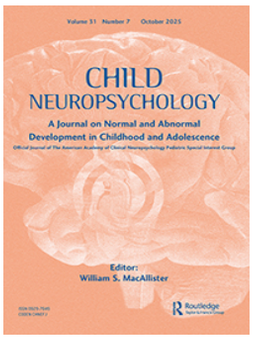

Routledge
Taylor & Francis Group

Child Neuropsychology

A Journal on Normal and Abnormal Development in Childhood and Adolescence

ISSN: 0929-7049 (Print) 1744-4136 (Online) Journal homepage: www.tandfonline.com/journals/ncny20

Language skills at 2 years predict reading comprehension at 11 in children born very preterm – a longitudinal cohort study

Eveliina Joensuu, Petriina Munck, Anna Nyman, Helena Lapinleimu, Leena Haataja & Suvi Stolt

To cite this article: Eveliina Joensuu, Petriina Munck, Anna Nyman, Helena Lapinleimu, Leena Haataja & Suvi Stolt (30 Sep 2025): Language skills at 2 years predict reading comprehension at 11 in children born very preterm – a longitudinal cohort study, Child Neuropsychology, DOI: 10.1080/09297049.2025.2566096

To link to this article: https://doi.org/10.1080/09297049.2025.2566096

Published online: 30 Sep 2025.

CHILD NEUROPSYCHOLOGY
https://doi.org/10.1080/09297049.2025.2566096

Routledge
Taylor & Francis Group

Language skills at 2 years predict reading comprehension at 11 in children born very preterm – a longitudinal cohort study

Eveliina Joensuu[a], Petriina Munck[b], Anna Nyman[c], Helena Lapinleimu[d], Leena Haataja[e] and Suvi Stolt[a]

[a]Department of Speech-Language Pathology, Faculty of Medicine, University of Helsinki, Helsinki, Finland; [b]Department of Psychology, Faculty of Medicine, University of Helsinki, Helsinki, Finland; [c]Department of Psychology, University of Turku, Turku, Finland; [d]Department of Paediatrics and Adolescent Medicine, University of Turku and Turku University Hospital, Turku, Finland; [e]Department of Pediatric Neurology, Children's Hospital, University of Helsinki and Helsinki University Hospital, Helsinki, Finland

ABSTRACT

Children born very preterm (VP, <32 gestational weeks and/or birth weight ≤1500 g) are at risk for difficulties in language and reading. It is unclear whether early language is predictive for later reading skills in this population. We aimed to investigate the predictive value of language at 2;0 for reading at 11;0 in children born VP. The study comprised 115 Finnish-speaking children born VP. At 2;0, language skills were assessed with the Finnish long-form of the MacArthur-Bates Communicative Development Inventory. At 11;0, reading fluency and reading comprehension were evaluated using the Finnish Primary School Reading Test. The language variables explained 32%–33% of the variance in reading comprehension at 11;0. No clear associations between early language and reading fluency were found. Early language had high specificity but low sensitivity for identifying weak reading comprehension at 11;0. The findings provide support for the continuum between early language and later reading comprehension in children born VP. Evaluating language skills at 2;0 provides important predictive insight into later reading comprehension. Validated parental-report instruments offer valuable data on the language skills of children born preterm at this age. It is recommended to include these tools in the clinical follow-up of very preterm children.

ARTICLE HISTORY
Received 23 May 2025
Accepted 19 September 2025

KEYWORDS
Early language skills; predictive value; reading comprehension; reading fluency; children born very preterm

Despite advanced neonatal care practices, children born very preterm (VP, <32 gestational weeks and/or birth weight ≤1500 g) are at risk for various developmental and learning difficulties, including problems in language (Sansavini et al., 2010; Stolt et al., 2014) and reading skills (Heikkinen et al., 2021; Kovachy et al., 2015). Previous systematic reviews and meta-analyses support the evidence that school-aged children born VP tend to perform poorer in reading compared to their full-term peers (Kovachy et al., 2015; McBryde et al., 2020). Also, depending on the study, deficits in language skills have reported to affect 16% to 45% of children born VP (Stipdonk

CONTACT Eveliina Joensuu eveliina.a.joensuu@helsinki.fi Department of Speech-Language Pathology, Faculty of Medicine, University of Helsinki, P.O. BOX 21, Haartmankinkatu 3, Helsinki FI-00014, Finland

et al., 2020; Stolt et al., 2014). Children born preterm have been reported to show poorer language and reading skills than their full-term peers, even in the absence of major neurodevelopmental impairments (NDI) such as cerebral palsy, significant hearing or visual deficits, or severe cognitive impairments (IQ < 70) (Kovachy et al., 2015; Sansavini et al., 2010). Moreover, longitudinal follow-up studies have shown that the incidence of weak language ability persists and even increases from early years through late childhood in children born very preterm (Nguyen et al., 2018; Stolt et al., 2014).

While previous studies have provided important knowledge regarding the continuum between early delayed language development and later language difficulties, the association between very early language ability and reading skills in later school age is not fully understood in preterm children (Guarini et al., 2010; Hedenius et al., 2025; Joensuu et al., 2021; Pritchard et al., 2014). Delayed early language development in toddlerhood has been shown to differentiate between children with and without later reading difficulties in full-term populations, e.g., in late-talking children (Rescorla, 2000, 2009) and in children with familial risk for dyslexia (Torppa et al., 2010). Also, full-term children with reading comprehension difficulties at school age have been shown to exhibit weak expressive language skills at ages 2 and 3 (James et al., 2025). In children born VP, associations between language and literacy skills have been studied mainly at school age (Borchers et al., 2019; Guarini et al., 2019; Joensuu et al., 2025). Especially, longitudinal follow-up studies investigating the predictive value of early language skills at toddler age for reading skills at later school age are scarce (Hedenius et al., 2025; Joensuu et al., 2021). The few existing studies have mainly focused on the prediction of reading fluency (Hedenius et al., 2025; Joensuu et al., 2021), while the predictive value of early language for later reading comprehension remains unknown in this population.

For adequate reading ability, proficiency in reading fluency and reading comprehension is essential (Ecalle et al., 2021; Hjetland et al., 2020). Reading fluency refers to the ability to decode from print to speech with proper speed and accuracy. *Reading comprehension* is the main goal of reading instruction, indicating the ability to construct meaning of what has been read through the technical decoding process (Hjetland et al., 2020; Leppänen et al., 2008). As shown in full-term populations, as the reading skills develop further, the impact of decoding skills on reading comprehension decreases, while the impact of linguistic skills, such as vocabulary, increases (Leppänen et al., 2008; Torppa et al., 2020). Difficulties in reading can emerge in one or both component skills (Torppa et al., 2020). Thus, when evaluating reading skills, it is important to consider both reading fluency and reading comprehension, and assess them separately (Ecalle et al., 2021; Joensuu et al., 2025; Torppa et al., 2020).

