Attention problems of very preterm children compared to age-matched term controls at school age

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Abstract

Objectives To clarify the severity, specificity, and neurocognitive underpinnings of attention problems in very preterm children.

Methods A sample of 66 preterm (<32 weeks gestation), mean (SD) age 7.5 (0.4) years, and 66 age-matched term controls participated. Symptoms of inattention were assessed using parent and teacher-rated questionnaires, and neurocognitive measures included speed and consistency in speed of information processing, lapses of attention (tau), alerting, orienting and executive attention, as well as verbal and visuospatial working memory. Group differences were investigated using ANOVA, and Sobel tests were used to clarify the mediating role of neurocognitive impairments on attention problems.

Results There was a large sized decrease in visuospatial working memory abilities (\(d=.87\), \(p<.001\)), and medium sized increases in tau (\(d=0.55\), \(p=.002\)) as well as parent and teacher ratings of inattention (range \(d=0.40-0.56\)) in very preterm children compared to term peers. Tau and visuospatial working memory were significant predictors of parent (\(R^2=.161, p<.001\) and \(R^2=.071, p=.001\); respectively) and teacher (\(R^2=.152, p<.001\) and \(R^2=.064, p=.002\); respectively) ratings of inattention, and completely explained the effects of very preterm birth on attention problems.

Conclusions Increased lapses of attention and poorer visuospatial working memory fully account for the attention problems in very premature children at school age.
**Introduction**

Improved perinatal care has increased survival rates of very preterm (<32 weeks of gestation) infants. However, very preterm birth has negative consequences on normal maturation processes in the brain, which consequently result in neurocognitive and behavioral problems in very preterm children in childhood. At school age, attention problems are among the most prominent behavioral problems reported in very preterm children. These attention problems may have a detrimental impact on school performance and social function in very preterm children, however, the exact nature is still poorly understood.

Attention is a multi-faceted construct and involves a range of neurocognitive abilities. Besides maintaining consistent fast and accurate levels of information processing, brain networks of orienting, alerting and executive attention, as well as working memory abilities are involved. Brain networks of orienting, alerting and executive attention are crucial in 1) the ability to orient to, 2) the ability to maintain focus and 3) ability to shift attention between events, respectively, and have been extensively studied in neurobiological research. Furthermore, proper working memory abilities are essential in guiding attention by holding in mind relevant information for the task at hand. Importantly, impairments in all these neurocognitive abilities involved in attention have been demonstrated to play a pivotal role in attention problems of children diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD). However, despite the potential for new treatment opportunities, the roles of these neurocognitive functions in attention problems of very preterm children have not been investigated.

To elucidate the neurocognitive underpinnings of attention problems in very preterm children, we studied: (1) the severity and specificity of attention problems in very preterm children using both parent and teacher ratings of inattention at school age; (2) the differences between very preterm children and term peers on neurocognitive abilities involved in attention; and (3) the possibility that these neurocognitive functions mediate the relationship between very preterm birth and attention problems at school age.
Methods

Subjects

A sample of 66 very preterm (<32 weeks gestation) children and 66 age-matched term controls participated. All 66 very preterm children had participated in a randomized controlled trial on enteral glutamine supplementation (0.3 g/kg/day) between day three and 30 of life. For this study, all very preterm children admitted between September 2001 and July 2003 to the level III neonatal intensive care unit (NICU) of the VU University Medical Center Amsterdam were eligible for inclusion, and baseline characteristics of the sample have been previously reported. Of the 102 infants included in the original study, 89 infants were alive at one year follow-up, and 74 were participating in the 6 years follow-up. At 7-8 years of age, parents of all 74 children were contacted and invited to participate in the current study, of which 68 (92%) agreed, and 66 (89%) successfully completed all neurocognitive tasks at the mean (SD) age of 7.5 (0.4) years (Table 1). The remaining two children were unsuccessful in completion of the neurocognitive test battery. There were no differences between the glutamine and the placebo group on any of the dependent variables (all p’s>.05; all d’s<0.49).

