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Attentional problems in children born very preterm or with extremely low birth weight at 7–9 years

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Abstract

Behavioral rating scales and tests of attention were used to study attentional problems in children born very preterm (≤27 weeks gestation) or with extremely low birth weight (ELBW; ≤1000 g). Psychological tests of attention (viz., Digits and Spatial Span Forward, Visual Attention from the NEPSY, Trail Making Test B, and Stroop Color and Word Test) were administered to 45 children born very preterm/ELBW and 49 full-term controls, aged 7–9 years of age. Behavioral ratings on an ADHD scale were provided by parents and teachers on inattentive and hyperactive–impulsive symptoms. Children born very preterm/ELBW were found to perform significantly more poorly on Spatial Span Forward, Visual Attention, and Trail Making B than controls. Group differences were also found on parents' ratings on inattentive and total symptoms. Finally, measures of psychological tests of attention were found to be significant predictors of parents' and teachers' ratings of symptoms.

Keywords: Attention; ADHD; Children; ELBW; Preterm

1. Introduction

Infants born very preterm or with extremely low birth weight (ELBW) have been found to have increased risks for health and developmental problems (Wood, Marlow, Costeloe, Gibson, & Wilkinson, 2000). In addition, cognitive and behavioral problems are commonly reported in these children when they reach school age (Taylor, Klein, & Hack, 2000). Attentional problems are one of the most common and persistent problems identified by their parents and teachers. Two approaches have been used to document the nature and extent of attentional problems in this group of children. The first involves comparing ratings of parents or teachers of term/normal birth weight and very preterm/ELBW children on behavioral symptoms of attention (e.g., cannot sit still, restless, daydreams, stares blankly). The second entails the administration of psychological tests of attention to compare the performance of the two groups of children.

In the literature, more studies have been conducted using the first approach. In one study, Szatmari, Saigal, Rosenbaum, and Campbell (1993) used the Child Behavior Checklist (CBCL) and DSM-III criteria to study three

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types of problems (viz., attention–deficit hyperactivity disorder (ADHD), conduct disorder, and emotional disorder). They found that parents of a group of 129 7–8-year-old ELBW children (501–1000 g) were more likely than parents of a group of 145 normal birth weight controls to report behavioral symptoms associated with ADHD than the other two types of problems. In another study, Taylor, Hack, and Klein (1998) asked parents and teachers to rate 68 children with ELBW (<750 g), 65 children with birth weights between 750 and 1499 g, and 61 term controls on a number of measures. They found that children with ELBW were rated by teachers to have significantly more attentional problems on the CBCL than the term controls.

In a study that involved four large prospective cohorts of preterm children from the USA, Canada, Germany, and the Netherlands, Hille et al. (2001) asked parents and teachers of 408 children with ELBW (<1000 g) and controls to use the CBCL to rate the children. They found significant differences between all four groups of ELBW children and their respective controls on the attentional problem scale of the CBCL. In a meta-analysis of studies spanning more than 20 years (1980–2001), Bhutta, Cleves, Casey, Cradock, and Anand (2002) demonstrated preterm birth to be associated with increased risk for ADHD at school age compared with term-born controls.

Although it is apparent from studies that used questionnaires or rating scales that children born very preterm/ELBW were more likely to be rated by their parents or teachers as showing attentional problems, most of these studies did not report their findings in terms of DSM-IV subtypes such as inattentive and hyperactive–impulsive (APA, 1994). One exception to this was conducted by Taylor et al. (1998) that used the attention problem scale of the CBCL and the Conner's Hyperactive Index and found that children with ELBW were rated by teachers to have inattentive rather than hyperactive–impulsive problems. More studies, therefore, are needed to clarify if the problem shown by children born very preterm/ELBW is inattentive or hyperactive–impulsive in nature (or both). To do so, it is important to use questionnaires or rating scales that have items and scales for parents or teachers to rate these two types of symptoms adequately and independently. Clarification of this issue may lead to better management and treatment of attentional problems in these children.

