Received: 2 May 2024 | Revised: 16 August 2024 | Accepted: 19 August 2024

DOI: 10.1111/apa.17408

ORIGINAL ARTICLE

ACTA PÆDIATRICA
NURTURING THE CHILD
WILEY

Predictors of language and reading outcomes in 12-year-old children born very preterm

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Funding information
Stiftelsen Sunnerdahls Handikappfond; Stiftelsen Sven Jerrings Fond; Hjärnfonden, Grant/Award Number: FO2016-0293; Vetenskapsrådet, Grant/Award Number: 2016-03109; Linnéa och Josef Carlssons Stiftelse; Stiftelsen Promobilia

Abstract

Aim: To investigate predictors of language and reading outcomes in 12-year-old Swedish children born very preterm (<32 gestational weeks) in 2004–2007.

Method: Children born very preterm ($n=78$, 43 girls), and term-born controls ($n=50$, 32 girls), were examined on verbal IQ, semantic and phonemic fluency, sentence recall, reading fluency, word and phonological decoding at 12 years of age. The results were related to neonatal characteristics, language development, measured with Bayley-III, at 2.5 years corrected age, and concurrent non-verbal IQ.

Results: Preterm children showed language and reading difficulties that were not completely accounted for by level of concurrent non-verbal IQ. Extremely preterm born children (<28 gestational weeks) demonstrated specific linguistic weaknesses. Administration of antenatal steroids, retinopathy of prematurity and persistent ductus arteriosus explained unique variance in language and reading outcomes. Language assessments at 2.5 years had low predictive value for language and reading outcomes at age 12.

Conclusion: Language and reading difficulties in 12-year-old children born preterm were not fully explained by concurrent non-verbal IQ, and were not reliably predicted by language assessments at 2.5 years. Renewed language assessments at school age are warranted for identifying children with persisting linguistic difficulties.

KEYWORDS
cognitive ability, language development, longitudinal study, reading ability, very preterm

1 | INTRODUCTION

Children born very preterm, below 32 weeks of gestation, are at risk of a range of neurodevelopmental sequelae, including persistent language and reading difficulties.[1,2] Two systematic reviews and meta-analyses reported that preterm children had lower reading performance compared to full-term children.[2,3] Moreover, receptive and expressive language problems may affect as many as 25%–45% of children born preterm.[4]

Deficits in language and reading skills are associated with psychiatric and emotional difficulties, behavioural problems and

Abbreviations: Bayley-III, Bayley Scales of Infant and Toddler Development, Third edition; EPT, extremely preterm; Verbal/non-verbal IQ, Verbal/non-verbal intelligence quotient in Wechsler Intelligence Scale for Children, Fifth edition; VPT, very preterm.

Martina Hedenius and Martin Johansson share first authorship and are presented in alphabetical order.

unemployment later in life.[5–7] Clinical and pedagogical intervention may help reduce long-term negative consequences of language and reading difficulties.[8] However, interventions for children born preterm are hampered by the lack of reliable tools for the identification of the children most at risk of persistent (as opposed to transient) difficulties.

Previous research showed that lower gestational age and lower birth weight, bronchopulmonary dysplasia and interventricular haemorrhage were risk factors for less favourable language and reading outcomes.[2] Research on the administration of antenatal steroids have produced conflicting findings. For children born extremely preterm, prenatal exposure to antenatal steroids has been shown to be a protective factor for neurodevelopmental outcomes. However, for children born later preterm or full-term, exposure to antenatal steroids may be linked to greater risks of adverse outcomes.[9,10]

In Sweden, the national neonatal follow-up programme recommends examination with the Bayley Scales of Infant and Toddler Development, Third edition (Bayley-III) at 24 months corrected age in high-risk neonates in order to identify children in need of clinical intervention.[11] Previous studies have shown modest correlations between Bayley-III scores and later intellectual ability in preterm children at 6.5 years of age.[12,13] However, the value of Bayley-III language scales for predicting persistent language and reading problems in early teenage in children born very preterm remains unexplored. At the age of 12, language and reading difficulties may generally be reliably identified. At the same time, even mild language and reading difficulties may have detrimental effects on academic achievement at this age due to increased school demands.

The present study aimed at investigating the prevalence of language and reading difficulties in 12-year-old children born very preterm in 2004–2007. We explored if potential language and reading difficulties were explained by general cognitive ability as represented by non-verbal IQ, based on visual processing. Moreover, the study aimed to examine the extent to which such difficulties may be predicted by prenatal and postnatal characteristics, including administration of antenatal corticosteroids. Lastly, we intended to investigate if language assessments at 2.5 years of age were useful for identifying children with later language and reading difficulties.

Key notes

- Language and reading difficulties were explored in 12-year-old children born very preterm as such difficulties may hinder everyday functioning and academic achievement.
- Difficulties at 12 years of age were not reliably predicted by language assessment at 2.5 years corrected age and were not fully explained by concurrent non-verbal IQ.
- Renewed language assessments at school age are warranted for identifying very preterm children with persisting linguistic difficulties.

