

Behavior Problems in Relation to Sustained Selective Attention Skills of Moderately Preterm Children

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Abstract Attention skills may form an important developmental mechanism. A mediation model was examined in which behavioral problems of moderately preterm and term children at school age are explained by attention performance. Parents and teachers completed behavioral assessments of 348 moderately preterm children and 182 term children at 8 years of age. Children were administered a test of sustained selective attention. Preterm birth was associated with more behavioral and attention difficulties. Gestational age, prenatal maternal smoking, and gender were associated with mothers', fathers', and teachers' reports of children's problem behavior. Sustained selective attention partially mediated the relationship between birth status and problem behavior. Development of attention skills should be an important focus for future research in moderately preterm children.

Keywords Moderately preterm · Late preterm · Premature · Attention skills · Behavior problems · DSM IV · School age

Children born moderately preterm, at a gestational age of 32–36 weeks, are at risk for developmental problems because of their immature brain development at birth (Kinney 2006). This moderate prematurity comprises 6% to 9% of all births (Engle 2006; Raju 2006). In The Netherlands, a 7.6% rate results in more than 13,000 children born with this condition each year (Stichting Perinatale Registratie Nederland 2009). Few studies are available on these children's developmental outcomes and the mechanisms involved, however. Gray et al. (2004) studied 869 low birth weight children, 80% of whom were born between 31 and 36 weeks' gestation. Around 20% of their parents reported behavior problems when the

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children were 3, 5 and 8 years old. This was almost twice as high as the prevalence expected in term children from the same population. In the United Kingdom, Huddy et al. (2001) found that parents and teachers of seven-year-old children born between 32 and 35 weeks' gestation indicated an abnormal hyperactivity score for 19% of them.

Several researchers indicate that children's sustained attention difficulties predict attentional, intellectual, and behavioral functioning among extremely and very preterm children (Lawson and Ruff 2004). Very preterm children who showed sustained attention during exploratory manipulation at 8 months had higher developmental scores on the Bayley Mental Scale and the Gesell schedules at 2 years of age (Van de Weijer-Bergsma et al. 2008). Children's attention performance therefore can be seen as a developmental outcome, but also as a mechanism that mediates the relationship between birth status and problem behavior in school-age children.

Next to the effect of the children's birth status, the effects of neonatal risk factors on children's developmental outcomes should additionally be taken into account. A gradient effect related to a lower gestational age and lower birth weight was found on achievement tests measuring reading, spelling, and arithmetic skills in a large sample of 5,319 ten-year-old children (Kirkegaard et al. 2006). The preterm children also performed worse than the term children in this study. Moderately preterm children are also at risk for neonatal complications such as hypoglycaemia and need for oxygen as a result of their immaturity, which may affect their brain development. The influence of neonatal complications is reflected by the finding that moderately preterm children showed a wider variation (1 to 23 days) in duration of neonatal hospital stay, as compared to term children (1 to 7 days) (Wang et al. 2004).

Other biological and environmental risk factors may also moderate behavioral outcomes of moderately preterm school-age children. Epidemiological research on characteristics of very preterm children suggests that boys have more behavior and attention problems at school age than girls, according to their parents and teachers, as they are more prone to a variety of neurodevelopmental disorders (Ingemarsson 2003; Reiss et al. 2004; McGrath et al. 2005). With regard to maternal lifestyle factors (e.g., prenatal maternal smoking and/or alcohol use), the study of Delobel-Ayoub et al. (2009) illustrated that smoking during pregnancy is associated with an increased risk of parent-reported behavioral problems among very preterm children.

We studied a mediation model explaining the relationship between moderately preterm birth and behavioral outcomes at school age, with sustained selective attention performance as a mediator. In addition, we explored the relationship between behavioral problems with neonatal characteristics, maternal lifestyle factors, and gender.