Comparatively, fewer studies have used psychological tests of attention to compare performance of children born very preterm/ELBW and controls. Breslau, Chilcoat, DelDotto, Andreski, and Brown (1996) used two tests (viz., Underlining Test and Continuous Performance Test) to measure two aspects of attention (viz., focused and sustained) along with a battery of other neuropsychological functions (viz., memory, language, spatial skills, fine motor coordination, and tactile perception) to compare 6-year-old children who were born with LBW (<2500 g) to normal birth weight children. They found that children in the LBW group scored significantly lower on focused attention.

In a study reviewed earlier, Taylor et al. (1998) compared the performance of their three groups of children on three attentional skills (viz., sustained attention, rapid naming and set shifting, and focused attention) using a computerised Continuous Performance Test, the Contingency Naming Test, and the Underlining Test. They found that children with ELBW performed significantly more poorly than the controls on sustained attention and rapid naming and set shifting. In a subsequent study, Taylor, Minich, Klein, and Hack (2004) reported that children with ELBW were also impaired on focused attention as measured by the Verbal Cancellation Test.

It is interesting to note that children born very preterm/ELBW showed impaired performance on attentional processes as measured by psychological tests. Nevertheless, some of the tests used in the studies reviewed are not commonly used in clinical practice. More importantly, previous studies have not compared the performance of children born very preterm/ELBW and controls on some processes (e.g., encoding and selective attention) that have been identified as important components of attention in children (e.g., Baron, 2004; Kelly, 2000; Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991; Shapiro, Morris, Morris, Flowers, & Jones, 1998). Therefore, it is important to find out if this group of children are also impaired on these other tests and processes.

Among the studies reviewed, not many have examined the relationships between behavioral ratings and performance on tests of attention. Although children born very preterm/ELBW have been found to have problems using both approaches, significant relationships between ratings on the behavioral scales and performance on psychological tests should not be assumed. Indeed, in the ADHD literature, behavioral ratings have not been found to correlate highly with performance on attention tests (Barkley, 1991). In the 1998 study reviewed earlier, Taylor et al. conducted one of the few studies that examined the relationship between behavioral ratings and psychological test performance in children born very preterm/ELBW. They found that measures of rapid naming and set shifting, focused and sustained attention to correlate significantly with one or more of the parents' and teachers' ratings on the CBCL attention scale and Conner's Hyperactivity Index. Although Taylor et al.'s results are interesting, they should be considered preliminary and more studies are needed to provide further support for these relationships.

The general aim of this study was to extend our understanding of attentional problems in children born very preterm/ELBW by using both behavioral rating scales and psychological tests. Specifically it aimed to (1) clarify if this group of children are more likely to be rated by parents and teachers as showing inattentive or hyperactive–impulsive symptoms or both, using a rating scale based on DSM-IV diagnostic criteria; (2) ascertain if this group of children performed significantly more poorly on tests of attention that are commonly used and tests that measure processes (viz., encoding and selective attention) that have not previously been studied; and (3) examine if performance on attention tests are related to behavioral ratings in this group of children.

2. Methods

2.1. Participants

2.1.1. Very preterm/ELBW

The criteria used to identify potential participants from the database of the Growth and Development Unit at Mater Children's Hospital, Brisbane, Australia were: (1) 7–9 years old at the time of testing; (2) gestational period ≤27 weeks or birth weight ≤1000 g; (3) resided within the Brisbane, Gold, and Sunshine Coast regions; (4) attended main stream school; (5) on previous assessment at 4 years old had a GQ >85 on the McCarthy Scales of Children's Ability; (6) no significant physical or neurological disabilities; (7) had recent or valid contact addresses.

Sixty children in the database fulfilled these criteria and were contacted. Parents of 45 of them (22 males and 23 females) consented for their children to take part in the study. The demographics of the 15 children whose parents did not consent were slightly different to those of the 45 who did. Although the mean maternal age of the two groups was the same (viz., 29.7 years old), there were proportionally more males among the non-participants than the participants (viz., 60% vs. 49%). Furthermore, the gestational age and birth weights of the non-participants were higher than those of the participants (i.e., 27.9 weeks vs. 26.44 weeks and 934.8 g vs. 838.24 g).

