

# Parent Report of Children's Abilities-Revised (PARCA-R)

## TECHNICAL & INTERPRETIVE MANUAL

Samantha Johnson; Vasiliki Bountziouka; Louise Linsell; Peter Brocklehurst; Neil Marlow; Dieter Wolke; Bradley Manktelow



UNIVERSITY OF  
**LEICESTER**



**NPEU**  
Clinical Trials Unit



UCL EGA  
Institute for  
Women's  
Health





# **Parent Report of Children's Abilities-Revised (PARCA-R)**

## **TECHNICAL & INTERPRETIVE MANUAL**

Samantha Johnson; Vasiliki Bountziouka; Louise Linsell; Peter Brocklehurst; Neil Marlow; Dieter Wolke; Bradley Manktelow

**Funding:** Standardisation of the Parent Report of Children’s Abilities – Revised (PARCA-R) was funded by an Action Medical Research project grant (Grant Reference: GN2580) to Samantha Johnson (University of Leicester), Louise Linsell (University of Oxford), Peter Brocklehurst (University of Birmingham), Neil Marlow (University College London), Dieter Wolke (University of Warwick) and Bradley Manktelow (University of Leicester).

**Printed By:** University of Leicester, Leicester, United Kingdom.

**This manual should be cited as:** Johnson S, Bountziouka V, Linsell L, Brocklehurst P, Marlow N, Wolke D, Manktelow B. Parent Report of Children’s Abilities – Revised (PARCA-R). Technical and Interpretive Manual. University of Leicester, Leicester, 2019.

© 2019 University of Leicester

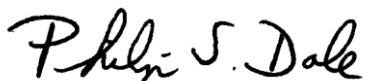


## FOREWORD

At a time when even toys and washing machines are internet-connected and include artificial intelligence, and research tools include brain imaging for both structure and functioning, molecular genetic assessment, and neural network modelling, it is reassuring to know that for some purposes human perception and insight are still irreplaceable. This is precisely because of our uniquely powerful ability and desire to identify the intentions of other people, including intentions to communicate and to transform the world, mentally or physically, which are in turn are a part of our drive to construct a 'theory of mind' of the significant other persons in our lives. And in the case of parental report about children's ability, there is an unequalled amount and diversity of experience on which to base that report. Properly tapped, the 'low-tech' approach of parental report is not only practical and cost effective, but is also, for certain purposes, simply better than the alternatives.

The Parent Report of Children's Abilities-Revised (PARCA-R) is an exceptionally successful example of such a tool. Drawing on research tools for language and non-verbal cognitive development, Samantha Johnson and her colleagues have developed a clinical instrument for the assessment of two-year olds. Translation from research to clinical use is more challenging than may be immediately apparent, because much higher standards must be met for clinical practice as we use these tools to make judgments about individuals, not groups. This entails high standards for reliability, validity, and sensitivity over the full range of the population along with diagnostic validity at the low end. It is gratifying to see this translation done so thoroughly and carefully for the PARCA, which was originally developed as part of the Twins Early Development Study (TEDS), as was the modified version of the MacArthur Communicative Development Inventory, which is also included in the PARCA-R. The translation required both selection and addition of items to the PARCA, and sophisticated current psychometric analyses, along with steps to make the instrument as user-friendly as possible, for both parents and clinicians.

My colleagues and I in the TEDS project hope that this instrument will contribute to the welfare of children both directly, through identification of children in need and monitoring of the effectiveness of their treatment, and indirectly, through research on refining the validity of risk prediction and intervention efficacy studies.



Philip S. Dale, PhD, Professor Emeritus  
Speech & Hearing Sciences  
University of New Mexico

## ACKNOWLEDGMENTS

The authors wish to thank Professor Robert Plomin and Professor Philip Dale, the developers of the original PARCA parent-based assessment, for their permission to revise, validate and standardise the PARCA-R questionnaire and distribute it non-commercially for research and clinical use.

Thanks are also offered to Professor David Field, Chief Investigator of the Late and Moderately Preterm Birth Study (LAMBS), and Professor Elizabeth Draper, Chief Investigator of the Preterm and After (PANDA) Study, both of the University of Leicester, for their permission to use anonymised data in the PARCA-R standardisation study.

Thanks are also offered to Professor Peter Brocklehurst, University of Birmingham, for permission to use anonymised data from the INFANT Trial and the INIS Trial (UK participants) in the PARCA-R standardisation study.

The authors also wish to thank Martin Perkins, University of Leicester, for developing the PARCA-R online questionnaire and score calculator, and Lynsey Morris and Jade Milton, parent advisors on the PARCA-R standardisation study, for their contribution to the research.

The authors are indebted to Action Medical Research for funding the standardisation study and the development of this manual and associated PARCA-R resources.

## AUTHOR AFFILIATIONS

Samantha Johnson is a Professor of Child Development in the Infant Mortality and Morbidity Studies Research Group, Department of Health Sciences, University of Leicester, Leicester, UK.

Vasiliki Bountziouka is an Applied Biostatistician and Research Fellow in the Infant Mortality and Morbidity Studies Research Group, Department of Health Sciences, University of Leicester, Leicester, UK.

Louise Linsell is the Lead Medical Statistician of the National Perinatal Epidemiology Unit Clinical Trials Unit, University of Oxford, Oxford, UK.

Peter Brocklehurst is a Professor of Women's Health and Director of the Birmingham Clinical Trials Unit, University of Birmingham, Birmingham, UK.

Neil Marlow is a Professor of Neonatal Medicine in the Division of Academic Neonatology, Elizabeth Garrett Anderson Institute for Women's Health, University College London, London, UK.

Dieter Wolke is a Professor of Developmental Psychology and Individual Differences in the Department of Psychology, University of Warwick, Coventry, UK.

Bradley Manktelow is an Associate Professor in Medical Statistics in the Infant Mortality and Morbidity Studies Research Group, Department of Health Sciences, University of Leicester, Leicester, UK.