2 | METHODS

2.1 | Participants

The Longitudinal study of visuomotor capacity (LOVIS) is a population-based prospective cohort study where all children born very preterm (gestational age < 32 weeks) in Uppsala County, Sweden, between 2004 and 2007 were approached, and 109 survived the first year (Figure 1). Prenatal and postnatal prospectively collected characteristics included gestational age, sex, birth weight and if the child was small for gestational age. Further, administration with at least one dose of betamethasone or developed intraventricular haemorrhage grades 3–4, cystic periventricular leucomalacia, and or retinopathy of prematurity stage 3 or higher were noted.

No child developed necrotising enterocolitis and no child received postnatal steroids.[14] The preterm cohort was divided into the groups: children born below 28 weeks of gestation – extremely preterm (EPT), and born between gestational weeks 28–31 – very preterm (VPT).

At 2.5 years, corrected for prematurity, language development was assessed in 98 of the 109 children whereof 30 were born EPT. At 12 years, 25 children born EPT and 53 born VPT participated in

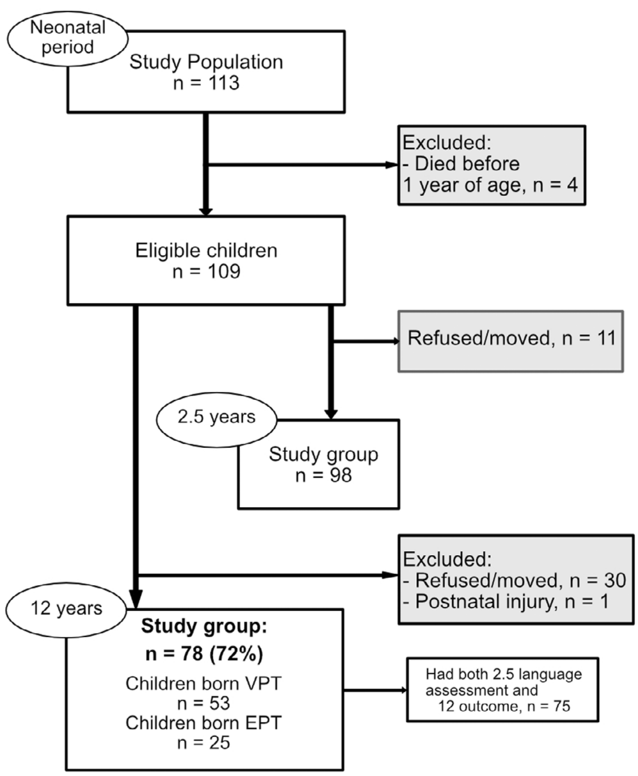

FIGURE 1 Overview of the LOVIS study and the preterm children included at age 2.5 and 12 years.

a follow-up study. Seventy-six of the very preterm participants were assessed both at 2.5 years corrected age and at 12 years of age. At 12 years, two children in the VPT group had a dyslexia diagnosis but no child had a clinically diagnosed language disorder. The results were compared with 50 age-matched reference group children from Uppsala regional Extremely Preterm infants in Sweden Study, with inclusion criteria: singleton birth, gestational age 37–41 weeks, APGAR at 5 min ≥7, as described in Serenius et al.[15]

Wechsler Intelligence Scale for Children, Fifth edition data were collected from 78 preterm children, semantic and phonemic fluency from 76 children and sentence recall, word recognition, phonological decoding and reading fluency from 70 preterm children. The corresponding numbers for the reference group were 50, 50 and 45, respectively. One child born VPT was considered a statistical outlier and was removed from all analyses.

2.2 | Study protocol

The children were assessed by clinical psychologists at the University Children's Hospital in Uppsala, Sweden.

At 2.5 years, language development of receptive and expressive communication was assessed with the Bayley-III.[16] The normative mean for the subscales is 10, with a standard deviation of 3. Due to the known limitations within the Bayley-III normative data, the full-term reference group was used for all comparisons in this study.

At 12 years, intelligence was measured using the Swedish version of the Wechsler Intelligence Scale, Fifth edition[17] giving scores for non-verbal index and verbal comprehension index (non-verbal IQ/verbal IQ). Non-verbal IQ refers to reasoning based on visual processing and verbal IQ refers to verbal reasoning, both with a mean of 100 and standard deviation of 15.

Verbal fluency was assessed by the Word generation subtest from the Developmental Neuropsychological Assessment, Second Edition.[18] It includes assessment of semantic and phonemic fluency. The task is designed to be differentially sensitive to deficits in semantic/conceptual versus phonological aspects of language. Phonemic fluency may be relatively more sensitive to deficits in executive function as semantic associations provided by given conceptual categories cannot be used.[19] In this task, children were asked to generate as many words as possible in 1 min given either a semantic category such as ‘animal’ or an initial phoneme such as ‘s’.

Sentence recall was assessed with the recalling sentences subtest from the Swedish version of the Clinical Evaluation of Language Fundamentals – 4.[20] The task is scored based on the number of correctly repeated sentences. Results on semantic, phonemic fluency and sentence recall are presented as scaled scores with a mean of 10 and standard deviation of 3.

