A Longitudinal Study of Reading Skills Among Very-Low-Birthweight Children: Is There a Catch-up?

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Objective To examine the development of reading skills among very-low-birthweight (VLBW) children and to what extent reading difficulties at 9 years of age persist unchanged, are attenuated, or are enhanced at 15 years of age. Methods Fifty-six VLBW and 52 normal birthweight (NBW) children were assessed on word decoding, word recognition, and reading comprehension at 9 and 15 years of age. Results VLBW children showed deficits in reading skill at 9 years of age, while most differences obtained at 15 years of age did not reach significance. VLBW children improved their reading comprehension between 9 and 15 years of age more than NBW children, and when controlling for individual differences in IQ, VLBW children improved both their reading comprehension and word-recognition skill. Conclusion The results suggest that VLBW children display positive changes over time in reading skills.

Key words longitudinal study; low-birthweight; reading skills.

Much research has shown that very-low-birthweight (VLBW) children (<1,500 g) from birth through adulthood are at risk for impaired developmental outcomes in the areas of cognition, motor skills, behavior, and language (Hack, Klein, & Taylor, 1995; Robinson & Gonzalez, 1999; Saigal, 2000; Taylor, Klein, & Hack, 2000). Impaired developmental outcome is also repeatedly found among neurologically intact VLBW children (Hack et al., 2002; Saigal, Hoult, Steiner, Stoskopf, & Rosenbaum, 2000). These differences between VLBW and normal birthweight (NBW) children have been replicated in younger VLBW cohorts, middle-school-aged VLBW children, and for VLBW children at adulthood ages (Saigal, 2000; Taylor, Klein, Minich, & Hack, 2000). The impression that differences between VLBW and NBW children at all ages up to adulthood remain stable over time is confirmed in a few longitudinal studies of VLBW children (Breslau, Paneth, & Lucia, 2004; Rickards, Ryan, & Kitchen, 1988; Saigal et al., 2000; Taylor, Klein, Minich, & Hack, 2000b). In fact, these studies suggest an increase in gross motor deficits, visual impairment, global developmental and cognitive delay, behavioral problems, and general academic achievement. However, Monset-Couchard, de Bethmann, and Kastler (1996, 2002) have shown that the number of premature children reported with language delay decreased over time, indicating some catch-up on language skills among VLBW children. This finding received further support in a recent study by Ment et al. (2003) demonstrating some catch-up among VLBW children in vocabulary development between 3 and 8 years of age. A potential for positive long-term...
change in language skills in VLBW children is in accordance with research indicating that language is less compromised than nonverbal cognition and in research reporting a higher risk for learning disabilities in math compared to reading (Johnson & Breslau, 2000; Klein, Hack, & Breslau, 1989; Marlow, Roberts, & Cooke, 1993; Saigal et al., 2000; Taylor, Hack, Klein, & Schatschneider, 1995). Thus, even if most longitudinal studies of VLBW children indicate that deficits in cognitive development remain or even worsen up to adolescence, there might be some potential for a catch-up in reading skills.

It is of fundamental importance for all school-age children to develop skills in reading. Literacy skills are highly valued by society and are the most important key to success in education. Most studies focusing on reading achievement have reported deficits in reading skills among VLBW children compared to term controls. This finding seems to apply to all components of reading such as word decoding, word recognition, and reading comprehension, and across all ages (Botting, Powls, Cooke, & Marlow, 1998; Breslau, Johnson, & Lucia, 2001; Hack et al., 2002; Klein et al., 1989; Marlow et al., 1993; O’Keeffe, Callaghan, Williams, Najman, & Bor, 2003; Samuelsson et al., 1999; Samuelsson, Finnstrom, Leijon, & Mård, 2000). However, there is only one study that has examined changes in reading skills over time (Saigal et al., 2000). In their study, extremely low-birthweight (ELBW) children (<1,000 g) show some, but not significant, improvement in reading between ages 8 and 10. Term controls exhibited significantly more improvement during the same period, indicating no real catch-up in reading skills among ELBW children.