# CONTENTS

Tables .....	vii
Figures.....	viii
Abbreviations.....	ix
Chapter 1 Development of the PARCA-R .....	1
1.1 Introduction .....	1
1.2 Development of the PARCA parent report .....	1
1.3 Development of the PARCA-R.....	2
1.4 Composition of the PARCA-R .....	3
1.5 Validity and reliability of the PARCA-R.....	4
1.6 Diagnostic accuracy of the PARCA-R.....	5
1.7 Limitations of raw scores .....	7
Chapter 2 Standardisation of the PARCA-R .....	9
2.1 Introduction .....	9
2.2 Composition of the standardisation sample.....	9
2.3 Representativeness of the standardisation sample.....	12
2.4 Distribution of PARCA-R raw scores in the standardisation sample.....	16
2.5 Statistical methods for developing the standard scores .....	18
Chapter 3 External validation .....	19
3.1 Introduction .....	19
3.2 Composition of the external validation sample.....	19
3.3 Distribution of PARCA-R raw scores in the external validation sample.....	21
3.4 External validity.....	22
Chapter 4 Clinical validation .....	25
4.1 Introduction .....	25
4.2 Composition of the clinical validation samples .....	25
4.3 Distribution of PARCA-R raw scores in the clinical validation samples .....	27
4.4 Clinical validity .....	28
Chapter 5 Scoring the PARCA-R .....	31
5.1 Introduction .....	31
5.2 Obtaining raw scores .....	32
5.2.1 Non-verbal cognitive scale raw score .....	32

5.2.2	Language scale raw score .....	32
5.3	Obtaining standard scores .....	33
5.3.1	Calculating standard scores by hand .....	33
5.3.2	Calculating standard scores using the online calculator.....	35
5.3.3	Interpreting PARCA-R scores.....	35
5.4	Adjusting for prematurity .....	36
	References .....	39
	Appendix A PARCA-R Questionnaire.....	43
	Appendix B Standard score conversion tables.....	51

## TABLES

<b>Table 2.1</b> Age and sex distribution of the term born children in the standardisation sample in relation to the total target standardisation sample size and required proportion of children born preterm.....	11
<b>Table 2.2</b> Age and sex distribution of data available for preterm born children. ....	11
<b>Table 2.3</b> Age and sex distribution of children the final standardisation sample compared with the target sample size. ....	12
<b>Table 2.4</b> Distribution of socio-demographic and birth characteristics in the standardisation sample (n=6,402) and the general population. ....	13
<b>Table 2.5</b> Distribution of socio-demographic and birth characteristics in the standardisation sample between males and females. ....	14
<b>Table 2.6</b> Distribution of socio-demographic and birth characteristics in the standardisation sample between the four age groups. ....	15
<b>Table 2.7</b> Distribution of raw scores on the PARCA-R non-verbal cognitive and language scales in the standardisation sample by sex.....	16
<b>Table 3.1</b> Distribution of socio-demographic and birth characteristics in the external validation sample, overall and by sex. ....	20
<b>Table 3.2</b> Distribution of socio-demographic and birth characteristics in the standardisation sample compared with the external validation sample. ....	21
<b>Table 3.3</b> Distribution of non-verbal cognitive and language development raw scores in the external validation sample, overall and by age group. ....	22
<b>Table 3.4</b> Standard scores in the external validation sample derived using the equations and the norms tables, overall and by sex.....	23
<b>Table 4.1</b> Characteristics of children in the very preterm clinical validation sample, overall and by sex....	26
<b>Table 4.2</b> Characteristics of children in the neonatal sepsis clinical validation sample, overall and by sex.	27
<b>Table 4.3</b> Distribution of non-verbal cognitive and language development raw scores in the clinical validation samples, overall and by sex. ....	28
<b>Table 4.4</b> Standard scores in the clinical validation samples derived using the equations and the norms tables, overall and by sex.....	29
<b>Table 4.5</b> Proportion of children with developmental delay in the clinical validation samples, overall and by sex. ....	30
<b>Table B1</b> Standard score conversion table for males aged 23 months 16 days to 24 months 15 days .....	53
<b>Table B2</b> Standard score conversion table for females aged 23 months 16 days to 24 months 15 days ....	57
<b>Table B3</b> Standard score conversion table for males aged 24 months 16 days to 25 months 15 days .....	61
<b>Table B4</b> Standard score conversion table for females aged 24 months 16 days to 25 months 15 days ....	65
<b>Table B5</b> Standard score conversion tables for males aged 25 months 16 days to 26 months 15 days.....	69
<b>Table B6</b> Standard score conversion table for females aged 25 months 16 days to 26 months 15 days ....	73
<b>Table B7</b> Standard score conversion table for males aged 26 months 16 days to 27 months 15 days .....	77
<b>Table B8</b> Standard score conversion table for females aged 26 months 16 days to 27 months 15 days ....	81

## FIGURES

<b>Figure 1.1</b> Composition of the PARCA-R questionnaire.....	4
<b>Figure 2.1</b> Existing data available for developing the standardisation sample. ....	9
<b>Figure 2.2</b> Standardisation sample and origin of data.....	12
<b>Figure 2.3</b> Distribution of non-verbal cognitive scale scores by age for males (left) & females (right). ....	17
<b>Figure 2.4</b> Distribution of language scale scores by age for males (left) & females (right).....	17
<b>Figure 3.1</b> Data available for the external validation sample.....	19
<b>Figure 4.1</b> Data available for the clinical validation samples.....	25
<b>Figure 5.1</b> Composition of the PARCA-R raw scores.....	31
<b>Figure 5.2</b> Obtaining standard scores. ....	34
<b>Figure 5.3</b> Screenshot of the PARCA-R online calculator and illustrative example. ....	35

## ABBREVIATIONS

AUC	Area Under the Curve
Bayley-III	Bayley Scales of Infant and Toddler Development, 3rd Edition
BSID-II	Bayley Scales of Infant Development, 2nd Edition
CI	Confidence Interval
ETS	Estimated True Score
INFANT	INFANT Trial
INIS	International Neonatal Immunotherapy Study
LAMBS	Late and Moderately Preterm Birth Study
MCDI:UKSF	MacArthur Communicative Development Inventories UK Short Form
MCDI:WS	MacArthur Communicative Development Inventories Words and Sentences
MDI	Mental Development Index
NPV	Negative Predictive Value
PANDA	Preterm and After Study
PARCA	Parent Report of Children's Abilities
PARCA-R	Parent Report of Children's Abilities-Revised
PDI	Psychomotor Development Index
PPV	Positive Predictive Value
ROC	Receiver Operating Characteristic
SD	Standard Deviation
SEE	Standard Error of Estimate
TEDS	Twins Early Development Study
UK	United Kingdom
VLBW	Very Low Birthweight



# CHAPTER 1

## DEVELOPMENT OF THE PARCA-R

### 1.1 Introduction

The Parent Report of Children's Abilities – Revised (PARCA-R) is a parent completed questionnaire that can be used to assess children's non-verbal cognitive and language development at 24 months of age. It typically takes less than 15 minutes for parents to complete and is available non-commercially, making it a cost-efficient alternative to a standardised developmental test administered by a trained professional. Since the first validation study was published in 2004, it has been used as an outcome measure in clinical trials and observational studies, and as a screening tool in child development clinics and neonatal follow up services. In this chapter, we describe the development and initial validation of the PARCA-R.

