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Parenting Practices and Prospective Levels of Hyperactivity/Inattention Across Early- and Middle-Childhood

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Abstract This study examined specific parenting practices as predictors of prospective levels of children's hyperactivity/inattention across early- and middle-childhood. Participants were a mixed-sex community cohort (N=976; 52 % boys) aged 4–10 years (M=6.5, SD=1.3). Measures of parenting practices, hyperactivity/inattention, conduct problems, and maternal education were collected at baseline, and hyperactivity/inattention re-assessed at 12-month follow-up. Analyses examined predictors of 12-month hyperactivity/inattention while controlling for levels at baseline. High levels of parental involvement were associated with reduced levels of hyperactivity/inattention, but only across early childhood. Conversely, increases in child age were associated with increased levels of hyperactivity/inattention across middle-childhood, but only among children exposed to high levels of inconsistent discipline. Inconsistent discipline and parental involvement appear to be uniquely associated with prospective hyperactivity/inattention across childhood, independent of associated conduct problems. Our results further suggest some developmental specificity with regard to the effects of these distinct dimensions of parenting on hyperactivity/inattention at different points in childhood.

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Attention-deficit/hyperactivity disorder (ADHD) is both genetically and environmentally determined, with research indicating that 20–30 % of phenotypic variability in symptoms are accounted for by environmental factors (Faraone et al. 2005). From a 'developmental psychopathology' perspective, ADHD is assumed to develop through multiple pathways, with genetic and environmental influences interacting to produce variations in age of onset, symptom expression, severity, and developmental course (Nigg et al. 2006). Genetic liability may also increase vulnerability to environmental risk and protective factors for the disorder (Belsky et al. 2009). Guided by this perspective, growing research has aimed to characterize the specific psychosocial variables through which such environmental influences operate. Despite extensive research into the environmental correlates of externalizing problems, it has been unclear to what extent specific family environment variables are uniquely associated with ADHD independent of commonly comorbid conduct problems (Johnston and Mash 2001). Questions concerning such associations are all the more important given evidence that ADHD may contribute to the emergence of conduct problems (e.g., features of oppositional defiant disorder and conduct disorder) across development (Burns and Walsh 2002).

Research into the unique family-environment correlates of ADHD symptoms has implicated a number of family process variables. Ellis and Nigg (2009) recently examined the unique cross-sectional associations between ADHD and specific parenting practices commonly associated with

externalizing problems more generally (Hawes and Dadds 2005). High levels of inconsistent discipline and low levels of parental involvement were each found to be uniquely associated with ADHD symptom severity, when controlling for other child characteristics including comorbid features of conduct problems (Ellis and Nigg 2009). This evidence associating ADHD with specific parenting practices builds on the findings of previous studies in which parenting has been operationalized largely in terms of global positive/-negative dimensions (e.g., Johnston 1996). The parenting practices investigated by Ellis and Nigg (2009) were indexed using parent reports on the Alabama Parenting Questionnaire (APQ; Shelton et al. 1996), which operationalizes inconsistent discipline in terms of inconsistent and lax punishment for misbehavior (e.g., "You let your child out of punishment early", "You threaten to punish your child and then do not actually punish him/her", "The punishment you give your child depends on your mood", "Your child talks you out of being punished"). Parental involvement, as indexed by the APQ, reflects parental warmth and engagement in positive activities with a child (e.g., "You ask your child about his/her day in school", "You talk to your child about his/her friends", "You play games or do other fun things with your child").

The potential importance of inconsistent discipline to the development and maintenance of ADHD has also been demonstrated by cross-sectional research into genetic x environmental interactions. Martel et al. (2011) found that the dopamine receptor D4 gene (DRD4) moderated family environmental effects on ADHD, such that it was associated with increased risk for the disorder only among children exposed to highly inconsistent discipline. The authors speculated that the DRD4 gene may confer risk for ADHD by increasing a child's responsivity to environmental contingencies (Martel et al. 2011), which in the case of inconsistent discipline are by definition significantly disrupted. On the basis of such evidence it has been speculated that parenting practices may serve as an important proximal environment through which genetic risk for ADHD is realized (Larsson et al. 2011; Martel et al. 2011). This is consistent with the view that self-regulatory capacities develop through extensive interchange between a child and family from the earliest years (Task Force on Research Diagnostic Criteria: Infancy and Preschool 2003).