In this study, we present results from 56 VLBW children and 52 NBW children who are participating in a longitudinal study of neurological, cognitive, language, and behavioral development at 9 and 15 years of age. The present report addresses the development of reading skills among VLBW children, particularly whether deficits in reading obtained at 9 years of age persist unchanged, are attenuated or are enhanced at 15 years of age. Three primary questions were addressed. Our first main question was how VLBW and NBW children compare on reading skills at 9 and 15 years of age. The second main question was whether any identified differences in reading skills persist when VLBW children with morphological insults are excluded. Finally, our third main question concerned the extent to which differences in reading skill at 9 years of age are stable over time.

Method
Participants
The original sample of VLBW children consisted of 86 survivors with a birthweight less than 1,500 g (mean gestational age was 30.6 weeks) who were born between February 1, 1987, and April 30, 1988 and treated at five hospitals in the Southeast region of Sweden. Seventy of these children (81.4%) returned to a follow-up study at 9 years of age and 61 VLBW children (71%) were assessed at 15 years of age. The main reasons for this dropout at 9 and 15 years of age were relocation and lack of interest. The original sample of 86 NBW children was selected as follows: for each VLBW child who survived the first 48 hr, one control child born in the same hospital at the same time with the same sex and parity was chosen. Seventy-two of these control children (83.7%) returned to the assessment at 9 years of age, and 56 (65%) were enrolled at 15 years of age. Relocation and lack of interest explained this drop out. A few children not taking part in the study at 9 years of age returned to the assessment at 15 years of age, and thus, there were 56 VLBW (65%) and 52 NBW (60%) children participating at both test occasions.

Comparisons between the original sample (n = 86) and the VLBW groups at 9 and 15 years on neonatal characteristics and sociodemographic factors indicated that the VLBW samples at 9 and 15 years were representative with the original population of VLBW children. There were no differences in birthweight, gestational age, Apgar score, frequency of mechanical ventilation and intraventricular hemorrhage, or in maternal age, mother’s and father’s education, and the number of siblings. In addition, there were no differences between VLBW and NBW on sex distribution, maternal age, mother’s education, parity, and number of siblings at 9 and 15 years of age.

Among VLBW children, 16 children showed brain insults identified by MRI at 15 years of age. On the basis of this information, two groups of VLBW were used for comparisons. These groups were the complete sample of VLBW children tested at 9 and 15 years of age and morphologically intact VLBW children (i.e., with those 16 VLBW children with brain insults excluded).

Sample characteristics for VLBW and NBW children assessed at both 9 and 15 years of age are described in Table I. All VLBW and NBW children did not differ significantly in gender, maternal age, mother’s education, primipara, and number of siblings. However, there was a significant difference in father’s education ($\chi^2 = 6.39, p < .05$), indicating that fathers to VLBW children had lower education compared to fathers in the NBW sample.
Comparisons between VLBW children with abnormal MRI (n = 16) compared to the morphologically intact (n = 44) indicated no significant differences in birthweight, gestational age, Apgar score, intraventricular hemorrhage, or in maternal age, mother’s and father’s education, and the number of siblings. However, there was a significant difference in the frequency of mechanical ventilation such that VLBW children with abnormal MRI had been in need of mechanical ventilation neonatally more frequently than morphologically intact VLBW children (χ² = 7.20, p < .05).

**Reliability Estimates for Measures of Reading Skills**

Cronbach’s α estimates of reliability based on internal consistency for each measure of reading skills are based on item-level analyses across both VLBW and NBW children. For reading tests using time restrictions, Cronbach’s α estimates were calculated based on the number of items completed by 75% of the total sample. Also, estimates of reliability for tests used at 9 years of age were based on item-by-item accuracy, while estimates were based on reading times for tests at 15 years of age, except for orthographic reading and reading comprehension. The reason for using reading times at 15 years of age was that most tests reached ceiling on accuracy.