### 1.2 Development of the PARCA parent report

In 1998, Kimberly Saudino and colleagues developed a parent-based assessment of children's non-verbal cognitive abilities at two years of age for use as an outcome measure in the Twins Early Development Study (TEDS), a prospective cohort study of all twins born in England and Wales between 1994 and 1996.<sup>1</sup> The assessment was named the Parent Report of Children's Abilities (PARCA) and comprised two components: a parent administered component and a parent report component.<sup>2</sup>

The parent report component comprised 26 questions to assess children's quantitative skills, spatial abilities, symbolic play, adaptive behaviours, planning and organising, and memory. These questions included modified items from existing parent reports, in addition to new questions developed for the PARCA parent report. For each question, parents were asked to indicate whether or not they had seen their child perform a specific task or activity, to which parents could respond 'yes', 'no', or 'don't know'. If parents were not sure whether their child was able to perform a task, they were encouraged to try it out with their child. Responses were scored 1 for 'yes', and 0 for 'no' or 'don't know'. Item scores were then summed to provide a total parent report component score. Internal consistency, assessed using Cronbach's alpha, was 0.74. For a more detailed description of the PARCA parent report see Saudino and colleagues' original publication.<sup>2</sup>

To provide an accompanying parent completed measure of language development for TEDS, Saudino and colleagues used the MacArthur Communicative Development Inventories: UK Short Form (MCDI:UKSF). This was an adaptation of the MacArthur Communicative Development Inventories: Words and Sentences (MCDI:WS) parent questionnaire of language development for children aged 16 to 30 months.<sup>3,4</sup> The MCDI:WS comprised an expressive vocabulary checklist of 680 words, and 37 forced choice items to assess sentence complexity. For TEDS, a shorter 100 word expressive vocabulary checklist that had previously been shown to have excellent prediction to the full 680 word checklist was used.<sup>5</sup> This formed the vocabulary scale of the MCDI:UKSF. Using this checklist, parents were asked to select each word they had heard their child say and the number of words

selected was summed to produce a vocabulary score (range 0 to 100). Internal consistency for the vocabulary scale was excellent (Cronbach's alpha = 0.98).

To assess sentence complexity, 12 sentence pairs were selected from the full list along with 6 questions about the child's emerging grammatical development. This formed the sentence complexity scale of the MCDI:UKSF. For each pair of sentences, parents were asked to select which one best reflected their child's current level of language development. For children who were not yet beginning to combine words, a score of 0 was assigned. Internal consistency for the sentence complexity scale was also excellent (Cronbach's alpha = 0.93). Together the vocabulary and sentence complexity scales formed the MCDI:UKSF.

To assess the validity of the PARCA parent report and MCDI:UKSF, the association between scores on these measures and scores on the Mental Development Index (MDI) of the 2<sup>nd</sup> Edition of the Bayley Scales of Infant Development (BSID-II)<sup>6</sup> was investigated in a sample of 107 two-year-old twins and triplets (mean age 2.2 years, Standard Deviation (SD) 0.26 years).<sup>2</sup> The BSID-II MDI is an examiner administered test of cognitive and language development for children aged 1 to 42 months, from which standardised scores with a normative mean of 100 and SD of 15 are derived. Saudino and colleagues found that PARCA parent report scores were significantly correlated with BSID-II MDI scores ( $r=0.49$ ,  $p<0.001$ ). Moreover, the addition of the MCDI:UKSF scores to the PARCA parent report scores significantly enhanced the predictive value ( $r=0.64$ ,  $p<0.0001$ ), demonstrating good concurrent validity of the combined parent report components. The authors concluded that the PARCA and MCDI:UKSF could be used to provide valid estimates of young children's cognitive and language abilities.<sup>2</sup>

### 1.3 Development of the PARCA-R

Routine screening for developmental delay in early childhood is particularly important for populations of children known to be at increased risk for developmental disorders, such children born preterm (< 37 weeks of gestation). Compared with children born at term, children born preterm are at increased risk for developmental delay<sup>7-10</sup>, cognitive and motor impairments<sup>10, 11</sup>, social, emotional and attention problems<sup>12, 13</sup>, psychiatric disorders<sup>12, 14, 15</sup>, learning disabilities<sup>16, 17</sup> and special educational needs.<sup>16</sup> These sequelae are evident in early childhood and persist throughout the lifespan on a population level.<sup>18-21</sup> The risk for disorders increases with decreasing gestational age at birth such that children born very preterm (< 32 weeks of gestation) are at greatest risk for adverse outcomes.<sup>22, 23</sup> National guidelines in the UK therefore recommend that neonatal services carry out developmental screening at two years of age for children born very preterm, or for those born late and moderately preterm with additional risk factors for developmental problems and disorders.<sup>24-26</sup>

Assessment at two years of age is also becoming the standard time point for evaluating long term outcomes in clinical trials of perinatal interventions and is frequently used as an outcome measure in epidemiological studies.<sup>27-29</sup> For both clinical and research purposes, an assessment carried out by a trained professional using a standardised developmental test would be considered the gold standard. However, the extensive resources required to administer such tests frequently prohibit their use on a large scale and alternative approaches must be sought. Whilst searching for a developmental assessment for use as an outcome measure at two years of age in a randomised trial



