ACTA PÆDIATRICA
NURTURING THE CHILD

Acta Pædiatrica ISSN 0803-5253

REGULAR ARTICLE

Multilingualism was associated with lower cognitive outcomes in children who were born very and extremely preterm

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Keywords
Cognition, Immigration, Language, Multilingual, Prematurity

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Received
12 February 2018; revised 24 May 2018; accepted 23 July 2018.

DOI:10.1111/apa.14516

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ABSTRACT

Aim: This study determined whether cognitive outcomes differed between very preterm (VPT) and extremely preterm (EPT) children who were monolingual or multilingual when they reached the corrected ages of two and five years.

Methods: The data were collected at the Emma Children's Hospital, Amsterdam, The Netherlands, as part of our national neonatal follow-up programme and comprised 325 VPT/EPT children born between January 1, 2007 and January 1, 2012. The study used the Third Editions of the Bayley Scales of Infant and Toddler Development and the Wechsler Preschool and Primary Scale of Intelligence.

Results: We compared 234 monolingual children, 65 multilingual children who spoke Dutch and at least one foreign language at home and 26 multilingual children who didn't speak Dutch at home. The best performers on the cognitive scale at two years of age and the verbal subscales at five years of age were the monolingual children, followed by the children who spoke Dutch and at least one foreign language at home, then the children who only spoke foreign languages at home.

Conclusion: In our study cohort from The Netherlands, multilingualism lowered the cognitive and verbal outcomes of VPT/EPT children at the corrected ages of two and five years.

INTRODUCTION

Children who are born very preterm (VPT) at 28–32 weeks of gestation or extremely preterm (EPT) at less than 28 weeks are at risk of cognitive problems in infancy, and these can persist into childhood and young adulthood (1–3). Cognitive tests are a major part of the assessments in follow-up programmes for VPT/EPT children (4). Factors related to pregnancy, birth and the neonatal period are associated with cognitive outcomes and socio-demographic factors, such as parental education, have also been reported to influence cognitive outcomes (5,6). Multilingualism is a potentially important, but understudied, socio-demographic factor that can influence cognitive outcomes in VPT/EPT children.

Abbreviations

Bayley-III, Bayley Scales of Infant and Toddler Development, Third Edition; ELBW, Extremely low birth weight; EPT, Extremely preterm; IQ, Intelligence quotient; SD, Standard deviation; VPT, Very preterm; WPPSI-III, Wechsler Preschool and Primary Scale of Intelligence, Third Edition.

Cognitive tests used in the follow-up of VPT/EPT children are usually administered verbally and rely greatly on the children's fluency in the language in which the test is administered. In term born children, some evidence points towards a beneficial effect of multilingualism on cognitive test outcomes (7,8). Multilingualism has been associated with increased brain volume and plasticity and enhanced executive function skills (8,9). It is believed that switching between languages trains inhibition and cognitive flexibility.

Key notes

- We examined the cognitive outcomes of 325 very and extremely preterm children who spoke different languages.
- The best performers on the cognitive scale at two years of age and the verbal subscales at five years of age were the monolingual Dutch speakers, followed by the children who spoke Dutch and at least one foreign language at home.
- The worst performers were the children who only spoke foreign languages at home.

However, neutral (10) and negative (11) associations between multilingualism and cognitive test outcomes have also been described. These discrepancies may be due to methodological differences.

Very preterm/extremely preterm children may find that learning two or more languages simultaneously or sequentially at an early age is more challenging. They are reported to have poorer language skills than their term born peers (12,13), even when results are controlled for the child's nonverbal intelligence and the socio-economic status of the family (14). Rather than enhancing the cognitive skills of VPT/EPT children, learning two languages at an early age may overload their cognitive capacities (15). However, research on this topic is scarce. In most studies of preterm children, outcomes are corrected for multilingualism (16–18). Böhm et al. (2002) reported that multilingualism decreased verbal and full-scale intelligence in very low birth weight children at the age of five years and that this explained 5.4% and 2.3% of the respective variance in these outcomes (17). A study that investigated the effects of multilingualism on cognitive outcomes in VPT/EPT and very low birth weight toddlers, found a negative association between multilingualism and the cognitive scale score of the Bayley Scales of Infant and Toddler Development, Second Edition (15). However, that version of the cognitive scale also covers language items. Lowe et al. (2013) (19) found that the cognitive scores of EPT children, whose primary language was Spanish, were similar to the scores of English speaking EPT children on the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III), which is less language dependent than the Second Edition. However, EPT children had significantly lower scores on the Bayley-III language scale if their native language was Spanish rather than English. As both studies reported outcomes when the subjects were toddlers, further information is needed about cognitive outcomes in older multilingual VPT/EPT children.