Word reading skills were assessed with two subtests from a standardised Swedish word reading test.[21] The phonological decoding subtest was used to test the ability to use knowledge of sound-letter correspondences to decode made-up non-words. The word recognition subtest measured the ability to recognise and decode real words. Children were asked to read two lists of non-words/words for each subtest, given 45 s to complete each list. The test score for each subtest was the total sum of successfully read non-words and words, respectively.

Reading fluency was assessed with the reading fluency subtest from the Diagnostic Reading and Spelling Test.[22] The children read a continuous text with 36 blanks where words were missing. Next to the blanks were three suggested words, and the children were instructed to underline the most suitable word for the context. The children were given 4 min for the task. Stanine scores with mean of 5 and standard deviation of 2 were obtained for word reading, phonological decoding and reading fluency.

2.3 | Statistical analysis

All data were checked for normality. Collected test scores were transformed into z-scores based on the reference groups' mean and standard deviation (SD) for readability. Both dimensional and categorical analyses were performed. Group differences in dimensional analyses were performed with *t*-test or Welch *T* as appropriate, when controlling for covariates analysis of covariance was performed. Cut-offs were derived from the reference group's mean and SD with mild difficulties defined as <−1 SD and >−2 SD for IQ indices and scaled scores and <−0.75 SD and >−1.75 SD for stanine scores which included Reading fluency, Word recognition and phonological decoding. Severe difficulties were defined as <−2 SD for IQ indexes and scaled scores and as <−1.75 SD for stanine scores. Different cut-offs were warranted due to the distribution of the stanine-scale for the two reading tests (Diagnostic Reading and Spelling Test and Standardised Swedish word reading test). Differences were calculated with the Chi-squared test or Fisher's exact test as appropriate. To manage family wise multiple comparisons, we applied the Holm–Bonferroni method. Associations were examined with univariate linear regressions. Hierarchical regression models were built with significant ($p < 0.05$) covariates: non-verbal IQ, prenatal and postnatal characteristics. Sensitivity and specificity were calculated based on categories of severe and mild difficulties from 2.5 years corrected age to outcome at 12 years.

2.4 | Ethics

All children's legal guardians provided written informed consent and the local ethics committee approved the study (Ups 03-665 and 2016/400). The study was conducted in accordance with the standards specified in the Declaration of Helsinki.

3 | RESULTS

This study investigated predictors of language and reading outcomes at 12 years of age in a group of children born very preterm. A dropout analysis for the 12-year follow-up has been previously described showing no systematic difference between non-participating and participating children except a higher prevalence of periventricular leucomalacia in the latter.[23] Missing data on specific tests were due to not understanding the assignment, fatigue or shortage of time. The children missing data for reading fluency had a higher prevalence of severe retinopathy ($p = 0.038$) of prematurity, persistent ductus arteriosus ($p = 0.006$) and a lower incidence of perinatal steroids ($p = 0.017$). The children missing data for semantic and phonemic fluency, word recognition and phonological decoding had a higher prevalence of persistent ductus arteriosus ($p = 0.006$).

3.1 | Language and reading outcomes at 12 years of age

Table 1 displays language and reading outcomes at age 12 years for the preterm cohort, as well as for the EPT and VPT groups separately. The preterm cohort had significantly lower scores, compared to the full-term reference group, on measures of verbal intelligence, semantic fluency, sentence recall and phonological decoding. The EPT group demonstrated significant difficulties on all language tests, except for the reading measures. When the effect of non-verbal IQ was controlled for, only the recalling of sentences remained significantly deficient in the EPT group ($p < 0.05$). The categorical analyses largely reproduced the pattern of results from the dimensional analyses. The proportion of preterm children with mild and severe difficulties were significantly larger for verbal intelligence, recalling sentences, reading fluency and phonological decoding, compared to the reference group (Figure 2).

3.2 | Prenatal and postnatal characteristics and outcomes at 12 years of age

Univariate regressions demonstrated that in the EPT group, antenatal steroids and severe retinopathy of prematurity were related to Verbal IQ, Verbal fluency (both phonemic and semantic) and phonological decoding ($R^2 = 0.17–0.28$, $\beta = 0.42–0.53$, $p < 0.01–0.05$). Persistent ductus arteriosus and severe retinopathy of prematurity were associated with poorer reading fluency ($R^2 = 0.20–0.26$, $\beta = -0.44$ to 0.51, $p < 0.05$) and persistent ductus arteriosus was associated with poorer word recognition ($R^2 = 0.28$, $\beta = -0.53$, $p < 0.01$). In the VPT group, gestational age was associated with recalling sentences ($R^2 = 0.11$, $\beta = -0.33$, $p < 0.05$). Sex, small for gestational age, intraventricular haemorrhage grades 3–4 and cystic periventricular leucomalacia did not demonstrate any significant associations with outcome variables.

Results of significant univariate regressions for early language scores related to language and reading at 12 years of age are presented in Table 2.

TABLE 1 Language and reading outcomes at 12 years of age for the preterm cohort, and the EPT and VPT subgroups.