Age-matched, term born peers from the same classrooms as attended by the very preterm children were invited to participate in the study. Controls were required to be born >37 weeks of gestation without any perinatal complications as reported by their parents, and to attend regular classes and to be free of behavioral and academic difficulties as reported by their teacher. Using this method of recruitment, age-matched controls were recruited for 41 very preterm children. Of the remaining 25 very preterm children, four attended special classes and 21 schools were not willing to participate in the recruitment of age-matched controls. Additional age-matched controls (n=25) were recruited by contacting other schools located in the same area as schools attended by the very preterm children. Socio economic status (SES) was determined by classifying the highest level of education in a household on a four point scale, with higher scores indicating higher levels of education and corresponding higher SES.
Growing into a different brain

Procedure

All parents completed written informed consent prior to the study, which was approved by the medical ethical committee of the VU Medical Center. Neurocognitive assessments took place at the VU University Amsterdam by qualified and trained testers using standardized instructions. Both parents and each child’s teacher were asked to complete questionnaires addressing behavioral problems including attention problems at home and at school, respectively.

Behavioral Measures

Parent ratings of inattention at home were derived from the Attention Problems scale of the Child Behavior Checklist (CBCL)\(^1\)\(^6\) and the Inattention scale of the Parent Disruptive Behavior Disorders rating scale (PDBD).\(^1\)\(^7\) Teachers completed the teacher equivalents of the parent scales, including the Teacher Report Form (TRF)\(^1\)\(^8\) and Teacher Disruptive Behavior Disorders rating scale (TDBD).\(^1\)\(^7\) Hyperactivity/impulsivity was measured using the Hyperactivity/Impulsivity scale of the parent-rated PDBD and teacher-rated TDBD. In addition, internalizing behavior problems and externalizing behavior problems were measured using the subscales of Internalizing Behavior and Externalizing Behavior from both the parent-rated CBCL and teacher-rated TRF. All four questionnaires are widely used and have excellent psychometric properties.\(^1\)\(^6\)-\(^1\)\(^8\) Scores on the CBCL and TRF were standardized using T-scores with a mean (SD) of 50 (10), and scores on the PDBD and TDBD were standardized with a mean (SD) of 10 (3), with higher scores indicating higher ratings of behavioral problems.

Intelligence quotient (IQ) was measured by a short-form of the Wechsler Intelligence Scale for Children third edition (WISC-III),\(^1\)\(^9\) including the subtests Vocabulary and Block Design. Both subtests correlate strongly (r>.90) with Full Scale IQ.

Orienting, alerting, and executive attention

Orienting, alerting, and executive attention were assessed using an adapted version of the Attention Network Test (ANT)\(^8\) suitable for the use with young children. In this task, children had to respond as fast as possible to the appearance of a target on the left side or the right side of the screen by pressing a button corresponding to the location at which the target appeared. There were four types of trials. Neutral trials contained a neutral cue in the
middle of the screen which preceded the target. Orienting trials contained a directional cue in the middle of the screen pointing to the position of the target which subsequently followed. Executive trials contained directional cues incongruent with the position of the target. Alerting trials contained no cue at all and the target was presented instantaneously. The four trial types were randomly presented in four blocks of 48 trials. Orienting attention was measured by comparing both speed and accuracy (percentage of errors) of the orienting trials with the neutral trials. Executive attention was measured by comparing both speed and accuracy between the executive trials and neutral trials. Alerting attention was measured by comparing both speed and accuracy between the alerting trials and neutral trials. Speed and accuracy measures of orienting, alerting, and executive attention were included as dependent variables in analysis.

**Speed and consistency in speed of information processing**

Speed and consistency in speed of information processing were assessed using the individual response time distributions derived from all correct ANT trials. An ex-Gaussian distribution model was fitted to the individual response time distributions, which combines a normal distributional shape with an exponential component on the right side of the distribution. This model allows for an accurate determination of average processing speed corrected for extremely slow responses (mu), fluctuations in processing speed (sigma), and the proportion of extremely slow responses assessing lapses of attention (tau) reflected in the exponential component of the reaction time distribution, which has proved its clinical relevance in recent studies. To minimize the possibility that extremely slow responses pertain to responses resulting from exogenously caused distractions, trials deviating more than three standard deviations from the mean of the child’s reaction time distribution were removed from the data. Mu, sigma and tau were calculated in MATLAB, and included as dependent variables in analysis.