### Tests of Cognitive Function and Reading Skills at 9 and 15 Years of Age

The general approach in this study was to explore the interaction between group (VLBW vs. NBW children) and time (9 vs. 15 years of age) on similar tests of reading skills. This approach should be the ideal way of studying a potential catch-up in reading skills among VLBW children. The main challenges with this approach are the age difference (i.e., at least 6 years between test occasions) and the fact that it is impossible to use identical tests on both occasions. However, the overlap between most measures used at 9 and 15 years of age was considerable. Word decoding was measured by a nonword-reading test and a test of phonological choice on both test occasions (Olson, Kliegl, Davidson, & Foltz, 1985; Rack, Snowling, & Olson, 1992). Similarly, word recognition was assessed using a test of orthographic choice (see Olson et al., 1985) and a test of orthographic reading at both times (cf. Høien & Lundberg, 2000). Lexical decision was used as a third test of word reading at 9 years of age, whereas a word-reading task was used at 15 years of age. However, both tasks force the children to read single words, presented one at a time, as quick as possible, and it should be reasonable to argue for a high degree of overlap between the tests. The tests of reading comprehension at 9 and 15 years of age were almost identical.

### Intellectual Abilities

Raven’s Standard Progressive Matrices (Raven, Court, & Raven, 1983) was used as an index of intelligence at 9 years of age. Intellectual ability at 15 years of age was assessed using Wechsler Intelligence Scale for Children (WISC-III) (Wechsler, 1991).

### Tests of Word-Decoding Skill at 9 Years of Age

Two tests were employed to assess word-decoding skill at 9 years of age: a nonword-reading task and a phonological choice test. These tests are designed to force children to read using phonological decoding. In the nonword-reading task, the child was required to read aloud 48 pronounceable nonwords, three, five, or seven letters in length. The nonwords were presented on a computer screen, one at a time, and the number of correctly pronounced nonwords was taken as a measure of word decoding (Cronbach’s α = .89).

In the phonological choice test, the children viewed pairs of nonwords and were asked to indicate, as quickly as possible, which nonword sounded exactly like a real word when pronounced. The number of correct nonwords chosen within 2 min was taken as a measure of word-decoding skill (Cronbach’s α = .77).
Tests of Word-Decoding Skill at 15 Years of Age
Similar tests of word-decoding skill were used at 15 years of age. In the nonword-reading test, the participants were instructed to read 48 nonwords, three, five, or seven letters in length. The nonwords were presented one at a time on a computer screen, and both time and accuracy were recorded. Analyses were based on the number of correctly read nonwords per minute (Cronbach’s $\alpha = .98$).

In the phonological choice test, 36 pairs of nonwords were presented one at a time on a computer screen, and the task was to decide which words sounded exactly like a real word. Again, analyses were based on the number of correctly identified words per minute (Cronbach’s $\alpha = .94$).

Tests of Word Recognition at 9 Years of Age
Word recognition was measured by three different tasks at 9 years of age. The first was a lexical decision task. In this task, 102 words and nonwords are presented one at a time on a computer screen, and the child is required to decide as quickly as possible whether each stimulus is a word or not. The number of correctly recognized words in 1 min (both real words and nonwords) was recorded as the dependent variable (Cronbach’s $\alpha = .98$).

The second test was an orthographic choice task. In this test, the children viewed pairs of words (there were 25 pairs of words on each page in the booklet) and were instructed to indicate, as quickly as possible, which word was spelled correctly. The other word in each pair was misspelled but phonologically identical to the correctly spelled word when pronounced. The number of words correctly identified within 2 min was taken as a second measure of word recognition (Cronbach’s $\alpha = .82$).

In the third task measuring word recognition, denoted orthographic reading, children were asked to read 60 words presented on a computer screen, one at a time, for very brief exposure periods (400 ms). The presentation rate was determined by the experimenter. The number of correctly read words was used as a measure of word recognition (Cronbach’s $\alpha = .97$).