Method

Participants

The selection criteria for moderately preterm children consisted of a gestational age at birth of 32 through 36 weeks + 6 days, no dysmaturity (birth weight below 10th

percentile), no Neonatal Intensive Care Unit (NICU) admittance needed, attending a regular primary school, and an age of 7 to 9 years. For the comparison group of term children, selection criteria consisted of a gestational age more than 37 weeks, no dysmaturity (birth weight below 10th percentile), no NICU admittance needed, attending a regular primary school and an age of 7 to 9 years. Children with severe congenital malformations or preterm children who had special education needs were excluded. The sample consisted of 348 moderately preterm children with a mean age of 8.3 years ($SD=0.62$) and 182 term children with a mean age of 8.5 years ($SD=0.85$), see Van Baar et al. (2009) for a detailed description of the sample.

In total, 264 moderately preterm children who were eligible for the study were not included in the final sample. Provided reasons for nonparticipation were that children could not be located (43.1%), children could not be studied within the time frame of the examiners (33.6%), their parents refused participation (3.4%), children did not show up at the time of the examination (1.1%), or the exact reason for nonparticipation was unknown (18.7%). Attrition effects were tested by comparing characteristics of moderately preterm children who were eligible for the study but were not included ($n=264$) against characteristics of moderately preterm children included in the final sample ($n=348$). A two-tailed t test revealed no age differences, $t(612)=2.65$, $p=.06$, and a chi-square test revealed no difference in gender composition, $\chi^2(1, N=611)=0.49$, $p=.49$. Concerning children's neonatal characteristics, two-tailed t tests revealed that the participating 348 moderately preterm children did not differ from the nonparticipants in gestational age, $t(609)=-0.73$, $p=.47$, days spent in the incubator, $t(291)=2.47$, $p=.11$, or birth weight, $t(607)=0.15$, $p=.88$. Furthermore, chi-square tests showed that the participating moderately preterm children did not differ from the nonparticipants in way of delivery, $\chi^2(4, N=587)=1.95$, $p=.75$, occurrence of hypoglycaemia, $\chi^2(1, N=466)=0.80$, $p=.37$, or in their need of any oxygen after birth, $\chi^2(1, N=472)=0.82$, $p=.37$. However, moderately preterm children included in the final sample had spent more days in hospital than moderately preterm children who did not participate, $M_{\text{group1}}=15.39$ ($SD=9.66$), $M_{\text{group2}}=13.54$ ($SD=9.06$), $t(551)=2.26$, $p=.02$, $d=0.20$, 95% CI [0.24, 3.48]. Finally, moderately preterm children in the final sample were less frequently part of multiples, 24.1% vs. 36.3%, $\chi^2(2, N=610)=11.31$, $p<.01$, $\phi=.14$, 95% CI [0.05, 7.38], as compared to the nonparticipants.

Procedure

The participating moderately preterm children were born between January 1996 and January 1998 in one of seven participating hospitals in the south of the Netherlands. We selected these children on the basis of the hospitals' archives. We approached their parents by letter and asked them to give their written informed consent if they wanted to participate. The term children were pupils of mainstream primary schools in the same geographical region, born between January 1996 and January 1999. Primary schools were located in the same cities as the hospitals, as well as in surrounding villages. First, a request to the directors of these schools was made for their school's participation. Next, children received an information letter for their parents that explained the study and requested their participation. When parents gave their written informed consent, examiners tested the child in the hospitals or schools.

Each examiner tested only preterm or only term children. Ethical approval was obtained from the Committee of Medical Ethics of the St Elisabeth Hospital in Tilburg, and from the local research ethics committees of the other participating hospitals.

Measures

Background Variables All parents completed a background questionnaire, in order to gather sociodemographic information. Maternal lifestyle factors were measured by two dichotomized items, namely “Did you smoke during pregnancy?” and “Did you use alcohol during pregnancy?” Neonatal data (e.g. gestational age, birth weight, hypoglycaemia, need for oxygen, and duration of hospital stay) of moderately preterm children were collected from the hospitals’ archives.