**Working Memory**

Two aspects of working memory were assessed. First, verbal working memory abilities were measured using the Digit Span subtest of the WISC-III. In this task, children had to verbally reproduce dictated series of digits in a forward and a backward condition. Secondly, visuospatial working memory abilities were measured using an adapted version of
a task developed by Nutley et al. In this task, children had to reproduce sequences of circles appearing in a 4x4 grid on a touch screen in a forward and a backward condition. Difficulty level was increased during the course of the task by increasing span and by manipulating the position of the stimuli. Two trials were administrated for each difficulty level, and the test was terminated when the child failed to accomplish both trials at a certain difficulty level. Given that the backward condition involves more attentional resources in terms of both holding the information in memory as well as reordering the information, maximal difficulty level of the backward condition for each working memory task were included as dependent variables in analysis.

**Statistical Analyses**

All analyses were performed using PASW Statistics 17.0 (SPSS Inc, Chicago, IL, USA) on data normalized using Van der Waerden transformation. Missing values on the questionnaires (7%) were replaced by means of Expectation Maximization. Independent t-tests were conducted to test group differences on IQ and parent and teacher ratings of inattention, hyperactivity/impulsivity, internalizing, and externalizing behavioral problems. Group differences on the neurocognitive measures were tested using MANOVA with group as between-subject factor. If a significant multivariate effect of group emerged, post-hoc ANOVA’s were conducted to investigate the nature of the multivariate effect. To test whether task manipulation of the ANT was successful, a repeated measure analysis was conducted with condition as within subject factor and group as between-subject factor.

To enhance reliability of the behavioral measures of inattention, principal component analysis was used to aggregate the two parent ratings of inattention and the two teacher ratings of inattention. Neurocognitive measures that significantly discriminated between very preterm children and term peers were entered in a stepwise linear regression analysis to test their predictive value for the aggregated parent and teacher ratings of inattention. Sobel-techniques were used to test if predictors significantly mediated the direct pathway of very preterm birth on the aggregated parent and teacher ratings of inattention (Figure 1). Group differences were quantified in terms of effect-sizes (Cohen’s d) with values of 0.20, 0.50 and 0.80 referring to small, medium and large effects, respectively. For all analyses, α was set at .05.
Results

Sample Characteristics

Age (p=.41), SES (p=.89), and gender (p=.39) were not different between very preterm children and their term peers (Table 1). No differences were present for age (p=.87), SES (p=.25), and gender (p=.23) between both recruiting methods of age-matched peers. Furthermore, no significant effects of gender and being small for gestational age were found on any of the included neurocognitive measures in very preterm children (all d’s<0.33, all p’s>.05). As expected, very preterm children had significantly lower full-scale IQ scores than term peers (d=0.92, p=.002).

Table 1. Characteristics of very preterm children and term controls

<table>
<thead>
<tr>
<th></th>
<th>Preterms (N=66)</th>
<th>Controls (N=66)</th>
<th>p</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at follow-up, years (mean ± SD)</td>
<td>7.5 (0.4)</td>
<td>7.6 (0.5)</td>
<td>.41</td>
<td>0.22</td>
</tr>
<tr>
<td>Socio economic status (mean ± SD)</td>
<td>3.2 (0.7)</td>
<td>3.2 (0.8)</td>
<td>.89</td>
<td>0.01</td>
</tr>
<tr>
<td>Sex, male (%)</td>
<td>33 (50.0)</td>
<td>28 (42.4)</td>
<td>.39</td>
<td></td>
</tr>
<tr>
<td>WISC-III Full scale IQ (mean ± SD)</td>
<td>96.6 (17.6)</td>
<td>105.8 (14.4)</td>
<td>.001</td>
<td>0.92</td>
</tr>
<tr>
<td>Birth weight, g (mean ± SD)</td>
<td>1241 (355)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gestational age, weeks (mean ± SD)</td>
<td>29.3 (1.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small for Gestational Age (&lt;10th percentile), n (%)</td>
<td>18 (27.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CRIB score (mean ± SD)</td>
<td>3.0 (2.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apgar score after 5 minutes &lt;6, n (%)</td>
<td>5 (7.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IVH, n (%)</td>
<td>14 (21.2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥ 1 infection with positive blood culture, n (%)</td>
<td>41 (62.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sepsis, n (%)</td>
<td>42 (63.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPD, n (%)</td>
<td>19 (28.8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cesarean delivery, n (%)</td>
<td>37 (56.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antenatal corticosteroid, n (%)</td>
<td>53 (80.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. BPD = Bronchopulmonary Dysplasia; CRIB = Clinical Risk Index for Babies; IVH = Intraventricular Hemorrhage; NA = Not Applicable; WISC-III = Wechsler Intelligence Scale for Children, third edition. Bold numbers pertain to a significant p-value (p<.05). Effect sizes are depicted as Cohen’s d.

