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REGULAR ARTICLE

Early lexical development and risk of verbal and nonverbal cognitive delay at school age

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ABSTRACT

Aim: To characterise the relationship between preschool lexical delay and language comprehension and nonverbal intelligence at school age.

Methods: The mothers of 2724 children completed the MacArthur Communicative Development Inventory when their child reached 1.5 years and the Language Development Survey and the Parent Report of Children's Ability at 2.5 years. When the children were 6 years old, we assessed vocabulary comprehension and nonverbal intelligence using Dutch batteries for language and nonverbal intelligence.

Results: Demographic factors explained 9.9% of the variance in vocabulary comprehension and 8.7% of the variance in nonverbal intelligence at 6 years. Male gender, low maternal education and non-Western ethnic background predicted vocabulary comprehension delay at 6 years. Lexical development at 1.5 and 2.5 years explained only 3.8% of the variance in language comprehension at the age of six. Late onset expressive vocabulary delay increased the risk of language comprehension and nonverbal intelligence delay at 6 years ($OR=2.31$, 95% CI : 1.62–3.29 and $OR=1.74$, 95% CI : 1.17–2.58, respectively).

Conclusion: Sociodemographic factors are important predictors of delays in language and nonverbal abilities as children enter school. In contrast, early expressive lexical delays, in particular before the age of two, have limited predictive power for language delays at the age of six.

INTRODUCTION

Expressive language delay is a common concern for parents and healthcare providers, despite large individual differences in vocabulary development (1). Children designated as late talkers demonstrate expressive vocabulary delay between 18 and 35 months of age, but show typical development in other domains, such as no intellectual disability or autism spectrum disorders (2). Studies of small numbers of late talkers indicate that most of these children attain normal language skills by school age (3). However, these studies also indicate that late talkers consistently

score lower on language measures than peers with typical language development (4). Significant predictors of verbal outcome in these studies included vocabulary size and nonverbal cognitive abilities at the age two, together with preschool expressive and receptive language. However, in these studies, about half the variance in school-age outcomes has been explained, at most (3).

Abbreviations

BSI, Brief Symptom Inventory; LDS, Language Development Survey; MCDI-N, MacArthur Communicative Development Inventory–Netherlands; NOSI-K, Nijmeegse Ouderlijke Stress Index; OR, Odds ratio; PARCA, Parent Report of Children's Ability; ROC, Receiver operating characteristic; SD, Standard deviation; SON-R 2½–7, Snijders-Oomen Niet-verbale intelligentie Test–Revisie; TvK, Taalttest voor Kinderen.

Key notes

- Our study of 2724 children sought to characterise the relationship between preschool lexical delay and language comprehension and nonverbal intelligence at school age.
- Male gender, low maternal education and non-Western ethnic background were key predictors of delay in language and nonverbal abilities at the age of six.
- Expressive lexical delays before age two had very limited predictive power for language delays at the age of six.

The outcome of early vocabulary delay has also been examined in a few epidemiological studies (2,5,6). In 3759 children from a highly diverse Dutch sample, including bilingual children, Henrichs et al. (5) reported that most children (71%) delayed at 1.5 years scored in the normal range at 2.5 years and that most children (70%) delayed at 2.5 years had not been delayed at 1.5 years. In their study, socioeconomic factors explained 5% of the variance in lexicon size at 2.5 years, with birth-related factors explaining an additional 0.2%, gender and age an additional 1% and expressive *z*-scores at 1.5 years an additional 11%. Zubrick et al. (2) reported similar findings from a large Australian sample of monolingual children. Likewise, Reilly et al. (6) reported that a mixture of biological and environmental factors, gender, birth weight and maternal education, predicted language development at 4 years of age in a different Australian sample comprising of monolingual and bilingual children. When the researchers included the information on expressive language at the age of two, this increased their ability to identify children who were likely to demonstrate expressive language delay at the age of four (6). Taken together, these studies demonstrate that birth characteristics and demographic factors typically explained <10% of the variance in language delay outcomes during the preschool period. The effect of demographic factors was stronger in bilingual households (2,5,6). Concurrent or earlier developmental measures have typically accounted for more of the explained variance, but most of the variance in outcomes remained unexplained (5).

Only a few large-scale studies have reported school-age outcomes for late talkers. A study by Armstrong et al. (7) on 689 monolingual and bilingual children reported that late talkers who experienced expressive vocabulary delays at 24, 36 and 54 months recorded lower scores than both late bloomers (children delayed at 24 months but not at 54 months) and children with no history of language delay throughout age 10. In an Australian sample of monolingual children, Rice et al. showed that late talkers and children with typical development did not differ when it came to sociodemographic variables or in nonverbal intelligence at the age of seven (2,8). However, they still recorded significantly lower scores than the typical and late bloomer groups when it came to language tasks.