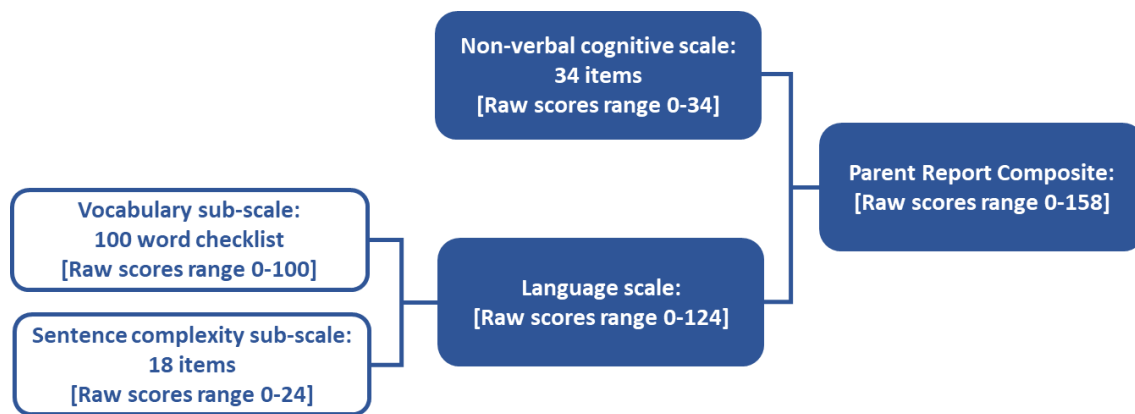
of high frequency ventilation for very preterm infants<sup>30</sup>, the study investigators considered the PARCA as a potential cost-efficient alternative to an examiner administered test. However, they were concerned that it may not be sensitive to the full range of developmental deficits observed in children born very preterm. Identifying moderate to severe developmental delay is a major objective both for outcome assessments in neonatal trials and for the detection of children in need of intervention in clinical services.<sup>24, 29</sup>

In 2002, in order to provide a developmental assessment and outcome measure for use in neonatal trials, and with permission from the authors, the PARCA was revised to ensure it was sensitive to the range of cognitive deficits observed in the very preterm population. As the PARCA parent report component correlated most strongly with BSID-II MDI scores and provided a more cost efficient measure than a parent administered tool, this component was adapted by including eight additional items to assess non-verbal cognitive abilities at a lower developmental level than was covered in the original PARCA. These items were adapted from the BSID-II MDI or the Griffiths Mental Development Scales<sup>31</sup> encompassing the non-verbal cognitive abilities of typically developing children aged 4 to 10 months. Including these items provided better discrimination of development at lower levels thus making the scale more appropriate for use in populations with high rates of developmental impairment. These questions were added to the non-verbal PARCA scale, which was then combined with the MCDI:UKSF to provide an assessment of children's cognitive and language development. Together these formed the PARCA-R (see Appendix A).<sup>32</sup>

#### **1.4 Composition of the PARCA-R**

The composition of the PARCA-R is as follows (see Figure 1):

- The non-verbal cognitive scale comprises 34 forced choice questions about the child's play from which item responses (yes=1; no/don't know=0) are totalled to provide a raw score for non-verbal cognitive development; raw scores range from 0 to 34.
- The language scale comprises two sub-scales, as follows:
  - The vocabulary sub-scale comprises the 100-word vocabulary checklist from which the number of words the child can say is summed to provide a vocabulary sub-scale raw score; raw scores range from 0 to 100.
  - The sentence complexity sub-scale comprises 18 questions about the child's emerging grammatical development from which item responses are totalled to provide a raw sub-scale score for sentence complexity; raw scores range from 0 to 24.
  - The vocabulary sub-scale score and sentence complexity sub-scale score are then summed to produce a total language scale score; language scale raw scores range from 0 to 124.
- Historically, the non-verbal cognitive development raw score and the language scale raw score were then summed to produce an overall Parent Report Composite (PRC) score; raw PRC scores range from 0 to 158.



**Figure 1.1** Composition of the PARCA-R questionnaire.

Detailed scoring instructions are provided in Chapter 5 and a copy of the PARCA-R questionnaire is provided in Appendix A.

## 1.5 Validity and reliability of the PARCA-R

The concurrent validity and reliability of the PARCA-R has been assessed in a number of studies, predominantly in clinical samples.

In the first published study of 64 children born at less than 30 weeks of gestation who were assessed at a mean corrected age of 24 months (range 21 to 28 months) in the UK, PARCA-R scores were significantly correlated with BSID-II MDI scores. PARCA-R non-verbal cognitive scale scores were moderately correlated with MDI scores ( $r=0.54$ ,  $p<0.001$ ), and PARCA-R language scale scores and total PRC scores were strongly correlated with MDI scores (language scale:  $r=0.66$ ,  $p<0.0001$ ; PRC:  $r=0.68$ ,  $p<0.0001$ ).<sup>32</sup> The revised 34-item non-verbal cognitive scale had a high degree of internal consistency (Cronbach's alpha 0.87) and factor analysis performed on the items revealed no clear groupings, indicating that all 34 items were required to elicit an accurate picture of the child's non-verbal cognitive development. Test-retest reliability was also assessed using data from 52 children for whom parents completed the PARCA-R on two occasions approximately two weeks apart. Most children had a higher score on the second administration of the questionnaire, as might be expected, with a median difference of 7 points. The two sets of PARCA-R scores were highly correlated ( $r=0.95$ ,  $p<0.0001$ ) demonstrating excellent test-retest reliability.<sup>32</sup>

In 2008, concurrent validity was again investigated in a UK sample of 164 children born at less than 32 weeks of gestation who were assessed at a mean corrected age of 24 months (range 23 to 28 months). The results were similar to the previous study: PARCA-R scores were significantly correlated with BSID-II MDI scores (non-verbal cognition:  $r=0.50$ , 95% CI 0.38, 0.61;  $p<0.01$ ; language:  $r=0.76$ , 95% CI 0.68, 0.81;  $p<0.01$ ; total PRC:  $r=0.77$ , 95% CI 0.69, 0.82;  $p<0.01$ ).<sup>33</sup> These correlations were comparable with the concurrent validity of other parent report measures<sup>34-36</sup>, with correlations between BSID-II MDI scores and other standardised cognitive tests<sup>6</sup> and with correlations that would be expected if two different examiners administered the BSID-II to the same child. The PARCA-R was therefore deemed to provide a measure that was as reliable as professional measurements for assessing outcomes in large studies or in clinical services in which multiple examiners are employed to assess development.<sup>33</sup>

Subsequently, in a sample of 204 children with suspected or confirmed neonatal sepsis in the International Neonatal Immunotherapy study (INIS)<sup>37</sup> in Australia and New Zealand, parents were asked to complete the PARCA-R at a mean age of 24 months (range 11 to 44 months). The children were also assessed using the 3<sup>rd</sup> edition of the Bayley Scales of Infant and Toddler Development (Bayley-III).<sup>38</sup> Unlike the BSID-II, the Bayley-III comprises separate scales to assess cognitive and language development from which standardised scores with a normative mean of 100 and SD of 15 are derived. PARCA-R scores were significantly correlated with Bayley-III scores within the same domain (PARCA-R and Bayley-III cognitive scores:  $r=0.43$ ,  $p<0.0001$ ; PARCA-R and Bayley-III language scores:  $r=0.71$ ,  $p<0.0001$ ). However, the PARCA-R was designed only to assess children at 24 months of age and it is notable that the correlations between PARCA-R and Bayley-III scores were stronger for the sub-set of 94 children who completed both assessments within one month of the target age and each other (PARCA-R and Bayley-III cognitive scores:  $r=0.48$ ,  $p<0.0001$ ; PARCA-R and Bayley-III language scores:  $r=0.81$ ,  $p<0.0001$ ).<sup>39</sup>