	Mean (SD)		
	Preterm cohort	EPT	VPT
	N = 70–77	*n* = 22–25	*n* = 48–52
WISC-V			
Verbal IQ	−0.40 (1.28)	−0.74 (1.37)**	−0.24 (1.21)
Non-verbal IQ	−0.66 (1.51)**	−1.10 (1.70)**	−0.45 (1.38)
NEPSY-II			
Semantic fluency	−0.33 (0.89)	−0.52 (0.96)*	−0.23 (0.86)
Phonemic fluency	−0.25 (0.96)	−0.53 (1.02)*	−0.12 (0.91)
CELF-4			
Sentences recall	−0.66 (1.47)**	−1.08 (1.39)**	−0.47 (1.49)
DLS			
Reading fluency	−0.08 (1.48)	−0.50 (1.37)	0.11 (1.51)
LäSt			
Word recognition	−0.17 (1.09)	−0.27 (1.30)	0−0.12 (0.99)
Phonological decoding	−0.53 (1.30)*	−0.66 (1.50)	−0.46 (1.21)

Note: Results are presented as z-scores derived from the reference groups' mean. The number of participants varied between the different tests.

Abbreviations: CELF-4, the Clinical Evaluation of Language Fundamentals, fourth edition; DLS, the Diagnostic Reading and Spelling Test; LäSt, the standardised Swedish word reading test; NEPSY-II, the Developmental Neuropsychological Assessment, Second edition; WISC-V, the Wechsler Intelligence Scale, fifth edition.

**$p < 0.01$; *$p < 0.05$.

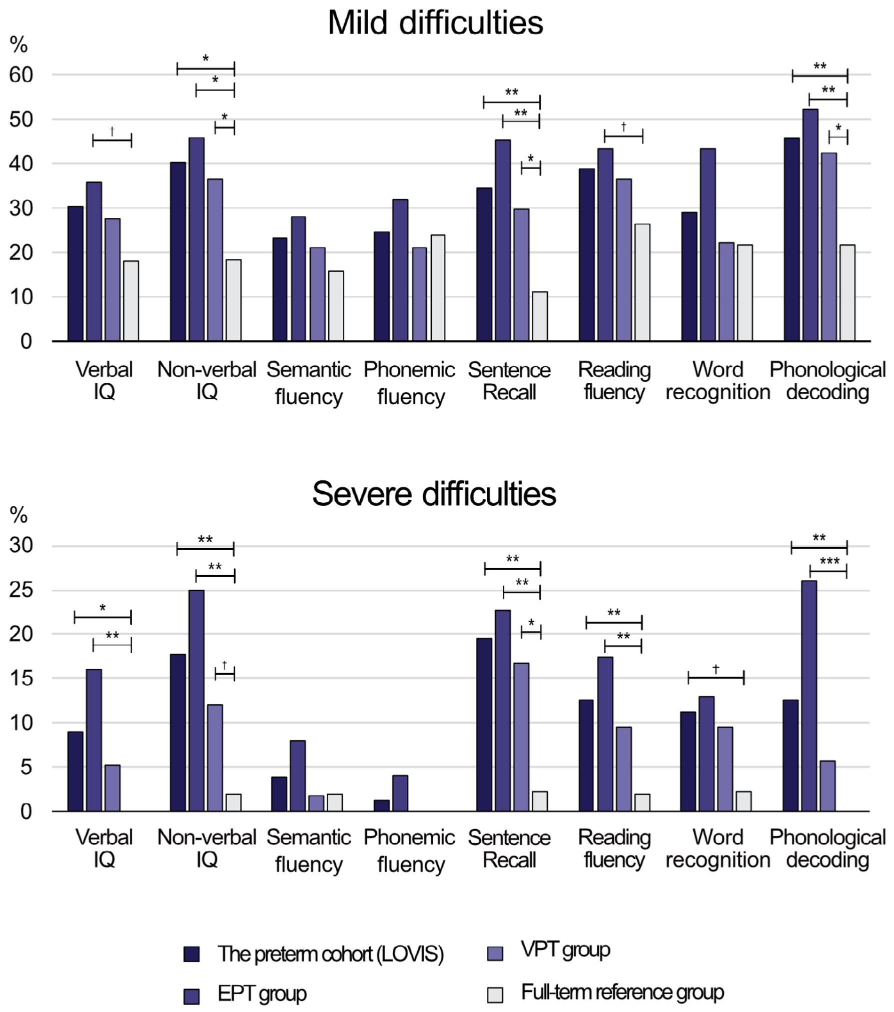

FIGURE 2 Categorised results for language and readings outcomes at 12 years of age for the preterm cohort, the EPT and VPT subgroups and full-term reference group. ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; †$0.05 < p < 0.10$.

The results from the hierarchical regression showed that some prenatal and postnatal factors predicted unique variance in language and reading outcomes, apart from the variance predicted by concurrent non-verbal IQ (Table 3). Specifically, administration of antenatal steroids was associated with better sentence recall in the VPT group, and with better semantic fluency and word recognition in the EPT group. Severe retinopathy of prematurity predicted poorer semantic fluency and word recognition in the preterm cohort, and poorer semantic fluency, reading fluency and phonological decoding in the EPT group. Persistent ductus arteriosus was negatively associated with reading fluency and word recognition in the preterm cohort as well as the EPT group.