Thus, the few existing epidemiological studies that examine school-age outcomes are consistent with the small-scale, case-control studies that show that many late talkers display normal range language skills by the age six, even though these are weaker than peers who show typical development. Furthermore, most children with language delay at school age have not shown language delays during the preschool period, indicating poor predictive value of early language assessment for later delay (9). However, the predictors of school-age outcomes for late talkers, as well as the predictors of language delays at the age of six in children with typical early vocabulary development, are largely unknown.

In this study, we determined vocabulary comprehension and nonverbal intelligence outcomes at the age of six in the

four groups of children previously identified: (i) children with no vocabulary delay at an early age, (ii) late bloomers, (iii) children with late onset delay and (iv) children with persistent delay (5,10). Secondly, we determined how well perinatal, demographic and early developmental factors can predict vocabulary comprehension and nonverbal intelligence scores at the age of six.

METHODS

Participants

The present research forms part of the Generation R Study, a population-based cohort based in Rotterdam, the Netherlands (11). Briefly, all pregnant women living in Rotterdam with an expected delivery date between April 2002 and January 2006 were invited to participate. The Medical Ethics Committee of the Erasmus Medical Centre, Rotterdam, approved the study. Written informed consent was obtained from all adult participants, and anonymity was guaranteed.

The parents of 7036 children gave consent for participation in the postnatal phases. Language data were obtained for 5330 of the children at 1.5 and/or 2.5 years, and language data were available for 3667 children at both ages. Language comprehension was assessed in 2724 children of the 3667 children at the age of six (74.2%), and these 2724 children comprised the participants for the main analyses reported here (Fig. S1).

In this sample, 80% of the children were monolingual and 91% spoke Dutch at home. Monolingualism and bilingualism were based on the parent's rating of the languages the child spoke at age 2.5 years.

Early language and cognition

Assessments were performed when the children were 1.5 and 2.5 years, by sending questionnaires to the parents in Dutch, English or Turkish depending on their language needs. A small percentage of the mothers (2%) only spoke Arabic and Arabic-speaking research assistants conducted interviews with them at home. To assess the child's vocabulary, the mothers were asked to report if the child understood and/or said words spontaneously. If the child said a word in a language other than their first language, the mother was asked to indicate the language next to the word. To assess nonverbal skills, the mother administered the test in the child's first language.

MacArthur Communicative Development Inventory–Netherlands

We assessed the child's lexical skills at 1.5 years (mean age = 18.2 ± 0.6 months) using the mothers' responses to the Dutch version of the MacArthur Short Form Vocabulary Checklist (MCDI-N) (12). The MCDI-N is appropriate for measuring the expressive and receptive vocabulary of children aged 16–30 months and has excellent internal consistency, test-retest reliability and concurrent validity (12). To identify vocabulary delay at 1.5 years, we converted the expressive and receptive MCDI-N raw scores

into age-specific and gender-specific percentile scores based on the Generation R sample, using 1-month age brackets. In line with previously described definitions, delay was defined as scores in the lowest 15th age-specific and gender-specific percentiles (10,13,14). An alternative clinical cut-off (5th percentile) was used to explore whether the observed effect depended on the cut-off choice.

Language Development Survey

Expressive vocabulary skills were assessed when the child was 2.5 years (mean age = 30.9 ± 1.2 months), using the mothers' responses to a Dutch translation of the Language Development Survey (LDS) (13). The LDS is appropriate for assessing vocabulary in children aged 18–35 months and has excellent internal consistency, test–retest reliability and concurrent validity (13,14). Children with delayed LDS were identified using age-specific and gender-specific cut-offs at both the 5th and 15th percentiles (14).

Parent Report of Children's Ability

Nonverbal cognition at 2.5 years (mean age = 30.9 ± 1.2 months) was measured using the Parent Report of Children's Ability (PARCA) (15). The parent-administered section of the PARCA comprises 22 items and assesses three functions in children: matching-to-sample, block building and imitation. The parent-report part consists of 26 questions on quantitative abilities, symbolic play, planning and organising, adaptive behaviours and memory. The PARCA can provide valid estimates of a child's nonverbal cognitive abilities at the age of 2 years (15).

Language comprehension and nonverbal intelligence at the age of six

When they were 6 years old (mean age = 6.0 ± 0.3 years), the children were invited to visit the Generation R research centre, where their vocabulary comprehension was assessed using a subtest of a Dutch battery: Taaltest voor Kinderen (TvK) (16). This test battery is composed of subtests that provide information about expressive and receptive vocabulary skills in children aged four to 6 years. In the receptive subset, each item of the test consists of two pictures, and the child has to choose the alternative that matches the given words. Due to the length of the original test and the need to minimise the burden on the children, we selected 27 difficult items from the full battery of 40 items. We added together the total correct answers for each child and divided this sum by the total number of items answered, yielding a percentage correct score. To ensure consistency with the preschool measures, we defined scores in the lowest 15th percentile as delay in vocabulary comprehension at 6 years. We also tested an alternative cut-off (5th percentile).

