

Gender Distinctive Impacts of Prematurity and SGA on Age-6 Attention-Problems

James Hall ^{a, b}, Julia Jaekel ^{a, c}, Dieter Wolke ^{a, d}

^a Department of Psychology, University of Warwick, UK; ^b Department of Education, University of Oxford, UK; ^c Institute of Neonatology, University Hospital Bonn, Germany; ^d Health Sciences Research Institute, University of Warwick Medical School, UK

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Corresponding Author: Dieter Wolke, *Department of Psychology and Health Sciences Research Institute, The University of Warwick, Warwick Medical School, Coventry CV4 7AL, United Kingdom*
Tel: +44 (0)24 7652 3537. Fax: +44 (0)24 7652 4225. Email: D.Wolke@warwick.ac.uk.

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List of Abbreviations: SGA: Small [birth weight] for Gestational Age; IUGR: Intrauterine Growth Restriction; BLS: Bavarian Longitudinal Study; CBCL: Child Behavior Checklist; TRCB: Testers' Rating of Child Behavior; SEM: Structural Equation Modeling.

ABSTRACT

Background: Predictors of attention problems remain uncertain. Here we distinguish prematurity from Small [birth weight] for Gestational Age (SGA).

Method: 1,437 children were studied between 0-6 years. Gender differences and indirect perinatal effects (via 20 month head circumference and cognition) were considered for age 6 attention problems.

Results: Boys, preterms, and SGA children were all at increased risk. Indirect perinatal effects differed between boys and girls.

Conclusions: In facilitating attention problems: SGA appears to reduce brain *volume* while prematurity alters brain *function*. Although less frequent, female attention problems are more strongly predicted by prematurity and cognitive dysfunction.

Key Words: Attention; Prematurity; SGA; Gender

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BACKGROUND

Numerous risk factors of childhood attention problems have been identified (Banerjee, Middleton, & Faraone, 2007; Harland, et al., 2002). Two of the earliest risks are a premature birth (Vanderbilt & Gleason, 2010) and *diminished fetal growth* (McCormick, Workman-Daniels, & Brooks-Gunn, 1996; Schlotz & Phillips, 2009) as indicated by *Intrauterine Growth Restriction* (IUGR; Rayco-Solon, Fiulford, & Prentice, 2005) – a condition that is commonly assessed by ‘Small [birth weight] for Gestational Age’ (SGA; Strang-Karlsson, et al., 2008). However, the accurate causal attribution of these perinatal risks to childhood attention problems is compounded by their frequent co-occurrence (Hack, 2006; Wilson-Costello & Hack, 2008). It therefore remains unclear whether prematurity or IUGR/SGA constitutes the more prominent risk for subsequent attention problems in childhood.

Past research into neurological deficits following prematurity or IUGR/SGA has suggested both similar and different underlying risk-mechanisms. For example, both IUGR and prematurity have been linked to reductions in brain volume (Inder, et al, 2005; Toft, et al., 1995) also reported in cases of ADHD (Krain & Castellanos, 2006) and which is commonly indicated by smaller-than-normal head circumference (Bartholomeusz, Courchesne, & Karns, 2002; Tuvemo & Lundgren, 2009). However, prematurity may have additional neurological consequences such as altered white matter microstructure and cortical folding, both increasing the likelihood of subsequent neuro-cognitive impairments (Ajayi-Obe, et al., 2000; Volpe, 2009), cognitive dysfunction (e.g. Frye, et al., 2010; Mento & Bisiacchi, in press), and with both white matter microstructure (Krain & Castellanos, 2006) and cortical folding (Wolosin, et al., 2009) having been found to differ in those with ADHD/attention problems.

The aim of disentangling IUGR/SGA from prematurity as distinct risk factors for attention problems is further complicated by child gender differences. Boys are more likely to present symptoms (Reijneveld, et al., 2006) both in the general population as well as in low birth weight and/or preterm samples. For both sexes however, childhood attention problems have been linked with decreased overall brain volume and in particular, a decreased volume of the cerebellar vermis (Castellanos, et al., 2001, 2002). Thus, Full Term (FT) boys display increased attention problems compared to FT

girls despite a gender-consistent neuro-cognitive impairment. However, does this also hold for Pre-Term (PT) boys and girls considering the neurological damage that is associated with a PT birth?