In a sample of 219 children born late and moderately preterm, at 32 to 36 weeks of gestation in the UK, similar moderate to large within-domain correlations were observed between PARCA-R scores and Bayley-III scores (PARCA-R and Bayley-III cognitive scores:  $r=0.38$ ,  $p<0.01$ ; PARCA-R and Bayley-III language scores:  $r=0.71$ ,  $p<0.01$ ). In addition, PARCA-R PRC scores were significantly correlated with an averaged Bayley-III cognitive and language composite score ( $r=0.66$ ,  $p<0.01$ ), again demonstrating good concurrent validity with scores on an examiner administered developmental test.<sup>40</sup>

To date, components of the PARCA-R have been translated into 14 different languages. These are available on the PARCA-R website ([www.parca-r.info](http://www.parca-r.info)). However, only the validity of the Italian and Dutch translations have been investigated.

In 2012, Cuttini and colleagues compared scores on the Italian version of the PARCA-R with scores on the BSID-II MDI for 120 children born at less than 32 weeks of gestation who were assessed at a mean corrected age of 24 months. Internal consistency in this sample was satisfactory, with Cronbach's alpha values of 0.83 for the non-verbal cognitive scale and 0.83 for the language scale. PARCA-R raw scores were moderately to strongly correlated with MDI scores (non-verbal cognition:  $r=0.46$ ,  $p<0.001$ ; language:  $r=0.58$ ,  $p<0.001$ ), with the total PARCA-R PRC score having the strongest correlation with MDI scores ( $r=0.60$ ,  $p<0.001$ ).<sup>41</sup>

The concurrent validity of the Dutch version of the PARCA-R was assessed in 86 children born with very low birthweight (VLBW;  $<1500\text{g}$ ) whose parents completed the PARCA-R at 2 years chronological age as part of the NIRTURE Trial.<sup>42</sup> Although not concurrent with the PARCA-R, BSID-II assessments were performed as part of routine clinical follow up at 9, 18 and 36 months of age. PARCA-R scores were moderately correlated with BSID-II MDI scores at each age (PARCA-R PRC score with MDI score: 9 months  $r=0.48$ ,  $p<0.0001$ ; 18 months  $r=0.38$ ,  $p=0.003$ ; 36 months  $r=0.52$ ,  $p=0.01$ ). In contrast, no significant correlations between PARCA-R scores and scores assessing a different construct, that is BSID-II Psychomotor Development Index (PDI) scores, were found indicating discriminant validity.<sup>43</sup>

## 1.6 Diagnostic accuracy of the PARCA-R

To be useful as an outcome measure, or for use in developmental screening, a questionnaire needs to have good diagnostic utility for identifying children at risk of developmental problems and

disorders. Thus, in addition to studies exploring the validity and reliability of the PARCA-R, researchers have also assessed the diagnostic utility of the PARCA-R for identifying children with developmental delay.

In the first published study of 64 children born very preterm (< 30 weeks of gestation), receiver operating characteristic (ROC) curves were constructed to determine the diagnostic utility of PARCA-R PRC scores for identifying children with moderate to severe developmental delay, defined conventionally as scores more than two SDs below the normative mean (i.e., MDI scores < 70). This revealed that PRC scores < 49 had optimal diagnostic utility, with both sensitivity and specificity of 81% (sensitivity: 0.81, 95% CI 0.54, 0.96; specificity: 0.81, 95% CI 0.67, 0.91) with an Area Under the Curve (AUC) of 0.86.<sup>32</sup>

In a sample of 164 children born very preterm, at less than 32 weeks of gestation, the sensitivity and specificity of a PARCA-R PRC cut-off of < 49 for identifying children with moderate to severe developmental delay similarly resulted in high sensitivity (0.85, 95% CI 0.58, 0.96), specificity (0.83, 95% CI 0.77, 0.88) and negative predictive value (NPV) (0.98, 95% CI 0.95, 0.99). However, the positive predictive value (PPV) was lower (0.31, 95% CI 0.18, 0.47) indicating that, whilst one can be assured that virtually all children with a PRC score of 49 or above are free of major developmental delay, 69% of children with PRC scores < 49 are incorrectly identified as having moderate to severe delay. Lowering the cut-off to scores < 44 marginally improved diagnostic utility (sensitivity: 0.85, 95% CI 0.58, 0.96; specificity: 0.87, 95% CI 0.81, 0.92; NPV: 0.98, 95% CI 0.95, 1.00; PPV: 0.37, 95% CI 0.22, 0.54; AUC 0.92) in this sample.<sup>33</sup>

In an Australasian sample of 476 children born at mean gestational age of 28.7 weeks (SD 4.5 weeks) and assessed with both the PARCA-R and the BSID-II MDI in the INIS Trial<sup>37</sup>, ROC curves constructed for a number of predictive models were all  $\geq 0.90$ . Among a sub-group of children for whom the PARCA-R and BSID-II were completed within one month of each other, the previously derived PRC cut-off of scores < 49 had sensitivity of 0.69 (95% CI 0.52, 0.83), specificity of 0.79 (95% CI 0.73, 0.84), NPV of 0.94 (95% CI 0.89, 0.97) and PPV of 0.36 (95% CI 0.26, 0.48). The PRC cut-off of scores < 44 also had similar predictive values (sensitivity: 0.62, 95% CI 0.45, 0.77; specificity 0.85, 95% CI 0.80, 0.90; NPV 0.93, 95% CI 0.88, 0.96; PPV 0.42, 95% CI 0.29, 0.56) for identifying moderate to severe delay (MDI < 70). In this sub-group, with a targeted specificity of 90%, a PRC cut-off of < 38 was found to have good diagnostic utility for identifying severe delay (MDI < 55) (sensitivity: 0.82, 95% CI 0.57, 0.96; specificity 0.90, 95% CI 0.86, 0.94; NPV 0.99, 95% CI 0.96, 1.00; PPV 0.37, 95% CI 0.22, 0.54).<sup>44</sup>

