0.05$). Analyzing whether this reduction was significant revealed a nonsignificant Sobel test statistic ($Z=1.64$, $p<0.1$; Fig. 2).

As for the fathers, the level of their ADHD symptoms contributed significantly to home chaos ($\beta=0.28$, $p<0.01$). Additionally, entering home chaos into the regression model, while controlling for paternal ADHD symptoms, revealed a significant contribution of home chaos to the child's aggression ($\beta=0.27$, $p<0.01$) and a reduced, nonsignificant contribution of paternal ADHD to the child's aggression ($\beta=0.13$, p=n.s.). Analyzing whether this reduction was significant revealed a significant Sobel test statistic ($Z=1.79$, $p<0.05$; Fig. 3).

Investigation of this mediation model for paternal inattention symptoms revealed a significant contribution of inattention to home chaos ($\beta=0.31$, $p<0.05$). Entering home chaos into the regression model, while controlling for paternal inattention symptoms, indicated home chaos contributed significantly to aggression ($\beta=0.28$, $p<0.01$), whereas the contribution of paternal inattention to the child's aggression was

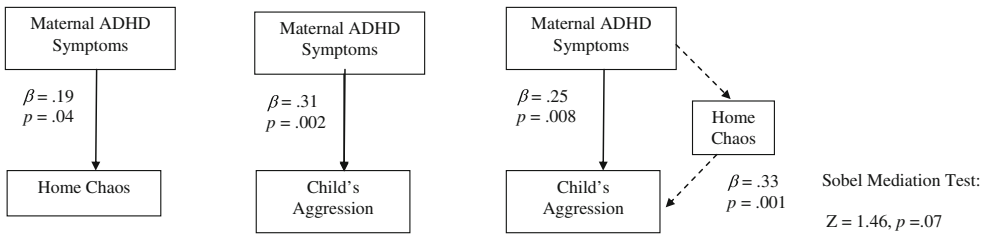

Fig. 1 Home chaos mediation of the relation between maternal ADHD symptoms and child aggression

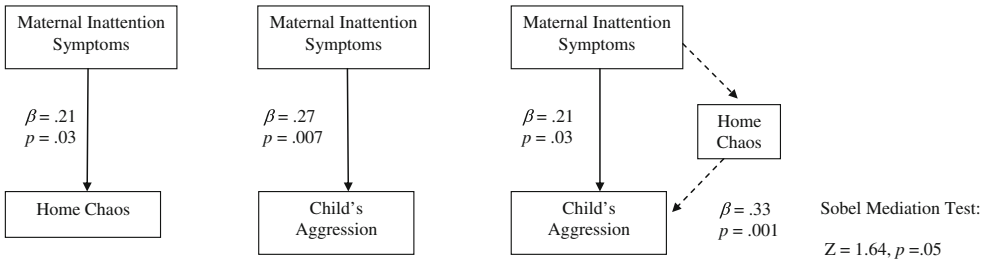

Fig. 2 Home chaos mediation of the relation between maternal inattention symptoms and child aggression

reduced to a nonsignificant level (β=0.10, p=n.s.). Assessing the significance of this mediation model with the Sobel test confirmed that the indirect effect of paternal inattention symptoms on the child's aggression, through home chaos, was significant (Z=1.88, p<0.05; Fig. 4).

Testing the mediation model for the trend found between paternal hyperactivity-impulsivity symptoms and child's aggression revealed that hyperactivity-impulsivity symptoms significantly contributed to the level of home chaos (β=0.20, p<0.05). Entering home chaos into the regression model, while controlling for paternal hyperactivity-impulsivity symptoms, indicated home chaos significantly contributed to aggression (β=0.28, p<0.01), whereas the contribution of paternal hyperactivity-impulsivity symptoms to the child's aggression was reduced to a nonsignificant level (β=0.10, p=n.s.). Assessing the significance of this mediation model with the Sobel test revealed a nonsignificant Sobel test statistic (Z=1.49, p<0.1; Fig. 5).