As part of our national neonatal follow-up programme, all children in The Netherlands who are born with a gestational age below 30 weeks or are born at a later gestational age but with a birth weight of below 1000 g are invited for a cognitive assessment at the corrected ages of two and five years. Data from this standard follow-up were used for this study, to determine whether cognitive outcomes differed between monolingual and multilingual VPT/EPT children. We hypothesised that multilingual VPT/EPT children would have lower cognitive outcomes at the ages of two and five years, when compared to the monolingual VPT/EPT children.

PATIENTS AND METHODS

Study design and participants

This was a retrospective single-centre study, conducted at the Emma Children's Hospital of the Academic Medical Centre, Amsterdam, The Netherlands. The study used data collected during regular patient care, as part of the Dutch neonatal follow-up programme. Dutch regulations approved the use of such data for scientific purposes and all the parents received written information on how it would be used. We used data on all children that met at least one of the inclusion criteria for the neonatal follow-up programme: that they were born with a gestational age of below 30 weeks or they were born with a birth weight below 1000 g, regardless of gestational age. Children were included if they were born between January 1, 2007 and January 1, 2012 and admitted to our Neonatal Intensive Care Unit and followed up at five years of age. The other inclusion criteria were information on maternal education and language exposure. Children were divided into three groups. The monolingual group consisted of children who were just exposed to the Dutch language. The multilingual Dutch and foreign language group (multilingual D/FL group) consisted of children who were exposed to the Dutch language as well as one or more foreign languages at home. The multilingual foreign language group (multilingual FL group) consisted of children who had not been exposed to the Dutch language at home, but who had been exposed to the Dutch language at day care, nursery and/or preschool and exposed to one or more foreign language at home.

Outcome assessments

Cognitive development was assessed by trained child psychologists when the children were two and five years of age. The assessors were not blinded to the degree of prematurity, neonatal history and previous testing. Sociodemographic data were assessed using parental reports.

Measures

Cognitive development at the age of two years was assessed with the cognitive scale of the Bayley-III (20). The cognitive composite score was derived according to standardised procedures provided in the manual. The score has been shown to have a reliability of 0.96 at the age of 24 months (20). Since Dutch norm scores only became available in 2014, American norms were used.

Cognitive development at the age of five years was assessed with the Wechsler Preschool and Primary Scale of Intelligence, Third Edition (WPPSI-III) for The Netherlands, which yields a full-scale intelligence quotient (IQ), verbal IQ, performance IQ, processing speed quotient and general language composite (21). Subtests administered to derive these IQ scores include the seven core subtests—block design, information, matrix reasoning, vocabulary, picture concepts, word reasoning and coding. The additional subtests are symbol search, receptive vocabulary and picture naming. All IQ scores were calculated according to standard procedures detailed in the manual (22). Scores were corrected for prematurity at both ages (23).

Parental educational level was defined with a three-point scale, based on the number of years of post elementary education, according to the Central Office of Statistics Netherlands, 2004. The cut-off scores were: low for less than six years, intermediate for six to eight years and high for more than eight years. Parental education was calculated by combining the maternal and paternal levels of education: low education was both low or one low and one intermediate; intermediate was both intermediate or one low and one high and high was both high or one high and one intermediate (24).