Behavior Problems Parents completed the 120-item Child Behavior Check List (CBCL; Achenbach and Rescorla 2001) for children 6 to 18 years of age, which measures children’s behavior problems that reflect the psychopathological syndrome classifications mentioned in the Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM-IV; American Psychiatric Association 2000). Teachers answered the Teacher Report Form (TRF; Achenbach and Rescorla 2001), a 118-item instrument that covers the same behavior problems as the CBCL. Both questionnaires have good psychometric qualities (Evers et al. 2000). Six DSM-IV-oriented syndrome scales were used: Affective problems, Anxiety problems, Somatic problems, Attention Deficit/Hyperactivity Disorder (ADHD), Oppositional Defiant Disorder (ODD) and Conduct Disorder (CD). All scores can be classified into a normal, a borderline, or a clinical range (Achenbach and Rescorla 2001).

Attention The Bourdon-Vos test (Vos 1998) was used to measure visual sustained selective attention. The Bourdon-Vos is a paper-and-pencil cancellation test for children between 6 and 17 years of age, consisting of 33 lines on one page. Each line contains 24 figures made of 3, 4, or 5 dots. Children were asked to mark all figures consisting of four dots (50% squares and 50% diamonds) as quickly and accurately as possible. Two lines were used to practice before the test began. Time to complete the rows and the total page was recorded. The test manual provides decile scores for speed, based on mean time per line and children’s age. The Dutch organisation (COTAN), which provides information on the psychometric properties of Dutch psychological tests and questionnaires, has reported acceptable validity, sensitivity, and reliability of the test, with a Cronbach’s α of .99, illustrating good internal consistency, and a test-retest reliability of .84 (with .83 for girls and .87 for boys) among a group of 785 children from 6 to 17 years of age. One hundred and sixteen children who needed special education were found to be generally slower in performance than 455 children in primary schools (Vos 1998). Arthur et al. (1991) demonstrated moderate predictive validity of sustained selective attention tests such as the Bourdon-Vos. Several other studies have considered the Bourdon-Vos test to be a clinically useful instrument (Hendriksen et al. 2007; Vos et al. 1995). In order to differentiate between children who performed quick, average, or slow on this task, we considered a score of 1 to 3 deciles to represent a below-average score, a score of

4 to 7 deciles an average score, and a score of 8 to 10 deciles an above-average score.

Missing Values

Little's Missing Completely At Random (MCAR; Little 1988) test revealed a normed χ^2 (χ^2/df) of 1.33, which indicates a good fit between sample scores with and without imputation (Bollen 1989). Therefore, we used single imputation for continuous variables in SPSS 18.0 to ensure that analyses included the full sample of moderately preterm and term children, as well as their fathers, mothers and teachers (Schafer 1997).

Statistical Analyses

Prior to the analyses, we evaluated the data for normality and checked for the existence of outliers. Because the number of mothers and fathers who had completed higher education was lower among moderately preterm children, analyses comparing moderately preterm and term children were adjusted for maternal education.

First, we used multivariate analyses of covariance (MANCOVAs) to test for differences between moderately preterm children and term children on the main outcome measures. Second, we conducted linear regression analyses to explore the role of neonatal characteristics (gender, birth weight, gestational age, hypoglycaemia, any need for oxygen, and days of hospital stay) and maternal lifestyle factors (smoking and drinking during pregnancy) in predicting behavioral outcomes among moderately preterm children. Finally, we used hierarchical regression analyses to test the proposed mediation model (Baron and Kenny 1986).

Results

Demographics

Table 1 presents frequencies and means of the basic neonatal and sociodemographic characteristics of moderately preterm and term children, and their parents. Groups differed as expected in gestational age, birth weight, and duration of hospital stay. Parents in the term group were more highly educated than the parents of moderately preterm children, and mothers of term children more often reported use of alcohol during pregnancy.