Tests of Word Recognition at 15 Years of Age
Three measures of word recognition were also used at 15 years of age. Two tests were identical with the measures used at 9 years of age, that is, orthographic choice and orthographic reading (Cronbach’s $\alpha$ was .98 and .97, respectively). The third task measuring word-reading ability was assumed to correspond to the lexical decision test used at 9 years. In the word-reading test, the children were asked to read aloud 48 Swedish words. The words varied in length between three and seven letters and also in complexity regarding spelling-sound correspondences (cf. KOAS, a test battery designed by Høien & Lundberg, 2000). All words were presented on a computer screen one at a time, and both accuracy and reading times were recorded. The number of correctly read words per minute was used as a measure of word recognition (Cronbach’s $\alpha = .98$).

Reading Comprehension at 9 Years of Age
The reading comprehension task used at 9 years of age was made up by 12 short passages followed by one to three multiple-choice questions (Malmquist, 1977). In all, there were 36 questions (Cronbach’s $\alpha = .80$).

Reading Comprehension at 15 Years of Age
At 15 years of age, subtests from a standardized reading comprehension test developed by the International Association for the Evaluation of Educational Achievement were administered (Elley, 1992). This task included six different text passages, each followed by four to six multiple-choice questions. In all, there were 30 questions (Cronbach’s $\alpha = .83$).

Cerebral MRI
At 15 years of age, 60 VLBW children were investigated using cerebral MRI. The findings included normal outcomes, periventricular white matter damage of various types and degrees of severity, and one child with congenital malformation (O. Flodmark, personal communication, May 2005). All these lesions represent damage to the brain occurring prenatally or in close time relation to birth. Among those VLBW children participating at both 9 and 15 years of age, there were 16 children with MRI reports at 15 years of age classified as abnormal.

Procedure
The reason for testing VLBW and NBW children at 9 years of age (i.e., grade 3) was to make sure that all children had received at least 2 years of formal reading instructions. The follow-up testing at 15 years of age (i.e., grade 9) was chosen to minimize the dropout rate because this is their last year in compulsory school in Sweden. Grade 9 was also chosen to optimize schooling time between test sessions. Great effort was made to track the samples of VLBW and NBW children during this period of 15 years. Both samples have been enrolled in follow-up testing at 18 months, 4, 9, and 12 years of age. Each family has received reports describing main findings from a series of publications, and the children have received birthday and Christmas cards throughout the project.
Assessments were carried out by psychologists, all of whom were blind to the results of assessments conducted before 9 years of age, the performance at 9 years of age, and also with respect to birth status. The psychologists administered all tests individually in the same order. The time needed to complete the reading tests at 9 and 15 years of age was about 1 hr.

**Analyses**

Differences between VLBW and NBW children on reading skills at 9 and 15 years of age were examined using $t$-tests for independent samples. The magnitude of the mean differences at 9 and 15 years of age was calculated using Cohen’s $d$ (Cohen, 1988). Cohen’s $d$ can be interpreted in terms of the percentage of nonoverlap in two distributions. An effect size of .20 indicates an overlap of 85.3% in the distribution of two samples and is considered to be rather small. An effect size of .50 is considered to be moderate, with a 67% overlap in the distribution of two samples. To analyze changes in reading skills between 9 and 15 years of age in the VLBW sample, standardization was performed on raw scores on reading tests used at 9 and 15 years of age. ANOVA was used to provide information about potential catch-up in reading, with group as a between-factor variable and time as a within-subject factor. To adjust for differences in intelligence between VLBW and NBW children, ANOVA was also performed on IQ-adjusted reading scores.

**Results**

**Mean Comparisons Between VLBW and NBW Children at 9 Years of Age**

Table II presents the results on reading skills for all 70 VLBW children and the morphologically intact VLBW subgroup ($n = 54$) compared with the NBW children ($n = 72$) at 9 years of age. The total VLBW sample demonstrated significantly poorer scores on all measures compared to NBW children. Cohen’s $d$ estimations varied between .36 and .57, with a mean effect size of .46. When the 16 children with morphological insults were excluded, the mean group performance for the VLBW group was improved for each reading measure. However, the differences between VLBW children without morphological insults and NBW children remained significant for nonword reading, orthographic reading, and reading comprehension. In addition, differences on lexical decision and orthographic choice were close to significant, indicating that most components of reading skill were impaired among morphologically intact VLBW children at 9 years of age.