Statistics

All dependent variables were screened for extreme outliers, which were defined as ±3 standard deviation (SD). This revealed four extreme outliers (+3SD) in the monolingual group and one extreme outlier (+3SD) in the multilingual D/FL group on the cognitive composite score. These extreme outliers were replaced by the value of the greatest outlier, according to Tabachnick and Fidell (2012) (25). Demographic characteristics were compared between the three language groups, with chi-square tests and *post hoc* Kruskal–Wallis tests for dichotomous variables or with one-way ANOVAs and *post hoc* Hochberg tests. If there were unequal variances, Games–Howell tests were used for continuous variables.

To test whether the cognitive outcomes of the monolingual group and the multilingual D/FL group differed from one another at the ages of two and five years, analyses of covariance were performed. Gestational age in days was entered as a covariate, and parental education was entered as a fixed factor. Preliminary analyses were conducted to check for interaction effects between multilingualism and parental education, and between multilingualism and gestational age. Analyses were rerun, with groups matched for parental education and gestational age.

To test whether the cognitive outcomes of the two multilingual groups differed from one another at both ages, analyses of covariance were performed. Parental education was entered as a covariate. Due to small sample sizes, we were not able to analyse parental education using the original three-point scale measure. We therefore dichotomised parental education into low versus high. A preliminary analysis was conducted to check for an interaction effect between multilingualism and parental education. Analyses were rerun, with groups matched for parental education.

In case of multiple comparisons, statistical significance was interpreted by applying the Bonferroni correction, which is the significance threshold of 0.05 divided by the number of tests performed. The threshold for statistical significance was set at $p < 0.05$ (two-tailed), and at $p < 0.0042$ (two-tailed) in the case of Bonferroni corrections for multiple comparisons. Effect sizes were expressed in Cohen's d, with values of 0.20, 0.50 and 0.80 referring to small, medium and large effects, respectively (26).

There were 37 multiples in the sample. Analyses were rerun randomly by selecting one of the multiples, to test the robustness of findings for correlated measures. All analyses were performed using the Statistical Package for Social Science, version 24.0 (IBM Corp, New York, NY, USA).

RESULTS

A total of 367 children visited our neonatal follow-up programme at the age of five years. Two children were excluded; one child due to a chromosomal abnormality and the other child due to foetal alcohol syndrome. Another 40 children were excluded because of missing information on maternal educational level. The final sample consisted of 325 children, divided into three groups: the monolingual group (n = 234), the multilingual D/FL group (n = 65) and the multilingual FL group (n = 26).

Data were not available on full scale IQ, verbal IQ, performance IQ, processing speed quotient and/or general language composite for 19 monolingual children and three multilingual FL children, due to child noncompliance (n = 18), or logistical reasons (n = 4). General language composite data were not available for 32 monolingual children, two multilingual D/FL children and one multilingual FL child, because this composite was only added to the follow-up programme from September 27, 2012 onwards. Data were not available on the cognitive composite score at two years of age for six monolingual children, three multilingual D/FL children and one multilingual FL child. The data that were missing at the age of two years were due to temporary residence abroad (n = 2), child noncompliance (n = 3), no shows (n = 2), check-ups elsewhere (n = 2) or logistical reasons (n = 1).

At the two years follow-up, the mean corrected age at assessment was 24.6 ± 1.34 months and at the five years follow-up it was 5.1 ± 0.12 years.

A total of 24 non-Dutch languages were spoken in the homes of the multilingual children including European, Asian, African and Caribbean languages. Turkish was the most frequently reported non-Dutch language in both the multilingual D/FL group (18.5%) and the multilingual FL group (42.3%). An overview of all the non-Dutch home languages is presented in Table 1.

Table 2 depicts the neonatal and socio-demographic background characteristics. The mean gestational age was significantly lower ($p < 0.02$) in the multilingual D/FL group (27.2 ± 1.9 weeks) than the monolingual group (28.3 ± 1.5 weeks). Parents in the multilingual FL group had a lower educational level than parents in the monolingual group ($p < 0.001$).