The same research group also compared PARCA-R scores with Bayley-III scores in 204 very preterm children from the Australasian arm of the INIS Trial.<sup>37</sup> In this study, raw PARCA-R non-verbal cognitive scale scores < 11 had sensitivity of 94% and specificity of 93% for identifying moderate to severe delay on the Bayley-III cognitive scale (AUC 0.83, 95% CI 0.77, 0.90). Likewise, raw PARCA-R language scale scores < 18 had sensitivity of 88% and specificity of 87% for identifying moderate to severe delay on the Bayley-III cognitive scale (AUC 0.91, 95% CI 0.86, 0.94).<sup>39</sup>

In a sample of children born late and moderately preterm, at 32 to 36 weeks of gestation, the cut-offs previously derived in samples of children born very preterm had poor diagnostic utility for identifying children with moderate to severe developmental delay (defined as an average of the Bayley-III cognitive and language scale scores < 80). For example, PRC scores < 49 had sensitivity 0.35 (95% CI 0.16, 0.56), specificity 0.90 (95% CI 0.86, 0.94), NPV 0.93 (95% CI 0.84, 0.94) and PPV 0.27 (95%

CI 0.12, 0.45). Increasing the cut-off to PRC scores < 73 resulted in an AUC of 0.82 and optimum diagnostic utility in this population (sensitivity: 0.90, 95% CI 0.75, 1.00; specificity 0.76, 95% CI 0.70, 0.82; NPV 0.99, 95% CI 0.97, 1.00; PPV 0.28, 95% CI 0.17, 0.39).<sup>40</sup>

Diagnostic utility of the PARCA-R when translated into other languages has also been assessed. In the Italian study described above, PARCA-R PRC scores < 46 had optimal diagnostic utility for identifying children with moderate to severe delay using the BSID-II MDI (score < 70), with sensitivity of 0.73 (95% CI 0.39, 0.94), specificity 0.77 (95% CI 0.68, 0.85) NPV 0.97 (95% CI 0.90, 0.99), PPV 0.24 (95% CI 0.11, 0.42), and AUC 0.83.<sup>41</sup> In the Dutch study of children born with VLBW, also described above, PARCA-R PRC scores at a mean chronological age of 24 months had an AUC of 0.93 (95% CI 0.84, 0.98) for predicting a BSID-II MDI score < 70 from a previous assessment at 9 months of age. Using PRC scores < 35 for predicting moderate to severe delay at 9 months of age, sensitivity was 100%, specificity 85%, NPV 100% and PPV 17%.<sup>43</sup>

Together, the results of these studies show that, using PARCA-R raw scores, the questionnaire has good diagnostic utility for identifying children with developmental delay at 24 months of age, or at earlier assessments. It should be noted that, in all studies, the PPV was relatively low, potentially resulting in high rates of false positive responses. However, low PPVs on developmental screening tests are not uncommon and may not be considered a significant issue. Although low PPVs may result in over-referrals for intervention, children with false positive scores have been shown to be an at-risk group in whom further assessment would be beneficial.<sup>45, 46</sup> Indeed, children with true negative PARCA-R results have been shown to have significantly higher developmental test scores than children with false positive results.<sup>33, 40</sup> Thus all children scoring below the cut-off on the PRC scale may benefit from referral and further diagnostic assessment. PPVs are also lower where the prevalence of the disorder of interest is relatively low, as was the case in some of the studies outlined above. An emphasis on maximising sensitivity is preferable if the benefit of identifying additional cases outweighs the disadvantages of an excess in false positive results. Overall, the authors of the above studies concluded that the PARCA-R is a valuable tool for identifying cognitive and language delay at 24 months of age, supporting its use in research and in clinical practice.<sup>33, 39-41,</sup>

<sup>43, 44</sup>

## 1.7 Limitations of raw scores

Although the PARCA-R has been shown to have internal consistency, test-retest reliability, concurrent validity and discriminative validity across a range of studies, the use of raw scores alone limits its precision as a developmental assessment. Cut-off scores for identifying children at risk of delay described in Section 1.5 were derived from small clinical samples, the largest being 476 children with suspected or confirmed neonatal sepsis, resulting in wide confidence intervals for observed predictive values and cut-off points that vary widely between different populations (e.g., from PRC scores < 44<sup>33</sup> to PRC scores < 73<sup>40</sup> for identifying moderate to severe developmental delay). Moreover, these cut-off scores were developed in order to identify moderate and/or severe delay; none have been developed for identifying children with mild delay who may also benefit from intervention. The lack of age standardised scores also means that an individual child's development cannot be quantified relative to the norm, thus limiting its use as an outcome measure for detecting differences in development between individuals or groups of children or for identifying children in need of support. Moreover, the lack of standardised scores means that the existing cut-off scores

cannot be applied to quantify impairment in other clinical groups or among children in the general population to identify either delayed or advanced development relative to the norm.

Standardising the PARCA-R would enable clinicians and researchers to derive norm-referenced scores to quantify a child's developmental level and identify delays of any severity through to advanced development at 24 months of age for all children in the general population. Derivation of standardised scores also means that the PARCA-R could be used as a continuous assessment to detect even small differences in development between individuals or groups of children in research studies, thus significantly improving its precision an outcome measure.

Recognising these limitations, in 2018-2019 we undertook a study to standardise the PARCA-R, the methods and results of which are described in Chapters 2 to 4.