Longitudinal research into the role of parenting variables in the developmental trajectory of ADHD has, however, been particularly limited, with researchers emphasizing a need for greater evidence regarding the effects of such variables on the persistence of hyperactivity/inattention over time (Deault 2010; Willoughby 2003). To date, evidence from such research has associated increased levels of ADHD with parenting practices involving restrictive control, and has suggested that such effects operate in the context of transactional parent–child dynamics (Gadeyne et al. 2004). Longitudinal studies examining parent-to-child effects on the development and maintenance of ADHD have focused largely on the quality of the parent–child relationship, and have demonstrated risk effects associated with criticism/rejection (Lifford et al. 2008; Peris and Baker 2000), as well as intrusiveness and lack of sensitivity (Carlson et al. 1995; Keown 2013). While these findings represent significant progress, longitudinal research in this area has been characterized by various limitations, including the use of different measures of ADHD at different assessment points (e.g., Keown 2013), and a general reliance on small samples. Importantly, such research has yet to examine prospective change in ADHD symptoms associated with inconsistent discipline—a parenting domain that cross-sectional research suggests to be of key importance to the development and maintenance of ADHD symptoms (Ellis and Nigg 2009; Martel et al. 2011).

The aim of the current study was to examine the relationship between maternal parenting practices and prospective levels of hyperactivity/inattention across the periods of early- and middle-childhood. Of primary interest were the dimensions of inconsistent discipline and parental involvement. Based on existing cross-sectional and longitudinal evidence regarding the effects of parenting on ADHD it was hypothesized that higher levels of inconsistent discipline would predict higher levels of hyperactivity/inattention symptoms 12-month later after controlling for time one measures of hyperactivity/inattention and conduct problems. It was further hypothesized that higher levels of parental involvement would predict lower levels of hyperactivity/attention 12-month later after controlling for time one measures of hyperactivity/inattention and conduct problems.

The current study was also informed by broader developmental-ecological perspectives on the role of family environment in the development and transformation of child psychopathology, which assume that distinct family variables operate on child outcomes differently in distinct periods of development (Dishion and Stormshak 2007). A rare example of a longitudinal study devoted to such questions in the ADHD literature is that conducted by Carlson et al. (1995). Among other things, it was found that while hyperactivity in 3 year olds was predicted by intrusive parenting practices, hyperactivity at later ages (6, 8, and 11 years) was more strongly predicted by marital relationship variables (Carlson et al. 1995). We are, however, aware of no studies in which the effects of parenting practices on prospective hyperactivity/inattention have been examined as a function of child age; that is, whether the parenting variables that predict symptom levels across one developmental period differ to those that predict levels across another. As the basis for formulating specific hypotheses regarding developmental effects of this kind was therefore limited, we tested the

non-directional hypothesis that the association between parenting practices and later hyperactivity/inattention would be moderated by child age.

Method

Participants

Research into risk factors for ADHD has frequently made use of community samples of children, based in part on evidence that hyperactivity/inattention represents continuous traits characterized by similar heritability estimates both at high levels and across the continuum (Gjone et al. 1996; Levy et al. 1997). Likewise, participants in the current study were a community sample of children aged 4–10 years. These participants were assessed in the context of an accelerated longitudinal design, each providing data at two timepoints: baseline and 12-month follow-up. Data from this sample have previously been used to examine conduct problems, callous-unemotional traits and hyperactivity/inattention as predictors of prospective parenting practices (Hawes et al. 2011). However, no longitudinal data on hyperactivity/inattention have been published previously from this sample. Eligibility for inclusion in the current study required that participants were not on medication for ADHD during participation in the study. As stimulant medication is the most established means of changing symptoms of ADHD (Hinshaw 2006), the exclusion of participants in receipt of such medication allowed for a more controlled investigation of other factors associated with prospective hyperactivity/inattention. This criterion resulted in the exclusion of $n=21$ participants (2.1 % of the total potential cohort), leaving a sample of $N=976$ children (52 % boys; mean age 6.50 years, SD=1.39).

Participants were recruited from 27 elementary schools in Brisbane—Australia's third largest city. These schools were chosen to represent the full range of inner-city and suburban locations of differing socioeconomic status. Total household income ranged from less than $20,000 (4 %), $20,000–$30,000 (8 %), $30,000–$70,000 (50 %), to over $70,000 (38 %). Parent levels of education ranged from completion of elementary school (1 %), to high school junior certificate (24 %), high school senior certificate (26 %), and tertiary education (university/ apprenticeship; 49 %). The majority of families (87 %) comprised two caregivers; 13 % comprised sole parents.