Among the 45 participants, 26 were born both very preterm (≤27 weeks) and ELBW (≤1000 g), 6 were very preterm only, and 13 were ELBW only. Two of the children were on medication for controlling ADHD symptoms, and were asked to be taken off this for the day of the testing session so as to not mask effects of attentional problems through medicative control. Apart from one child of Indian origin, all the other participants were Caucasian. No children had hearing impairments and children with vision problems wore glasses to correct for this. Demographic variables of this group of 45 participants are summarised in Table 1.

2.1.2. Controls

The control group comprised 49 children (25 males and 24 females) who were born with 37 or more weeks of gestation or with birth weights equal to or greater than 2500 g. All of these children were Caucasian. Similar to participants in the very preterm/ELBW group, children in the control group were 7–9 years old at the time of testing, had no significant physical or neurological disabilities, and attended mainstream schools. Children in this group were recruited from the general community in response to requests to take part in the study. None of the children in the control group were taking ADHD medication or were diagnosed with psychiatric illnesses and no children suffered hearing impairments or had uncorrected vision problems.

As expected, the two groups of participants differed significantly on gestational age and birth weight (see Table 1) but they did not differ significantly in regards to gender ($\chi^2(1) = 0.04$, $p > 0.05$), age, or year level in school.

Table 1
Demographics for the very preterm/ELBW and control groups

	Very preterm/ELBW		Controls		t (92)	p	Cohen's d
	M	S.D.	M	S.D.			
Age at time of testing (months)	99.91	11.37	98.93	10.61	0.43	0.333	0.09
Birth weight (g)	838.24	151.70	3577.84	516.47	−34.24	0.000	7.20
Gestation period (weeks)	26.44	1.88	39.86	1.49	−38.56	0.000	7.91
Grade at school	2.71	1.06	2.88	0.90	−0.82	0.207	0.17

2.2. Measures

2.2.1. Digits and Spatial Span Forward

In this study, the Digits Forward subtest from the Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler, 1991) and the Spatial Span Forward subtest from the WISC-III as a Process Instrument (WISC-III PI; Kaplan, Fein, Kramer, Delis, & Morris, 1999) were used to assess attention span. In Digits Forward, the child is read a sequence of numbers and asked to repeat them after the examiner finishes. The sequence becomes progressively longer as the child correctly repeats the sequence. When two consecutive trials of the same length are incorrectly given, the test finishes and the total score is the sum of all trials passed. Spatial Span Forward is similarly administered. However, the child taps a sequence on nine randomly affixed blocks, in the same order as shown by the administrator. This allowed measurement of both aurally and visually presented information. Measures obtained were raw scores for total Digits Forward and total Spatial Span Forward. Span tests are commonly used to assess attention in children (Baron, 2004) and they have been found in factor-analytic studies involving children to load on a component called encoding (e.g., Kelly, 2000; Mirsky et al., 1991).

2.2.2. Visual Attention subtest of the NEPSY

This subtest of the NEPSY measures "the speed and accuracy with which a child is able to focus selectively on and maintain attention to visual targets within an array" (Korkman, Kirk, & Kemp, 1997, p. 119). According to Anderson, Northam, Hendy, and Wrennall (2001), it is a commonly used test of focused attention. There are two tasks in this subtest. The first is a simple search in which the child must cross out all of the cats in a random array of different objects. The second is more complex, with two target faces identified at the top of the page and the child having to cross out the same ones in the array of other, similar looking faces below. The score obtained was a raw score that combined both tasks and factored in speed and accuracy.

2.2.3. Trail Making Test part B (TMT B; Reitan & Wolfson, 1993)

This is a widely used and easily administered test of attention for children (Baron, 2004). This timed test requires the participant to connect circles of alternating numbers and letters in ascending order, as quickly as possible. The measure obtained from this test was the total time in seconds it took to complete the task. The TMT B has been found in factor analytic studies involving children to load on a component called focused attention (e.g., Kelly, 2000; Mirsky et al., 1991).