This study investigated the impacts of prematurity and SGA in boys and girls at age 6;3 years whose attention problems were measured via maternal self-report and researcher observations. We first hypothesized that attention problems would more often be found in boys rather than girls, and that both prematurity and IUGR would predict higher ratings of attention problems. Second, we then hypothesized that the effects of prematurity and SGA would be mediated via reduced brain growth (as indicated by head circumference) and cognitive function at age 20 months. Finally, we considered whether these mediations would be moderated by child gender.

METHOD

Participants were children and families who participated in the Bavarian Longitudinal Study (BLS) between child birth and child age 6;3 years. All children were born within a geographically defined area of Southern Bavaria (Jan. 1985 – Mar. 1986) and required admission to a children's hospital within the first 10 days of life (n=7,505; 10.6% of all live births; the 'Index Group')(Schneider, Wolke, Schlagmüller, & Meyer, 2004). An additional 916 term healthy infants (the 'Control Group') were born in the same obstetric hospitals as the Index Group, were cared for on normal postnatal wards and were discharged home with their mothers during the same period. Of these 8,421 children, randomly-selected samples of both the Index Group (n=1,169) and the Control Group (n=344) were followed to age 6;3 years (n=1,513). Full details of the sampling criteria and dropout rates are provided elsewhere (Gutbrod, et al., 2000; Wolke & Meyer, 1999a; Wolke, et al., 1994). Ethical permission for the study was granted by the Ethics committee of the University of Munich Children's Hospital and the Bavarian Health Council (Landesaerztekammer). Mothers gave written informed consent within 48 hours of their child's birth.

This paper concentrates on 1,452 of the potential 1,513 children who received *both* of the two behavioral assessments undertaken at 6;3 years of age (96%): 1) a maternal self-report, and 2) a researcher administered test. The 6;3 year old children (n=61) with incomplete behavioral data were more likely to have been born SGA ($\chi^2= 6.53$, $p<0.05$) or premature (<37 weeks gestation; $\chi^2= 56.71$, $p<0.001$). In addition, these children were more likely to have had poor cognitive scores at age 20

months ($t=-5.73$, $p<0.001$) and their families had faced a greater number of adversities (on average) before child birth ($t=2.13$, $p<0.05$). These $n=61$ children had incomplete age 6 behavioral data for one of two reasons: first, $n=44$ children and families participated in the BLS at age 6 years solely via parental telephone interview (so no observer assessments of child behavior); second, the remaining $n=17$ children simply had incomplete behavioral data due to participant refusal. The characteristics of the final sample here analyzed are shown in Table 1.

[Insert Table 1 about here]

Perinatal measures. Gestational age was determined by maternal records of last menstrual period and serial ultrasounds during pregnancy. Dubowitz examination results (Dubowitz, Dubowitz, & Goldberg, 1970) were used if maternal-reports and ultrasound findings differed by more than two weeks. Prematurity was defined as a birth at less than 37 weeks gestation. SGA was defined as a birth weight less than the sex-specific 10th percentile for the respective gestational age according to a normative sample during the initial recruitment period (Riegel, et al., 1995).

Data concerning children and their families were collected by structured parent interviews within the first 10 days of birth. Data included maternal age, the number of cigarettes a mother smoked before and during pregnancy, and maternal education. Information concerning family adversity was recorded in 8 items from maternal interview, medical records, and research-nurse records of maternal mental health (Wolke, et al., 2009).

Measures taken at child age 20 months (corrected for prematurity) included child head circumference and cognition. Head circumference was measured by research-nurses and coded on a 4-point ordinal scale: 1= head circumference within the lowest 3% according to norms ($n=47$; 4.6%); 2= between the lowest 3-10% ($n=107$; 10.4%); 3= between the 90th and 10th percentiles ($n=764$; 74.5%); 4= within the top 10% ($n=108$; 10.5%). Cognition was assessed with the Griffiths Scales of Babies Abilities (Brandt, 1983). A total developmental quotient ($M=103.29$; $SD=11.92$) was computed based on constituent domains, standardized according to German norms (Wolke & Meyer, 1999a), and recoded as: *(developmental age score/age at assessment) x 100*.