During the same session, the children's nonverbal intelligence was assessed using two subtests of a Dutch nonverbal intelligence test: Snijders-Oomen Niet-verbale intelligentie Test–Revisie (SON-R 2½-7) (17). The two subsets were Mosaics, which assesses spatial visualisation abilities, and Categories, which assesses abstract reasoning abilities. In a different sample of 626 children, aged

4.5–7.5 years, the correlation between the total scores derived from the Mosaics and Categories subsets, and the IQ scores derived from the complete test, was $r = 0.86$ (18). For this study, raw test scores were converted into nonverbal intelligence scores using norms tailored to the child's exact age. Information on nonverbal intelligence at 6 years was available in 2596 children (71% of the 3667 children with data on early lexical development). Children with scores in the lowest 15th percentile were defined as delayed. The analyses were rerun with an alternative clinical cut-off of the 5th percentile. Language and nonverbal intelligence were assessed in Dutch, because, by the age of six, more than 95% of the children in the Netherlands have attended 2 years of Dutch schooling (19).

Perinatal and demographic variables

Information on the child's birth date, gender, Apgar score at 1 min and birth weight was obtained from midwives and hospital registries. Gestational age at birth was established using ultrasound examination during pregnancy. Parity, parental age, parental ethnic background, maternal history of smoking and parental education were assessed by questionnaires at enrolment. When the children were 6 years old, information on marital status and household income were obtained using questionnaires.

The child's ethnic background was defined based on the parents' country of birth using the Statistical Netherlands classification (5). If both parents were born in the Netherlands, the child was considered 'Dutch'. If only one parent was born in the Netherlands, and the other parent was born in another European countries, United States, Canada, Australia, Japan or Indonesia, the child was classified as 'Other Western'. If one parent was born in the Netherlands or a Western country, but the other parent was born in Cape Verde, Morocco, the Dutch Antilles, Surinam, Turkey or an economically disadvantaged country, the child was categorised as 'Other non-Western'.

Parental education was defined by the highest completed education, using the categories established by Statistics Netherlands, and classified as 'low education', 'mid-low education', 'mid-high education' and 'high education' (5). Maternal smoking was assessed at enrolment and in mid- and late pregnancy to define whether the mother had never smoked during pregnancy, stopped smoking when pregnant or continued smoking during pregnancy.

We used the Brief Symptom Inventory (BSI), a validated self-report questionnaire, to measure maternal psychopathology during pregnancy (20). When the child was 3 years old, we used items from the BSI on depressive symptoms, such as 'thoughts of ending life' and 'feeling lonely', to measure the mother's depressive symptoms. The ability of these items to identify clinical depression has been demonstrated within a subsample of Generation R (21), and high validity and reliability have been reported for the Dutch translation (20).

When the children had reached the age of 1.5 years, the parents filled out questionnaires based on a parenting stress

measure, the Nijmeegse Ouderlijke Stress Index (NOSI-K). The NOSI-K is a shortened and factor-analytically derived version of the Dutch version of the Parenting Stress Index (22). Some items identify parenting stress due to parental factors, while others focus on stress due to child factors. For the present study, we calculated the parenting stress scores by just averaging the 12 parent domain items. Internal consistency of the parent domain items was adequate ($\alpha = 0.74$).

Attrition analyses

We used chi-square statistics and independent sample *t*-tests to compare the baseline characteristic of the children with language data at 1.5, 2.5 and 6 years ($n = 2724$) with the children who had language data at age 1.5 and 2.5 years but not at age 6 years (attrition at age 6-year follow-up, $n = 943$). No significant association was found between participation at the age of six and gender, ethnic background, maternal age, maternal history of smoking, maternal psychopathology and parenting stress. However, the children we saw at the age 6 years had lower PARCA scores at 2.5 years (mean difference 1.9 scores, $p = 0.02$) and lower expressive MCDI-N scores (mean difference = 1.9 scores, $p = 0.002$) than those who did not visit the centre at the age of 6 years. Furthermore, the children included in the analyses were more likely to be from families with low incomes (4.0% versus 2.1% income <1200 Euros, $p = 0.002$) and had less educated mothers (34.3% versus 39.5% high education level, $p = 0.02$) than those excluded because of missing data of the vocabulary comprehension at the age of 6 years.

We also compared the 2724 children included in the analysis with those excluded because of attrition at baseline ($n = 3369$). We found that the excluded children had mothers with lower levels of education, were from lower income families and were mainly from a non-Western national origin. These children had also lower birth weights and gestational age at birth than those included in the analyses.

Statistical analysis

Children with language measures at 1.5, 2.5 and 6 years were included in the main analyses. Missing data for all the covariates were less than 10%, except for maternal psychopathology during pregnancy (20%) and paternal education (30%). Missing values of the covariates were imputed using multiple imputations. Five copies of the original data set were generated, with missing values replaced by values randomly generated from the predictive distribution, on the basis of the correlation between the variable with missing values (covariates) and other variables (language and cognitive scores). The analyses were repeated in the original and five independent imputed data sets. Effect sizes and confidence intervals were estimated by taking the average effect size of the five imputed data sets.