In the clinical follow-up of children born preterm, development is typically monitored until age 2 years, at least in some hospitals. Children with major neurodevelopmental impairments (NDI) are usually well identified and more likely to receive ongoing assessment and support. However, the language-related problems of those very preterm children without major NDI may not be identified early. As clinicians must prioritize which developmental domains to evaluate and how to allocate limited resources, they would benefit from evidence on whether early language skills, acquired by the end of the second year of life when basic lexical and syntactic abilities typically emerge, predict later reading fluency and comprehension in children born very preterm. Furthermore,

understanding whether toddlers at risk for future reading difficulties can be identified through cost-efficient screening methods would support timely intervention and effective resource planning (Joensuu et al., 2021, 2025; Stipdonk et al., 2020).

Validated parental report instruments are increasingly utilized in clinical decision making, especially in the assessment of children's early language acquisition (Skarakis-Doyle et al., 2009). Previous studies of VP cohorts point out the utility of the long-form version of the MacArthur – Bates Communicative Development Inventories (CDI) (Fenson et al., 1994) in evaluating early language skills to predict developmental deficits in language (Rescorla, 2000; Borchers et al., 2019) and literacy skills at the beginning of schooling (Joensuu et al., 2021). Still, the value of identifying a VP born toddler's early language for predicting reading fluency and reading comprehension at later school age needs further investigation. To address these gaps in the current knowledge, the present study aims (1) to analyze the longitudinal associations between language skills at 2 years of corrected age and reading ability (reading fluency and reading comprehension) at 11 years, in a regional cohort of Finnish-speaking children born VP, (2) to assess how much early language variables explain the variance in reading skills when confounding factors are taken into account, and (3) to evaluate the sensitivity, specificity, and positive and negative predictive values of weak language skills at 2 years for reading skills at 11.years

Materials and methods

Participants

This study is part of a prospective follow-up study PIPARI (Development and Functioning of Very Low Birth Weight Infants from Infancy to School Age). All children born VP (<32 weeks of gestational age and/or with birth weight ≤1500 g) in Turku University Hospital, Finland, in 2001–2006 were invited to participate, with consent obtained during their stay in the neonatal intensive care unit. From 2001 to 2003, the inclusion criteria were birth weight ≤1500 g and prematurity (<37 gestational weeks). From the beginning of 2004, the inclusion criteria were expanded to include all infants born <32 weeks of gestation, regardless of birthweight. Children with severe congenital anomalies or diagnosed syndromes affecting their development were excluded. The present study sample consisted of 115 children born VP participating in the PIPARI study and living in monolingual Finnish-speaking families who had data available from the language assessment at 2 years of age, and reading assessment at 11 years of age. The flowchart of the children included in the current study is presented in Figure 1 The age of the children born VP was corrected for prematurity (i.e., age was calculated from the due date) until the age of two years. The chronological age (i.e., age calculated from the birth date) was used thereafter.

The PIPARI study protocol was approved by the Ethics Review Committee of the Hospital District of Southwest Finland in December 2000 and January 2012. After receiving oral and written information, all parents who agreed to participate provided written informed consent. At 11 years, the participants also gave their own consent after receiving written information. The families and participants were able to withdraw from the study at any time, and withdrawal did not affect their treatment.

The neonatal and background characteristics of the children participating in the present study are presented in Table 1. Neurodevelopmental impairment (NDI)

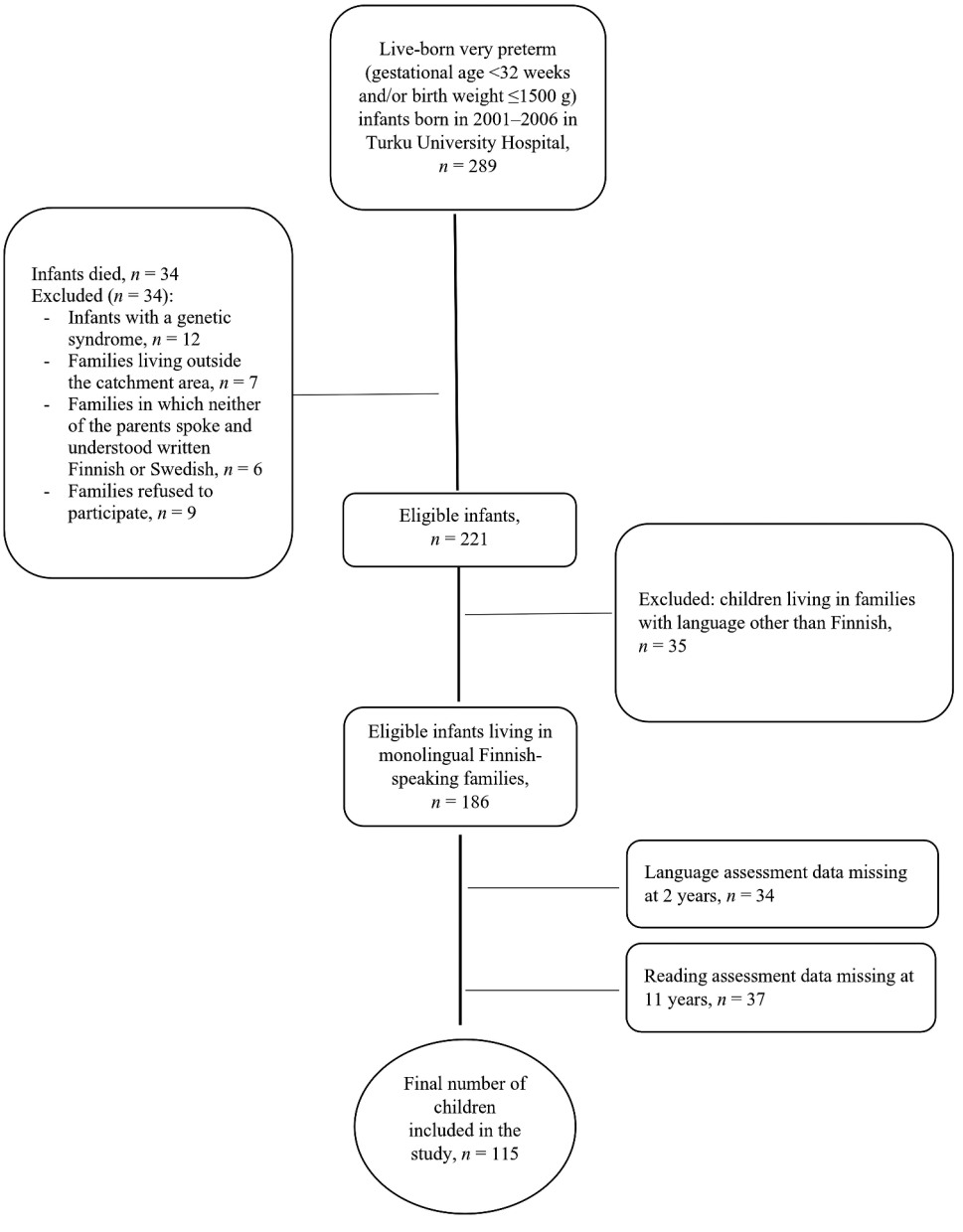

Figure 1. Flowchart of the participants of the present study.

was defined if one or more of the following was present: cognitive impairment at 11 years of age (Full-scale IQ [FSIQ] of the Wechsler Intelligence Scale, Fourth Edition, Finnish translation (Wechsler, 2011) [WISC-IV]; composite score <70, <−2SD), cerebral palsy by 2 years of corrected age, severe hearing impairment (hearing loss requiring amplification in at least one ear), and/or severe visual impairment (blindness).