## CHAPTER 2

### STANDARISATION OF THE PARCA-R

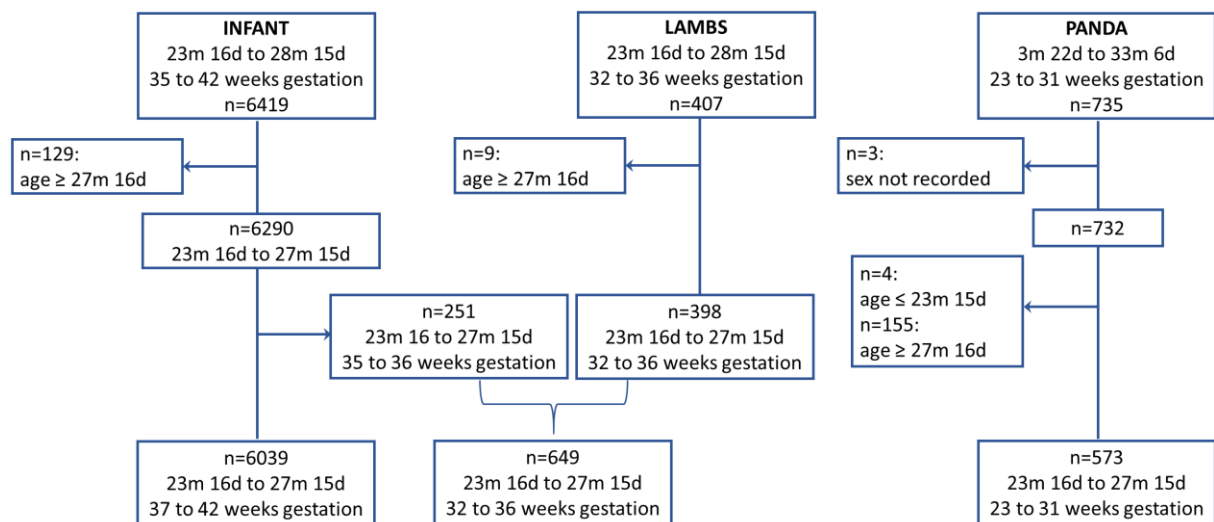
#### 2.1 Introduction

In 2018-2019, the PARCA-R was standardised in order to produce norm-referenced scores for assessing children's cognitive and language development in four 1-month age bands spanning 23 months to 27 months of age, separately by sex. The standardisation sample and the methods used to develop the standard scores are summarised below. A more detailed description of the standardisation process has been published elsewhere.<sup>47</sup>

Although previous validation studies focused on assessing the diagnostic utility of the PRC score for identifying children at risk of delay, the total composite score may mask children who have delays in individual developmental domains. Therefore, for clinical use, standardisation of the PARCA-R was carried out for the non-verbal cognitive and language scales separately.

#### 2.2 Composition of the standardisation sample

Anonymised extracts of existing PARCA-R data from three sources were used to produce a standardisation sample that was representative of the UK population in terms of sex, gestational age, multiple births, ethnicity and socio-economic status (see Figure 2.1).



**Figure 2.1** Existing data available for developing the standardisation sample.

The final standardisation sample comprised PARCA-R data for 6,402 children who were assessed between the age of 23 months 16 days and 27 months 15 days. This was derived as follows.

First, an anonymised extract of data from INFANT<sup>48</sup>, a randomised trial of computerised interpretation of fetal heart rate during labour, was used to form the major portion of the

standardisation sample. This comprised PARCA-R data for 6,419 children born at 35 to 42 weeks of gestation between 2010 and 2013 to mothers participating in the trial. Of these, data for 129 children whose age at assessment exceeded 27 months 15 days were excluded, leaving data available for 6,290 children assessed between 23 months 16 days and 27 months 15 days chronological age. Of these, 6,039 (96%) were born at term (37 to 42 weeks of gestation) and 251 (4%) preterm (35 to 36 weeks of gestation). As the proportion of preterm births in this sample (4%) was smaller than in the general population (7%; comprising 6% born late and moderately preterm [32-36 weeks of gestation] and 1% born very preterm [23-31 weeks of gestation])<sup>49</sup>, the standardisation sample was supplemented with randomly selected data for children born preterm from two additional sources (Figure 2.1).

Based on the total data available for children born at term, the target standardisation sample size was 6,494 (i.e.,  $6039/0.93 = 6493.5$ ), to include 6% ( $n = 390$ ) born late and moderately preterm and 1% ( $n = 65$ ) born very preterm.

Standard scores for the non-verbal cognitive and languages scales were to be developed in four 1-month age bands, separately for males and females, as follows:

- **24 months:** 23 months 16 days to 24 months 15 days
- **25 months:** 24 months 16 days to 25 months 15 days
- **26 months:** 25 months 16 days to 26 months 15 days
- **27 months:** 26 months 16 days to 27 months 15 days

As such, it was important to try to ensure an appropriate proportion of preterm and term born children were included in each age group and for each sex. The distribution of term born males and females in the standardisation sample by age group is shown in Table 2.1, along with the target number of preterm born children needed to match the proportion of preterm births in the UK population in each sub-group.

For late and moderately preterm births, PARCA-R data were available for a total of 649 children (Figure 2.1). This comprised the 251 children born late and moderately preterm in the INFANT sample, alongside data for 398 children born at 32 to 36 weeks of gestation who were assessed between 23 months 16 days and 27 months 15 days chronological age in the Late and Moderately Preterm Birth Study (LAMBS), a geographical population-based cohort study of outcome following birth at late and moderately preterm gestations in the UK.<sup>10, 50</sup> For very preterm births, PARCA-R data were available for a total of 573 children born at 23-31 weeks of gestation who were assessed between 23 months 16 days and 27 months 15 days chronological age in the Preterm And After (PANDA) Study, a study of the feasibility of using a parent questionnaire for routine neonatal follow-up in the UK.<sup>51</sup>



**Table 2.1** Age and sex distribution of the term born children in the standardisation sample in relation to the total target standardisation sample size and required proportion of children born preterm.

			Target for standardisation sample		
			Total sample	Preterm	
				32-36 weeks (6%)	23-31 weeks (1%)
Males	Total	INFANT sample Term born	3125	3360	
	24 months	1081	1162	70	12
	25 months	1311	1410	85	14
	26 months	529	569	34	6
	27 months	204	219	13	2
Females	Total	2914	3134		
	24 months	1018	1095	66	11
	25 months	1243	1337	80	13
	26 months	475	511	31	5
	27 months	178	191	11	2

It was not possible to identify the appropriate number of preterm born children for both sexes and in all age groups given the distribution of sex and age at assessment in the available data (see Table 2.2). For example, data were available for a total of 55 males born at 32 to 36 weeks of gestation who were assessed at 24 months of age (Table 2.2), whilst the target sample size for that sub-group was 70 (Table 2.1). This was particularly the case for very preterm born children in the youngest age groups since children in PANDA were assessed as close as possible to 24 months of age corrected for prematurity, thus their chronological age at assessment was approximately 2 to 3 months greater.