The findings presented in Table II also demonstrate that the presence of cerebral insults indicated by morphologically abnormal MRI scans does not seem to have an impact on reading performance. Instead, reading performances assessed for all VLBW children are almost identical with the performances displayed by morphologically intact VLBW ($t$-values are all below .51). These findings suggest that variability in the number and severity of reading deficits is not simply attributable to a small number of VLBW children with evidence of brain injury. Finally, most differences between both subgroups of VLBW and NBW children were significant following a Bonferroni correction. However, differences on phonological awareness and orthographic choice between all VLBW and NBW children were not significant when adjusting for multiple comparisons.

**Mean Comparisons Between VLBW and NBW Children at 15 Years of Age**

Means and standard deviations for measures of reading skills at 15 years of age are presented in Table III. Again,
there are only marginal differences in reading skills for the entire group of VLBW children and the remaining 44 VLBW children without morphological abnormalities (t-values are all below 1.61). For reading comprehension, the performance is even lower in the subgroup of morphologically intact VLBW children compared to the entire sample of VLBW children. It is a trend that VLBW children perform below NBW children on most aspects of reading skills. However, the differences between the entire VLBW sample and NBW children for most components of reading skills, except for orthographic choice, are not statistically significant. Note that the difference between all VLBW and NBW children on orthographic choice remained significant following a Bonferroni correction. Cohen’s $d$ estimations varied between .24 and .59, with a mean effect size of .35, indicating that the absence of significant differences was not simply due to smaller samples of VLBW and NBW children at 15 years of age. The findings when comparing morphologically intact VLBW and NBW children further reinforce the impression that there is a decrease in differences between VLBW and NBW children on reading.

**Changes in Reading Skills Between 9 and 15 Years of Age for VLBW Children**

The findings of significant differences between VLBW and NBW children in reading skills at 9 years of age and the absence of significant differences at 15 years of age might indicate a real catch-up in reading skills between 9 and 15 years of age. However, to assess a catch-up over time, it is necessary to explore the interaction between group and time. To examine the interaction between sample and follow-up testing, standardization was performed on raw scores on each reading measure at 9 and 15 years of age across the samples of VLBW and NBW children.

Tables IV and V present the mean Z-scores for each component of reading skill for the entire sample of VLBW children, the morphologically intact VLBW subgroup, and the sample of NBW children. There is a

### Table IV. Means and Standard Deviations for Standardized Reading Scores at 9 and 15 Years for All Very-Low-Birthweight (VLBW) Children (n = 56) and Normal Birthweight (NBW) Children (n = 52) and Interaction Effects (Group × Time) Indicating Change in Reading Skills Between 9 and 15 Years of Age

<table>
<thead>
<tr>
<th>Measure</th>
<th>All VLBW children</th>
<th>NBW children</th>
<th>Interaction effect from ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>9 years</td>
<td>15 years</td>
<td>9 years</td>
</tr>
<tr>
<td>Nonword reading</td>
<td>−17 (.08)</td>
<td>−11 (.02)</td>
<td>.18 (.88)</td>
</tr>
<tr>
<td>Phonological choice</td>
<td>−17 (.89)</td>
<td>−16 (.94)</td>
<td>.18 (.08)</td>
</tr>
<tr>
<td>Word reading</td>
<td>−26 (.08)</td>
<td>−15 (.0)</td>
<td>.27 (.83)</td>
</tr>
<tr>
<td>Orthographic choice</td>
<td>−26 (.91)</td>
<td>−29 (.04)</td>
<td>.27 (.02)</td>
</tr>
<tr>
<td>Orthographic reading</td>
<td>−33 (.02)</td>
<td>−16 (.12)</td>
<td>.34 (.86)</td>
</tr>
<tr>
<td>Reading comprehension</td>
<td>−34 (.91)</td>
<td>−13 (.94)</td>
<td>.36 (.96)</td>
</tr>
</tbody>
</table>

*p < .05.
pattern of decrease in differences between VLBW and NBW children across time on several measures of reading skills. The interaction effect with reading comprehension as the dependent variable reached significance, $F(1,106) = 3.95, p < .05$, and there was a tendency for a significant interaction between group and time for orthographic reading, $F(1,105) = 2.96, p = .088$. The subgroup of morphologically intact VLBW children increased their performance significantly on orthographic reading between 9 and 15 years of age. Thus, there was a positive direction of changes over time in reading skills for the VLBW children, but only two interactions reached significance.