When we compared cognitive outcomes between the monolingual group and the multilingual D/FL group, we found that parental education and gestational age were significantly different between the two groups and were therefore entered as fixed factor and covariate, respectively. There were no significant interactions between multilingualism and parental education or between multilingualism and gestational age. The monolingual group performed significantly better than the multilingual D/FL group on the Bayley-III cognitive score at the age of two years ($p < 0.0042$, Cohen's d = 0.42). The monolingual group also performed significantly better than the multilingual D/FL group on the WPSSI-III-NL full scale IQ ($p < 0.0042$, Cohen's d = 0.48), verbal IQ ($p < 0.0042$, Cohen's

Table 1 Languages reported by parents of multilingual children (n = 91)

	Frequency	%
European		
Czech	1	1.1
English	10	11.0
French	3	3.3
German	1	1.1
Italian	3	3.3
Portuguese	4	4.4
Rumanian	1	1.1
Spanish	3	3.3
Other		
Arabic	9	9.9
Armenian	1	1.1
Dioula	1	1.1
Farsi	2	2.2
Gha	1	1.1
Hindu	1	1.1
Indonesian	3	3.3
Korean	1	1.1
Moroccan	9	9.9
Papiamento	3	3.3
Sranan	6	6.6
Tamazight	4	4.4
Thai	1	1.1
Turkish	23	25.3
Twi	5	5.5
Urdu	1	1.1

Five children had more than one non-Dutch language exposure.

d = 0.65) and general language composite ($p < 0.0042$, Cohen's d = 0.55) at the age of five years (Table 3).

Comparable group differences were found in the sensitivity analyses in which groups were matched for gestational age and parental education (Table S1). The matched groups did not differ on any of the neonatal or socio-demographic characteristics (all $p > 0.05$).

When we compared cognitive outcomes between the multilingual D/FL group and the multilingual FL group, we entered parental education as a covariate. There were no significant interactions between group and parental education. The groups did not differ on the Bayley-III cognitive score at the age of two years. The multilingual D/FL group performed significantly better than the multilingual FL group on the WPSSI-III-NL verbal IQ ($p < 0.0042$, Cohen's d = 0.97), and general language composite ($p < 0.0042$, Cohen's d = 0.94) at the age of five years (Table 4). The results did not differ when the analyses were rerun excluding the two children with a neurosensory handicap.

Again, comparable group differences were found in the sensitivity analyses when the groups were matched for parental education (Table S2). The matched groups did not differ with regards to any neonatal or socio-demographic characteristics (all $p > 0.05$).

For all analyses mentioned above, results did not differ when analyses were rerun with one of the multiples included.

DISCUSSION

This study of VPT/EPT children showed that the two multilingual groups had significantly lower cognitive outcomes at the ages of two and five years than the monolingual group, with a small effect size at the age of two years and small to large effect sizes at the age of five years. The negative impact of multilingualism on cognitive outcomes after preterm birth was not related to parental education, as the results remained unchanged after adjustment and matching for parental education in the sensitivity analyses. In addition, we showed that the multilingual children without Dutch language exposure at home underperformed at the age of five years compared with multilingual children who had been exposed to the Dutch language as well as one or more foreign language at home.

In line with previous studies, our study found multilingualism to be negatively associated with cognitive outcomes in these vulnerable preterm children (15,17). These results were also in line with a study that focused more specifically on executive functioning (27). In that study, bilingual preterm children performed more poorly than monolingual children on tasks that demanded reasoning and flexibility (27). This finding contradicted the hypothesis of Head et al. (28), who speculated that multilingualism may serve as a strategy to improve executive functioning in preterm children, based on the findings in typically developing children in which multilingualism had been associated with increased brain volume and plasticity, with enhanced executive function skills (9). In contrast, exposing preterm children to two different languages at a young age might cause an overload of information, as these children are already at risk for poorer language and communication skills at this young age (12,13,29). This overload might negatively affect their overall cognitive development. Previous research has found that preterm children at risk for language impairment showed a poorer general cognitive development at two years of age (30). However, to verify whether multilingualism affected cognitive outcomes differently in VPT/EPT children than in full-term children, a full-term comparison group could be included in future studies.