2.2.4. Stroop Color Word Test (Stroop)

This is another commonly used test of attention for children (Anderson et al., 2001; Baron, 2004). Golden's (1978) version of the Stroop was used in this study and it uses three colors (red, green, and blue) and has three trials (word, color, and color-word). For the word trial, the names of the three colors are printed in black, in five columns of 20 words. The child reads out loud the words, as quickly as they can in 45 s. For the color trial, the words are replaced with four Xs printed in one of the three colors and the child is asked to read out loud the color they see printed there. The color-word trial has the three color words printed in a contrary color (i.e., the word blue is printed in the color red). The child has to name the color of the ink that the word is written in and not read the word. The score obtained for this test was a ratio score obtained by dividing the number of items read in the color-word trial by the number of items read in the color trial (Graf, Utte, & Tuokko, 1995). This test is considered to measure the ability to respond selectively to competing stimulus information or selective attention (Cooley & Morris, 1990).

2.2.5. Ratings of attention

The ADHD Rating Scale-IV developed by DuPaul, Power, Anastopoulos, and Reid (1998) was used to provide ratings of attention for the two groups of participants. This scale was developed based on the DSM-IV criteria for ADHD and comprises 18 items with a 4-point Likert response scale (0, never or rarely; 1, sometimes; 2, often; 3, very often). Teachers were asked to rate children based on their behaviour in the classroom over the past 6 months and parents were asked to consider the child's home behaviour for each of the items over the past 6 months. The scores obtained were the two subscale scores of inattentive and hyperactive–impulsive symptoms (nine items each) and a total score provided by a parent and a teacher.

2.3. Procedure

All children were tested individually at the Psychology Clinic of Griffith University. While their children were being tested, parents were asked to complete the ADHD Rating Scale-IV, the Conners' Parent Ratings Scale – Revised (results of this scale not used in this study) as well as some demographic information. Parents were also given the teacher's questionnaire along with an information sheet, consent form and replied paid envelope and asked to give the package to their child's school teacher.

The attention tests were part of a larger battery of tests administered to the children. All tests were administered in the same order and took approximately 1½–2 h, with breaks encouraged when needed (either on request of child or if they seemed tired or restless). In order, tests administered were: the Visual Attention subtest of the NEPSY; the Wechsler Individual Achievement Test-Second Edition-Abbreviated; Digit Span Forward and Backward; the Stroop, the Controlled Oral Word Association Test, Spatial Span Forward and Backward; TMT A and B; and the Tower of London (four discs).

3. Results

SPSS for Windows (version 14) was used to analyze the data. Given that significant correlations were found between age and attention test performance, independent group *t*-tests with age as a covariate were used to compare the performance of the two participant groups on these tests. Independent group *t*-tests were used to determine if the very preterm/ELBW and the control groups were significantly different on the ADHD Rating Scale-IV. Covariate analyses were not used for these tests because age was not found to correlate significantly with ratings. An alpha level of 0.01 was adopted for these group comparisons to control for Type 1 errors. Relationships between the rating scale and tests of attention were evaluated using hierarchical multiple regressions and an alpha level of 0.05 was adopted for these analyses.

3.1. Group differences on attention tests

Table 2 summarises the performance of the very preterm/ELBW and the control groups on the tests of attention administered. Children in the very preterm/ELBW group were found to have a significantly lower score on Spatial Span Forward ($d = 0.58$) but not on Digits Forward ($d = 0.30$) than the control group. On the Visual Attention subtest of the NEPSY, children in the very preterm/ELBW group were found to have a significantly lower score than children in the control group ($d = 0.49$). The two groups of children were found to be significantly different on TMT B. Specifically, children in the very preterm/ELBW group were found to take significantly longer times to complete this test than children in the control group ($d = 0.50$). Finally, children in the two participant groups were not found to be significantly different on the Interference score of the Stroop ($d = 0.08$).