Measures

Strengths and Difficulties Questionnaire (SDQ; Goodman 1997). The 25-item SDQ screens for child behavior and psychopathology on five subscales: Hyperactivity/Inattention, Conduct Problems, Emotional Symptoms, Peer Problems, and Prosocial Behavior. The psychometric properties of the measure have been supported through extensive evaluations with clinic-referred and community populations. For example, in a representative community sample of young Australian children ($N=1,359$; ages 4–9 years) coefficient alphas across the SDQ subscales ranged from 0.59 to 0.82, and Hyperactivity scores showed a strong correlation ($r=0.51$) with diagnostic ratings of ADHD produced by clinician-administered diagnostic interview (Hawes and Dadds 2004). This is consistent with international research supporting the reliability and validity of the SDQ Hyperactivity/Inattention scale as a measure of ADHD symptoms (Stone et al. 2010). This Hyperactivity/Inattention subscale has been used to index ADHD symptoms in previous longitudinal research into the effects of parenting dimensions on change in ADHD (e.g., Keown 2013), and was used to measure parent reports of child hyperactivity/inattention in the current study.

In addition to global levels of hyperactivity/inattention, some factor analytic research has suggested that items from this subscale can be used to index distinct dimensions of hyperactivity versus inattention (Marzocchi et al. 2004). In accordance with such evidence, we also calculated scores for hyperactivity/impulsivity (SDQ items: "Restless, overactive, cannot stay still long"; "Constantly fidgeting or squirming"; "Thinks things out before acting"), and inattention (SDQ items: "Easily distracted, concentration wonders"; "Good attention span, sees chores or homework to the end"). The importance of considering these distinct dimensions is supported by evidence that these dimensions show distinct developmental patterns (e.g., Freitag et al. 2013; Greven et al. 2011; Hart et al. 1995; Sonuga-Barke 2005) as well as distinct family environment correlates (e.g., Martel, et al. 2011). However, given that the use of the SDQ to index these distinct dimensions is unconventional, these scores were used in post-hoc analyses only. The original SDQ hyperactivity/inattention subscale, and the respective 'hyperactivity/impulsivity' and 'inattention' scores calculated, all showed adequate internal consistency (see Table 1), however, it should be noted that the internal consistency for hyperactivity/impulsivity was below 0.70.

The *Alabama Parenting Questionnaire* (APQ; Shelton et al. 1996) was used to assess maternal parenting practices, consistent with previous research into parenting correlates of ADHD symptoms (e.g., Ellis and Nigg 2009; Martel et al. 2011). The APQ consists of 42 items presented with a 5-point endorsement scale (Never, Almost Never, Sometimes, Often, Always). Items are divided into five subscales, which index the extent to which parents engage in Inconsistent Discipline (e.g., "the punishment you give your child depends on your mood", "you threaten to punish your child and then do not actually punish him/her"), Poor Supervision (e.g., "your child goes out without a set time to be home"); Corporal Punishment (e.g., "you spank your child with your

Table 1 Descriptive statistics and correlations among time 1 and 2 parenting and child variables

	1	2	3	4	5	6	7	8	9	10	11
1. Child age	–1										
2. Maternal education	−.09**	–1									
3. Hyperactivity/ inattention T1	−.00	−.17**	–1								
4. Inattention only T1	−.03	−.19**	−.86**	–1							
5. Hyperactivity only T1	−.01	−.13**	−.91**	−.59**	–1						
6. Conduct problems T1	−.02	−.13**	−.51**	−.43**	−.48**	–1					
7. Hyperactivity/ inattention T2	−.04	−.15**	−.72**	−.63**	−.64**	−.49**	–1				
8. Inattention only T2	−.04	−.13**	−.60**	−.62**	−.47**	−.40**	−.87**	–1			
9. Hyperactivity only T2	−.00	−.12**	−.77**	−.52**	−.81**	−.47**	−.79**	−.51**	–1		
10. Parental involvement	−.12**	−.17**	−.29**	−.27**	−.25**	−.31**	−.27**	−.23**	−.25**	–1	
11. Inconsistent discipline	−.06*	−.14**	−.25**	−.21**	−.24**	−.33**	−.22**	−.18**	−.22**	−.29**	1
M	6.50	3.63	3.34	1.44	1.90	1.65	3.29	1.40	1.90	40.62	13.70
SD	1.39	1.39	2.49	1.21	1.57	1.73	2.62	1.41	1.55	4.51	3.32
α	-	-	0.78	0.72	0.65	0.67	0.76	0.63	0.67	0.74	0.72