Table 1. Neonatal and background characteristics of all children born very preterm (VP, birth weight ≤1500 g and/or <32gestational weeks) participating in the study and the subgroup of children born VP without neurodevelopmental impairment (NDI). Numbers (percentages) are shown. When means (M), standard deviation (SD), minimum, maximum (min, max) are presented, they are indicated separately.

Characteristic	Children born very preterm ($n = 115$)[d]	Children born very preterm without NDI ($n = 98$)
Gestational age (weeks), *M* (SD) [min, max]	29.0 (2.6) [23.0, 35.3]	29.0 (2.5) [24.3, 35.3]
Birth weight (grams), *M* (SD) [min; max]	1133 (313) [525; 1855]	1123 (295) [565; 1820]
Small for gestational age[a]	36 (31)	32 (33)
Prenatal corticosteroids	110 (96)	94 (96)
Multiple birth	48 (42)	39 (40)
Male	62 (59)	55 (56)
Bronchopulmonary dysplasia	15 (13)	13 (13)
Sepsis	22 (19)	15 (15)
Operated necrotizing enterocolitis	5 (4)	3 (3)
Laser-treated retinopathy of prematurity	3 (3)	3 (3)
Neurodevelopmental impairment	17 (15)	–
Full Scale Intelligence Quotient <70	10 (9)	–
Cerebral palsy	7 (6)	–
Hearing impairment	3 (3)	–
Visual impairment	0	–
Brain pathology, MRI at term age[b]		
Normal finding or minor abnormality	82 (72)	77 (79)
Major abnormality	32 (28)	20 (21)
Mother's self-reported reading difficulties	11 (11)	9 (11)
Father's self-reported reading difficulties	11 (11)	10 (12)
Maternal education		
High level	75 (65)	65 (68)
Intermediate and low level	39 (34)	31 (32)
Paternal education[c]		
High level	36 (32)	34 (35)
Intermediate and low level	76 (68)	63 (65)

[a]Small for gestational age was defined as a birth weight <−2.0 SD, according to the age- and sex-specific Finnish growth charts. [b]See specific magnetic-resonance imaging (MRI) protocol and details about the classification of the findings in (Setänen et al., 2013). [c]High level is defined as a bachelor's degree, master's degree, or doctoral degree; Intermediate level is defined as high school or vocational school; Low level is defined as primary or lower secondary school or less.

Drop-out analysis

The background characteristics (Table 1) were compared between the children participating in the present study and those monolingual Finnish-speaking children participating in the main PIPARI study whose language data at 2 years of corrected age and reading data at 11 years of age were unavailable ($n = 71$) (Figure 1). In the dropout group there were fewer multiple births compared to the study children (23%, $n = 16$, of the dropouts vs. 42%, $n = 48$, of the study children; $p = 0.007$). No other statistically significant difference in the background characteristic was found.

Measures

Assessment at 2 years of corrected age

Language skills were studied using a validated and standardized parental report measure, the Finnish long-form version of the MacArthur-Bates Communicative Development Inventory (FinCDI, toddler version) (Fenson et al., 1994; Lyytinen, 1999). The FinCDI is

a structured parental report instrument evaluating the development of child's expressive lexicon and grammar including inflectional morphological skills. The FinCDI questionnaire was given to the families at the end of the 2-year assessment visit by a researcher psychologist of the PIPARI Study group. Families completed and returned the questionnaires within two weeks. The mean (SD) [minimum; maximum] age for the children born VP at the time the FinCDI questionnaire was completed was 24.3 months (SD 0.38) [22.6; 26.2]. The variables of the FinCDI used in the current study were the lexicon size and the mean length of the three longest utterances (M3L). Lexicon size is the number of words that the parent estimates their child is using, based on a word list of 595 words. The M3L is calculated in morphemes (the smallest unit in language carrying a meaning) based on the three longest recent utterances the child has made. For the 2-year language variables (lexicon size and M3L), the 10%ile cutoff values (lexicon size <30 words and M3L <2,06) were based on the Finnish normative sample of the method (Lyytinen, 1999) (specific 10%ile cutoff values: e-mail from K. Eklund, February 6 2017).

Assessment at 11 years of age

Reading fluency and reading comprehension skills were evaluated using the standardized Finnish Primary School Reading Test (Lindeman, 1999). The testing took place in a group setting in schools, in the spring semester of Grade 4 of the Finnish primary school. The children's reading skills were tested by the special education teacher or the class teacher during the school day.

The subtest of reading fluency comprised 78 word chains, with two to four words in each chain typed together. The children separated the non-spaced words from each other and marked the word boundaries with a line using a pencil; for example, jarvilaulaaulospuu > jarvi/laulaa/ulos/puu (in English lakesingouttree → lake/sing/out/tree). The fluency test score (max 214) was the number of accurately recognized words during the time limit of 3.5 minutes. In the subtest of reading comprehension, the children read two texts silently and then answered 24 multiple-choice questions regarding the content. The first text was an informational text about the effect of light on plant growth, and the second text was a cooking recipe (for detailed description of the subtests of the method and scoring, see Nguyen et al., 2018). One point was given for each correct answer (max 24). The cutoff values (−1 SD, reading fluency raw scores <98; −1 SD reading comprehension raw scores <14, see detailed description of the scoring in Nguyen et al., 2018) were based on the normative sample (n = 1675) (Wechsler, 2011) of the Finnish Primary School Reading Test.

Statistical analysis

The analyses were performed separately for all children born VP participating and for the subgroup of children born VP without NDI. Pearson's correlation coefficient (r) was used to investigate the correlations between the continuous language variables, and the continuous reading fluency and reading comprehension variables. Four multiple linear regression models were conducted to analyze how much the 2-year language variables explain the variance in reading skills at 11, when the effect of confounding factors was taken into consideration. Normal distribution assumption was checked from studentized residuals. The explanatory variables in the regression models were lexicon size and M3L measured at 2 years. Since the variables were strongly correlated with each other (r = .85,

p = <.001), they were analyzed in separate models. Based on preliminary analyses and previous literature, gestational age, mother's self-reported reading difficulties, father's self-reported reading difficulties, paternal education, and child's sex were included in the models as confounding factors. In the preliminary analysis, paternal education correlated more strongly with the outcome than maternal education. Due to multicollinearity between maternal and paternal education, only paternal education was included. Receiver operating characteristic curve (ROC) analysis was performed to study the sensitivity and specificity of 2-year language variables for weak reading fluency and weak reading comprehension skills at 11. The level of significance was set at p-value <0.05 (two-tailed). All analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA).