We defined four groups of children on the basis of lexical delay at 1.5 and 2.5 years: (i) no delay – children with normal lexical development at 1.5 and 2.5 years, (ii) late

bloomers – children with expressive lexical delay at 1.5 years, but normal lexical development at 2.5 years, (iii) late onset delay – children without lexical delay at 1.5 years, but delayed at 2.5 years and (iv) persistent expressive delay at 1.5 and 2.5 years (5). Within each of these four groups, subgroups were defined based on whether the child was delayed, versus not delayed, on language comprehension at 6 years.

Prenatal, demographic and developmental characteristics were described for each of these four pairs of children. Perinatal factors consisted of the child's gender, birth weight and gestational age at birth. Demographic factors included the child's ethnic background, the family income, the mother's age and education and the parent's marital status. Early development factors were the child's receptive and expressive MCDI-N, PARCA and LDS scores. Because of co-linearity, maternal and paternal education was not entered into the model simultaneously. However, the models were rerun with paternal education to explore any difference in effect by adjustment.

Our initial analyses involved linear regressions conducted with the full study sample ($n = 2724$). Three regressions were run for each outcome at the age of six (vocabulary comprehension and nonverbal intelligence), each with a different set of predictors (perinatal, demographic and early developmental characteristics). Then, the significant predictors from each set, which had been derived from these three regressions, were entered into final combined linear regression models to explore the percentage of unique variance explained in each outcome measure. The scores of the early developmental scales were *SD*-standardised, so that their associations with later vocabulary comprehension or nonverbal intelligence delay could be interpreted via *SD* increments in these predictors.

Next, the variables with significant effects on language comprehension and intelligence scores at 6 years that had been derived from the separate linear regression were entered simultaneously into multiple logistic regression models to determine significant predictors of delayed versus typical outcomes.

The univariate analysis showed that bilingualism was associated with lower scores on expressive vocabulary at 2.5 years and on both vocabulary comprehension and nonverbal intelligence at age 6 years. After adjustment for socioeconomic factors, including maternal age and education and household income, the effect estimates were attenuated substantially, but remained significant (e.g. unadjusted *B* for nonverbal intelligence = 5.49, 95% *CI*: 1.06–3.64; adjusted *B* = 2.81, 95% *CI*: 2.39–3.23). We repeated the analyses just using the sample of 2179 monolingual children. From 2179 monolingual children, 1829 children had a Dutch ethnic background, according to the Statistic Netherlands classification. We also ran the analyses on all of the 1917 Dutch children to exclude possible effect of ethnicity on observed association. Because of the large sample size, *p* value <0.01 was considered as significant.

RESULTS

Descriptive statistics

Of the 2724 children in our study, 2101 (77.1%) had no delay in expressive vocabulary at 1.5 and 2.5 years and 198 of these showed vocabulary comprehension delay at 6 years (9.4%). Of the 263 late bloomers, 32 (12.2%) were delayed at 6 years. Of the 234 children with late onset vocabulary delay, 68 (29.1%) were delayed at 6 years, whereas 23 (18.3%) of the 126 with persistent lexical delay were delayed at 6 years. Of the 321 children with vocabulary comprehension delay at 6 years, 62% were never delayed, 10% were late bloomers, 21% had late onset vocabulary delay, and 7% were persistently delayed at 1.5 and 2.5 years.

Most children delayed at 1.5 years on expressive MCDI-N had normal range language comprehension score at 6 years of age (positive predictive value = 14%), and most children delayed at 6 years had not scored below the 15th percentile at 1.5 years (sensitivity = 17%). Negative predictive value and specificity were 0.89% and 0.86 for expressive MCDI-N delay. The receiver operating characteristic (ROC) curve using MCDI-N expressive scores at 1.5 years to predict language comprehension delay at 6 years had an area under the curve of 0.57 (95% CI: 0.54–0.60). Similar results emerged with receptive MCDI-N. Delayed LDS scores at 2.5 years had a better predictive value for language comprehension delay at the age of 6 years (positive predictive value = 25%, sensitivity = 28%, specificity = 89% and negative predictive value = 90%). Area under the curve for LDS scores to predict language comprehension delay at 6 years was 0.65 (95% CI: 0.61–0.68).

Table 1 presents the characteristics of the children with, and without, vocabulary comprehension delay at 6 years, split into the four preschool vocabulary status groups. The most important findings included in this table concern the children with no expressive vocabulary delay at 1.5 and 2.5 years ($n = 2101$). Within this group, the 198 children with vocabulary comprehension delay at 6 years differed significantly from the 1903 children with normal comprehension at the age of six in three ways: (i) they had younger and less educated parents; (ii) they were more likely to be boys, from low-income families and with a non-Western ethnic background; and (iii) they had lower LDS and PARCA scores at 2.5 and lower nonverbal intelligence scores at the age of six.