Measures taken at child age 6;3 years. Mothers rated child attention with the 'Attention Problems' subscale of the Child Behavior Check List (Achenbach & Edelbrock, 1991) (M=3.47; SD=2.77). 119 children (13.71%) scored above the normative clinical cut-off level (90th percentile) (Renschmidt & Walter, 1990). Considering the validity of the Attention Problems subscale, the CBCL is a well-known internationally established instrument and its validity has been documented by various publications of four decades of research. It's quantitative scale scores significantly distinguish between demographically-matched referred and non-referred children (p <.01) and for Attention Problems, its cut-off scores significantly discriminate between the normal and clinical range (OR = 12; % of referred children with deviant scores = 48; point biserial correlation with DSM-IV diagnoses by clinicians = .53 (Cohen's kappa = .49), all p <.01)(Achenbach & Rescorla, 2001).

Trained researchers, blind to group membership and family background, independently rated the same children who were rated on the CBCL with the 'Task Orientation' subscale of the Testers' Rating of Child Behavior (TRCB; Wolke & Meyer, 1999b) (M=39.81; SD=8.65). The TRCB is based on observations of child behavior during a 1 hour 20 minute cognitive test situation and consists of thirteen 9-point rating scales (clinical cut-offs to be established). Child behavior was evaluated in vivo during a cognitively challenging test situation. Guided by Principal Component Analysis, six of the 13 subscales (1. Attention, 2. Robustness and Endurance, 3. Demandingness [recoded], 4. Cooperativeness, 5. Compliance, and 6. Difficulty [recoded]) were summed to indicate 'Task Persistence' (Cronbach's α = .90; range 1-9). Inter-rater reliability was established based upon the responses of 32 participants and by comparing the scores of all BLS raters: twelve raters against one master. via intraclass correlation coefficients suggested good to excellent inter-rater reliability with scores ranging from 0.63 to 0.97. The TRCB manual includes a detailed description of the 13 subscales and is available from the authors. Correlation of DSM-IV diagnoses of Attention Deficit Disorder at 6;3 years with the CBCL 'Attention Problems' and TRCB 'Task Orientation' scales in our sample were $r_s=0.39$ ($p<0.01$) and $r_s=0.21$ ($p<0.01$), respectively.

Statistical Analysis

All analyses were conducted by the authors using SPSS/PASW Version 17 (SPSS Inc, Chicago, Illinois) and AMOS Version 17 (Arbuckle, 2008). All reported tests are two-tailed. First, the impacts of gender, prematurity, and SGA on attention problems were tested with 3-factorial ANOVAs. Second,

the different associations between variables within boys and girls were considered with bivariate correlations. Finally, Structural Equation Modeling (SEM) was used to test the direct and indirect impacts of prematurity and SGA on attention problems while considering gender and rater (mothers versus researchers) effects. A 2x2 design (child gender x rater of attention problems) was applied to the analysis such that the same 2-group statistical model (boys vs. girls) was independently specified for each of the two raters of age 6 attention problems (mother and researcher). The *total* effects of prematurity and SGA were evaluated simultaneously while taking into account their level of association. These competing total effects were composed of two elements: a *direct* effect on attention problems as well as a *total indirect* effect via age 20 months head circumference and/or cognition. Four potential confounding variables were included in the SEMs: 1. maternal age, 2. maternal smoking pre- and 3. during pregnancy, and 4. family adversity.