### Adjusting for Differences in Intelligence

Results summarized in Tables II and III show substantial differences in intelligence between VLBW and NBW children. One common approach when examining longitudinal outcomes among VLBW children is to adjust for such differences, with the argument that such statistical procedures clarify whether differences in outcomes are selectively impaired among VLBW children rather than explained by global deficits in intellectual abilities (Taylor et al., 2002). However, because most outcome measures are naturally related to intellectual abilities, long-term effects of VLBW solely based on IQ-adjusted scores lack in ecological validity and are sometimes hard to interpret. Reading skill is not an exception, and in the present study, correlations between components of reading skills and IQ at 9 years of age (Raven’s matrices) were all statistically significant and varied between .32 and .54. Corresponding correlations using full-scale IQ at 15 years of age were also significant and varied between .34 and .61. As intelligence accounted for 10–36% of the variance on measures of reading achievement at 9 and 15 years of age, it is reasonable to use reading scores without adjusting for IQ (see Tables IV and V). However, we also provide analyses of change in reading skills using regression-adjusted reading scores to obtain potential catch-up in reading skills among VLBW children over and above the impact of intelligence.

To adjust for differences in IQ when comparing reading skills between VLBW and NBW, we decided to examine the residual scores of each reading measure once the effect of intelligence had been taken into account. These residual scores concern what transcends the enabling skills of each reading measure over and above the impact of intelligence. We used Raven’s matrices as an index of intelligence at 9 years of age and full-scale IQ at 15 years of age to calculate IQ-adjusted reading scores at 9 and 15 years of age, respectively. It should be noted that the correlation between Raven’s matrices at 9 years of age and full-scale IQ obtained at 15 years of age was .72. Standardization was performed on raw scores on each reading measure at 9 and 15 years of age across samples of VLBW and NBW children. In addition, these standardized scores were adjusted for individual differences in intelligence at 9 and 15 years of age.

Tables VI and VII present the mean Z-scores for each component of reading skill for the entire sample of VLBW children, morphologically intact VLBW children, and the sample of NBW children. Although the main focus is on the interaction effects indicating a catch-up in reading skills, it should be noted that there are no significant differences between VLBW and NBW children on any component of reading skills at 9 and 15 years of age ($t$-values are all less than 1.61 at 9 years of age and .91 at 15 years of age). These findings indicate that reading skill is not selectively impaired among VLBW children, but rather generally depressed by substantial deficits in global intelligence. Mean Z-scores for VLBW children were even better compared to NBW children at 15 years of age for five of six measures when adjusting for IQ. These improvements were significant for reading comprehension for the entire VLBW sample. The improvement in orthographic reading reached significance for the morphologically intact VLBW children.
Differences between all and intact interactions displayed in Tables IV–VII on reading comprehension and orthographic reading are mainly explained by comparing VLBW children with abnormal MRI reports (n = 16) and the morphologically intact VLBW subgroup (n = 40) on these tests across time. These analyses revealed that VLBW children with abnormal MRI increased their mean Z-scores on reading comprehension from −0.57 to −0.15 between 9 and 15 years of age. The corresponding increase for morphologically intact VLBW children was from −0.24 to −0.14.

The interaction between subgroups of VLBW children and time almost reached significance, F(1,54) = 3.10, p = .08. The opposite pattern was observed for orthographic reading. Intact VLBW children increased their mean Z-scores on orthographic reading from −0.27 at 9 years of age to .05 at 15 years of age, whereas the VLBW children with abnormal MRI decreased their mean performances from −0.42 to −0.66.