Linear regressions

After running the separate linear regression models for the perinatal, demographic and developmental variables, we combined significant predictors from these separate analyses into the final linear regression models shown in Table 2. Although the full model explained 15% of the variance of vocabulary comprehension at the age of six, most of this variance was explained by the demographic predictors (9.9%), with only 5.3% explained by the four developmental predictors: receptive MCDI-N at 1.5 years = 0.3%, expressive MCDI-N at 1.5 years = 1.5%, PARCA at 2.5 years = 1.5% and LDS at 2.5 years = 2.0%. When a parallel analysis was

run with nonverbal intelligence at the age of six as the outcome measure, the demographic covariates explained 8.7% of the variance and the PARCA at 2.5 years explained an additional 2.3%. The preschool lexicon measures did not predict nonverbal intelligence at the age of six.

We found that the main predictors of vocabulary comprehension in monolingual children were birth weight, maternal education, the child's ethnicity and the expressive MDCI-N, LDS and PARCA scores. The explained variance in lexical development by sociodemographic factors at the age of six was smaller in the monolingual group than the whole cohort (Table S1). When the analyses were just restricted to Dutch children, the explained variance by sociodemographic factors was less than the whole sample (Table S3), which was consistent with the fact that the children from Dutch ethnic background had more favourable sociodemographic backgrounds. Performing the analyses with paternal education level did not affect the results.

Logistic regressions

We used multiple logistic regression models, with the same set of predictors included in the linear regressions models, to predict delayed versus nondelayed outcomes at the age of six (Table 3). Being a girl was associated with a lower risk of vocabulary comprehension delay at the age of six. Lower levels of maternal education increased the risk of vocabulary comprehension delay (*OR* for low education = 2.97, 95% *CI*: 1.92–4.59). Children with non-Western ethnicity were at a higher risk of vocabulary delay at 6 years old than children with Dutch national origin (*OR* = 1.88, 95% *CI*: 1.38–2.55). The children with late onset lexical delay had a higher risk of delay at 6 years old compared to children with no delay at 1.5 and 2.5 years (*OR* = 2.31, 95% *CI*: 1.62–3.29). However, being a late bloomer, and having persistent preschool vocabulary delay, was not associated with language comprehension delay at the age of six.

The logistic regression showed that maternal education levels (*OR* for low education = 3.95, 95% *CI*: 2.54–6.15), child's ethnic background (*OR* for non-Western ethnic background = 1.88, 95% *CI*: 1.38–2.55) and late onset vocabulary delay (*OR* = 1.74, 95% *CI*: 1.17–2.58) significantly predicted nonverbal intelligence at the age of six.

Tables S2 and S4 present the results of similar analyses in monolingual children and in children with Dutch ethnic background, respectively.

When the clinical cut-off of the 5th percentile was used to define verbal and nonverbal cognitive delay at 1.5, 2.5 and 6 years of age, the results remained unchanged (Table S5).

DISCUSSION

Although a few previous studies based on large samples have reported school-age language outcomes for children identified with early language delays (2,8), research on predicting school-age comprehension and nonverbal delay is still quite limited. Our study tested an extensive range of

Table 1 Descriptive for the children with and without lexical delay at ages 1.5, 2.5 and 6 years. The Generation R Study