Discussion

The goal of this study was to explore the associations between a child's DRD4 genetic risk, parental ADHD symptoms, and the interactive influence these two factors have on preschool aggression. A further aim was to explore the mediating role of home chaos.

The results show a significant contribution of the DRD4 risk to the child's aggression at the age of 4.5 years. This finding is consistent with previous findings, which have shown that dopaminergic genes are involved in aggressive behaviors (Chen et al. 2005) and, specifically, that the DRD4 7-repeat allele is related to the child's reported aggression (Schmidt et al. 2002). However, the correlation between the DRD4 7-repeat allele and aggression in our study was only moderate. This could be the result of using a normative sample of children with relatively low levels of aggression.

Our results also indicate that self-reported parental (both paternal and maternal) ADHD symptoms, which were collected when the child was 2 to 6 months of age, were significantly correlated to the child's aggression as reported 4 years later. Although the association between parental ADHD symptoms and child preschool aggression has not been directly investigated before, the associations between various parental psychopathologies and children's adverse outcomes are well known. A wide range of parental psychopathologies, such as depression and anxiety, have been associated with children's increased risk for developing behavioral problems, emotional disorders, and other regulatory difficulties (Canino et al. 1990; Vostanis et al. 2006). Parental ADHD has also been investigated in relation to parenting effectiveness. Since noneffective parental behaviors are known to be related to children's behavioral problems, (Campbell et al. 2000; Casas et al. 2006) these studies are relevant to the present research findings. Previous studies investigating maternal ADHD have found an association between maternal symptoms and reduced monitoring and knowledge of child's activities, inconsistent discipline strategies, lax parenting, and over-reactivity (Banks et al. 2008; Chronis-Tuscano et al. 2008; Mokrova et al. 2010; Weiss et al. 2000). Studies of paternal ADHD and parenting are scarce; one study showed paternal symptoms to be associated with less consistent discipline, less involvement, and nonsupportive responses to their child's negative emotions (Mokrova et al. 2010). Another study found that involved

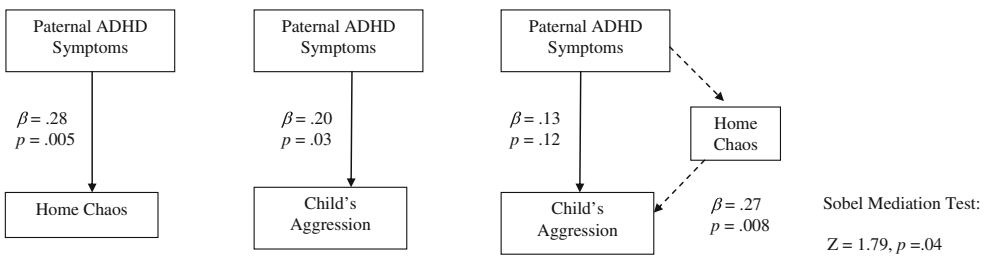

Fig. 3 Home chaos mediation of the relation between paternal ADHD symptoms and child aggression

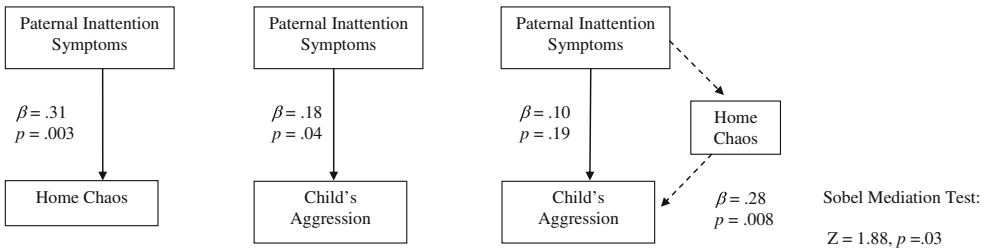

Fig. 4 Home chaos mediation of the relation between paternal inattention symptoms and child aggression

fathers with high levels of ADHD symptoms show higher over-reactivity compared to fathers without ADHD symptoms (Arnold et al. 1997).