3.3 | Bayley-III language scales and reading outcomes at 12 years of age

The hierarchical regressions for 12 years language and reading outcomes showed that the Bayley-III language scales predicted some unique variance in language. Expressive communication scale scores at 2.5 years for the whole preterm cohort correlated significantly with better ability of sentence recall at 12 years ($R^2 = 0.06$, $\beta = 0.40$, $p < 0.05$). Higher scores on the receptive communication scale at 2.5 years of age predicted better phonemic ($R^2 = 0.08$, $\beta = 0.31$, $p < 0.05$) fluency in the VPT group. There were no other significant associations between early language abilities at 2.5 years and 12-year language and reading outcomes.

Early expressive and receptive communication ability from the Bayley-III assessments at 2.5 years corrected age showed high specificity (94%–100%) in predicting 12-year severe difficulties of verbal IQ, semantic and phonemic verbal fluency, sentence recall and reading ability. The sensitivity ranged from 0% to 67%. The highest sensitivity was found for the verbal fluency ability. Early communication ability showed the lowest sensitivity for the investigated reading skills. The sensitivity for predicting reading ability and sentence recall ranged from 0% to 12%. When calculating sensitivity and specificity for mild difficulties across tests the results were generally similar with some increase in sensitivity and decrease in specificity. A full account can be found in Tables S1 and S2.

4 | DISCUSSION

The present study demonstrated language and reading difficulties at 12 years of age in Swedish children born very preterm between

TABLE 2 Statistically significant univariate regressions for early language scores as predictors of language and reading outcomes at age 12 in the preterm cohort and in the VPT and EPT groups separately.

	Bayley-III Receptive communication at 2.5 years		Bayley-III Expressive communication at 2.5 years	
	R^2	β	R^2	β
WISC-V, Verbal IQ at 12 years				
Preterm cohort	0.23***	0.48	0.24***	0.49
EPT	0.35***	0.59	0.43***	0.66
VPT	0.28***	0.52	0.21***	0.46
NEPSY-II, Verbal fluency (semantic) at 12 years				
VPT	0.16**	0.40	0.13*	0.36
NEPSY-II, Verbal fluency (phonemic) at 12 years				
Preterm cohort	0.09**	0.29	0.07*	0.26
VPT	0.14**	0.37		
CELF-4, Sentence recall at 12 years				
Preterm cohort	0.13***	0.36	0.23***	0.48
EPT	0.30**	0.55	0.27*	0.52
VPT	0.05*	0.22	0.19**	0.43
DLS, Reading fluency at 12 years				
Preterm cohort			0.07*	0.26

Note: R^2 denotes explained variance in the model and β represents effect size of the observed relation.

Abbreviations: CELF-4, the Clinical Evaluation of Language Fundamentals, fourth edition; DLS, the Diagnostic Reading and Spelling Test; NEPSY-II, the Developmental Neuropsychological Assessment, second edition; WISC-V, the Wechsler Intelligence Scale, fifth edition.

***$p < 0.001$; **$p < 0.01$; *$p < 0.050$.

2004 and 2007. The preterm born children had significantly lower scores than the reference group on measures of verbal intelligence, semantic and phonemic fluency, sentence recall and phonological decoding. Further, the categorical analyses revealed that the proportions of preterm children performing under the cut-offs for clinically significant difficulties were significantly larger than in the reference group for verbal intelligence, sentence recall, reading fluency and phonological decoding. These results align with previous studies showing language and reading difficulties at school-age in children born preterm in the first decade of 2000s.[3]

In line with previous research,[24] it was shown that a substantial proportion of the variance in language and reading abilities could be accounted for by concurrent non-verbal IQ, suggesting that these deficits were related to general cognitive ability. The difference between the EPT group and full-term reference group remained significant for the recalling sentences task, even when controlling for non-verbal IQ. This finding suggested the presence of a particular linguistic vulnerability in EPT children that was not fully explained by global intellectual deficits. The sentence recall test taps abilities related to speech perception, lexical knowledge, grammatical skills and speech production,[25] and the test is widely used in clinical and research settings to identify children with developmental language impairment.[26] In line with Imgrund et al.,[27] our findings suggest that this task may be particularly suitable to detect persistent language problems in children born very preterm.

Only two children in the preterm cohort (2.5%) had a diagnosis of dyslexia as per parent report. The functional diversity for reading in the preterm group suggests that this is an underestimation of the prevalence of reading disabilities in this population. No child had a clinical language disorder in either of the groups. At the age of 12, language and reading deficits may be reliably diagnosed and there still remain years in school during which interventions could be made. Our results highlight the need for continuous follow-up concerning undetected language and reading abilities and stress the necessity of extra help and adjustments in the remaining school years for many preterm children.

Verbal and non-verbal IQ are both essential in general intelligence. Differences between preterm and term groups in verbal function often disappear when controlling for general intelligence.[28] This has been taken as evidence that many of the verbal dysfunctions found in preterm children are due to general cognitive ability, rather than to specific language disorders.[28] Also in our study, a large part of the observed language difficulties were explained by concurrent non-verbal IQ that relies on visual perception and perceptual reasoning ability. One can assume that deficits within these domains have negative effects during language development. Language difficulties may thus be overshadowed by either more general, or perception/motor related, functional difficulties. Moreover, reading demands fine-tuned visual perception where deficits may have had effects on latter reading ability. Nevertheless, language difficulties should not be neglected, because of their known effects on

TABLE 3 Hierarchical regressions for variables predicting language and reading outcomes at age 12 in the preterm cohort, and in the EPT and VPT subgroups.