RESULTS

Gender, Prematurity, SGA, and Attention Problems:

Table 2 shows the results of the two conducted ANOVAs (child gender x premature birth x SGA birth). Mother-rated Attention Problems varied significantly by child gender (boys: mean=3.79, Standard Deviation, SD=2.84; girls: mean=3.13, SD=2.66), prematurity (preterms: mean=3.93, SD=3.06; fullterms: mean=3.18, SD=2.54), and SGA (mean=3.98, SD=2.79; AGA: mean=3.30, SD=2.75). However, no significant interaction effects were found. Similar findings were found for the researcher TRCB 'Task Orientation' scale (Table 2): Boys (mean=38.73, SD=8.91; girls: mean=40.92, SD=8.23), preterms (mean=37.86, SD=9.18; fullterms: mean=41.04, SD=8.07), and SGA born children (mean=37.62, SD=9.00; AGA: mean=40.55, SD=8.41) all exhibited significantly poorer task orientation (thus greater attention problems). Table 3 reveals the bivariate correlations between all of the measures included in this investigation and shows their variation by child gender.

[Insert Table 2 here]

[Insert Table 3 here]

Testing Pathways of SGA vs. Prematurity to Attention Problems:

Figure 1 illustrates the pair of two-group Structural Equation Models that were specified in this study. The SEM in the top half of Figure 1 details mother-rated attention problems while the bottom half models researcher-rated 'Task Orientation' (reverse coded). Common across both models are the specification of prematurity and SGA as statistical predictors of age 6 attention problems and the hypothesized indirect effects associated with age 20 months head circumference and cognition. Further, both SEMs are contextualized by the inclusion of [four](#) potential confounders (maternal age, family adversity, maternal smoking habits (during and pre-pregnancy)) and by the division according to child gender. Both statistical models showed the exact same high degree of model fit (for both cases: $\chi^2= 42.74$, $p<0.001$; CFI=0.93; RMSEA=0.034).

The SEM illustrated in the top-half of Figure 1 reveals that when the indirect effects of age 20 months head circumference and cognition were taken into account, neither prematurity nor SGA maintained the significant direct effects on age 6 attention problems as suggested by the ANOVAs. Instead, both prematurity and SGA were found to impact attention via reduced head circumference and cognition at age 20 months.

[Insert Figure 1 here]

Clear differences emerged [between](#) the effects of prematurity and SGA when comparing their indirect effects on mother-rated attention problems. The top half of Figure 1 shows that prematurity was more strongly related to lower levels of cognition and SGA was more closely associated with decreased head circumference. Statistical comparisons of these effects ($\Delta\chi^2$ model fit with 1 degree of freedom) suggest moderation by child gender. It was only when examining pre-cursors of attention problems *within-girls* that the differential relationships between prematurity and SGA on cognition ($\Delta\chi^2=10.70$; $p<0.01$), as well as prematurity and SGA on head circumference ($\Delta\chi^2=6.88$; $p<0.01$) reached statistical significance.

The top-half of Figure 1 also shows female cognition to be the largest predictor of age 6 attention problems when compared to the impacts of male cognition and the impacts of head circumference within both genders ($\Delta\chi^2=24.27$; $p<0.001$). The total indirect effect (through cognition and head circumference) of *prematernity within girls* ($\beta=0.10$; $p<0.001$) was larger than that within boys ($\beta=0.06$;

$p > 0.05$) as well as larger than that associated with SGA for either gender (girls: $\beta = 0.07$; $p < 0.01$; boys: $\beta = 0.05$; $p < 0.01$).

The bottom-half of Figure 1 illustrates the SEM that was specified to examine the direct and indirect effects of prematurity and SGA on the age 6 attention problems as rated by researchers. Many of the results are identical to those found when considering mother-rated attention problems. However, there are also noticeable differences between boys and girls when examining the impacts of cognition and head circumference.

While for boys it was head circumference rather than cognition that was the largest direct predictor of attention problems as rated by *mothers* (respective β s: -0.16 vs. -0.15; $\Delta\chi^2 = 12.62$; $p < 0.01$), the opposite was true (cognition being larger) for attention problems as rated by *researchers* (β s: -0.09 vs. -0.27; $\Delta\chi^2 = 3.73$; $p = 0.05$). However, this difference did not extend to girls. Instead, female cognition *remained* a significantly larger predictor of attention problems when compared to head circumference regardless of whether attention problems were rated by mothers (respective β s: -0.34 vs. -0.12; $\Delta\chi^2 = 10.70$; $p < 0.001$) or researchers (β s: -0.24 vs. -0.16; $\Delta\chi^2 = 11.38$; $p < 0.001$).