Results

Descriptive statistics for language at 2 years of corrected age and reading fluency and reading comprehension at 11 years in children born VP are presented in Table 2. Mean lexicon size at 2 years was 235 (corresponding value in the norming group of the method: mean 279 words, SD 163). Seventeen children (15%) had a small lexicon size (10th percentile, <30 words) and 24 children (23%) had a weak M3L (10th percentile, <2.06). Mean reading fluency score at 11 years was 94 (corresponding value in the norming group: 128) and mean reading comprehension score was 18 (corresponding value in the norming group:18). Weak reading fluency (-1 SD) was found in 56 children (54%), and weak reading comprehension (-1 SD) in 27 children (24%).

Associations between language development at 2 years of corrected age and reading fluency and reading comprehension at 11 years

Significant correlations (r-values between 0.20 and 0.49, p <0.01 – <0.05) were found between lexicon size and M3L and reading fluency and reading comprehension (Table 3) After excluding children with NDI, the correlations remained significant between language measures and reading comprehension.

Table 2. Means (M), standard deviations (SD), and minimum and maximum (min, max) of language at 2 years of corrected age and reading fluency and reading comprehension at 11 years of age. Values for all children born very preterm (VP, birth weight ≤1500 g and/or <32 gestational weeks) and for the subgroup of children born VP without neurodevelopmental impairment (NDI) are presented.

	Children born very preterm	Children born very preterm without NDI
Measure	M (SD) [min, max] n = 115[a]	M (SD) [min, max] n = 98
At 2 years		
Lexicon size	235 (161) [2, 574]	249 (152) [4, 525]
M3L[a]	5 (3) [1, 14]	5 (3) [1, 14]
At 11 years		
Reading fluency	94 (39) [0, 210]	99 (35) [2, 210]
Reading comprehension	18 (4) [0, 24]	18 (4) [7, 24]

[a]M3L = Mean length of the three longest utterances value form FinCDI calculated in morphemes (Charkaluk et al., 2019; Skarakis-Doyle et al., 2009).

Table 3. Pearson's correlation coefficient values (Pearson's *r*-values and *p*-values) between language measures at 2 years and reading fluency and reading comprehension at 11 years. Values for all children born very preterm (VP, birth weight ≤1500 g and/or <32 gestational weeks) and for the subgroup of children born very preterm without neurodevelopmental impairment (NDI) are presented.

	Reading fluency at 11 years		Reading comprehension at 11 years	
2-year measures	*r*	*p*	*r*	*p*
Children born VP[a]				
Lexicon size	.20	**0.04**	.49	<0.001
M3L[a]	.29	**0.005**	.48	<0.001
Children born VP without NDI[b]				
Lexicon size	.11	0.31	.41	<0.001
M3L[a]	.20	0.07	.41	<0.001

[a]M3L = Mean length of the three longest utterances value form FinCDI (Charkaluk et al., 2019; Skarakis-Doyle et al., 2009).
[b]NDI = Neurodevelopmental impairment.

The explanatory value of language development at 2 years on reading fluency and reading comprehension at 11 years

The results of the four linear regression models are presented in Table 4. All models were significant (p for F <0.001). The models with lexicon size and the confounding factors (i.e., gestational age, mother's reading difficulties, father's reading difficulties, paternal education, and sex) as explanatory variables explained 29% of the variance in reading fluency and 32% of the variance in reading comprehension. The models with M3L and the background factors as explanatory variables explained 34% of the variance in reading fluency and 33% of the variance in reading comprehension. In the models with reading fluency as the outcome, only sex, and mother's and fathers reading difficulties were significant independent explanators. In the models with reading comprehension as the outcome, lexicon size, M3L and sex were significant independent explanators. After exclusion of the children born VP with NDI, the models explained 25%–27% of the variance in reading comprehension.

The predictive value of language development at 2 years for reading fluency and reading comprehension at 11 years

The specificity, sensitivity, positive and negative predictive values, and the AUC values of the language variables (10th percentile cutoff) measured at 2 years for identifying weak (−1SD) reading fluency and weak (−1SD) reading comprehension at 11 years are presented in Table 5. The models with lexicon size and M3L for identifying weak reading comprehension were significant (p <0.001, AUC values 0.76 and 0.74). The M3L had the best specificity (86.2) and sensitivity (44.0) for identifying weak reading comprehension in children born VP.

The ROC-curve representing the ability of lexicon size at 2 years to predict weak reading comprehension at 11 years is presented in Figure 2, and the ability of M3L value at 2 years to predict weak reading comprehension at 11 years is presented in Figure 3.

Discussion

This study investigated the longitudinal associations between language skills at 2 years of corrected age and reading fluency and reading comprehension ability at 11 years of age in

Table 4. Results of multiple variable linear regression analyses (four models) with lexicon size at 2 years together with background factors (Model 1 and Model 2), and M3L at 2 years together with background factors (Model 3 and Model 4) as explanatory variables. The outcome variables are reading fluency and reading comprehension at 11 years. Results of all very preterm children are presented.

	Model 1 Reading fluency at 11 y		Model 2 Reading comprehension at 11 y	
	b (95% CI)	*p*	*b* (95% CI)	*p*
Gestational age	−1.2 (−4.0 to 1.6)	.41	−0.04 (−0.3 to 0.3)	.82
Reading difficulties				
Mothers	38.4 (15.4 to 61.5)	.001	1.5 (−1.2 to 4.1)	.27
Fathers	27.7 (5.23 to 50.2)	.02	1.6 (−1.0 to 4.1)	.23
Paternal education	5.8 (−9.4 to 21.0)	.45	1.6 (−0.02 to 3.3)	.053
Sex	32.3	<.001	2.8 (1.1 to 4.4)	.001
Lexicon size at 2 y	0.002 (−0.05 to 0.05)	.93	0.01 (0.01 to 0.02)	<.001
Fit statistics for the models				
F	5.2		6.9	
P for F	**<0.001**		**<0.001**	
R^2	0.29		0.32	
ΔR^2	0.23		0.27	
	Model 3 Reading fluency at 11 y		Model 4 Reading comprehension at 11 y	
	b (95% CI)	p	*b* (95% CI)	p
Gestational age	−1.0 (−3.5 to 1.6)	.45	−0.10 (−0.37 to 0.3)	
Reading difficulties				
Mothers	33.6 (12.6 to 54.7)	.002	1.7 (−0.9 to 4.3)	.21
Fathers	27.0 (6.1 to 48.0)	.012	1.4 (−1.2 to 4.0)	.30
Paternal education	9.1 (−5.1 to 23.5)	.20	1.5 (−0.7 to 3.2)	.08
Sex	27.0 (12.8 to 40.1)	<.001	2.5 (0.8 to 4.2)	.01
M3L[a] at 2 y	0.43 (−0.1 to 0.1)	.11	0.1 (0.1 to 0.2)	<.001
Fit statistics for the models				
F	6,5		7.0	
P for F	**<0.001**		**<0.001**	
R^2	0.34		0.33	
ΔR^2	0.29		0.28	

[a]M3L = Mean length of the three longest utterances value form FinCDI (Charkaluk et al., 2019; Skarakis-Doyle et al., 2009).