	Preterm cohort		EPT		VPT	
Predictors	ΔR^2	β	ΔR^2	β	ΔR^2	β
WISC-V: Verbal IQ						
Step 1: Non-verbal IQ	0.41***	0.64***	0.56***	0.75***	0.30***	0.55***
Step 2: Prenatal risk factors			0.03			
Antenatal Steroids		No		0.20		No
Step 3: Postnatal risk factors	0.00		0.00			
Severe retinopathy of prematurity		−0.04		0.08		No
NEPSY-II: Verbal fluency, semantic						
Step 1: Non-verbal IQ	0.10**	0.32**		No	0.06	0.24
Step 2: Prenatal risk factors			0.20*			
Antenatal Steroids		No		0.45*		No
Step 3: Postnatal risk factors	0.06*		0.13*			
Severe retinopathy of prematurity		−0.27		−0.41*		No
NEPSY-II: Verbal fluency, phonemic						
Step 1: Non-verbal IQ	0.18***	0.42***	0.47***	0.69***		No
Step 2: Prenatal risk factors			0.02			
Antenatal Steroids		No		0.16		No
Step 3: Postnatal risk factors	0.03		0.00			
Severe retinopathy of prematurity		−0.19		−0.04		No
CELF-4, Sentence recall						
Step 1: Non-verbal IQ	0.30***	0.54***	0.38**	0.62**	0.25***	0.50***
Step 2: Prenatal risk factors	0.03†				0.12*	
Antenatal steroids		0.17†		No		0.29*
Gestational Age		No		No		−0.16
Step 3: Postnatal risk factors	0.00					
Severe retinopathy of prematurity		−0.00		No		No
DLS, Reading fluency						
Step 1: Non-verbal IQ	0.14**	0.37**		No	0.12*	0.35*
Step 2: Prenatal risk factors						
Step 3: Postnatal risk factors	0.10*		0.44**			
Bronchopulmonary dysplasia		−0.03		No		No
Severe retinopathy of prematurity		−0.06		−0.42*		No
Persistent Ductus Arteriosus		−0.29*		−0.49**		No
LäSt, Word recognition						
Step 1: Non-verbal IQ		No		No		No
Step 2: Prenatal risk factors			0.18*			
Antenatal Steroids		No		0.43*		No
Step 3: Postnatal risk factors	0.16**		0.14†			
Persistent Ductus Arteriosus		−0.30*		−0.43†		No
Severe retinopathy of prematurity		−0.20†		No		No
LäSt, Phonological decoding						
Step 1: Non-verbal IQ	0.10**	0.32**		No		No
Step 2: Prenatal risk factors	No		No		No	
Step 3: Postnatal risk factors	0.03		0.18*			
Severe retinopathy of prematurity		−0.18		−0.43*		No

Note: The regressions include different predictors, as univariate dependencies for different groups differ. ΔR^2 – depicts change in explained data variance on each additional regression step, but not for individual variable 0.

Abbreviations: CELF-4, the Clinical Evaluation of Language Fundamentals, fourth edition; DLS, the Diagnostic Reading and Spelling Test; LäSt, the standardised Swedish word reading test; NEPSY-II, the Developmental Neuropsychological Assessment, second edition; no, variable not entered into the hierarchical regression because of non-significant association in univariate analysis; WISC-V, the Wechsler Intelligence Scale, fifth edition.

***$p<0.001$; **$p<0.01$; *$p<0.05$; †$0.05<p<0.1$.

academic achievement. In school settings, the abilities to understand through spoken and written language, as well as to reason and convey knowledge through speech or writing, are essential.

In addition to concurrent non-verbal IQ, administration of antenatal steroids, retinopathy of prematurity and persistent ductus arteriosus were found to be significant predictors of variance in language and reading outcomes at age 12. Antenatal steroids were associated with better performance on the recalling sentences task in the preterm cohort, and with better semantic fluency and word reading in the EPT group. This finding is in line with earlier research within this cohort where the administration of antenatal steroids was related to better general intelligence at 6.5 and 12 years of age in the EPT subgroup.[13,23] Additionally, the presence of severe retinopathy of prematurity predicted worse semantic fluency, phonological decoding and reading fluency, and persistent ductus arteriosus was negatively associated with reading comprehension and word recognition, in the EPT subgroup. Thus, apart from the effect of antenatal steroids on sentence recall in the preterm cohort, the prenatal and postnatal factors showed significant effects in the EPT subgroup only. This finding could potentially be explained by the observation that retinopathy of prematurity often affects the most immaturely born infants and may be a symptom of a more systemic disorder within the central nervous system.[29]