Further comparison of the models illustrated in Figure 1 reveals that the *indirect* effects of prematurity and SGA are strongly driven by the varying impacts of head circumference and cognition across the raters and child genders. Figure 2 illustrates the differences between all eight indirect effects. Although the absolute sizes of the indirect effects are small ($\beta = 0.05$ to $\beta = 0.14$), a number of trends can be observed. First, researcher-ratings of attention problems in both boys and girls and for those born premature or SGA were consistently greater than equivalent mother ratings. This suggests greater sensitivity of researcher-ratings to attention problems. Second, the indirect effects associated with SGA for attention problems were consistently lower than the equivalent prematurity effects regardless of child gender or rater. Third, girls either premature or SGA were both more likely to demonstrate attention problems when compared to premature/SGA equivalent boys.

[Insert Figure 2 here]

DISCUSSION

This study confirms that both prematurity and SGA are independent predictors of childhood attention problems (Arpino, et al., 2010; Rayco-Solon, et al., 2005; Vanderbilt & Gleason, 2010) and that attention problems are more frequently observed in boys than girls (Reijneveld, et al., 2006). The central novel-finding from this investigation is that prematurity and SGA are risk-factors that are mediated by cognition and brain growth (via head circumference; Bartholomeusz, et al., 2002) at age 20 months. While the risk from prematurity was more likely to operate through reduced cognition, the risk from SGA was more closely linked to poorer head growth. Importantly however, statistical comparison of these mediated effects revealed it was also necessary to take into account gender differences.

Concordantly, previous studies have found a decrease in overall brain volume in cases of SGA/IUGR (Wilson-Costello & Hack, 2008) and reduced brain volume may be significantly related to increased attention problems (Castellanos, et al., 2002). Similarly, recent neurological research on children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) has shown the same pattern of limited cortical folding (Arpino, et al., 2010) that has been observed in children born premature (Kapellou, et al., 2006). Such research is consistent with our findings that suggest distinct underlying neurological mechanisms [explaining](#) the associations of prematurity and SGA with attention problems.

Aside from possible neurological mechanisms, our findings also indicate that prevalence rates of attention problems are generally higher in boys than in girls. However, for girls who are exhibiting attention problems these difficulties are more closely associated with both premature and/or SGA births (consistent with Eme's gender paradox; Eme, 1992). Considering possible explanations, there has been very sparse research examining gender differences in the neurology of children with attention problems. However, it has been suggested that female attention problems are more closely linked with reduced cortical folding rather than brain volume (Mahone & Wodka, 2008). In line with the broader research that has associated prematurity with limited cortical folding more generally, such evidence provides further support for our findings.

Importantly however, this study and its results are not without limitations. Primarily, our study used anthropometric measures of head growth and functional measures of cognitive function. We treated head circumference as a proxy measure of brain growth (Gale, et al., 2006) and assumed cognitive ability was an accurate reflection of brain function (Wolke, 1998). Ultimately however, only structural

and functional MRI studies can provide conclusive evidence and thus our results should be interpreted with due caution. Such future work would also benefit from focusing more on Very and Extremely Preterm (VP, EP) infants as well – especially as here we found VP 6 year olds to demonstrate significantly greater attention problems (mean = 4.38 vs. 3.41; $t(570)=3.83, p<0.001$) and lower task orientation (mean = 36.08 vs. 39.89; $t(570)=-5.10, p<0.001$) than non-VP preterms.

Nonetheless, our results are in line with such past research while the novel strength of our study comes from the use of both mother and researcher assessments of attention problems. Replicating the same analysis across independent reports of attention problems yielded remarkably similar longitudinal relationships and this supports the ecological validity of our results.