Most studies of parental ADHD have not included a separate analysis of the different ADHD symptom domains, i.e., inattention and hyperactivity-impulsivity (Arnold et al. 1997; Banks, et al. 2008; Chronis-Tuscano et al. 2008; Mokrova et al. 2010; Weiss et al. 2000). However, as suggested by Johnston et al. (2012), a more detailed consideration of the differential effects of the ADHD symptom domains could benefit our understanding of the associations found between parental ADHD and child outcomes. Therefore, the present study also separately examined the associations between the parents' inattention/hyperactivity-impulsivity symptoms and child's aggression, rather than limiting our examination to the total ADHD scale. These analyses indicate that both maternal and paternal inattention were correlated with child's aggression. Regarding the hyperactivity-impulsivity symptoms, the correlation with child's aggression was significant only for the mothers. Although it appears that paternal hyperactivity-impulsivity may also contribute to the child's aggression, this association was only borderline. The findings regarding maternal inattention are in line with previous studies suggesting that maternal inattention is correlated with parenting impairments (Chen and Johnston 2007; Murray and Johnston 2006). However, these studies provide limited information regarding maternal hyperactivity-impulsivity. Chen and Johnston (2007) have mentioned that the mothers in their sample had only low levels of hyperactivity, which may have reduced their ability to examine parental influences. In addition, Murray and Johnston (2006) had only a small sample of mothers diagnosed with the hyperactive-impulsive subtype of ADHD and thus, they were excluded from their analysis. Unfortunately, regarding the fathers, it seems that to date, there are no studies that have included a separate analysis of paternal inattention and hyperactivity-impulsivity symptoms. Overall, it appears further studies are needed in order to clarify the separate influences of inattention and hyperactivity-impulsivity in both fathers and mothers, not just on their parenting effectiveness, but also on their children's developmental outcomes.

In the present study, the child's DRD4 risk did not moderate the influence of parental ADHD symptoms on the child's level of aggression. The lack of a moderation effect may be related to the characteristics of the sample: 1) it may be that the predicted moderation effects did not emerge because of the small sample size; and 2) the use of a nonclinical sample in this study may have attenuated the possibility of finding a moderating DRD4 effect. Only a small percentage of the parents and children could be characterized as having clinical levels of ADHD or aggression. Therefore, the current study may not have provided an adequate test of the moderating hypothesis. Studies that have found a moderating effect for the DRD4 genetic risk examined it in relation to various environmental contributions, such as maternal sensitivity (Bakermans-Kranenburg and van Ijzendoorn 2006; DiLalla et al. 2009) and inconsistent parenting practices (Martel et al. 2011). However, to our knowledge, DRD4 moderation of the association between parental ADHD per se and children's outcomes has not been investigated.

Regarding the hypothesized role of home chaos as a mediator of the association between parental ADHD symptoms and children's aggression: For fathers, the results indicate that home chaos fully mediated the association between the levels of the fathers' total ADHD symptoms and the child's level of

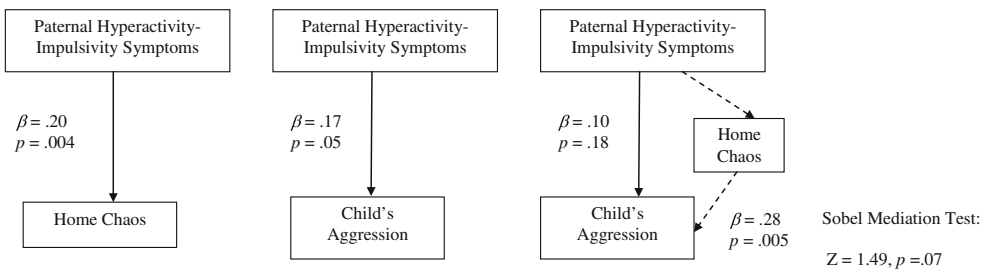

Fig. 5 Home chaos mediation of the relation between paternal hyperactivity-impulsivity symptoms and child aggression

aggression. This was also the case regarding paternal inattention symptoms. For the mothers, none of the mediation models involving home chaos reached statistical significance.