The present study showed that performance on the Bayley-III language scales at 2.5–3 years of age was weakly related to later language and reading outcomes and had quite low sensitivity for predicting specific language and reading difficulties at 12 years of age. This finding concurs with previous research showing that the performance on Bayley-III languages scale at 2.5–3 years of age was a modest predictor of school age neurodevelopmental outcomes.[13] The language scores in toddlerhood may be confounded by differences regarding when developmental milestones were reached, leading to a greater variance. Further, abilities measured at 12 years of age, such as reading, could be difficult to predict at toddlerhood as reading may not be directly linked to expressive and receptive communication abilities at this age. Moreover, environmental factors such as parental education and social risk factors were shown to be related to later language development alongside with the effect from preterm birth.[1] In our study, socioeconomic status was not included in the analysis and the impact from it could not be accounted for. However, in clinical settings, medical and assessment scores constitute the baseline for recommendations and the specific predictive values from a BSID-III assessment were of interest for neonatal follow-up programmes, including Sweden. Although of great clinical importance, early identification of children at risk of persistent language difficulties is notoriously difficult,[30] and further research is needed in order to determine which language characteristics in toddlers should be regarded as red flags that motivate clinical intervention. This is particularly true for covert or subtler language difficulties that may nevertheless have a severe impact on future academic and psychosocial outcomes.[4,5] Because the predictive value of language assessments has been shown to increase dramatically from the age of 4–5,[30] renewed language assessments at this age are warranted to detect the children in further need of clinical and pedagogical support at school age.

4.1 | Study strengths and limitations

The strengths of the present study include its prospective design and rather low attrition. Among its limitations is the lack of information about which children had received special education support in school. Such data would have been an informative addition to the standardised measures and could have shed light on associations with daily functioning. The relatively small sample sizes, especially within the EPT subgroup, likely influenced statistical power.

5 | CONCLUSION

The present study revealed mild-to-severe language and reading difficulties in 12-year-old Swedish children born very preterm. These difficulties were largely, but not completely, accounted for by their level of concurrent non-verbal IQ. Administration of antenatal steroids, retinopathy of prematurity and persistent ductus arteriosus explained unique variance in language and reading outcomes at 12 years of age. Language assessments with Bayley-III at 2.5 years of age gave important information about the child's level at the time of assessment. However, these assessments had low predictive value for language and reading outcomes at age 12, and were not reliable for identifying preterm children with language difficulties at school age. Assessment at school age is necessary to identify persisting language and reading difficulties that could hinder preterm children's well-being and academic achievement.

AUTHOR CONTRIBUTIONS

Martina Hedenius: Writing – review and editing; methodology; writing – original draft; conceptualization. **Martin Johansson:** Visualization; investigation; writing – original draft; writing – review and editing; methodology; data curation; validation; funding acquisition. **Ylva Fredriksson Kaul:** Investigation; writing – review and editing; writing – original draft; methodology; validation; funding acquisition. **Eric Andersson:** Formal analysis; writing – review and editing; data curation. **Cecilia Montgomery:** Writing – review and editing; validation. **Lena Hellström-Westas:** Validation; funding acquisition; writing – review and editing. **Olga Kochukhova:** Funding acquisition; writing – original draft; writing – review and editing; supervision; conceptualization; validation; project administration.

ACKNOWLEDGEMENTS

We thank the children and parents participating in the study and acknowledge the contribution of RN Cecilia Ewald, neonatologists Katarina Strand Brodd and Uwe Ewald and psychologist Lina Degréus.

FUNDING INFORMATION

Financial support was obtained from the Swedish Research Council (2016–03109), the Swedish Brain Foundation, the Linnéa and Josef Carlsson Foundation, the Promobilia Foundation, the Sunnerdahls Handikappsfond, and Sven Jerrings Foundation. The funders were not involved in the study.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