**Discussion**

The present study examined the impact of being born with very low birthweight on three major components of reading skills. The reason for focusing on reading was that reading deficits influence school performance across most domains, are one of the main reasons for being in need of special education, and are a potential cause of long-term behavioral problems. The presence of reading difficulties also helps explain why VLBW children are less likely to be enrolled in higher education programs and to a much less extent graduate from high school (Hack et al., 2002). This study is the first conducting serial assessment of VLBW children to determine the presence and direction of change over time in reading skills.

The key findings were as follows: (a) VLBW children, both the entire sample and morphologically intact, showed significantly impaired reading skills at 9 years of age, (b) most differences in reading skills between VLBW and NBW children were not significant at 15 years of age, and (c) significant interactions between group and time on reading comprehension and orthographic reading indicated some catch-up over time in reading skills among VLBW children.

By narrowing the study of outcomes among VLBW children to components of reading skill, our study shows that the presence of deficits in reading skills obtained at 9 years of age seem not to persist through adolescence, and the direction of changes across time...
shows an improvement rather than an increased risk for reading impairment. Reading ability depends primarily on two component skills: language comprehension and word recognition (Hoover & Gough, 1990). The current conception of word decoding and word recognition is that this skill is determined by an encapsulated phonological system involved in mapping speech sounds to units of the written language (Vellutino, Fletcher, Snowling, & Scanlon, 2004). This phonological module is largely unrelated to higher cognitive functions such as executive controls and intelligence (Stanovich & Siegel, 1994), and there is a considerable heredity in the development of phonological processing skills (Samuelsson et al., 2005). Higher levels of language include the semantic system, specialized for processing meaning, which is strongly associated with reading comprehension. To what extent VLBW represents a biological risk for phonological processing deficits is still unknown. However, there are several studies indicating that some language functions such as vocabulary and receptive language are relatively intact in VLBW children (Aylward, 2002; Ment et al., 2003). As reading difficulties are mainly determined by verbal deficits, with phonological skills causally related to word reading and vocabulary related to reading comprehension, it is reasonable to expect more positive outcomes in reading for VLBW children. This is also confirmed in a recent paper demonstrating minor and nonsignificant differences in reading performance between VLBW and NBW children (Litt, Taylor, Klein, & Hack, 2005). The present study is in accordance with this finding by showing only modest differences in reading skills between VLBW and NBW children at 15 years of age.

The percentages of VLBW children receiving remedial services in school at 9 and 15 years of age were 39 and 25%, respectively. Corresponding percentages for NBW children were 10 and 11%. However, remedial services received at school do not explain this tendency of a catch-up in reading skills among VLBW children. Comparisons between the 14 VLBW children receiving special education at 15 years of age and the remaining VLBW children show substantial differences in standardized reading scores at 15 years of age. For example, mean performance on the nonword-reading test was −.69 for VLBW children receiving remedial services compared to .14 for the remaining VLBW sample. Mean performance in reading comprehension was −1.01 for VLBW children in remedial services and .14 for the remaining VLBW children. The differences on the other reading tests were at similar magnitudes. Thus, improvements in reading skills should mainly be explained by natural cognitive developmental processes rather than by a higher rate of remedial services offered at school.

Reading ability is mainly based on word-recognition skill and language comprehension. In childhood, word decoding and word recognition are skills under development and far from modularized. Full automatization is not achieved until the end of compulsory school. Our samples of VLBW and NBW children were from their last year in compulsory school in Sweden, and many children were skilled in word recognition. With this potential restriction for further improvement in word-reading skills, the absence of differences between VLBW and NBW children at 15 years of age might be caused by the very nature of reading development. However, reading comprehension engages higher cognitive functions and improves beyond fluent word-recognition skills. Thus, our findings indicating some improvement in reading comprehension among VLBW children are best explained by a true catch-up.

In conclusion, the results of this study indicate some catch-up in reading skills among VLBW children. Despite this trend for amelioration in reading skills, persistent global cognitive impairments have a moderating effect on reading skills among VLBW adolescents, and the need for special academic assistance across school ages continues.

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