Behavioral outcomes

Compared to term peers, very preterm children had higher parent and teacher ratings of inattention as assessed with the Attention Problems scale of the CBCL, Inattention scale of the PDBD, Attention Problems scale of the TRF and Inattention scale of the TDBD (Table 2). There were no group differences in terms of hyperactivity/impulsivity, internalizing behavior problems or externalizing behavior problems, as obtained from the CBCL, PDBD, TRF and TDBD, indicating that very preterm birth is specifically related to attention problems.
Table 2. Behavioral parent and teacher ratings

<table>
<thead>
<tr>
<th></th>
<th>Very Preterms (N=66)</th>
<th>Term controls (N=66)</th>
<th>p</th>
<th>Effect-size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Parent Rated Questionnaires</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CBCL Internalizing Behavior scale</td>
<td>50.0</td>
<td>8.3</td>
<td>52.6</td>
<td>13.2</td>
</tr>
<tr>
<td>CBCL Externalizing Behavior scale</td>
<td>48.8</td>
<td>9.0</td>
<td>47.7</td>
<td>8.5</td>
</tr>
<tr>
<td>CBCL Attention Problems scale</td>
<td>55.8</td>
<td>12.6</td>
<td>49.2</td>
<td>9.7</td>
</tr>
<tr>
<td>PDBD Inattention scale</td>
<td>11.8</td>
<td>3.6</td>
<td>11.1</td>
<td>1.3</td>
</tr>
<tr>
<td>PDBD Hyperactivity/Impulsivity scale</td>
<td>10.9</td>
<td>1.4</td>
<td>10.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Teacher Rated Questionnaires</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRF Internalizing Behavior scale</td>
<td>48.0</td>
<td>9.3</td>
<td>47.6</td>
<td>9.5</td>
</tr>
<tr>
<td>TRF Externalizing Behavior scale</td>
<td>48.5</td>
<td>10.3</td>
<td>48.6</td>
<td>9.2</td>
</tr>
<tr>
<td>TRF Attention Problems scale</td>
<td>53.8</td>
<td>9.4</td>
<td>49.4</td>
<td>5.9</td>
</tr>
<tr>
<td>TDBD Inattention scale</td>
<td>12.0</td>
<td>2.2</td>
<td>11.3</td>
<td>2.9</td>
</tr>
<tr>
<td>TDBD Hyperactivity/Impulsivity scale</td>
<td>11.3</td>
<td>1.7</td>
<td>11.1</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Note. CBCL = Child Behavior Checklist; PDBD = Parent Disruptive Behavior Disorders; TDBD = Teacher Disruptive Behavior Disorders; TRF = Teacher Report Form. 1Statistics were performed on raw data. 2T-scores. 3Scaled scores (M=10, SD=3). M and SD pertain to mean and standard deviation, respectively. Bold numbers pertain to a significant p-value (p<.05). Effect sizes are depicted as Cohen’s d.

Orienting, alerting, and executive attention

Differences between very preterm children and term peers for the dependent measures derived from the ANT were not significant (p=.21, see Table 3). However, the inbuilt task manipulations were successful as shown by a significant condition effect of orienting, alerting and executive attention on the dependent measures (p<.001) using a repeated measure analysis.