Effects of Preterm Birth and Gender on Behavioral Functioning and Sustained Selective Attention Performance

DSM-IV-Oriented Syndrome Scales Mothers' reports of DSM-IV-oriented syndrome scales demonstrated a main effect for birth status, $F(6, 520)=2.61, p=.017, \eta_p^2=.03$. No main effect for gender existed, $F(6, 520)=1.98, p=.067, \eta_p^2=.02$, nor did a birth status-by-gender interaction, $F(6, 520)=1.55, p=.161, \eta_p^2=.02$. Univariate birth

Table 1 Sociodemographic and neonatal characteristics of moderately preterm and term children

Characteristic	Moderately Preterm			Term		
	Range or <i>N</i> (%)	<i>M</i>	<i>SD</i>	Range or <i>N</i> (%)	<i>M</i>	<i>SD</i>
Gestational age (wk)	32-36	34.7**	1.2	37-43	39.5**	1.4
Birth weight (g)	1340-3564	2425**	438	2385-4750	3431**	441
Days hospitalized	2-51	15.4**	9.7	0-11	1.3**	2.3
Boys	178 (51.1)			87 (47.8)		
Maternal education						
Primary level	14 (4.0)			7 (3.8)		
Secondary level	262 (75.3)			111 (61.0)		
Tertiary level	60 (17.2)**			50 (27.5)**		
Maternal smoking	58 (16.7)			21 (11.5)		
Maternal alcohol use	31 (8.9)*			27 (14.8)*		

Significance tests used to determine mean differences are *t* scores and chi-squares for percentile differences. Frequencies may vary due to missing values

* $p < .05$. ** $p < .01$

status differences on mothers' reports of DSM-IV-oriented syndrome scales are illustrated in Table 2. Moderately preterm children showed more problems in affective behaviors, anxiety, somatic functioning, and ADHD, but not in ODD or CD. On mothers' total problem behavior scores, 11.5% of the moderately preterm

Table 2 Univariate analyses of covariance comparing moderately preterm and term children on behavioral measures

Measures	Moderately Preterm			Term			ANCOVA			
	<i>M</i>	<i>SE</i>	95% CI	<i>M</i>	<i>SE</i>	95% CI	$F^l(1, 525)$	<i>p</i>	η_p^2	
Mothers	Affective	55.84	0.33	[55.20, 56.48]	54.35	0.45	[53.45, 55.24]	7.05	.008	.01
	Anxiety	55.03	0.31	[54.42, 55.63]	53.66	0.43	[52.82, 54.50]	6.67	.010	.01
	Somatic	56.22	0.34	[55.55, 56.90]	54.79	0.48	[53.85, 55.72]	5.97	.015	.01
	ADHD	55.02	0.33	[54.36, 55.68]	53.38	0.46	[52.47, 54.29]	8.21	.004	.02
	ODD	54.55	0.27	[54.02, 55.08]	53.78	0.37	[53.04, 54.51]	2.79	.095	.01
	CD	53.39	0.25	[52.90, 53.89]	53.21	0.35	[52.53, 53.90]	0.17	.682	<.01
Teachers	Affective	53.78	0.26	[53.27, 54.29]	52.57	0.36	[51.86, 53.28]	7.44	.007	.01
	Anxiety	55.74	0.31	[55.14, 56.34]	53.60	0.42	[52.77, 54.43]	16.76	<.001	.03
	Somatic	52.36	0.24	[51.89, 52.84]	51.28	0.34	[50.62, 51.94]	6.75	.010	.01
	ADHD	53.64	0.26	[53.13, 54.16]	53.25	0.36	[52.54, 53.97]	0.76	.383	.01
	ODD	53.66	0.25	[53.17, 54.14]	52.61	0.34	[51.94, 53.29]	6.07	.014	.01
	CD	51.98	0.20	[51.59, 52.36]	51.81	0.27	[51.27, 52.34]	0.26	.608	.01

ADHD = Attention Deficit Hyperactivity Disorder. ODD = Oppositional Defiant Disorder. CD = Conduct Disorder. F^l Pillai's Trace

children scored above the borderline cut-off score of 60, compared to 7.1% of term children ($\chi^2(2)=4.71, p=.095, \phi=.09, 95\% \text{ CI } [0.05, 7.38]$).

Fathers' reports of DSM-IV-oriented syndrome scales were nonsignificant for main effects of birth status, $F(6, 520)=0.41, p=.872, \eta_p^2=.01$, and gender, $F(6, 520)=1.53, p=.165, \eta_p^2=.02$. The birth status-by-gender interaction was also nonsignificant, $F(6, 520)=1.17, p=.322, \eta_p^2=.01$. On fathers' total problem behavior scores, 5.2% of the moderately preterm children scored above the borderline cut-off score of 60, compared to 4.4% of term children ($\chi^2(2)=0.23, p=.889, \phi=.02, 95\% \text{ CI } [0.05, 7.38]$).