Our results in VPT/EPT children at the age of two years supports the above mentioned theory. The multilingual children had lower cognitive outcomes than the monolingual children, when they were measured using Bayley-III at the age of two years. Considering that administration and execution of this test requires little language, this suggests a somewhat slower general cognitive development in multilingual children. The results obtained at the age of five years did not suggest general cognitive delay, but differences in the IQ scores were specifically found in the verbal subscales. We could question whether the general cognitive test outcomes in the multilingual children were fair indicators of cognitive development or a delay in language comprehension. Whatever the cause, these children are at risk of academic underachievement, as the native language is usually used in schools. Consequently, these children may need educational support, which deserves attention in neonatal follow-up studies.

Table 2 Neonatal and socio-demographic characteristics of the monolingual group, the multilingual D/FL group, and the multilingual FL group (N = 325)

	Monolingual group (n = 234)[1]	Multilingual D/FL group (n = 65)[2]	Multilingual FL group (n = 26)[3]	p Value	*Post hoc*
Neonatal outcomes					
Boys, n (%)	126 (53.8)	34 (52.3)	15 (57.7)	0.90	
Gestational age in weeks, mean (SD)	28.3 (1.5)	27.2 (1.9)	27.1 (1.8)	0.01	1 > 2
<28 weeks, n (%)	79 (33.8)	37 (56.9)	15 (57.7)	0.00	1 < 2
28–30 weeks, n (%)	149 (63.7)	25 (38.5)	11 (42.3)	0.21	
≥30 weeks but birth weight <1000 g, n (%)	6 (2.6)	3 (4.6)	0 (0.0)	0.94	
Birth weight in grams, mean (SD)	1081.9 (254.7)	999.5 (263.4)	961.6 (195.3)	0.01	n.s.
<1000 g	94 (40.2)	37 (56.9)	16 (61.5)	0.01	1 < 2
Multiple gestation, n (%)	65 (27.8)	10 (15.4)	7 (26.9)	0.12	
SGA (<P10), n (%)	56 (23.9)	12 (18.5)	5 (19.2)	0.59	
Dexamethasone use for chronic lung disease, n (%)	9 (3.8)	3 (4.6)	0 (0.0)	0.56	
Bronchopulmonary dysplasia @ 36 weeks PMA, n (%)	27 (11.5)	8 (12.3)	4 (15.4)	0.85	
Necrotizing enterocolitis (grade II/III), n (%)	16 (6.8)	3 (4.6)	1 (3.8)	0.71	
Brain damage*, n (%)	16 (6.8)	3 (4.6)	0 (0.0)	0.33	
Medical outcomes at age five years					
Cerebral Palsy†, n (%)	15 (6.4)	1 (1.5)	1 (3.8)	0.28	
Visual impairment‡, n (%)	1 (0.4)	0 (0.0)	0 (0.0)	0.82	
Hearing impairment corrected with aids, n (%)	1 (0.4)	0 (0.0)	1 (3.8)	0.08	
Socio-demographic outcomes					
Parental education				0.00	1 > 3
High, n (%)	96 (41.0)	18 (27.7)	2 (7.7)	0.00	1 > 3
Intermediate, n (%)	67 (28.6)	19 (29.2)	7 (26.9)	0.98	
Low, n (%)	71 (30.3)	28 (43.1)	17 (65.4)	0.00	1 > 3

SD = Standard deviation; SGA = Small for gestational age; PMA = Post menstrual age; GMFCS = Gross Motor Function Classification System; n.s. = nonsignificant.
The superscript numbers 1, 2 and 3 refer to the numbers used in the 'post hoc' column in the same table.
*Brain damage includes: intraventricular haemorrhage ≥grade III, periventricular leukomalacia ≥grade II, intraparenchymal haemorrhage grade IV, post haemorrhagic ventricle dilatation.
†16 cases GMFCSI, 4 cases GMFCSII, 1 case GMFCSIII.
‡Visual impairment consisted of 30–40% vision limitation and Cerebral Visual Impairment.