*p<.05; **p<.01

hand"); Parental Involvement (e.g., "you ask your child what his/her plans are for the coming day"); and Positive Parenting (e.g., "you praise your child when she does something well"). The measure has been subject to extensive psychometric research across a range of populations, and is regarded as a valid and reliable index of parenting practices (McMahon and Frick 2007). Psychometric research conducted with clinic-referred and community samples has supported the reliability and validity of the measure in Australia. Dadds et al. (2003) reported results from a large representative community sample of Australian families to indicate that the subscales of the measure demonstrated moderate to adequate internal consistency, validity in terms of predicted relationships with child variables, and good test-retest stability. Likewise, Hawes and Dadds (2006) reported support for the external validity of the measure in clinic-referred families in Australia, with parent reports on the measure corresponding well with observations of parent–child interactions, and found to be sensitive to change following parent-training intervention. The psychometric properties of the corporal punishment subscale, which comprises only three items, have, however, been called to question in validation research (Shelton et al. 1996). Likewise, Ellis and Nigg (2009) found the subscale to be unreliable and therefore excluded it from analyses of parenting correlates of ADHD. This subscale was likewise omitted from the current study, which employed the same remaining subscales of the APQ previously examined by Ellis and Nigg (2009): Inconsistent Discipline, Parental Involvement, Poor Supervision, and Positive Parenting.

Procedure

Permission to conduct the research was obtained from the Griffith University Human Research Ethics Committee (Brisbane, Australia) and from the equivalent educational committees that govern research in the participating schools. The test battery was distributed through the schools to all children within the relevant age ranges and sent home to parents. Information sheets and consent forms were included that explained the nature of the research and the requirements of the participants. Participation was not compensated. Completed questionnaires were returned to the researchers in self-addressed envelopes with return rates ranging from 32.5 % to 74.8 % across schools (M=67.3). Of the N=1274 children whose mothers completed the time 1 parent-report measures, (79 %) completed time two measures 12 months later. As reported previously for this sample, variations in return rates were not associated with sample characteristics, according to the means, standard deviations, and ranges of all child, parent, and demographic variables (see Hawes et al. 2011).

Results

Descriptive Statistics

Descriptive statistics and correlations among the key variables measured at time one are presented in Table 1. Hyperactivity/inattention was found to be highly stable across the 12-month follow-up period, with time 1 and 2 SDQ Hyperactivity/Inattention scores correlating $r = 0.72$ ($p < .001$), and time 1 Hyperactivity/Inattention scores accounting for 52 % of the variance in time 2 scores. Each of the four parenting practices examined at time 1 were significantly correlated with each other, with Pearson's coefficients ranging from $r = -.19$ (between Poor Supervision and Positive Parenting) to $r = .52$ (between Parental Involvement and Positive Parenting). Each of these parenting subscales were also associated with time 1 SDQ hyperactivity/Inattention scores. High levels of hyperactivity/inattention were positively associated with Inconsistent Discipline ($r = .23$, $p < .001$) and Poor Supervision ($r = .14$, $p < .001$), and negatively associated with Parental Involvement ($r = -.27$, $p < .001$) and Positive Parenting Practices ($r = -.14$, $p < .001$). The same pattern of significant correlations was seen between SDQ Conduct Problems scores and each of the respective parenting practices. Consistent with the well-documented comorbidity between ADHD and the disruptive behavior disorders (Costello et al. 2006), strong positive correlations were also seen between SDQ hyperactivity/inattention and conduct problems scores ($r = .49$, $p < 001$).

Predictors of Prospective Levels of Hyperactivity/Inattention

Given the significant inter-correlations between the subscales of the APQ, scores on these subscales were examined simultaneously in regression in order to identify the unique correlates of the respective parenting practices. This analytic plan is consistent with that used by Ellis and Nigg (2009) to examine unique cross-sectional associations between parenting and ADHD symptoms, although expanded here to test parenting practices as predictors of prospective hyperactivity/inattention across a 12-month follow-up period. Associations between parenting practices and prospective hyperactivity/inattention were examined using maximum likelihood estimation in Amos for Windows (Version 20).

A model was specified based on the direct and moderated associations formulated in the hypotheses, as illustrated in Fig. 1. This model comprised paths between the time 1 variables (conduct problems, inconsistent discipline, parental involvement) and time 2 hyperactivity/inattention, while controlling for the path between time 1 and time 2 hyperactivity/inattention. In order to examine child age as a potential moderator of the paths involving parenting practices, paths to time 2 hyperactivity/inattention were also drawn from the child age at time 1, and the respective two-way (Inconsistent Discipline x age, Parental Involvement x age) interaction terms for these variables. To account for the known covariance between the main effects and interaction terms in testing the proposed model, these variables were