Teachers' reports of DSM-IV-oriented syndrome scales demonstrated a significant main effect for birth status, $F(6, 520)=4.10, p<.001, \eta_p^2=.05$, and gender, $F(6, 520)=6.43, p<.001, \eta_p^2=.07$. No significant birth status-by-gender interaction was found, $F(6, 520)=0.70, p=.650, \eta_p^2=.01$. Tables 2 and 3 provide an overview of univariate birth status and gender differences. Moderately preterm children showed more problems in affective behaviors, anxiety, somatic functioning, and ODD, but not in ADHD or CD. On teachers' total problem behavior scores, 6.0% of the moderately preterm children scored above the borderline cut-off score of 60, compared to 2.2% of term children ($\chi^2(2)=8.40, p=.015, \phi=.13, 95\% \text{ CI } [0.05, 7.38]$). Regarding gender, 6.4% of the boys scored above the borderline cut-off score of 60, compared to 3.0% of the girls ($\chi^2(2)=5.67, p=.059, \phi=.10, 95\% \text{ CI } [0.05, 7.38]$).

Attention Children's average time needed to complete a line and children's deciles scores on the Bourdon-Vos test both demonstrated a main effect for birth status, $F(2, 524)=13.53, p<.001, \eta_p^2=.05$. Moderately preterm children needed more time to complete a line than did term children, $M_{z\text{-scoregroup1}}=0.14 (SE=0.05), 95\% \text{ CI } [0.04, 0.24], M_{z\text{-scoregroup2}}=-0.32 (SE=0.07), 95\% \text{ CI } [-0.46, -0.17], F(1, 525)=26.33, p<.001, \eta_p^2=.05$, and they had higher decile scores on the Bourdon-Vos test than term children, $M_{\text{group1}}=6.96 (SE=0.16), 95\% \text{ CI } [6.65, 7.28], M_{\text{group2}}=5.76 (SE=0.22), 95\% \text{ CI } [5.33, 6.19], F(1, 525)=19.47, p<.001, \eta_p^2=.04$. No main effects were found for gender, $F(2, 524)=2.80, p=.062, \eta_p^2=.01$ or for the birth status-by-gender interaction, $F(2, 524)=1.96, p=.142, \eta_p^2=.01$. Concerning children's decile scores, 47.1% of the moderately preterm children scored above

Table 3 Univariate analyses of covariance comparing boys and girls on behavioral measures

Measures	Boys			Girls			ANCOVA		
	<i>M</i>	<i>SE</i>	95% CI	<i>M</i>	<i>SE</i>	95% CI	<i>F</i> ^{<i>l</i>} (1, 525)	<i>p</i>	η_p^2
Affective	53.52	0.32	[52.90, 54.14]	52.83	0.31	[52.22, 53.44]	2.46	.118	.01
Anxiety	54.63	0.37	[53.90, 55.36]	54.70	0.36	[53.99, 55.42]	0.02	.894	<.01
Somatic	51.48	0.30	[50.89, 52.06]	52.17	0.29	[51.60, 52.74]	2.77	.097	.01
ADHD	54.02	0.32	[53.39, 54.65]	52.88	0.31	[52.26, 53.50]	6.44	.011	.01
ODD	53.93	0.30	[53.34, 54.52]	52.34	0.30	[51.76, 52.92]	14.24	<.001	.03
CD	52.84	0.24	[52.37, 53.31]	50.94	0.23	[50.49, 51.40]	32.10	<.001	.06

ADHD = Attention Deficit Hyperactivity Disorder. ODD = Oppositional Defiant Disorder. CD = Conduct Disorder. *F*^{*l*} Pillai's Trace

average, showing difficulties in sustained selective attention, as compared to 35.2% of term children ($\chi^2(2)=15.52, p<.001, \varphi=.17, 95\% \text{ CI } [0.05, 7.38]$).