Up to age 3 years At age 6 years	Lexical development		Late bloomers (n = 263)		Late onset delay (n = 234)		Persistent delay (n = 126)	
	No delay (n = 2101)		Comprehension delay		Comprehension delay		Comprehension delay	
	No	Yes	No	Yes	No	Yes	No	Yes
	n = 1903	n = 198	n = 231	n = 32	n = 166	n = 68	n = 103	n = 23
Maternal characteristics								
Age at enrolment, years	31.9 (0.1)	30.7 (0.3)	32.4 (0.3)	33.9 (0.9)	30.8 (0.4)	29.1 (0.6)	31.9 (0.5)	30.8 (1.1)
Education, %								
Low	8.7	24.4	11.4	20.6	24.7	40.6	19.0	26.1
Mid-low	26.2	34.9	26.0	19.4	26.8	31.5	34.2	18.3
Mid-high	28.5	24.9	25.8	13.1	19.5	17.0	17.5	24.3
High	36.6	15.7	37.8	46.9	30.0	10.9	29.3	31.3
Family income, %								
<1200 Euros	2.8	7.9	3.1	8.8	12.2	15.6	7.6	11.3
1200–2000 Euros	9.2	20.3	9.6	13.1	15.5	28.5	15.7	20.9
>2000 Euros	88.0	71.8	87.3	78.1	72.3	55.9	76.7	67.8
Marital status, single, %	30.2	30.3	28.6	15.6	33.7	26.5	26.2	21.7
Paternal characteristics								
Age and enrolment, years	34.0 (0.1)	33.5 (0.4)	34.8 (0.4)	34.6 (1.0)	33.5 (0.5)	32.6 (0.7)	34.2 (0.7)	32.2 (1.3)
Education, %								
Low	13.5	27.1	16.2	20.0	25.3	33.2	25.2	30.4
Mid-low	24.1	30.5	22.3	25.6	24.9	39.7	28.2	30.4
Mid-high	22.6	18.7	19.0	20.6	20.5	15.6	19.8	20.0
High	39.8	23.7	42.5	33.8	29.3	11.5	26.8	19.2
Child characteristics								
Gender, Boys, %	48.4	58.6	47.6	53.1	52.4	50.0	47.6	56.5
Gestational age at birth, weeks	40.0 (0.1)	39.9 (0.1)	39.6 (0.1)	38.8 (0.5)	39.8 (0.1)	39.8 (0.3)	40.0 (0.2)	39.2 (0.6)
Birth weight, grams	3488 (12)	3416 (36)	3388 (43)	3152 (138)	3393 (45)	3356 (77)	3407 (61)	3195 (136)
Ethnicity, %								
Dutch	75.0	55.1	77.1	59.4	49.4	38.2	63.1	52.2
Other Western	8.6	7.7	9.5	3.1	13.3	12.1	12.6	13.0
Non-Western	16.4	37.2	13.4	37.5	37.3	49.7	24.3	34.8
Receptive MCDI, at 1.5 years	59.1 (0.5)	59.7 (1.9)	43.7 (0.1)	49.1 (5.5)	48.4 (2.2)	58.2 (3.8)	42.0 (2.9)	50.6 (7.8)
Expressive MCDI, at 1.5 years	19.9 (0.4)	18.1 (1.1)	1.6 (0.1)	1.4 (0.1)	11.7 (0.8)	11.1 (1.0)	1.3 (0.1)	1.1 (0.3)
PARCA, at 2.5 years	47.5 (0.1)	46.5 (0.5)	46.0 (0.4)	43.9 (1.1)	44.1 (0.4)	43.3 (0.8)	43.5 (0.7)	41.7 (1.6)
LDS, at 2.5 years	259.4 (0.7)	248.8 (2.7)	238.7 (2.5)	223.8 (7.1)	127.9 (3.9)	117.1 (5.4)	118.5 (4.9)	92.7 (9.2)
Language comprehension at 6 years, percentage of correct answers	89 (0.2)	63 (1)	88 (0.4)	64 (1)	85 (1)	62 (1)	85 (1)	62 (1)

Table 1 (Continued)

Up to age 3 years At age 6 years		Lexical development		Late bloomers (n = 263)		Late onset delay (n = 234)		Persistent delay (n = 126)	
No delay (n = 2101)		Comprehension delay		Comprehension delay		Comprehension delay		Comprehension delay	
No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
n = 1903	n = 198	n = 231	n = 32	n = 166	n = 68	n = 103	n = 23		
106.2 (0.3)	94.7 (0.9)	105.5 (1.0)	93.7 (2.7)	101.8 (1.2)	88.6 (1.9)	101.9 (1.6)	87.0 (3.2)		
Nonverbal intelligence at 6 years, score									
Numbers are means (standard errors) unless otherwise indicated.									
(i) no delay: children with normal vocabulary development at 1.5 and 2.5 years,									
(ii) late bloomers: children with expressive vocabulary delay at 1.5 years but normal vocabulary development at 2.5 years,									
(iii) late onset vocabulary delay: children who were normal at 1.5 years but delayed at 2.5 years and (iv) persistent expressive vocabulary delay at 1.5 and 2.5 years.									
MCDN = MacArthur Short Form Vocabulary Checklist-Dutch version; PARCA = Parent Report of Children's Ability; LDS = Language Development Survey.									
Numbers of children in eight groups were 2379, 106, 120, 7, 74, 17, 17 and 4 using 5th percentile score as cut-off to define children with lexical delay.									

variables tested and provides important evidence regarding demographic and developmental predictors of vocabulary comprehension and nonverbal intelligence at the age of six. Although our full model contained perinatal, demographic and early developmental predictors, it explained only 15% of the variance in vocabulary comprehension at the age of six, leaving most variance unexplained. This is consistent with prediction studies of language delay in the preschool period (2,5).

At the age of six, the majority of the children in all four preschool language status groups had vocabulary comprehension scores in the average range, but the percentage of children with comprehension delay varied significantly across the groups. This finding was independent of cut-off choice. Thus, children who had typical expressive language at 1.5 years, but expressive vocabulary delay at 2.5, had the highest risk of comprehension delay at the age of six.

Of the 321 children with vocabulary comprehension delay at the age of six, 61% had not demonstrated lexical delay at 1.5 and 2.5 years. This indicates that children with language delays at 6 years old were not, by and large, delayed in lexical development before the age of three. This finding suggests that the children delayed at school age are not among those with vocabulary delay during the preschool period. Of the 2101 children in our sample with no expressive vocabulary delay at 1.5 and 2.5 years, those with vocabulary comprehension delay at the age of six were more likely to have younger and less educated mothers and to come from lower income families and from non-Western ethnic backgrounds. The children with comprehension delay in at the age of six also had lower LDS and PARCA scores at 2.5 years, although not low enough for them to be categorised as 'delayed'. Furthermore, these children had a lower mean nonverbal intelligence score at the age of six than the children with no language comprehension delay at the age of six, suggesting that their demographic risk affected both verbal and nonverbal abilities.