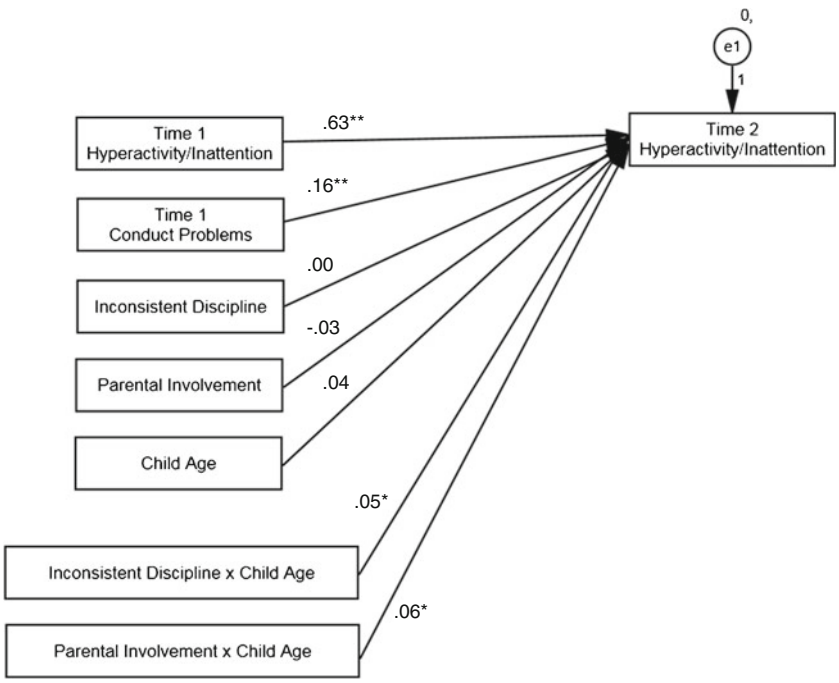

Fig. 1 Standardized regression coefficients for time 1 predictors of time 2 hyperactivity/ inattention. *$p < .05$. **$p < .01$

allowed to covary with one another. Covariates included in the model were maternal education and child sex. The paths for time 1 hyperactivity/inattention (B=.62, SE=.02, p<.01) and Conduct Problems (B=.16, SE=.04, p<.01) were statistically significant. The paths for the two-way interaction terms involving both parenting domains and child age were also significant (Inconsistent Discipline x age: B=.05, SE=.01, p<.05; Parental Involvement x age: B=.06, SE=.01, p<.01). The model fit the data well (RMSEA=.01; 90 % CI: 0.00, 0.07; CFI=1.00; TLI=.99; RFI=.96).

Significant interaction terms were analyzed post-hoc using the established method of simple slope analysis (Aiken and West 1991; Cohen et al. 2003), which is recommended for interpreting interactions in child and family research (Holmbeck 2002). Using this method, conditional moderator variables, corresponding to ±1 SD from the centered value for each participant, were computed to test the significance of the respective IV at high/low levels of the moderator variable.

Based on the hypothesized role of child age as a moderator of the association between parenting practices and later hyperactivity/inattention, the regression of hyperactivity/inattention on inconsistent discipline was calculated at ±1 SD levels of age. However, neither of these slopes were significant ($t_{B\ at\ high}=0.03/0.03=1.06^{ns}$, df=965; $t_{B\ at\ low}=-0.02/0.02=-0.97^{ns}$, df=965). In order to account for the significant inconsistent discipline x child age interaction term, the alternative form of moderation was therefore tested (i.e., inconsistent discipline as a moderator of the association between child age and time 2 hyperactivity). This showed that child age was significantly associated with high levels of inattention/hyperactivity at time 2 among children exposed to high (+1 SD) levels of inconsistent discipline ($t_{B\ at\ high}=0.13/0.06=2.21$, df=965, p<.05), but not among children exposed to (−1 SD) low ($t_{B\ at\ low}=0.00/0.06=0.03^{ns}$, df=965) or mean levels of inconsistent discipline ($t_{B\ at\ mean}=0.06/0.04=1.54^{ns}$, df=965). This interaction is plotted in Fig. 2a.