Effects of Sustained Selective Attention Subgroups (Below-Average; Average; Above-Average) on Behavioral Functioning

DSM-IV-Oriented Syndrome Scales Mothers' reports of DSM-IV-oriented syndrome scales demonstrated a significant main effect for subgroup, $F(12, 1038)=1.83, p=.039, \eta_p^2=.02$, but no birth status-by-subgroup interaction, $F(12, 1038)=0.48, p=.927, \eta_p^2=.01$. Table 4 displays estimated marginal means, standard errors, 95% confidence intervals, and Fisher's LSD post hoc results for tests of sustained selective attention subgroup differences. Concerning mother's total problem behavior scores, it appeared that 12.7% of the children who scored above average on the Bourdon-Vos test also scored above the borderline cut-off score of 60, as compared to 11.0% of the children who had an average score and 2.7% of the children who had a below-average score on the Bourdon-Vos test ($\chi^2(4)=9.89, p=.042, \varphi=.14, 95\% \text{ CI } [0.48, 11.14]$).

Fathers' reports of DSM-IV-oriented syndrome scales demonstrated no main effect for subgroup, $F(12, 1038)=1.73, p=.055, \eta_p^2=.02$, and no birth status-by-subgroup interaction, $F(12, 1038)=0.57, p=.865, \eta_p^2=.01$. Concerning fathers' total problem behavior scores it appeared that 5.3% of the children scoring above average on the Bourdon-Vos test also scored above the borderline cut-off score of 60, as compared to 5.2% of the children who had an average score and 3.6% of the children who had a below-average score on the Bourdon-Vos test ($\chi^2(4)=1.85, p=.763, \varphi=.06, 95\% \text{ CI } [0, 9.49]$).

Table 4 Parameter estimates of children with and without sustained selective attention difficulties on behavioral measures

Measures	Above Average (n=228)			Average (n=191)			Below Average (n=111)			
	M	SE	95% CI	M	SE	95% CI	M	SE	95% CI	
Mothers	Affective	56.11 _a	0.45	[55.23, 56.99]	54.63 _b	0.47	[53.71, 55.55]	54.05 _{ab}	0.58	[52.91, 55.18]
	Anxiety	54.67	0.43	[53.84, 55.51]	54.36	0.45	[53.49, 55.24]	53.71	0.55	[52.63, 54.79]
	Somatic	55.38	0.47	[54.45, 56.31]	55.98	0.50	[55.01, 56.96]	54.94	0.61	[53.74, 56.14]
	ADHD	54.94 _a	0.46	[54.05, 55.84]	54.42 _b	0.48	[53.48, 55.35]	52.68 _{ab}	0.59	[51.52, 53.84]
	ODD	54.49	0.37	[53.76, 55.22]	53.90	0.39	[53.14, 54.66]	53.85	0.48	[52.91, 54.79]
	CD	53.79 _a	0.34	[53.11, 54.46]	53.11 _a	0.36	[52.40, 53.82]	52.64 _b	0.44	[51.76, 53.51]
Teachers	Affective	53.91 _a	0.36	[53.21, 54.61]	52.43 _b	0.37	[51.70, 53.16]	53.01 _{ab}	0.46	[52.11, 53.91]
	Anxiety	54.92	0.42	[54.10, 55.75]	54.35	0.44	[53.49, 55.21]	54.79	0.54	[53.73, 55.85]
	Somatic	52.02	0.34	[51.37, 52.68]	51.35	0.35	[50.66, 52.04]	52.32	0.43	[51.47, 53.17]
	ADHD	54.66 _a	0.36	[53.96, 55.36]	53.02 _b	0.37	[52.28, 53.75]	52.27 _b	0.46	[51.36, 53.17]
	ODD	53.67	0.34	[53.00, 54.34]	52.90	0.36	[52.20, 53.60]	52.67	0.44	[51.80, 53.54]
	CD	52.43 _a	0.28	[51.89, 52.97]	51.59 _b	0.29	[51.02, 52.16]	51.51 _b	0.36	[50.81, 52.21]