Finally, our findings have implications for both researchers and practitioners. First, the fetal programming hypothesis (Barker, 1998) may benefit from further specification as to the impacts that are associated with premature and SGA births. While the true risk-effects may be similar to those suggested here and elsewhere (e.g. Inder, et al., 2005; Tuvemo & Lundgren, 2009), the actual mechanisms (and thus potential means for intervention) may differ. Second, the physical and functional indicators used in this study may provide pointers for more detailed future neuro-functional investigations of children born premature, SGA, or who demonstrate attention problems. Third, it is possible that early interventions that aim to improve postnatal head growth (Samara, Marlow, & Wolke, 2008) may also prove beneficial for reducing the likelihood of subsequent childhood attention problems.

What's Known:

- Although prematurity and SGA are risk factors for childhood attention problems, their mechanisms of effect remain uncertain

What's New:

- SGA impacts age 6 attention problems via: *reduced brain volume*
- Prematurity impacts age 6 attention problems via: *altered brain function*
- Consistent with Eme's Gender Paradox, attention problems from prematurity were more apparent in girls not boys

What's Clinically Relevant:

- Early interventions that aim to improve postnatal head growth may reduce future attention problems
- Middle childhood follow-up of premature and SGA children should be sensitive to gender differences

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Table 1. Background characteristics of participants in the Bavarian Longitudinal Study who received behavioral assessments when children were aged 6;3 years

	Boys n: 736 Mean (SD), or n (%)	Girls n: 716 Mean (SD), or n (%)	Total N: 1,452 Mean (SD), or n (%)
Birthweight (grams)			
<1.5kg	120 (16.30%)	134 (18.72%)	254 (17.49%)
<2.5kg	301 (40.89%)	291 (40.64%)	592 (40.77%)
SGA (<10 th percentile birthweight)	183 (24.86%)	183 (25.56%)	366 (25.21%)
Gestation			
<32 weeks	142 (19.29%)	110 (15.36%)	252 (17.36%)
<37 weeks	294 (39.95%)	266 (37.15%)	560 (38.57%)
Days of initial hospitalization	23.36 (32.53)	21.03 (29.94)	22.21 (31.29)
Maternal Age	28.83 (5.02)	28.70 (5.05)	28.77 (5.03)
Pre-pregnancy smoking (no. cigs)	4.38 (8.36)	4.54 (8.81)	4.46 (8.58)
Pregnancy smoking (no. cigs)	1.01 (3.12)	1.10 (3.74)	1.06 (3.44)
Maternal Education Level			
<11 years equivalent	248 (33.97%)	265 (37.43%)	513 (35.67%)
>10 years equivalent	482 (66.03%)	443 (62.57%)	925 (64.33%)
Family Adversity Index	1.21 (1.16)	1.23 (1.23)	1.22 (1.19)
Head circumference groupings			
<3 rd percentile	33 (6.29%)	14 (2.79%)	47 (4.58%)
Within 3 rd -11 th percentiles	36 (6.86%)	71 (14.17%)	107 (10.43%)
Within 10 th -90 th percentiles	397 (75.61%)	367 (73.25%)	764 (74.46%)
>90 th percentile	59 (11.24%)	49 (9.78%)	108 (10.53%)
Griffiths Developmental Quotient	102.42 (11.55)	104.19 (12.23)	103.29 (11.92)
Attention Problems (CBCL)	3.79 (2.84)	3.14 (2.66)	3.47 (2.77)
Task Orientation (TRCB)	38.73 (8.91)	40.92 (8.23)	39.81 (8.65)

SGA: Small [birth weight] for Gestational Age; CBCL: Child Behavior Check List; TRCB: Tester's

Rating of Child Behavior

Table 2. Attention Problems at age 6;3 years and the impacts of child gender, prematurity, and Small for Gestational Age