Speed and consistency in speed of information processing

Very preterm children had significantly lower speed and consistency in speed of information processing compared to term peers (F(3,128)=3.48, p=.02). Post-hoc ANOVAs showed that group differences in the reaction time distribution were fully accounted for by a greater proportion of extremely slow responses (tau, F(1,130)=10.06, p=.002; d=0.55). In contrast, average processing speed (mu, F(1,130)=0.28, p=.60; d=0.09) and fluctuations in processing speed (sigma, F(1,130)=0.04, p=.84; d=0.04) were not different between both groups.
A MANOVA on the dependent variables derived from the verbal and visuospatial working memory tasks, showed a significant group difference between very preterm children and term peers ($F(2,129)=12.42, p<.001$). Post-hoc ANOVAs showed that very preterm children had poorer visuospatial working memory abilities ($F(1,130)=24.98, p<.001; d=0.87$), but their verbal working memory abilities ($F(1,130)=2.01, p=.16; d=0.25$) were not different from controls.

### Mediation analysis

Aggregated parent and teacher ratings of inattention were derived using principal component analysis with varimax rotation, explaining 83% and 93% of the variance in the scores on the Attention Problems scale of the CBCL/TRF and the Inattention scale of the PDBD/TDBD, respectively. A stepwise linear regression indicated that the proportion of extremely slow responses and visuospatial working memory abilities both significantly predicted parent ($R^2=.161, p<.001$ and $R^2=.071, p=.001$, respectively) and teacher ($R^2=.152, p<.001$ and $R^2=.064, p=.002$, respectively) ratings of inattention. Sobel’s tests of mediation
showed that the direct pathway of very preterm birth on parent and teacher ratings of inattention became non-significant after controlling for the effects of the indirect pathway (all p’s>.08, see Table 4), indicating that the increase in attention problems of very preterm children compared to term peers was completely mediated by tau and visuospatial working memory abilities.

**Discussion**

Our study confirms that very preterm birth is associated with a medium sized increase in attention problems as reported by both parents and teacher (range $d=0.40$-$0.56$). Furthermore, we found multiple deficits in the neurocognitive functions involved in attention, including a greater proportion of extremely slow responses (tau) and poorer visuospatial working memory abilities for very preterm children compared to age-matched term peers. Importantly, our findings clearly indicate that behavioral symptoms of inattention in very preterm children are completely explained (mediated)²⁶ by these extremely slow responses and deficits in visuospatial working memory.

In contrast to the presence of attention problems in very preterm children, parents and teacher did not report more internalizing or externalizing problem behavior compared to term controls. Furthermore, reported behavior problems are similar to the ADHD inattentive subtype,²⁷ as no differences were present in reported hyperactivity/impulsivity between very preterm children and term controls. These findings are in line with the increasing amount of literature showing evidence for a prominent and central role of attention problems in very preterm children.²;³;⁵

Our findings show an increase in tau in very preterm children, whereas no differences were present in mu, illustrating that the frequently replicated finding of overall slower processing speed in very preterm children²⁸-³⁰ can be traced back to an increase in the proportion of extremely slow responses. In other words, most very preterm children are capable of making fast and adequate responses, but fail to make them continuously, ending up with a slower average response time as compared to term peers. These so-called ‘lapses of attention’ translate into short moments of attention loss, which may interfere with daily
Table 4. Results of mediation analysis for behavioral parent and teacher ratings of inattention of very preterm children

<table>
<thead>
<tr>
<th></th>
<th>Path A</th>
<th>Path B</th>
<th>Path C</th>
<th>Test of Mediation</th>
<th>Path C (adjusted for indirect path)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a (S_a) )</td>
<td>( b (S_b) )</td>
<td>( c (S_c) )</td>
<td>( Z )</td>
<td>( p )</td>
</tr>
<tr>
<td><strong>Parent</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visuospatial Working Memory</td>
<td>-0.73 (0.15)</td>
<td>&lt;.001</td>
<td>0.43 (0.09)</td>
<td>&lt;.001</td>
<td>-0.49 (0.17)</td>
</tr>
<tr>
<td>Tau</td>
<td>-65.01 (17.82)</td>
<td>&lt;.001</td>
<td>0.004 (0.001)</td>
<td>&lt;.001</td>
<td>-0.49 (0.17)</td>
</tr>
<tr>
<td><strong>Teacher</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>&lt;.001</td>
<td>-0.48 (0.16)</td>
</tr>
<tr>
<td>Tau</td>
<td>-65.01 (17.82)</td>
<td>&lt;.001</td>
<td>0.003 (0.001)</td>
<td>&lt;.001</td>
<td>-0.48 (0.16)</td>
</tr>
</tbody>
</table>