Within rows, estimated marginal means sharing a common subscript are not statistically different at $\alpha = .05$ according to Fisher's LSD procedure. ADHD = Attention Deficit Hyperactivity Disorder. ODD = Oppositional Defiant Disorder. CD = Conduct Disorder. F^l Pillai's Trace

Teachers' reports of DSM-IV-oriented syndrome scales demonstrated a significant main effect for subgroup, $F(12, 1038)=2.28$, $p=.007$, $\eta_p^2=.03$, but no significant birth status-by-subgroup interaction, $F(12, 1038)=0.85$, $p=.601$, $\eta_p^2=.01$, see Table 4. Concerning teachers' total problem behavior scores, it appeared that 5.3% of the children who scored above average on the Bourdon-Vos test also scored above the borderline cut-off score of 60, as compared to 4.7% of the children who had an average score and 3.6% of the children who had a below-average score on the Bourdon-Vos test ($\chi^2(4)=5.82$, $p=.213$, $\phi=.11$, 95% CI [0.48, 11.14]).

Effects of Neonatal Characteristics and Maternal Lifestyle Factors

Separate linear regression analyses for the preterm children with regard to mothers' reports of children's total problem behavior showed that gestational age was the most important predictor of children's problem behavior ($\beta=.15$, $p=.016$), accounting for a small but significant percentage of the variance ($R^2=.02$, $p=.016$). With regard to fathers' reports of children's total problem behavior, maternal smoking during pregnancy emerged as the most important predictor ($\beta=.13$, $p=.036$), accounting for a small but significant percentage of the variance ($R^2=.02$, $p=.036$). Finally, none of the neonatal characteristics or maternal lifestyle factors reached significance in predicting teachers' reports of children's total problem behavior.

Mediation Model

Preliminary analyses confirmed that all requirements were met regarding the relationships between children's sustained selective attention performances, children's birth status, and problem behavior as reported by mothers and by teachers. First, the results showed that children's birth status was significantly related to children's sustained selective attention performances ($\beta=.19$, $p<.001$). Second, the results showed that children's birth status affected mothers' reports of children's total problem behavior ($\beta=.18$, $p<.001$). Birth status was also significantly related to teachers' reports of children's total problem behavior ($\beta=.13$, $p=.004$). Finally, children's sustained selective attention performances were significantly related to mothers' reports of children's total problem behavior ($\beta=.17$, $p<.001$). Children's sustained selective attention performances were also significantly related to teachers' reports of children's total problem behavior ($\beta=.18$, $p<.001$).

Next, we entered children's birth status as the predictor variable, and this significantly accounted for variance associated with children's problem behavior (as reported by both mothers and teachers). In the second step, we entered both children's birth status and sustained selective attention performance into the regression equation. It appeared that children's sustained selective attention performance uniquely contributed to the variance in both mothers' and teachers' reports of children's total problem behavior. Moreover, the contribution of children's birth status decreased, indicating partial mediation (see Table 5). Sobel's test confirmed that children's sustained selective attention performance functioned as a

Table 5 Summary of hierarchical regression analyses for children's birth status and children's sustained selective attention performance predicting children's problem behavior, as reported by mothers and teachers

	Variable	<i>B</i>	<i>SE B</i>	95% CI	β	<i>p</i>	<i>sr</i> ²
<i>Source: Mother</i>							
Step 1	Birth status	3.58	0.88	[1.86, 5.31]	.18	<.001	.03
Step 2	Birth status	3.04	0.88	[1.29, 4.78]	.15	.001	.02
	Sustained selective attention	0.44	0.14	[0.17, 0.72]	.14	.002	.02
<i>Source: Teacher</i>							
Step 1	Birth status	2.13	0.74	[0.68, 3.58]	.13	.004	.02
Step 2	Birth status	1.59	0.74	[0.13, 3.05]	.09	.033	.01
	Sustained selective attention	0.44	0.12	[0.21, 0.67]	.16	<.001	.03

B indicates unstandardized *B*; β , standardized β ; *sr*², squared semipartial correlation. Adjusted *R*² = 0.03 for Step 1 (*p* < .001); $\Delta R^2 = 0.05$ for Step 2 (*p* < .001) for both mother and teacher sources

significant partial mediator between children's birth status and reports of children's total problem behavior provided both by mothers, $z=2.91$, $p=.004$, and by teachers, $z=2.61$, $p=.009$.