	<i>Type III Sum of Squares</i>	<i>df</i>	<i>Mean square</i>	<i>F</i>	<i>p</i>	<i>Partial Eta Squared</i>
Predicting Attention Problems (CBCL)						
Child gender (CG)	125.38	1	125.38	16.73	<.001	.01
Premature birth (PB)	99.86	1	99.86	13.33	<.001	.01
Small for Gestational Age birth (SGA)	71.25	1	71.25	9.51	.002	.01
CG * PB	.94	1	.94	.13	.724	.00
CG * SGA	3.68	1	3.68	.49	.483	.00
PB * SGA	1.91	1	1.91	.25	.614	.00
CG * PB * SGA	19.57	1	19.57	2.61	.106	.00
Error	9929.78	1325	7.49			
Total	26786.00	1333				
Predicting (poor) Task Orientation (TRCB)						
Child gender (CG)	1152.79	1	1152.79	16.31	<.001	.01
Premature birth (PB)	2177.94	1	2177.94	30.80	<.001	.02
Small for Gestational Age birth (SGA)	1303.83	1	1303.83	18.44	<.001	.01
CG * PB	2.85	1	2.85	.04	.841	.00
CG * SGA	11.98	1	11.98	.17	.681	.00
PB * SGA	35.47	1	35.47	.50	.479	.00
CG * PB * SGA	4.69	1	4.69	.07	.797	.00
Error	93680.16	1325	70.70			
Total	2216479.00	1333				

CBCL: Child Behavior Check List; TRCB: Tester's Rating of Child Behavior

Table 3. Pearson Correlations between measures used in this paper - within each child gender.

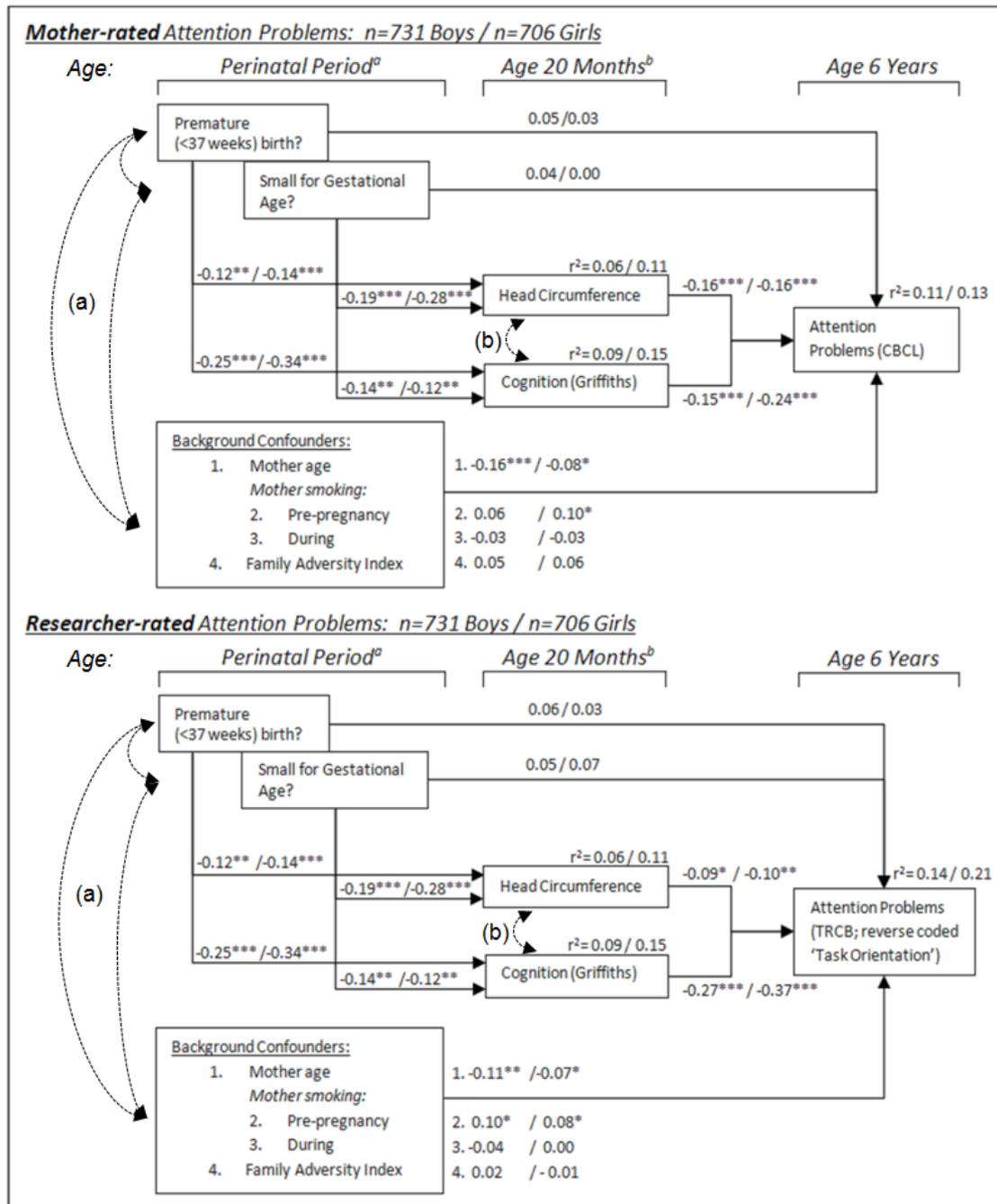
Measures drawn from the perinatal period, at age 20 months, and at age 6;3 years