Table 5. Specificity, sensitivity, positive and negative predictive values, and the area under the receiver operating characteristic curve (AUC) values for lexicon size (10th percentile, <30 words) and M3L (10th percentile, <2,06) at 2 years for identifying weak reading fluency (−1SD, <98 scores) and weak reading comprehension (<14 scores) skills at 11 years of age. Results for all children born very preterm are presented.

	Reading fluency at 11 years					
	Specificity, %, (95% CI)	Sensitivity, % (95% CI)	PPV, % (95% CI)	NPV, % (95% CI)	AUC, % (95% CI)	*p* for AUC
FinCDI at 2 years						
Lexicon	85.4 (72.2–93.9)	17.0 (7.6–28.3)	56.3 (34.1–76.2)	46.6 (42.5–50.7)	54.1 (43.0–64.0)	.47
M3L[a]	83.0 (68.6–92.2)	28.0 (19.5–46.7)	66.7 (48.6–80.9)	52.8 (46.9–58.5)	56.9 (45.0–69.0)	.24
	Reading comprehension at 11 years					
	Specificity	Sensitivity	PPV	NPV	AUC	p for AUC
Lexicon	88.5 (79.8–95.4)	26.0 (11.1–46.3)	41.2 (22.8–62.4)	79.4 (75.3–82.9)	74.0 (65.0–82.0)	<.001
M3L[a]	86.2 (75.3–92.0)	44.0 (27.8–68.7)	50.0 (34.0–65.9)	83.9 (78.0–88.5)	76.0 (65.0–86.9)	<.001

[a]M3L = Mean length of the three longest utterances value form FinCDI (Charkaluk et al., 2019; Skarakis-Doyle et al., 2009).

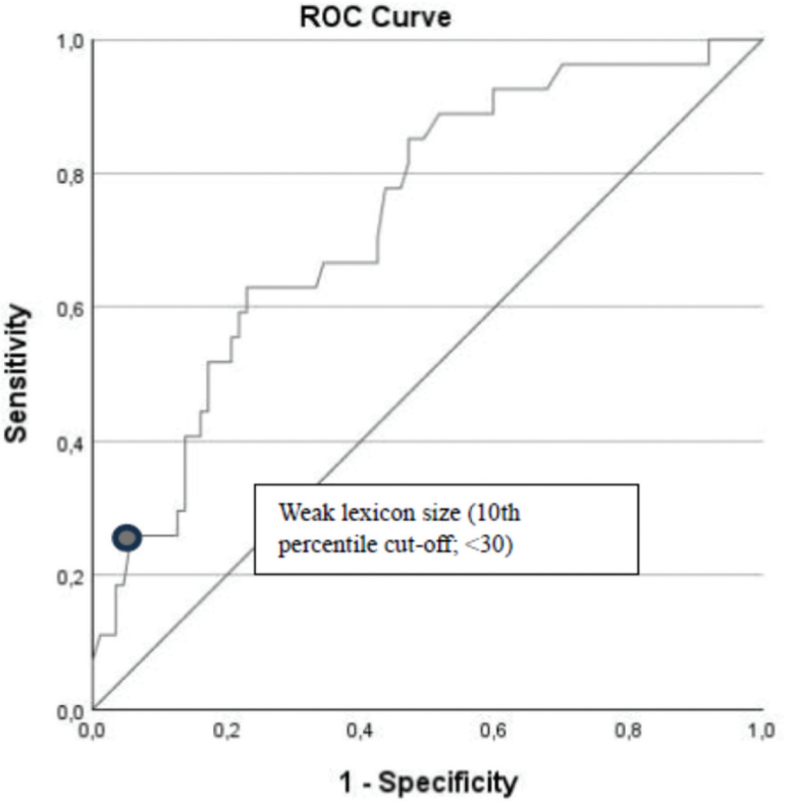

Figure 2. Receiver operating characteristic curve analysis presenting the ability of the lexicon size (10th percentile cut-off, <30 words) of the FinCDI measured at 2 years of corrected age to predict weak reading comprehension (−1SD, <98 scores) skills at 11 years of age in children born very preterm (AUC 0.74, $p < 0.001$).

children born very preterm. Significant correlations were found between early language and later reading fluency and reading comprehension. After excluding children with NDI, the associations remained significant between early language measures and reading comprehension. Lexicon size and M3L at 2 years of age were significant predictors in the regression models explaining the variance in reading comprehension at 11 years. According to AUC values, early language had fair overall ability to predict later reading comprehension at 11 years. Further, 2-year language variables had high specificity but low sensitivity for identifying weak reading comprehension almost a decade later in children born VP.

Clear correlations between early language skills at 2 years of corrected age and reading comprehension at 11 years were found in children born very preterm. Our findings are well-aligned with previous studies evaluating the reading comprehension of full-term populations (Hjetland et al., 2020; Lyytinen & Erskine, 2016; Torppa et al., 2020), as well as with the Simple View of Reading (SVR) model (Hoover & Gough, 1990), indicating that after the beginning phases of reading acquisition, the predictive associations between linguistic skills (such as expressive vocabulary) and later reading comprehension ability