Discussion

Moderately preterm children at school age have more affective, anxious, somatic, ADHD, and ODD symptoms, as compared to term children. According to the teachers, preterm children also more often had borderline levels of behavioral problems, although these rates with 6% and 2.2%, respectively, were not as high as what might have been expected from population norms or other studies (Gray et al. 2004). Male gender was important in teachers' assessments of behavioral problems, with boys showing more problems. Furthermore, moderately preterm children displayed more sustained selective attention difficulties when compared to term children, with many children in both groups (47% and 35%, respectively) showing difficulties in sustained selective attention. The mediation model showed that children's sustained selective attention performance partially mediated the association between children's birth status and problem behavior. Therefore, the differences between moderately preterm and term children can be partly, but not fully, explained through the children's sustained selective attention performance. The subgroup of moderately preterm children with above-average sustained selective attention difficulties also did not have more behavior problems in comparison to term born children with clear attention difficulties, or to children without such difficulties. As no full mediation was found, other factors are important to consider in the relationship between moderately preterm birth and behavior problems. Regression analyses conducted on a number of neonatal characteristics and maternal lifestyle factors revealed no consistent pattern of associations with the behavioral outcomes, however.

Factors that might be considered in future studies include maternal stress during pregnancy, which was found to be related to an increase in preterm birth

(Glynn et al. 2008) and to behavior problems in children (De Bruijn et al. 2009). The unique structural brain abnormalities that may be related to behavioral problems and sustained selective attention difficulties, and that have also been found in moderately preterm children, are also important (Kinney 2006). Parents of moderately preterm children may also interact more intrusively with their children, as compared to parents of term children, which may affect the children's learning processes and outcomes (Wijnroks 1997). Future studies should try to incorporate both structural and functional analyses of the brain, in order to gain a better understanding of the relationships between preterm birth and developmental outcomes (Conrad et al. 2009), as well as the roles of parenting and parent-child interaction quality.

The higher incidence of behavioral and sustained selective attention difficulties among moderately preterm children, as compared to term children, corroborates previous research and resembles the pattern found among extremely and very preterm children (Bayless and Stevenson 2007; Reiss et al. 2004; Van de Weijer-Bergsma et al. 2008). This may indicate the importance of neonatal characteristics associated with very preterm birth, but it could also indicate the importance of the quality of development during week 32 to 36 post-conception, both for very preterm as well as moderately preterm children.

Overall, assessments of behavior problems by mothers and teachers, but not by fathers, revealed a pattern of subtle but clear disadvantages faced by moderately preterm children. The lack of significance among fathers' behavioral ratings may be attributable to the fact that fathers observed their children in a different period of time than did mothers and teachers, and in a more playful context where problem behaviors may be less noticeable (Yogman et al. 1995).

A limitation of this study concerns the use of cross-sectional data for examining the relationship between children's sustained selective attention performance and problem behavior. Hence, we can make no firm conclusions regarding developmental trajectories of moderately preterm and term children. Furthermore, attrition analyses indicated that the current sample of moderately preterm children had spent more days in hospital, and were less frequently part of multiples, as compared to the children who did not participate. Therefore, the generalization of the results is limited to this somewhat more vulnerable sample. Another potentially important consideration concerns our adjustments for maternal education in the analyses, which may have been a form of overcorrection. Preterm birth is generally associated with maternal education, as lower-educated women more frequently deliver too soon, and higher educated women more extensively adjust their lifestyle to their pregnancy and seek help more efficiently in case of signals of premature labor (Goldenberg et al. 2008; Reedy 2007).

Behavioral outcomes of moderately preterm children at school age is partially related to sustained selective attention skills. Development of sustained selective attention skills should be an important focus for follow-up, and for future studies on moderately preterm children. Attempts to improve attention skills of moderately preterm children seem worthwhile, in order to reduce behavioral problems at school age.

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