At the age of 2.5 years, nonverbal cognition explained 1.4% of the variance in vocabulary comprehension at the age of six, and this is consistent with some previous research (23,24). However, preschool lexicon scores did not predict nonverbal intelligence at 6 years old. Consistent with previous evidence (25), the main predictors of nonverbal intelligence at the age of six were demographic factors, such as maternal education and the child's ethnic background, as well as nonverbal abilities at 2.5 years. However, as with language comprehension at the age of six, most of the variance remained unexplained.

An important conclusion from our study is that lexical delay measured before the age of three had low predictive utility for language comprehension delay at the age of six. This suggests that a practical strategy to decrease the rate of language delay at school entry is to target children with risk factors for later language, such as low maternal education or ethnic minority background, who are also beginning to lag behind their peers in language and nonverbal abilities at the age of three. This is consistent with the conclusions

Table 2 Linear regression models predicting vocabulary comprehension delay and nonverbal intelligence delay at the age of 6 years. The Generation R Study

Predictors	Vocabulary comprehension at 6 years N = 2724				ΔR^2	Nonverbal intelligence at 6 years N = 2596		
	ΔR^2	B	95% CI	p		B	95% CI	p
Perinatal factors								
Gender, girls		0.01	0.00, 0.02	0.05		–	–	–
Birth weight, per 500 grams		0.01	0.002, 0.01	0.004		1.03	0.56, 1.51	<0.001
Demographic factors								
Maternal education	0.099*	0.02	0.01, 0.02	<0.001	0.087*	2.49	1.94, 3.05	<0.001
Maternal marital status		0.01	0.004, 0.02	0.01		–	–	–
Maternal history of smoking		–	–	–		–1.14	–1.99, –0.29	0.01
Family income		0.01	0.003, 0.02	0.01		–	–	–
Child's ethnicity		–0.02	–0.02, –0.01	0.001		–2.09	–2.77, –1.40	<0.001
Developmental scores, per SD								
Receptive MCDI-N, at 1.5 years	0.003*	–0.01	–0.01, –0.002	0.003	0.000	–0.85	–1.42, –0.27	0.004
Expressive MCDI-N, at 1.5 years	0.015*	0.01	0.004, 0.01	<0.001	–	–	–	–
PARCA, at 2.5 years	0.015*	0.01	0.004, 0.01	<0.001	0.023*	1.90	1.29, 2.51	<0.001
LDS, at 2.5 years	0.020*	0.02	0.01, 0.02	<0.001	0.005	1.28	0.69, 1.87	<0.001

MCDI-N = MacArthur Short Form Vocabulary Checklist-Dutch version; PARCA = Parent Report of Children's Ability; LDS = Language Development Survey.

For each outcome at the age of 6 years (vocabulary comprehension and nonverbal intelligence), three regressions were run, each of these three with a different set of predictors (i.e. perinatal, demographic and early developmental characteristics). Significant predictors from each set derived from these three regressions were entered into final combined linear regression models to explore the percentage of unique variance explained in each outcome measure.

* $p < 0.001$.

from the important Hart and Risley study, which documented the large and enduring language deficit found in children from lower sociodemographic status backgrounds by the age of three (26).

In our sample of preschool children, persistent language delay was not a predictor of language comprehension delay at the age of six. A possible explanation for this finding is that the children with persistent delay may have received interventions in the first 2 years of life, which may have allowed them to catch up when it came to language skills. In this study, we defined persistent language delay based on expressive language delay at the age of 1.5 and 2.5 years. Previous studies have shown that this group of the children benefit the most from interventions administered by parents and clinicians (27).

Our study sample consisted of a diverse population of children, including 20% who were bilingual. Using instruments such as MCDI-N and LDS, we assessed children's lexical achievement across languages. In this study, although bilingual children had lower scores on vocabulary comprehension and nonverbal intelligence, the effect of bilingualism on verbal and nonverbal cognition was largely accounted for by socioeconomic factors such as maternal education and household income. We also showed that the predictors of school-age vocabulary comprehension and nonverbal intelligence were similar in monolingual children and in the rest of the cohort. This is in line with findings of previous studies, which show that bilingualism does not appear to impair the ability to learn and use language, as long as both languages the child speaks are taken into account in the assessment (28). Furthermore, we only found an increased risk of vocabulary comprehension delay in non-Western children, as other

Western children were not at a higher risk of vocabulary comprehension delay and nonverbal intelligence than Dutch children. The findings observed in monolingual children, and also in the full cohort, imply that the negative effect associated with a non-Western ethnic background may reflect less favourable socioeconomic factors in this group, rather than poor understanding of the Dutch language. Nevertheless, we cannot entirely rule out an effect of cultural differences on children's performance in verbal and nonverbal tests at school age.