Variable	Variable no.										
	1	2	3	4	5	6	7	8	9	10	11
1. Female Child Gender	1	-.030	-.003	.005	-.012	-.011	-.018	-.003	.070**	-.119***	-.126***
BOYS											
2. Premature birth		1									
3. Small for Gestational Age birth		.183***	1								
4. Family Adversity Index		.128***	.048	1							
5. Mother's age		.052	-.079*	-.143***	1						
6. Mother smoking prior to pregnancy (no. cig)		.080*	.033	.166***	-.123**	1					
7. Mother smoking during pregnancy (no. cig)		.138***	.058	.190***	-.117**	.697***	1				
8. Age 20 months head circumference		-.174***	-.209***	-.080*	.062	-.042	-.069	1			
9. Age 20 months cognition		-.284***	-.166***	-.225***	-.025	-.157***	-.177**	.330***	1		
10. Age 6 years attention problems (CBCL)		.128**	.125**	.161***	-.186***	.135***	.097**	-.263***	-.280***	1	
11. Age 6 years task orientation (TRCB; reversed)		.162***	.132***	.083*	-.095**	.161***	.117***	-.218***	-.356***	.350***	1
GIRLS											
2. Premature birth		1									
3. Small for Gestational Age birth		.191***	1								
4. Family Adversity Index		.108**	.026	1							
5. Mother's age		.091*	-.017	-.017	1						
6. Mother smoking prior to pregnancy (no. cig)		.033	-.017	.147***	-.065	1					
7. Mother smoking during pregnancy (no. cig)		.121**	.043	.144***	-.068	.605***	1				
8. Age 20 months head circumference		-.168***	-.297***	-.057	.001	.044	.040	1			
9. Age 20 months cognition		-.345***	-.174***	-.102**	-.021	.008	-.061	.304***	1		
10. Age 6 years attention problems (CBCL)		.134***	.094*	.108**	-.069	.106**	.062	-.234***	-.297***	1	
11. Age 6 years task orientation (TRCB; reverse coded)		.186***	.162***	.056	-.060	.074*	.086*	-.213***	-.427***	.309***	1

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$;

CBCL: Child Behavior Check List; TRCB: Tester's Rating of Child Behavior

Figure 1. Mother and teacher-rated age 6;3 year attention problems: Direct and indirect effects of prematurity and Small for Gestational Age



* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; r^2 = proportion of variance explained by all predictors;

^a All perinatal measures also simultaneously correlated with one another, see Table 3;

^b Age 20 months head circumference and cognition also correlated, see Table 3;

CBCL: Child Behavior Check List; TRCB: Tester's Rating of Child Behavior

Figure 2. The total indirect effects of prematurity and Small for Gestational Age on age 6;3 year attention problems via head circumference and cognition at age 20 months: Differences by child gender and rater