The significant parental involvement x age interaction was then analyzed by testing the regression of hyperactivity/inattention on parental involvement at older (+1 SD), mean, and younger (−1 SD) ages. Consistent with the moderating role of child age hypothesized, parental involvement predicted reduced levels of hyperactivity/inattention across time, but only within the younger age range of the sample ($t_{B\ at\ low}=-0.04/0.02=-2.33$, df=

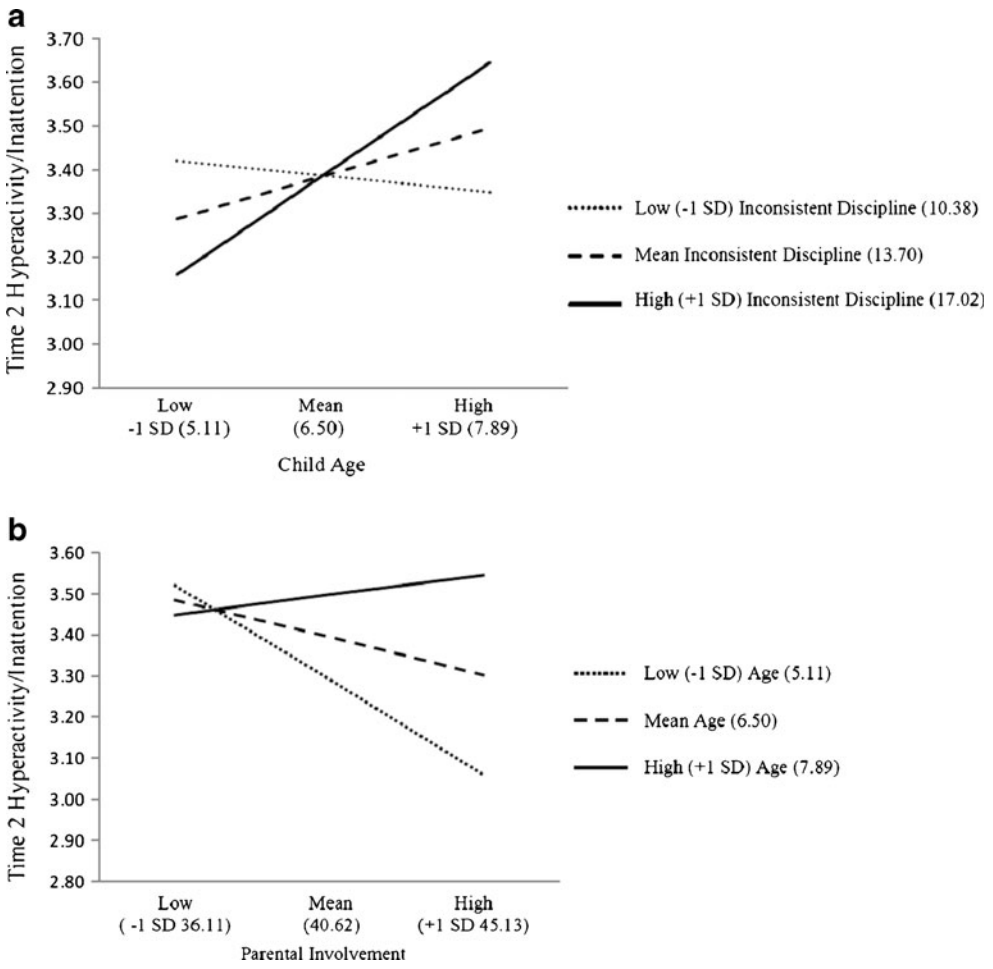

Fig. 2 **a**. Interaction between inconsistent discipline and child age in predicting time 2 hyperactivity/inattention after controlling for time 1 hyperactivity/inattention. **b**. Interaction between parental involvement and child age in predicting time 2 hyperactivity/inattention after controlling for time 1 hyperactivity/inattention

965, $p<.05$); Parental Involvement was not significantly associated with time 2 hyperactivity/inattention among children at older ($t_{B\ at\ high}=0.00/0.02=0.03^{ns}$, df=965) or mean ($t_{B\ at\ mean}=-0.02/0.01=-1.52^{ns}$, df=965) ages. This interaction is plotted in Fig. 2b.

Finally, post-hoc analyses were conducted to examine whether the parenting variables associated with global hyperactivity/inattention were differentially associated with features of hyperactivity versus inattention. For this purpose, the SEM model was re-run twice, with time 1 and 2 scores for hyperactivity/inattention replaced first with time 1 and 2 hyperactivity/impulsivity scores, and second, with time 1 and 2 inattention scores. Standardized beta coefficients for both models are reported in Table 2. In the model examining prospective levels of hyperactivity/impulsivity, no parenting variables were significant predictors. In the model examining prospective levels of inattention, time 2 inattention was predicted by the interaction term for Inconsistent Discipline x age ($B=.06$, $SE=.01$, $p<.05$). This model fit the data well (RMSEA=.00; 90 % CI: 0.00, 0.06; CFI=1.00; TLI=1.00; RFI=.96). Standardized beta coefficients for these models are reported in Table 2. Consistent with the analysis of this interaction in the previous model (testing predictors of time 2 hyperactivity/inattention), the analysis of this interaction in the prediction of time 2 inattention revealed that child age was significantly associated with time 2 inattention among children exposed to high levels of inconsistent discipline ($t_{B\ at\ high}=0.08/0.04=2.18$, df=965, $p<.05$), but not among children exposed to low ($t_{B\ at\ low}=-0.00/0.04=-0.05^{ns}$, df=965) or mean levels ($t_{B\ at\ mean}=0.04/0.03=1.46^{ns}$, df=965) of inconsistent discipline.