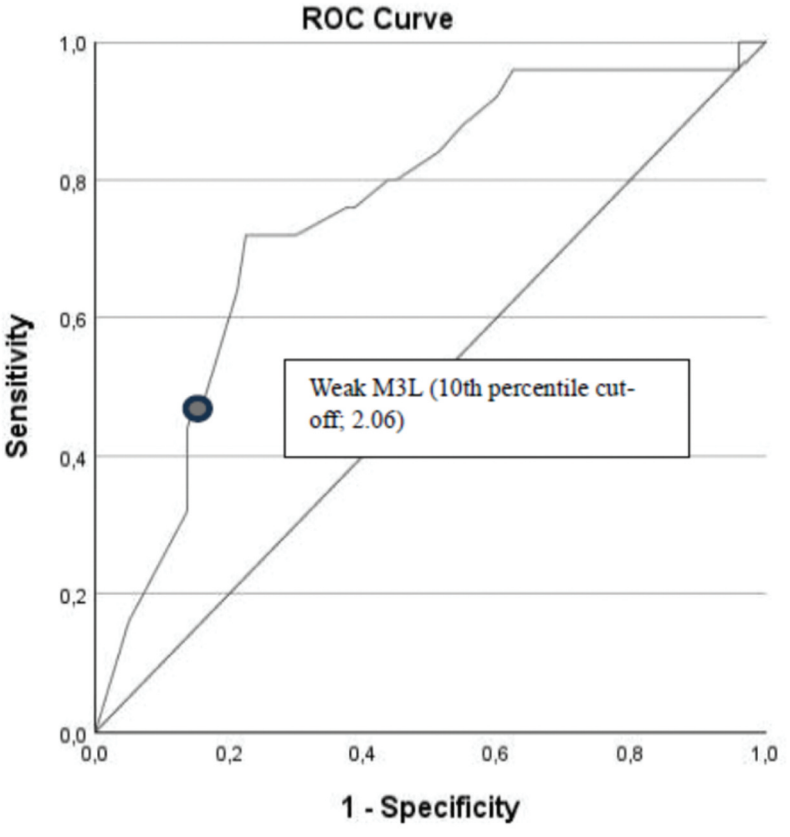

Figure 3. Receiver operating characteristic curve analysis presenting the ability of the M3L (mean length of the three longest utterances, cut-off 10th percentile <2.06) measured at 2 years of corrected age to predict weak reading comprehension (−1SD, <98 scores) at 11 years of age in children born very preterm (AUC 0.76, $p < 0.001$).

become more evident (Hoover & Gough, 1990; Torppa et al., 2020). Our results add to the current knowledge suggesting, for the first time, that the association between early expressive language skills (lexicon size and M3L) and later reading comprehension is evident also in children born VP, already at 2 years of corrected age. These associations remained significant even after the children with NDI were excluded.

By contrast, for reading fluency at 11 years, the correlations with early language were low. After the children with NDI were excluded, the associations were no longer significant. Previously, the association between 2-year language development and later reading fluency in the population of children born VP has been the subject of only two longitudinal studies (Hedenius et al., 2025; Joensuu et al., 2021). Our findings for reading fluency are in line with the recent longitudinal study reporting no significant associations between the language scales of Bayley III at 2.5 years and reading fluency skills at 12 years in a Swedish VP cohort (Hedenius et al., 2025). In an earlier study of the same PIPARI cohort (Joensuu et al., 2021), we reported associations between language at 2 years of corrected age measured with the long-form version of the FinCDI, and early literacy skills at 7 years, which is the age when Finnish children begin formal schooling after spending

1 year in preschool offering 4 hours of systematic education. Interestingly, the decoding ability at 7 years was associated with language at 2 years of age. However, the current results suggest that this association diminishes during the school years as decoding skills become automatized, and reading fluency is no longer associated with the earliest phases of language development in children born VP.

Early language at 2 years of corrected age together with confounding factors explained 32%–33% of the variance in reading comprehension 9 years later, at age 11 years, in children born VP. Delayed early language development in toddlerhood has been predictive for later literacy difficulties in full-term populations, for example, in late-talking children (Rescorla, 2000, 2009) (i.e., children with small expressive lexicon at 2 years with age-appropriate cognitive skills and no neurological condition explaining the slow language acquisition). Late talkers performed consistently weaker in language and literacy at school age and even in adolescence than their peers (Rescorla, 2000, 2009). The present findings suggest that small lexicon and short utterance length at 2 years of corrected age are risk factors for later deficits in reading comprehension also in children born VP.

Among the confounding factors in the regression models, child's sex was a significant variable explaining unique variance in reading comprehension. Male sex is a well-known risk factor for both cognitive and educational deficits in preterm children (Linsell et al., 2015). In the former studies regarding the same PIPARI cohort, male sex was found to be a significant risk for working memory and processing-speed functioning at 11 years (Nyman et al., 2017) and a significant predictor in the association between 1st grade-literacy skills and later reading ability of school-aged children born VP (Joensuu et al., 2025). Our results support these earlier findings suggesting that sex continues to have an impact on reading ability from early years up to later school age in children born VP. Interestingly, preliminary analyses indicated that paternal education was more strongly associated with later reading skills than maternal education and was therefore included as a confounding factor. Although maternal education is a well-established predictor, emerging evidence suggests that paternal influences, such as educational level, interaction style, and caregiving involvement, may also contribute to children's language and literacy development (Leech et al., 2013; Nyman et al., 2017; Rowe et al., 2017). These factors may help explain the observed associations, even though paternal education did not reach statistical significance in the final models.

Lexicon size and M3L at age 2 had fair ability to predict weak reading comprehension skills almost a decade later, at 11 years (AUC values 0.74 and 0.76, p <0.001). Both small lexicon size and weak M3L (at the 10th percentile cutoffs) had acceptable specificity (0.88 and 0.85) as well as fair negative predictive values (0.79 and 0.84), suggesting that most children without difficulties in reading comprehension at 11 years were correctly identified at the corrected age 2 years. Sensitivity (0.26 and 0.48) and positive predictive values (0.41 and 0.50), in turn, were lower, implying 2-year language variables were able to identify, at best, half of the children with weak reading comprehension skills 9 years later. It is interesting to interpret our results in light of findings from a recent cohort study by James et al. (James et al., 2025) which examined full-term children with reading comprehension difficulties. The authors reported that early oral language ability at ages 2 and 3 was the most consistent and robust predictor of weak reading comprehension at age 9, although overall classification accuracy was low (AUC values below 0.60). The likelihood

of later reading comprehension difficulties increased when additional risk factors, such as verbal memory at ages 4 and 5, nonverbal IQ at age 4, and phonemic awareness at age 5, were included, although predictive accuracy remained weak (AUC <.60). These findings emphasize the challenges of precisely predicting individual outcomes and highlight the importance of considering a broader set of variables. On the other hand, the results of the present study regarding the overall ability (i.e., AUC values) of 2-year language variables of the CDI to predict later reading comprehension (AUC 0.74–0.77) were quite similar to the AUC values of a school readiness framework consisting of wide multidisciplinary neurodevelopmental assessment with a board set of variables measured at 4 years on the prediction of math and reading skills at age 6 and 9 years (AUC 0.77) in children born VP reported by Pritchard et al. (Pritchard et al., 2014) Our results extend this previous finding (2014) to very early language skills at 2 years of age, providing further knowledge of the predictive value of 2-year language skills assessed using a parental report instrument on later reading comprehension up to 11 years in children born VP.