Table 3 Cognitive outcomes adjusted for gestational age for the monolingual group and the multilingual D/FL group

	Monolingual group		Multilingual D/FL group		
	n	M (SD)	n	M (SD)	p Value*
Bayley-III (age two years)					
Cognitive CS, mean (SD)	228	100.4 (11.4)	62	95.5 (11.5)	0.004
WPPSI-III-NL (age five years)					
Full scale IQ	234	96.4 (14.6)	65	89.6 (14.3)	0.001
Verbal IQ	234	99.0 (14.9)	65	89.5 (14.8)	0.000
Performance IQ	234	95.5 (14.9)	65	92.4 (14.4)	0.130
Processing speed quotient	229	95.0 (16.4)	65	92.8 (16.0)	0.353
General language composite	199	99.6 (15.0)	62	91.6 (14.8)	0.000

Bayley-III = Bayley Scales of Infant and Toddler Development, third edition; CS = Composite score; WPPSI-III-NL = The Dutch version of the third edition of the Wechsler Preschool and Primary Scale for Intelligence.
*All p-values adjusted for gestational age and parental education.

Table 4 Cognitive outcomes adjusted for parental education for the multilingual D/FL group and the multilingual FL group

	Multilingual D/FL group		Multilingual FL group		
	n	M (SD)	n	M (SD)	p Value
Bayley-III (age two years)					
Cognitive CS, mean (SD)	62	94.5 (10.5)	25	91.8 (10.6)	0.277
WPPSI-III-NL (age five years)					
Full scale IQ	65	88.0 (15.6)	24	77.8 (15.7)	0.008
Verbal IQ	65	87.8 (15.7)	25	72.7 (15.8)	0.000
Performance IQ	65	91.2 (15.9)	23	87.5 (16.1)	0.320
Processing speed quotient	65	91.6 (18.1)	26	89.7 (18.2)	0.681
General language composite	62	90.2 (15.0)	21	76.3 (15.2)	0.001

Bayley-III = Bayley Scales of Infant and Toddler Development, third edition; CS = Composite score; WPPSI-III-NL = The Dutch version of the third edition of the Wechsler Preschool and Primary Scale for Intelligence.

In our study design, we distinguished between multilingual children who did and did not have any exposure to the Dutch language at home. As expected, children who did not have any exposure to the Dutch language at home had a longer delay in Dutch language comprehension and poorer cognitive outcomes than those who did. At the age of five years, speaking only non-Dutch languages at home meant that children recorded scores that were roughly 1 SD lower on the verbal IQ and general language composite than those who also spoke Dutch at home. However, these groups did not differ on the Bayley-III cognitive score or on the WPPSI-III-NL full scale IQ, performance IQ and processing speed quotient scores. This indicated that the more severe delay observed in the group that did not speak Dutch at home predominantly impacted language-related skills, but not nonverbal reasoning and speed. As such, analysing all the multilingual children as one group would have inflated the difference between monolingual children and multilingual children. Thus, we recommend that the languages that are spoken at home, not just multilingualism and monolingualism are taken into account.

Our study had several limitations. First, it is possible that the results were not solely due to multilingualism, but could also have been explained by immigrant status, low income, overall home literacy, cultural influences and/or ethnicity. We did not have in-depth information on these factors, and we could not control for them in our sample. Second, we were not able to examine whether the lower verbal cognitive scores persisted throughout childhood or whether these caught up due to the ongoing exposure to the Dutch language at primary school. This should be subject of a future study. Lastly, due to our retrospective design, we did not include a control sample of full-term children.

CONCLUSION

Our results showed that multilingualism was associated with lower cognitive outcomes in very and EPT children, with a small effect size at the age of two years, and small to large effect sizes at the age of five years. Hence, multilingualism should be taken into account when conducting analyses and interpreting findings in both research and clinical settings. Collecting data on multilingualism and parental education should be standard practice in neonatal follow-up programmes. As multilingual children are more prone to having language and cognitive delays, early language support must be considered as this could improve school outcomes.

ACKNOWLEDGEMENTS

We thank all parents and children who participated in this study.

CONFLICT OF INTERESTS

The authors have no conflict of interests to declare.

FINANCE

This work was supported by the Emma Foundation (grant number 2015.168); and the Janivo Foundation (grant number 2015-002).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Table S1 Cognitive outcomes for the monolingual group and the multilingual D/FL group, matched for parental education and gestational age.
Table S2 Cognitive outcomes for the multilingual D/FL group and the multilingual FL group, matched for parental education.