Note. Path A = Effect very preterm birth on neurocognitive functioning; Path B = Effect neurocognitive functioning on behavioral ratings of inattention; Path C = Effect very preterm birth on behavioral ratings of inattention; Path C (adjusted for indirect path) = Effect very preterm birth on behavioral ratings of inattention, adjusted for indirect path via path A and path B; \( a, b, \) and \( c \) are unstandardized path coefficients; \( S_a, S_b, \) and \( S_c \) are the standard errors of the path coefficients.

Figure 1. Model of direct and indirect effects of very preterm birth on attention problems. Besides the direct effect of very preterm birth on attention problems (Path C), an indirect pathway from very preterm birth to attention problems via neurocognitive functions involved in attention may be present (Path A and Path B combined).
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life both at home and at school in particular in situations that demand continuous concentration for a longer period of time. Furthermore, we confirm the presence of poorer visuospatial working memory skills in very preterm children, showing that these children have more difficulty maintaining visual information in mind for the task at hand than term peers. Previous studies found that slow processing speed and poorer working memory are essential factors involved in poorer executive functioning and poorer academic attainment of very preterm children at school age. These relations may be further unraveled as our results suggest a pathway from lapses of attention and poorer visuospatial working memory abilities to behavioral symptoms of inattention in very preterm children. These attention problems may subsequently be related with their poorer academic attainment.

For both lapses of attention as well as visuospatial working memory, similar outcomes have been described in ADHD. Multiple interventions have been developed to specifically address and improve the underlying neurocognitive dysfunctioning, including neurofeedback and working memory training, and both interventions effectively reduce behavior problems in children with ADHD. Interestingly, lapses of attention are related to alterations in the default attention network activation and fluctuations of the brain’s arousal system in ADHD, which are involved in maintaining concentration above a certain minimum threshold level. Furthermore, dysregulated dopaminergic and noradrenergic arousal systems may modulate visuospatial working memory processes by altering frontostriatal pathways in the brain of ADHD children. In very preterm children, the mediating role of lapses of attention and visuospatial working memory in behavioral symptoms of inattention, as well as the specific vulnerability of the striatum in hypoxic-ischemic events, may reflect a crucial involvement of the underlying brain’s arousal system. As these findings indicate a window of opportunity for interventions, future studies investigating (medical) treatment and involvement of the arousal system in attention problems of very preterm children are warranted.

This study has some limitations that need to be taken into account. First, differences in IQ capacities exist between very preterm children and their term peers which may in part explain differences on the neurocognitive tasks. However, we did not find any evidence for an impact of IQ on differences in neurocognitive task performance in the current study. Second, group sizes were relatively small in this study. Nevertheless, power was sufficient to
detect small to medium-sized differences between very preterm children and term peers, as calculated using G-power software.\(^4\) Third, we only included term peers free of behavioral and academic difficulties, whereas a non-selected group of peers might have led to different results. Taken together, future studies should be encouraged to use a larger, IQ-stratified sample, providing the opportunity to explore the impact of various perinatal characteristics, infections, and behavioral abnormalities (i.e. autism, ADHD) on neurocognitive abilities mediating attention problems in very preterm children.

This study showed that very preterm birth is specifically associated with an increase in attention problems as compared to term peers at school age. Furthermore, we clarified the nature of attention problems in very preterm children, showing that lapses of attention and visuospatial working memory abilities fully account for these attention problems. Our findings in very preterm children are similar to those obtained in children with ADHD, suggesting that treatments effective in ADHD might also effectively reduce attention problems in very preterm children.

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