This study has several clinical implications. The results highlight the clinical importance of evaluating very early language skills of children born VP at the corrected age of 2 years. Our findings suggest that the association between early weak language and later weak reading comprehension in VP children is evident even without NDI. This is an important finding since clinical follow-up of children born VP to detect deviant development, is often provided up to the corrected age of 2 years, and rarely continued if NDI, or other specific developmental risk is not present. In addition, our study adds to the growing body of evidence indicating that parents can provide valuable information on their child's language development when structured, validated instruments are used (Charkaluk et al., 2019; Joensuu et al., 2021; Skarakis-Doyle et al., 2009). In light of the present results, the long-form version of the CDI (Fenson et al., 1994; Lyytinen, 1999) appears to be a cost-effective tool for screening toddlers at risk for later reading difficulties and could be recommended as part of a broader evaluation carried out in the early follow-up of children born VP.

The strength of this study is its prospective longitudinal design with a well-defined, regional cohort of children born VP providing an excellent setting to assess longitudinal associations from toddlerhood to later school age. Methods used to evaluate early language development in this study are helpful and widely available. (Pritchard et al., 2014; Rescorla et al., 2009) At 11 years, the core components of reading were evaluated separately, enabling us to analyze the predictive value of early language skills for both reading fluency and reading comprehension. As a limitation, it was not possible to compare the longitudinal associations with the full-term control group of the PIPARI study since the reading evaluation at 11 years included only children born VP. Also, measures of early language used in the study provide information on expressive language only. Information on early receptive language could have contributed to a more comprehensive understanding of the predictive value of early language development. Furthermore, assessing pragmatic skills and the social use of language in toddlerhood may offer additional insight into the relationship between early language and later reading skills. It may also be valuable to include additional risk factors that influence later development in the analyses, such as environmental variables (e.g., birth order, early childhood experiences, school experiences) and a broader range of cognitive factors (e.g., verbal and nonverbal IQ, verbal short-term memory). Further, in this study, reading

fluency at age 11 was assessed using a word-chain test, where children marked word boundaries in a string of unspaced words. This test is particularly suitable for languages with highly transparent orthography, such as Finnish, and is widely used as a research tool in Finland (Leppänen et al., 2008; Torppa et al., 2020). However, to capture a more comprehensive view of reading fluency, future studies should consider using a wider range of assessment methods. For future studies, we emphasize the importance of controlled trials regarding effective early interventions for children born VP with delayed language development.

Conclusions

For early intervention, it is important to identify potential risks for learning deficits as early as possible. The current study provides evidence that risk for difficulties in reading comprehension in later school age could be identified already in toddlerhood, at age 2 years in children born VP. If weak expressive language is detected based on the results of a parental report instrument, such as the long-form version of the CDI, a comprehensive clinical assessment of language skills by a speech-language pathologist is recommended.

Acknowledgments

We thank for the following persons in the PIPARI Study Group: Satu Ekblad; Eeva Ekholm; Linda Grönroos; Minttu Helin; Max Karukivi; Pentti Kero; Riikka Korja; Katri Lahti; Liisa Lehtonen; Tuomo Lehtonen; Marika Leppänen; Annika Lind; Sofia Sapattinen; Jonna Maunu; Laura Haveri; Eeva Mäkilä; Laura Määttänen; Pekka Niemi; Helena Ollila; Riitta Parkkola; Päivi Rautava; Liisi Ripatti; Katriina Saarinen; Tiina Saarinen; Susanna Salomäki; Sirkku Setänen; Virva Saunavaara; Matti Sillanpää; Päivi Tuomikoski-Koiranen; Timo Tuovinen; Karoliina Uusitalo; Anniina Väliaho; Milla Ylijoki.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This study was funded by the Doctoral Programme in Cognition, Learning, Instruction, and Communication, University of Helsinki, Finland (four-year salaried doctoral researcher position for E.J.).

References

Borchers, L. R., Bruckert, L., Travis, K. E., Dodson, C. K., Loe, I. M., Marchman, V. A., & Feldman, H. M. (2019). Predicting text reading skills at age 8 years in children born preterm and at term. *Early Human Development*, *130*, 80–86. https://doi.org/10.1016/j.earlhumdev.2019.01.012

Charkaluk, M. L., Rousseau, J., Benhammou, V., Datin-Dorriere, V., Flamant, C., Gire, C., Kern, S., Pierrat, V., Kaminski, M., & Marret, S. (2019). Association of language skills with other developmental domains in extremely, very, and moderately preterm children: EPIPAGE 2 cohort study. *Journal of Pediatrics*, *208*, 114–120.e5. https://doi.org/10.1016/j.jpeds.2018.12.007

Ecalle, J., Dujardin, E., Gomes, C., Cros, L., & Magnan, A. (2021). Decoding, fluency and reading comprehension: Examining the nature of their relationships in a large-scale study with first graders. *Reading and Writing Quarterly*, *37*(5), 444–461. https://doi.org/10.1080/10573569.2020.1846007

Fenson, L., Dale, P. S., Reznick, J. S., Bates, E., Thal, D. J., Pethick, S. J., & Stiles, J. (1994). Variablitiy in early communicative development. *Monographs of the Society for Research in Child Development*, *59*(5), i-185, 134–141.

Guarini, A., Bonifacci, P., Tobia, V., Alessandroni, R., Faldella, G., & Sansavini, A. (2019). The profile of very preterm children on academic achievement. A cross-population comparison with children with specific learning disorders. *Research in Developmental Disabilities*, *87*, 54–63. https://doi.org/10.1016/j.ridd.2019.02.001

Guarini, A., Sansavini, A., Fabbri, C., Savini, S., Alessandroni, R., Faldella, G., & Karmiloff-Smith, A. (2010). Long-term effects of preterm birth on language and literacy at eight years. *Journal of Child Language*, *37*(4), 865–885. https://doi.org/10.1017/S0305000909990109

Hedenius, M., Johansson, M., Kaul, Y. F., Andersson, E., Montgomery, C., Hellström-Westas, L., & Kochukhova, O. (2025). Predictors of language and reading outcomes in 12-year-old children born very preterm. *Acta Paediatrica*, *114*(1), 100–108. https://doi.org/10.1111/apa.17408

Heikkinen, M., Kallankari, H., Partanen, L., Korkalainen, N., Kaukola, T., & Yliherva, A. (2021). Children born before 32 weeks of gestation displayed impaired reading fluency, comprehension and spelling skills at 9 years of age. *Acta Paediatrica*, *110*(2), 521–527. https://doi.org/10.1111/apa.15456

Hjetland, H. N., Brinchmann, E. I., Scherer, R., Hulme, C., & Melby-Lervåg, M. (2020). Preschool pathways to reading comprehension: A systematic meta-analytic review. *Educational Research Review*, *30*, 100323. https://doi.org/10.1016/j.edurev.2020.100323

Hoover, W. A., & Gough, P. B. (1990). The simple view of reading. *Reading & Writing*, *2*(2), 127–160. https://doi.org/10.1007/BF00401799