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REFERENCES

1. Thi-Nhu-Ngoc Nguyen T, Spencer-Smith M, Zannino D, et al. Developmental trajectory of language from 2 to 13 years in children born very preterm. Pediatrics. 2018;141(5):e20172831. doi:10.1542/peds.2017-2831
2. Kovachy V, Adams J, Tamaresis J, Feldman H. Reading abilities in school-aged preterm children: a review and meta-analysis. Dev Med Child Neurol. 2015;57:410-9. doi:10.1111/dmcn.12652
3. McBryde M, Fitzallen GC, Liley HG, Taylor HG, Bora S. Academic outcomes of school-aged children born preterm: a systematic review and meta-analysis. JAMA Netw Open. 2020;3(4):e202027.
4. Stipdonk LW, Dudink J, Utens E, Reiss IK, Franken M. Language functions deserve more attention in follow-up of children born very preterm. Eur J Paediatr Neurol. 2020;26:75-81. doi:10.1016/j.ejpn.2020.02.004
5. Conti-Ramsden G, Durkin K, Toseeb U, Botting N, Pickles A. Education and employment outcomes of young adults with a history of developmental language disorder. Int J Lang Commun Disord. 2018;53(2):237-55.
6. Curtis P, Frey J, Watson C, Hampton L, Roberts M. Language disorders and problem behaviors: a meta-analysis. Pediatrics. 2018;142(2):e20173551.
7. Law J, Rush R, Schoon I, Parsons S. Modelling developmental language difficulties from school entry into adulthood: literacy, mental health, and employment outcomes. J Speech Lang Hear Res. 2009;52:1401-16.
8. Zijlstra H, van Bergen E, Regtvoort A, de Jong P, van der Leij A. Prevention of reading difficulties in children with and without familial risk: short- and long-term effects of an early intervention. J Educ Psychol. 2021;113(2):248-67. doi:10.1037/edu0000489
9. Ninan K, Liyanage SK, Murphy KE, et al. Evaluation of long-term outcomes associated with preterm exposure to antenatal corticosteroids: a systematic review and meta-analysis. JAMA Pediatr. 2022;176(6):e220483. doi:10.1001/jamapediatrics.2022-0483
10. Räikkönen K, Gissler M, Tapiainen T, et al. Associations between maternal antenatal corticosteroid treatment and psychological developmental and neurosensory disorders in children. JAMA Netw Open. 2022;5(8):e2228518. doi:10.1001/jamanetworkopen.2022.28518
11. Çelik P, Ayranci Sucakli İ, Yakut HI. Which Bayley-III cut-off values should be used in different developmental levels? Turk J Med Sci. 2020;50(4):764-70.
12. Månsson J, Källén K, Eklöf E, Serenius F, Ådén SK. The ability of Bayley-III scores to predict later intelligence in children born extremely preterm. Acta Paediatr. 2021;110(11):3030-9.
13. Kaul YF, Naseh N, Strand Brodd K, Böhm B, Holmström G, Hellström-Westas L. Average 2.5-year neurodevelopmental test results in children born very preterm did not rule out cognitive deficits at 6.5 years of age. Acta Paediatr. 2021;110:846-54.
14. Strand Brodd K, Grönqvist H, Holmström G, Grönqvist E, Rosander K, Ewald U. Development of smooth pursuit eye movements in very preterm born infants: 3. Association with perinatal risk factors. Acta Paediatr. 2012;101:164-71.
15. Serenius F, Kallen K, Blennow M, et al. Neurodevelopmental outcome in extremely preterm infants at 2.5 years after active perinatal Care in Sweden. JAMA. 2013;309(17):1810-20. doi:10.1001/jama.2013.3786
16. Bayley N. Bayley Scales of Infant and Toddler Development. 3rd ed. Pearson; 2006.
17. Wechsler D. Wechsler Intelligence Scale for Children – Fifth Edition, Swedish version. NCS Pearson, Inc; 2016.
18. Korkman M, Kirk U, Kemp SL. NEPSY Ii, Swedish version. NCS Pearson Inc; 2011.
19. Luo L, Luk G, Bialystok E. Effect of language proficiency and executive control on verbal fluency performance in bilinguals. Cognition. 2010;114(1):29-41.
20. Semel E, Wiig E, Secord W. Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4). The Psychological Corporation/A Harcourt Assessment Company; 2003.
21. Elwér Å, Fridolfsson I, Samuelsson S, Wiklund C. LäSt: Test i läsförståelse, läsning och stavning för åk. Psykologiförlaget Hogrefe; 2016:1-6.
22. Järpsten B, Taube K. DLS för skolår 4-6 Reviderad utgåva. Hogrefe Psykologiförlaget; 2010.
23. Kochukhova O, Fredriksson Kaul Y, Johansson M, Montgomery C, Holmström G, Strand Brodd K. Antenatal steroids and neurodevelopment in 12-year-old children born extremely preterm. Acta Paediatr. 2022;111:314-22.
24. Lee E, Yeatman J, Luna B, Feldman H. Specific language and reading skills in school-aged children and adolescents are associated with prematurity after controlling for IQ. Neuropsychologia. 2011;49(5):906-13.
25. Klem M, Melby-Lervåg M, Hagtvet B, Lyster SAH, Gustafsson JE, Hulme C. Sentence repetition is a measure of children's language skills rather than working memory limitations. Dev Sci. 2015;18(1):146-54.
26. Conti-Ramsden G, Botting N, Faragher B. Psycholinguistic markers for specific language impairment (SLI). J Child Psychol Psychiatry. 2001;42(6):741-8.
27. Imgrund C, Loeb D, Barlow S. Expressive language in preschoolers born preterm: results of language sample analysis and standardized assessment. J Speech Lang Hear Res. 2019;62(4):884-95. doi:10.1044/2018_JSLHR-L-18-0224
28. Rush TM. Language function after preterm birth. In: Nosarti C, Murray RM, Hack M, eds. Neurodevelopmental Outcomes of Preterm Birth. Cambridge University Press; 2010:176-84.
29. Ingvaldsen S, Morken T, Austeng D, et al. Visuopathy of prematurity: is retinopathy just the tip of the iceberg? Pediatr Res. 2022;91:1043-8.
30. Bishop D, Snowling M, Thompson P, Greenhalgh T, CATALISE Consortium. CATALISE: a multinational and multidisciplinary Delphi consensus study. Identifying language impairments in children. PLoS One. 2016;11(7):e0158753.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Hedenius M, Johansson M, Kaul YF, Andersson E, Montgomery C, Hellström-Westas L, et al. Predictors of language and reading outcomes in 12-year-old children born very preterm. Acta Paediatr. 2025;114:100–108. https://doi.org/10.1111/apa.17408