3.2. Group differences on ADHD rating scale

For the ADHD Rating Scale-IV, 1 parent of a child in the very preterm/ELBW group, 5 teachers of children in the very preterm/ELBW group, and 10 teachers of children in the control group did not return the results. Means and

Table 2
Performance on measures of attention (adjusted means and standard deviations) for the very preterm/ELBW and control groups

Measures	Very preterm/ELBW		Controls		*t* (91)	*p*	Cohen's *d*
	M	S.D.	*M*	S.D.			
Digits Forward	7.52	1.89	8.09	1.88	−1.45	0.075	0.30
Spatial Span Forward	5.37	1.51	6.25	1.51	−2.81	0.003	0.58
Visual Attention (total)	14.48	4.64	16.75	4.63	−2.37	0.010	0.49
TMT B (s)	84.71	43.68	63.31	42.05	2.42[a]	0.009	0.50
Stroop interference (CW/C)	0.53	0.13	0.52	0.13	0.13	0.447	0.08

[a] d.f. = 84.

Table 3
Scores on ADHD Rating Scale-IV (means and standard deviations) for the very preterm/ELBW and control groups

Scale	Very preterm/ELBW		Controls		t (91)	p	Cohen's d
	M	S.D.	M	S.D.			
Inattentive (parent)	8.66	6.59	5.45	5.15	2.63	0.005	0.54
Hyperactive–impulsive (parent)	6.66	6.77	4.39	5.18	1.83	0.038	0.38
Total (parent)	15.32	12.55	9.84	9.45	2.39	0.009	0.49
Inattentive (teacher)	8.18	7.67	5.21	5.76	1.94[a]	0.028	0.44
Hyperactive–impulsive (teacher)	4.35	5.24	4.59	6.44	−0.18[a]	0.428	0.04
Total (teacher)	12.53	12.09	9.79	11.47	1.03[a]	0.154	0.24

[a] d.f. = 77.

standard deviations for the remaining children on the ADHD Rating Scale-IV are shown in Table 3. Children in the very preterm/ELBW group were rated by their parents to be significantly higher on the inattentive and total scales than children in the control group ($d = 0.54$ and 0.49). The two groups of children were not rated significantly different on the three scales by their teachers.

Scores on the ADHD Rating Scale-IV were examined to determine how many children in the very preterm/ELBW and control groups would be considered "at risk" for ADHD diagnosis (see Table 4). Raw scores were converted to percentile scores to assess risk. Scores in the 95th percentile and greater were considered "at risk". Significant differences were found between the two groups of participants based on parents' ratings on the inattentive scale ($\chi^2(1) = 5.32$, $p < 0.05$) and the total ADHD scale ($\chi^2(1) = 4.80$, $p < 0.05$), with very preterm/ELBW children being more "at risk" than the controls. On the inattentive scale, 22.7% of very preterm/ELBW children were considered "at risk" compared to 6.1% of full-term children. For the total ADHD scale, 18.2% of the very preterm/ELBW group were "at risk" compared to 4.1% of the full-term group. There were no significant differences between the groups based on parents' ratings on the hyperactive-impulsive scale and on teachers' ratings on inattentive, hyperactive–impulsive, and total scales.

3.3. Relationship between attention tests and ADHD ratings

Four hierarchical multiple regressions were conducted to evaluate the relationships between ADHD ratings by parents and teachers with scores on tests of attention. For two of the regressions, rating of inattentive and hyperactive–impulsive symptoms by parents was used as the criterion. For the other two regressions, ratings in the same two areas by teachers were used as the criterion. In all four regressions, group membership was entered first as a predictor, followed by five measures of attention tests (viz., Digits Forward, Spatial Span Forward, Visaul Attention, TMT B, and Stroop Interference). Results of these regressions are summarised in Tables 5–8.