James, E., Thompson, P., Bowes, L., & Nation, K. (2025). Language and beyond: A registered report examining single and multiple risk models of later reading comprehension weaknesses. *Developmental Science*, *28*(5), e70048. https://doi.org/10.1111/desc.70048

Joensuu, E., Munck, P., Nyman, A., Setänen, S., Rautava, P., & Stolt, S. (2025). Finnish children born very preterm have good reading comprehension but weak reading fluency at age 11 years – A longitudinal cohort study. *Child Neuropsychology*, *31*(4), 585–612. https://doi.org/10.1080/09297049.2024.2415531

Joensuu, E., Munck, P., Setänen, S., Lipsanen, J., Huhtala, M., Lapinleimu, H., & Stolt, S. (2021). Associations between language at 2 years and literacy skills at 7 years in preterm children born at very early gestational age and/or with very low birth weight. *Children*, *8*(6), 510. https://doi.org/10.3390/children8060510

Kovachy, V. N., Adams, J. N., Tamaresis, J. S., & Feldman, H. M. (2015). Reading abilities in school-aged preterm children: A review and meta-analysis. *Developmental Medicine & Child Neurology*, *57*(5), 410–419. https://doi.org/10.1111/dmcn.12652

Leech, K., Salo, V., Rowe, M., & Cabrera, N. (2013). Father input and child vocabulary development: The importance of wh questions and clarification requests. *Seminars in Speech and Language*, *34*(4), 249–259. https://doi.org/10.1055/s-0033-1353445

Leppänen, U., Aunola, K., Niemi, P., & Nurmi, J. E. (2008). Letter knowledge predicts grade 4 reading fluency and reading comprehension. *Learning & Instruction*, *18*(6), 548–564. https://doi.org/10.1016/j.learninstruc.2007.11.004

Lindeman, J. (1999). *Allu - reading test for primary school*. The Center for Learning Research.

Linsell, L., Malouf, R., Morris, J., Kurinczuk, J. J., & Marlow, N. (2015). Prognostic factors for poor cognitive development in children born very preterm or with very low birth weight: A systematic review. *JAMA Pediatrics*, *169*(12), 1162–1172. https://doi.org/10.1001/jamapediatrics.2015.2175

Lyytinen, H., & Erskine, J. (2016). Early identification and prevention of reading problems. In *Encyclopedia on early childhood development: Learning disabilities* (pp. 1–5). Centre of

Excellence for Early Childhood Development. https://www.child-encyclopedia.com/pdf/complet/learning-disabilities

Lyytinen, P. (1999). *The adapted Finnish long-form version of the MacArthur-Bates Communicative development inventories*. Niilo Mäki-Instituutti.

McBryde, M., Fitzallen, G. C., Liley, H. G., Taylor, H. G., & Bora, S. (2020). Academic outcomes of school-aged children born preterm: A systematic review and meta-analysis. *JAMA Network Open*, *3*(4), e202027–e202027. https://doi.org/10.1001/jamanetworkopen.2020.2027

Nguyen, T.-N.-N., Spencer-Smith, M., Zannino, D., Burnett, A., Scratch, S. E., Pascoe, L., Ellis, R., Cheong, J., Thompson, D., Inder, T., Doyle, L. W., & Anderson, P. J. (2018). Developmental trajectory of language from 2 to 13 years in children born very preterm. *Pediatrics*, *141*(5), e20172831. https://doi.org/10.1542/peds.2017-2831

Nyman, A., Korhonen, T., Munck, P., Parkkola, R., Lehtonen, L., & Haataja, L. (2017). Factors affecting the cognitive profile of 11-year-old children born very preterm. *Pediatric Research*, *82* (2), 324–332. https://doi.org/10.1038/pr.2017.64

Pritchard, V. E., Bora, S., Austin, N. C., Levin, K. J., & Woodward, L. J. (2014). Identifying very preterm children at educational risk using a school readiness framework. *Pediatrics*, *134*(3), e825–e832. https://doi.org/10.1542/peds.2013-3865

Rescorla, L. (2000). Do late-talking toddlers turn out to have reading difficulties a decade later? *Annals of Dyslexia*, *50*(1), 85–102. https://doi.org/10.1007/s11881-000-0018-2

Rescorla, L. (2009). Age 17 language and reading outcomes in late-talking toddlers: Support for a dimensional perspective on language delay. *Journal of Speech, Language, & Hearing Research*, *52*(1), 16–30. https://doi.org/10.1044/1092-4388(2008/07-0171)

Rowe, M., Leech, K., & Cabrera, N. (2017). Going beyond input quantity: Wh-questions matter for toddlers' language and cognitive development. *Cognitive Science*, *41*(S1), 162–179. https://doi.org/10.1111/cogs.12349

Sansavini, A., Guarini, A., Justice, L. M., Savini, S., Broccoli, S., Alessandroni, R., & Faldella, G. (2010). Does preterm birth increase a child's risk for language impairment? *Early Human Development*, *86*(12), 765–772. https://doi.org/10.1016/j.earlhumdev.2010.08.014

Setänen, S., Haataja, L., Parkkola, R., Lind, A., & Lehtonen, L. (2013). Predictive value of neonatal brain MRI on the neurodevelopmental outcome of preterm infants by 5 years of age. *Acta Paediatrica*, *102*(5), 492–497. https://doi.org/10.1111/apa.12191

Skarakis-Doyle, E., Campbell, W., & Dempsey, L. (2009). Identification of children with language impairment: Investigating the classification accuracy of the MacArthur–Bates Communicative Development Inventories, Level III. *American Journal of Speech-Language Pathology*, *18*(3), 277–288. https://doi.org/10.1044/1058-0360(2009/08-0035)

Stipdonk, L. W., Dudink, J., Utens, E., Reiss, I. K., & Franken, M. (2020). Language functions deserve more attention in follow-up of children born very preterm. *European Journal of Paediatric Neurology*, *26*, 75–81. https://doi.org/10.1016/j.ejpn.2020.02.004

Stolt, S., Matomäki, J., Lind, A., Lapinleimu, H., Haataja, L., & Lehtonen, L. (2014). The prevalence and predictive value of weak language skills in children with very low birth weight – A longitudinal study. *Acta Paediatrica*, *103*(6), 651–658. https://doi.org/10.1111/apa.12607

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities*, *43*(4), 308–321. https://doi.org/10.1177/0022219410369096

Torppa, M., Vasalampi, K., Eklund, K., Sulkunen, S., & Niemi, P. (2020). Reading comprehension difficulty is often distinct from difficulty in reading fluency and accompanied with problems in motivation and school well-being. *Educational Psychology*, *40*(1), 62–81. https://doi.org/10.1080/01443410.2019.1670334

Wechsler, D. (2011). *Wechsler Intelligence scale for children -IV. Handbook I. (Administration and Scoring)*. Psykologien Kustannus.