The main limitation of this study is that we did not assess language production in the children when they were 6 years old and to do so would have broadened our findings. However, it has been shown that receptive and expressive language skills tend to be highly correlated in school-age children (29). In our study, we did not have any information available about whether the bilingual children attended a Dutch school. In addition, we did not have any measures of family history of language delay, or of early grammar or verbal memory skills, all of which are important predictors of language delay (30). Had such measures been available, our prediction models might have explained more of the variation in language comprehension. Furthermore, we had no information on whether any of the children received interventions for lexical delay. However, a meta-analysis by Law et al. (27) showed inconclusive findings regarding the effectiveness of interventions after the age of two in children with receptive language difficulties. Therefore, we can speculate that the course of children's language comprehension might have changed somewhat.

Despite the limitations noted, our study has several notable strengths, including a large population-based

Table 3 Multiple logistic regression models predicting vocabulary comprehension and nonverbal intelligence delay. The Generation R Study

	Vocabulary comprehension delay at 6 years			Nonverbal intelligence delay at 6 years		
	OR	95% CI	p	OR	95% CI	p
Perinatal factors						
Gender, girls	0.72	0.56, 0.92	0.01	–	–	–
Birth weight, per 500 grams	0.89	0.80, 0.99	0.04	0.92	0.82, 1.03	0.15
Demographic factors						
Maternal education						
Low	2.97	1.92, 4.59	<0.001	3.95	2.54, 6.15	<0.001
Mid-low	1.87	1.31, 2.67	0.001	2.45	1.65, 3.63	<0.001
Mid-high	1.46	1.01, 2.11	0.04	1.69	1.12, 2.57	0.01
High	ref	ref	ref	ref	ref	ref
Maternal marital status, single	0.68	0.51, 0.92	0.01	–	–	–
Maternal history of smoking						
Never	–	–	–	ref	ref	ref
Smoked until pregnancy was known	–	–	–	0.81	0.47, 1.37	0.43
Continued smoking in pregnancy	–	–	–	1.37	0.96, 1.98	0.09
Family income						
<1200 Euros	1.51	0.85, 2.71	0.16	–	–	–
1200–2000 Euros	1.45	0.98, 2.14	0.06	–	–	–
>2000 Euros	ref	ref	ref	–	–	–
Child's ethnicity						
Dutch	ref	ref	ref	ref	ref	ref
Other Western	1.19	0.76, 1.86	0.44	1.39	0.88, 2.19	0.15
Non-Western	1.88	1.38, 2.55	<0.001	1.71	1.26, 2.33	0.001
Early vocabulary development						
No delay	ref	ref	ref	ref	ref	ref
Late bloomers	1.18	0.78, 1.78	0.45	1.23	0.80, 1.91	0.35
Late onset delay	2.31	1.62, 3.29	<0.001	1.74	1.17, 2.58	0.01
Persistent delay	1.38	0.83, 2.30	0.22	1.66	0.99, 2.77	0.06
PARCA, score at 2½ years	0.77	0.67, 0.88	<0.001	0.76	0.65, 0.87	<0.001

(i) no delay: children with normal vocabulary development at 1.5 and 2.5 years, (ii) late bloomers: children with expressive vocabulary delay at 1.5 years but normal vocabulary development at 2.5 years, (iii) late onset vocabulary delay: children who were normal at 1.5 years but delayed at 2.5 years and (iv) persistent expressive vocabulary delay at 1.5 and 2.5 years.

PARCA = Parent Report of Children's Ability.

The number of children included in one or more analyses was 2724.

Variables with significant effects on vocabulary comprehension and intelligence scores at the age of 6 years from the separate linear regression were entered simultaneously in multiple logistic regression models to determine significant predictors of delayed versus typical outcomes.

multi-ethnic sample, the prospective design, repeated measurements of language skills and combination of parental report and direct assessment.

CONCLUSION

In conclusion, our study of 2724 children living in the Netherlands, and assessed at the ages of 1.5, 2.5 and 6 years, shows that sociodemographic factors are important predictors of delays in language and nonverbal abilities as children enter school. In contrast, early expressive lexical delays, in particular before the age of two, have limited predictive power for language delays at the age of six.

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CONFLICT OF INTEREST

There is no conflict of interest for the authors.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1 The flowchart of the study participants: lexical development at 1.5, 2.5, and 6 years.

Table S1 Early lexical development and verbal and non-verbal cognitive abilities up to the age of 6 years in monolingual children included in the Generation R Study.

Table S2 Multiple logistic regression models predicting vocabulary comprehension and nonverbal intelligence delay in monolingual children included in the Generation R Study.

Table S3 Linear regression models predicting vocabulary comprehension delay and nonverbal intelligence delay at the age of 6 years in children with a Dutch ethnic background included in the Generation R Study.

Table S4 Multiple logistic regression models predicting vocabulary comprehension and nonverbal intelligence

delay in children with a Dutch ethnic background included in the Generation R Study.

Table S5 Multiple logistic regression models predicting vocabulary comprehension and nonverbal intelligence

delay. The Generation R Study (using vocabulary comprehension and nonverbal intelligence scores below 5th percentile as cut-offs).