Parents' ratings on inattentive symptoms were used as the criterion in the first regression analysis. After Step 1, with group membership in the equation, $R^2 = 0.071$, $F(1,84) = 6.379$, $p < 0.05$. Measures of tests of attention were added to the equation in Step 2. After this step, $R^2 = 0.207$, $F(6,79) = 3.430$, $p < 0.01$, and R^2 change = 0.136, F for

Table 4
Proportion and percentage of children (preterm/ELBW and controls) at risk based on parents' and teachers' ratings

Scales	Ratings			
	Parents		Teachers	
	Preterm/ELBW (%)	Controls (%)	Preterm/ELBW (%)	Controls (%)
Inattentive	10/44 (22.73)	3/49 (6.12)	0/40 (0.00)	1/39 (2.56)
Hyperactive–impulsive	4/44 (9.09)	3/49 (9.90)	0/40 (0.00)	2/39 (5.13)
Total	8/44 (18.18)	2/49 (4.08)	0/40 (0.00)	1/39 (2.56)

Table 5
Hierarchical multiple regression of group membership and measures of attention on inattentive scale (parent)

Step	Variable	Inattentive	Group	Digits Forward	Spatial Forward	Visual Attention	TMT B	Stroop	B	β	sr^2
1	Group	−0.27							−3.21*	−0.27	−0.27
2	Digits Forward	−0.22	0.13						−0.29	−0.09	−0.08
	Spatial Forward	−0.35	0.25	0.39					−1.07*	−0.29	−0.24
	Visual Attention	−0.11	0.20	0.25	0.22				0.00	0.00	0.00
	TMT B	0.00	−0.23	−0.22	−0.36	−0.22			−0.02	−0.14	−0.11
	Stroop	−0.22	−0.04	0.16	0.16	0.06	0.31		−6.06	−0.12	−0.11
	M	6.97	0.52	7.82	5.83	15.66	73.38	0.52		$R^2 = 0.21$	
	S.D.	6.10	0.50	1.99	1.65	5.18	47.56	0.12		$R = 0.46$	

* $p < 0.05$.

Table 6
Hierarchical multiple regression of group membership and measures of attention on hyperactive–impulsive scale (parent)

Step	Variable	Hyperactive	Group	Digits Forward	Spatial Forward	Visual Attention	TMT B	Stroop	B	β	sr^2
1	Group	−0.19							−2.27	−0.19	−0.19
2	Digits Forward	−0.22	0.13						−0.27	−0.09	−0.08
	Spatial Forward	−0.27	0.25	0.39					−0.62	−0.17	−0.14
	Visual Attention	−0.23	0.20	0.25	0.22				−0.18	−0.16	−0.15
	TMT B	−0.03	−0.23	−0.22	−0.36	−0.22			−0.01	−0.11	−0.09
	Stroop	−0.32	−0.04	0.16	0.16	0.06	0.31		−11.98*	−0.24	−0.21
	M	5.46	0.52	7.82	5.83	15.66	73.38	0.52		$R^2 = 0.21$	
	S.D.	6.06	0.50	1.99	1.65	5.18	47.56	0.12		$R = 0.46$	

* $p < 0.05$.

change (5,79) = 2.711, $p < 0.05$. Among the predictors, unique variance was significantly contributed by performance on Spatial Span Forward.

In the second regression analysis, parents' ratings on hyperactive-impulsive symptoms were used as the criterion. After Step 1, with group membership in the equation, $R^2 = 0.035$, $F(1,84) = 3.088$, $p > 0.05$. Measures of tests of attention were added to the equation in Step 2. After this step, $R^2 = 0.208$, $F(6,79) = 3.450$, $p < 0.01$, and R^2 change = 0.172, F for change (5,79) = 3.432, $p < 0.01$. Among the predictors, unique variance was significantly contributed by performance on the Stroop.

The criterion in the third regression analysis was teachers' ratings on inattentive symptoms. After Step 1, with group membership in the equation, $R^2 = 0.047$, $F(1,72) = 3.528$, $p > 0.05$. Measures of tests of attention were added to the equation in Step 2. After this step, $R^2 = 0.230$, $F(6,67) = 3.333$, $p < 0.01$, and R^2 change = 0.183, F for change (5,67) = 3.187, $p < 0.05$.