Discussion

Despite growing recognition that parenting and family environment influence the development and expression of ADHD, relatively little research has examined the unique associations between specific parenting variables and hyperactivity/inattention across development. This study examined maternal parenting practices as predictors of prospective (12-month) levels of hyperactivity/inattention across the developmental periods of early- and middle-childhood. Time 2 levels of hyperactivity/inattention were found to be predicted by the interaction between inconsistent discipline and child age. In previous cross-sectional research, inconsistent discipline has been uniquely associated with ADHD symptom severity (Ellis and Nigg 2009). It has also been implicated in a gene x environment interaction, with Martel et al. (2011) finding a specific dopaminergic gene to be associated with increased risk for ADHD only in the presence of highly inconsistent discipline. Our data add to this evidence by showing, for the first time, that prospective levels of hyperactivity/inattention can be predicted by inconsistent discipline in interaction with child age, while controlling for baseline severity of hyperactivity/inattention and comorbid conduct problems. Our finding of an interaction between inconsistent discipline and child age suggests that this parenting domain may be implicated in a developmental effect concerning the stability of hyperactivity/inattention across middle-childhood.

While child age was not directly associated with absolute symptom levels of hyperactivity/inattention, age was associated with temporal levels of these symptoms, and these levels were found to vary as a function of inconsistent discipline. Specifically, increases in child age were associated with increased levels of hyperactivity/inattention across middle-childhood, but only among children exposed to high levels of inconsistent discipline. There is recent longitudinal evidence from twin research to suggest that significant individual differences in ADHD symptom trajectories can be differentiated across childhood, with Robbers et al. (2011) identifying stable-low, high-decreasing, and low-increasing trajectories of ADHD symptoms between the ages of 6 to 12 years. While little is known about the child and family

Table 2 Unique predictors of child hyperactivity/inattention, hyperactivity/impulsivity, and inattention, across 12-month follow-up

Time 1 predictor variables	Time 2 outcome variables		
	Hyperactivity/Inattention	Hyperactivity/Impulsivity	Inattention
Child age	.04	.00	.04
Conduct Problems	.16**	.09**	.12**
Inconsistent Discipline	.00	.00	.00
Parental Involvement	−.03	−.03	−.03
Inconsistent Discipline x Age	.05*	.01	.05*
Parental Involvement x Age	.06**	.01	.04
Hyperactivity/Inattention	.63**	-	-
Hyperactivity/Impulsivity	-	.76**	-
Inattention	-	-	.56**

Values are standardized beta weights for direct paths between Time 1 predictor variables and time 2 outcomes. *$p<.05$; **$p<.01$

characteristics that may account for variations in such trajectories, our findings suggest that the disrupted environmental contingencies associated with highly inconsistent discipline may in part contribute to the persistence of hyperactivity/inattention across middle-childhood.

Like inconsistent discipline, parental involvement was also found to predict hyperactivity/inattention in interaction with child age. Specifically, high levels of parental involvement were associated with reduced symptoms of hyperactivity/inattention over time, but only among children in the lower age range of the sample. This finding is consistent with evidence from previous longitudinal studies, which have measured parental involvement using the same self-report scale as in the current study (Ellis and Nigg 2009), and have operationalized analogous parenting constructs using direct observation of parental sensitivity (Keown 2013), children's subjective reports of parental acceptance/rejection (Lifford et al. 2008), and indices of parents' expressed emotion (Peris and Baker 2000). Our results replicate this unique longitudinal association in a sample of participants considerably larger than those used in previous studies, the largest of which involved a community sample of n=194 children (Lifford et al. 2008). Furthermore, while these previous studies examined the prospective relationship between parenting and ADHD symptoms in among children of similar ages to those in our sample, the current study is the first to our knowledge to test child age as a moderator of this relationship. Our findings suggest that maternal parenting characterized by high levels of warmth/involvement is more strongly associated with prospective hyperactivity/inattention during early childhood than at later points in development.