A possible explanation for these results may be related to the different roles mothers' and fathers' play in childcare and household activities. In the case of the mothers, although there was a correlation between their total ADHD symptoms and inattentiveness with home chaos, the mediation models were not significant. A question arises as to why, in the mothers' case, the symptoms contributed to the child's aggression directly and not via the level of home chaos. Despite an overall increase in the fathers' involvement in recent years, mothers still spend more time with their children (Craig 2006; Wall and Arnold 2007). In this case, maternal inattentiveness, which may impair a wide range of life areas related to the mother herself (self-esteem, parental efficacy, prosocial abilities, etc.) and to her parental abilities (parenting practices, maternal sensitivity and involvement, etc.), may also contribute to her child's aggressive behavior, regardless of the level of home chaos. Regarding the fathers' mediation model, we found that their ADHD symptoms contributed indirectly to the child's aggression, via the level of home chaos. This is surprising, considering that the mothers bear the main responsibility for home organization and daily routines (Craig 2006). A possible explanation for this result comes from Eakin et al. (2004), who have found that spouses of adults with ADHD reported that their ADHD partners' behavior interfered with their functioning, especially within the domains of general household organization, time management, and child rearing. It may be that fathers' ADHD symptoms interfere with the mothers' ability to create and maintain an organized, predictable home environment.

An additional aspect of the results worth mentioning is that parental inattention was a more consistent predictor of home chaos than hyperactivity-impulsivity. Parents with attentional difficulties may find it challenging to follow-through with the household chores, to keep track of family activities, and to establish and maintain routines in a way that contributes to an organized child-rearing environment (Johnston et al. 2012; Weiss et al. 2000). The consistency of the contribution of inattention to home chaos, compared to hyperactivity-impulsivity, is supported by studies that have shown that executive function deficits are more highly related to inattention symptoms than to hyperactivity-impulsivity symptoms (Chhabildas et al. 2001; Nigg et al. 2005; Willcutt et al. 2005). Thus, it may be that inattention symptoms, rather than hyperactivity-impulsivity symptoms, are more closely associated with a disorganized, unpredictable home environment, particularly for mothers.

There are several limitations to this study. Since ADHD symptoms may be influenced by other psychopathologies, such as anxiety and depression, we cannot rule out the possibility that other psychiatric conditions play a role in parental inattentiveness and hyperactivity-impulsivity symptoms, and thus, may be related to the child's behavioral outcome. Additionally, the lack of a concurrent measure of parental ADHD limited our ability to assess the extent to which parental symptomatology has changed over time and the impact this may have had on home chaos and child aggression. Furthermore, since ADHD symptomatology and aggressive behaviors in childhood often co-occur, the results obtained may not be unique to the prediction of childhood aggression. Another limitation of the study concerns the small sample size, which, according to the power analysis conducted, was adequate to detect large effects but not smaller ones. In addition, the study is based on the same informants for measuring parental ADHD, home chaos, and child aggression. However, using a longitudinal approach and measuring home chaos and child aggression 4 years after measuring parental ADHD partially helps to overcome this limitation. And finally, the ability to generalize our results is limited because the sample was restricted to boys.

In summary, the current study supports previous findings of the contribution of DRD4 genetic risk to child aggression. Moreover, this research emphasizes the importance of longitudinally investigating the contribution of parental ADHD symptoms to preschool aggression. Separately examining the influence of maternal/paternal inattention and hyperactivity-impulsivity symptoms enabled a better understanding of the different roles that parental inattention and hyperactivity-impulsivity had on the level of home chaos and child aggression. Furthermore, home chaos acted as a mediator between paternal ADHD symptoms and the child's aggression. This finding has practical implications, since home chaos as an environmental risk factor can be a target of behavioral interventions.

Conflict of Interest The authors declare that they have no conflict of interest.

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