Table 7
Hierarchical multiple regression of group membership and measures of attention on inattentive scale (teacher)

Step	Variable	Inattentive	Group	Digits Forward	Spatial Forward	Visual Attention	TMT B	Stroop	B	β	sr^2
1	Group	−0.22							−2.98	−0.22	−0.22
2	Digits Forward	−0.30	0.15						−0.60	−0.17	−0.16
	Spatial Forward	−0.32	0.30	0.31					−0.94	−0.22	−0.19
	Visual Attention	−0.28	0.34	0.24	0.22				−.25	−0.19	−0.18
	TMT B	0.00	−0.24	−0.26	−0.35	−0.23			−0.02	−0.17	−0.14
	Stroop	−0.22	−0.05	0.12	0.19	0.02	0.30		−5.67	−0.10	−0.09
	M	6.71	0.49	7.91	5.89	15.85	75.53	0.53		$R^2 = 0.23$	
	S.D.	6.91	0.50	2.01	1.59	4.86	49.41	0.12		$R = 0.48$	

Table 8
Hierarchical multiple regression of group membership and measures of attention on hyperactive–impulsive scale (teacher)

Step	Variable	Hyperactive	Group	Digits Forward	Spatial Forward	Visual Attention	TMT B	Stroop	B	β	sr^2
1	Group	0.02							0.24	0.02	0.02
2	Digits Forward	−0.33	0.15						−0.90*	−0.31	−0.28
	Spatial Forward	−0.24	0.30	0.31					−0.76	−0.21	−0.18
	Visual Attention	0.04	0.34	0.24	0.22				0.13	0.11	0.11
	TMT B	−0.16	−0.24	−0.26	−0.36	−0.23			−0.03	−0.23	−0.19
	Stroop	−0.29	−0.05	0.12	0.16	0.02	0.30		−6.90	−0.14	−0.13
	M	4.47	0.49	7.82	7.91	15.85	75.53	0.53		$R^2 = 0.24$	
	S.D.	5.82	0.50	1.99	2.01	4.86	49.41	0.12		$R = 0.49$	

* $p < 0.05$.

In the last regression analysis, teachers' ratings on hyperactive–impulsive symptoms were used as the criterion. After Step 1, with group membership in the equation, $R^2 = 0.000$, $F(1,72) = 0.031$, $p > 0.05$. Measures of tests of attention were added to the equation in Step 2. After this step, $R^2 = 0.236$, $F(6,67) = 3.449$, $p < 0.01$, and R^2 change = 0.236, F for change $(5,67) = 4.131$, $p < 0.01$. Among the predictors, unique variance was significantly contributed by performance on Digits Forward.

4. Discussion

This study aimed to extend our understanding of attentional problems in children born very preterm/ELBW by using an ADHD rating scale and psychological tests. Children born very preterm/ELBW were found to perform significantly more poorly than controls on a test that measures attention span or encoding (viz., Spatial Span Forward) and two tests that measure the ability to focus and maintain attention to visual targets or focused attention (viz., Visual Attention subtest from the NEPSY and TMT B). While children born very preterm/ELBW have been found in previous studies (e.g., Breslau et al., 1996; Taylor et al., 2004) to perform significantly more poorly on tests of focused attention than control children, impairment of this group of children on a test of attention span or encoding has not been reported previously. It should also be noted that the two tests of focused attention included in this study are commonly used tests that have not been administered in previous studies.