It has been argued that the neural attention networks that support self-regulatory capacities are shaped through repeated transactions between a child's biologically-based characteristics and family environment factors across development (Rothbart and Posner 2006). There is also growing recognition that key contexts for these transactions include the family interactions emphasized in social learning models of behavioral development. From this perspective, the capacity to become self-directed with respect to regulating goal-directed behavior and attention is seen to be highly embedded in relationship dynamics and behavioral interactions such as turn-taking and listening to others (Dishion and Stormshak 2007). In accordance with this, the results of the current study add to growing evidence that family process variables are uniquely associated with temporal levels of hyperactivity/inattention, independent of the conduct problems that commonly co-occur with ADHD, and are more proximally related to family environment in comparison (Hawes and Dadds 2005).

The prediction of prospective hyperactivity/inattention by parenting practices in the current study was characterized by small effect sizes, which is not surprising given the high degree of stability generally seen in symptoms of ADHD (Nigg et al. 2006). Importantly, however, these associations were independent of maternal education level—a variable commonly used to index socio-economic risk in child populations. This is noteworthy given a recent twin study in which parental education was found to moderate the effects of latent genetic influences on ADHD (Pennington et al. 2009). It is also noteworthy that like Ellis and Nigg (2009), we found that parenting practices related to poor supervision and positive parenting were not uniquely associated with hyperactivity/inattention when controlling for other child/-family characteristics. As such, the two sets of parenting practices found to predict prospective hyperactivity/inattention through interactions with child age—inconsistent discipline and parental involvement – are the same that have previously demonstrated unique associations with symptoms of ADHD in cross-sectional research using the same measure of parenting (Ellis and Nigg 2009). Furthermore, post-hoc analyses examining distinct dimensions of hyperactivity/impulsivity and inattention in the current study suggested that the interaction involving inconsistent parenting was associated specifically with prospective levels of inattention. This is particularly interesting given Martel et al. (2011) finding that the dopamine receptor D4 gene interacts with inconsistent parenting to increase susceptibility to inattentive ADHD symptoms, but not hyperactive-impulsive ADHD symptoms.

A number of limitations should be considered when interpreting the results of the current study. First, the Hyperactivity/Inattention subscale of the SDQ has been widely used to index symptoms of ADHD in large-cohort studies of children due to its brief format and strong psychometric properties (Stone et al. 2010), however it was not originally designed to index the distinct dimensions of ADHD (e.g., inattention/disorganization, hyperactivity/impulsivity) examined in our post-hoc analyses. These post-hoc findings should therefore be interpreted with caution. Second, the design of the current study precluded examination of the extent to which parenting associations with hyperactivity/inattention were themselves a product of genetic influences. The possibility of such a confound has been suggested by previous research into the relationship between ADHD and parent–child hostility. Using a twin design, Lifford et al. (2009) showed that while parent–child hostility was associated with ADHD, this association was primarily accounted for by genetic factors. Research using genetically informative designs has yet to examine the relationship between ADHD and the parenting domains examined in the current study, and therefore represents an important aim for future research. Likewise, the measurement of parental ADHD in future research may further help to clarify the extent to which apparent parenting effects may be an artifact of genetic predispositions shared by children

and their parents. Third, it should be noted that the internal consistency of the scales used to measure a number of variables in the study (i.e., conduct problems, hyperactivity/impulsivity, poor supervision) was below 0.70. This limitation may represent a potential limitation for the SEM model in particular, which assumes that all predictors are measured with perfect reliability. Finally, the current study examined the parenting practices of mothers only. As previous research has found the parenting practices of mothers and fathers to be differentially associated with symptoms of ADHD (e.g., Lifford et al. 2008), it is important that future longitudinal research involving the parenting domains examined here measure both mothers' and fathers' parenting practices.

In conclusion, the current study replicates previous findings that high levels of parental involvement predict reduced levels of hyperactivity/inattention over time, and provides initial evidence that inconsistent discipline is associated with increased levels of hyperactivity/inattention over time. Our findings also suggest some developmental specificity with regard to the effects of distinct dimensions of parenting on hyperactivity/inattention at different ages. These findings indicate that it may be in early childhood predominantly, during which parental warmth/involvement confers protective effects on the regulatory capacities that are compromised in ADHD. Alternatively, disruptions to environmental contingencies—as seen in inconsistent discipline – appear to operate most adversely on these capacities later, in middle childhood. It is hoped that ongoing research in this area may inform translational research into family-based interventions that target distinct environmental mechanisms to promote optimal management of ADHD-related behaviors in children of specific ages.

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