On the ADHD Rating Scale-IV, children born very preterm/ELBW were rated by parents to have more symptoms on the inattentive and total scales than the controls. Overall, these findings are similar to those reported in previous studies (e.g., Szatmari et al., 1993; Taylor et al., 1998) in that children born very preterm/ELBW were reported by their parents and teachers as showing more attentional symptoms than controls. As mentioned in Section 1, however, most of these studies did not ask parents and teachers to rate the children according to the DSM-IV ADHD diagnostic criteria of inattentive and hyperactive–impulsive symptoms separately. The finding that this group of children was rated by parents to have more inattentive symptoms was further supported by the fact that children born very preterm/ELBW were found to be significantly more at risk than controls for being diagnosed as the inattentive but not the hyperactive–impulsive subtype of ADHD. Although ratings provided by teachers in this study were not found to be significantly different between the two groups of participants, this finding should be interpreted with caution. This could be due to inadequate power for the teacher rating analyses resulting from a larger number of non-returns of rating scales. While 1 parent of a child in the very preterm/ELBW group did not return the ADHD Rating Scale-IV, 5 teachers of children in the very preterm/ELBW group and 10 teachers of children in the control group did not do so. More research, therefore, is needed to clarify if teachers rate these children to have more inattentive symptoms than controls.

Although children born very preterm/ELBW were found to have significantly lower scores on tests of attention and rating scales, it does not necessarily follow that scores obtained using these two approaches will correlate significantly. As mentioned in Section 1, this relationship has not been reliability demonstrated in the ADHD literature. Four multiple regressions were conducted to ascertain if these relationships exist. Results suggest that performance of the children in the very preterm/ELBW and control groups on the tests of attention significantly added to the prediction of scores by parents and teachers on the ADHD-IV Rating Scale after the effect of group membership was controlled for. As

mentioned in Section 1, only one study (viz., Taylor et al., 1998) has been conducted to examine such relationships and the results found in that study are similar to those found in this study. The demonstration of such relationships provides converging evidence to support the utility of the two common approaches used to study and assess attentional problems in this group of children. Results also suggest that performance on some tests of attention significantly contributed unique variance to the prediction of ratings on ADHD scales. While this finding is interesting, specific relationships between rating scales and test performance should be interpreted with caution given the correlations between tests of attention. To further clarify these relationships, future studies that use a larger sample size than this study are needed.

There are a number of limitations to the study. First, the sample size is relatively small. Although the number of clinical and control participants are adequate for the univariate statistics conducted, a larger sample size for both groups of participants would be better for the regression analyses carried out. This is especially true for the analyses that involved teachers' ratings where there were quite a number of non-returns. Second, the participants in the very preterm/ELBW group included in the study can be considered quite high functioning. All of them attended mainstream schools, had a GQ >85 at 4 years old, and did not have any serious neurological problems. Consequently, results of the present study may not be generalisable to children who were born preterm/ELBW but at a lower level of functioning. Third, one of the more common attention tests namely, the Continuous Performance Test, was not included in the study to assess sustained attention. Although children born very preterm/ELBW have been found in previous studies to be impaired on sustained attention using this test, failure to include this test did not allow the relationship between this test and ratings of inattention and hyperactive–impulsive symptoms to be evaluated. Fourth, this study did not collect information for some variables (viz., SES for the two groups of children, details of neurological findings for children in the very preterm/ELBW group) that are known to affect behavioral and cognitive outcomes in children born very preterm/ELBW. Reporting details of these variables and controlling for their effects is important for strengthening the validity of findings of this study. Fifth, all but one of the participants of this study were Caucasians. Replication using participants from other ethnic backgrounds is necessary before the results of this study can be generalized.

To conclude, findings of this study have extended our understanding of the nature and extent of attentional problems in children born very preterm/ELBW. By including commonly used tests of attention and by assessing attentional processes that have not been investigated in previous studies, results of the present study provide further support that these children show attentional problems in middle childhood. By using an instrument that separates attention symptoms into the DSM-IV ADHD diagnostic criteria of inattentive and hyperactive–impulsive symptoms, this study also allowed parents and teachers to rate these two sets of symptoms separately and independently for these children. Finally, by showing that ratings by parents and teachers on inattention and hyperactive–impulsive symptoms can be significantly predicted by performances on tests of attentional processes, the present study has provided converging evidence to support the utility of these two approaches in assessing and understanding attentional problems in this group of children.

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