**Table 2.2** Age and sex distribution of data available for preterm born children.

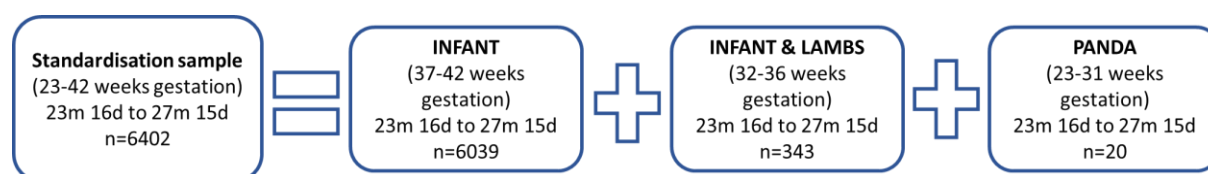
		Data origin	
		INFANT/LAMBS 32-36 weeks	PANDA 23-31 weeks
Males	Total	363	286
	24 months	55	0
	25 months	177	0
	26 months	99	137
	27 months	32	149
Females	Total	286	287
	24 months	30	1
	25 months	157	3
	26 months	73	127
	27 months	26	156

However, despite these limitations, the size of the final standardisation sample was close to the target sample size overall and for each sub-group (see Table 2.3).

**Table 2.3** Age and sex distribution of children the final standardisation sample compared with the target sample size.

		Target Total sample	Final sample			
			Total sample	Full term 37-42wks	Preterm 32-36wk 23-31wks	
<b>Males</b>	Total	3360	3321	3125	187	9
	24 months	1162	1136	1081	55	0
	25 months	1410	1395	1311	84	0
	26 months	569	570	529	34	7
	27 months	219	220	204	14	2
<b>Females</b>	Total	3134	3081	2914	156	11
	24 months	1095	1049	1018	30	1
	25 months	1337	1329	1243	83	3
	26 months	511	511	475	31	5
	27 months	191	192	178	12	2

In total, there were 6,402 children in the standardisation sample. This comprised 6,039 (94%) children born at term, 343 (5.4%) born late to moderately preterm, and 20 (0.3%) born very preterm (see Figure 2.2).



**Figure 2.2** Standardisation sample and origin of data.

## 2.3 Representativeness of the standardisation sample

To determine the representativeness of the standardisation sample, the distribution of sex, ethnicity, Index of Multiple Deprivation (IMD; a composite measure of relative deprivation for small geographical areas<sup>52</sup>), gestational age and multiple births was compared with census data for the UK general population. The distribution of sex, ethnicity (white vs. other ethnic background) and IMD quintiles in the standardisation sample was compared with data from the Office for National Statistics 2011 Census<sup>53</sup>, and the distribution of gestational age and multiple births was compared with gestation-specific birth data from the Office for National Statistics for England and Wales<sup>49</sup> and from the Information Services Division for Scotland<sup>54</sup> for children born in 2011.

The standardisation sample was representative of the general population in terms of sex, IMD quintiles and multiple births (see Table 2.4). However, it was not possible to determine representativeness of ethnicity as this was not recorded for 14% of children in the standardisation sample (Table 2.4). Moreover, as previously noted, there was a smaller proportion of very preterm births in the standardisation sample compared with that of the UK general population.

**Table 2.4** Distribution of socio-demographic and birth characteristics in the standardisation sample (n=6,402) and the general population.

		Standardisation Sample	General UK population <sup>a</sup>	Difference % (95% CI) Standardisation-UK
<b>Child's sex, n (%)</b>			757686	
	Males	3321 (51.9)	386833 (51.1)	0.8 (-0.4, 2.0)
	Females	3081 (48.1)	370853 (48.9)	-0.8 (-2.0, 0.4)
<b>Ethnic background, n (%)</b>			3789571 <sup>b</sup>	
	White	5009 (78.2)	2956304 (78)	0.2 (-0.8, 1.2)
	Other ethnic background	508 (7.9)	833267 (22)	-14.1 (-14.7, -13.4)
	Missing	885 (13.8)	-	-
<b>IMD Quintile, n (%)</b>			755118	
	1st Quintile (most deprived)	1651 (25.8)	195221 (25.9)	-0.1 (-1.1, 1.0)
	2nd Quintile	1284 (20.1)	162041 (21.5)	-1.4 (-2.4, -0.4)
	3rd Quintile	1081 (16.9)	141071 (18.7)	-1.8 (-2.7, -0.9)
	4th Quintile	1217 (19.0)	130374 (17.3)	1.7 (0.8, 2.7)
	5th Quintile (least deprived)	1078 (16.8)	126117 (16.7)	0.1 (-0.8, 1.1)
	Missing	91 (1.4)	-	-
<b>Preterm birth, n (%)</b>			772814	
	Term (≥ 37 weeks)	6039 (94.3)	717277 (92.8)	1.5 (0.9, 2.1)
	Late & moderately preterm (32-36 weeks)	343 (5.4)	45896 (5.9)	-0.6 (-1.1, 0.0)
	Very preterm (< 32 weeks)	20 (0.3)	9613 (1.2)	-0.9 (-1.1, -0.8)
<b>Multiple birth, n (%)</b>			772814	
	Singleton	6234 (97.4)	748342 (96.8)	0.5 (0.1, 0.9)
	Multiple birth	168 (2.6)	24472 (3.2)	-0.5 (-0.9, -0.1)

IMD: Index of Multiple Deprivation. <sup>a</sup>Distribution of sex, ethnicity and IMD quintiles obtained from the Office for National Statistics; Distribution of preterm and multiple births obtained from the Office for National Statistics for England and Wales and from the Information Services Division for Scotland for children born in 2011. <sup>b</sup>The 2011 Census refers to children aged 0-4 years.

Within the standardisation sample, the distribution of socio-demographic characteristics was similar between males and females (Table 2.5) and across the four age groups (Table 2.6).

**Table 2.5** Distribution of socio-demographic and birth characteristics in the standardisation sample between males and females.

	Males n=3321	Females n=3081
<b>Chronological age, n (%)</b>		
24 months	1136 (34.2)	1049 (34.0)
25 months	1395 (42.0)	1329 (43.1)
26 months	570 (17.2)	511 (16.6)
27 months	220 (6.6)	192 (6.2)
<b>Ethnic background, n (%)</b>		
White	2593 (78.1)	2416 (78.4)
Other ethnic background	276 (8.3)	232 (7.5)
Missing	452 (13.6)	433 (14.1)
<b>IMD Quintile, n (%)</b>		
1st Quintile (most deprived)	854 (25.7)	797 (25.9)
2nd Quintile	664 (20.0)	620 (20.1)
3rd Quintile	562 (16.9)	519 (16.8)
4th Quintile	643 (19.4)	574 (18.6)
5th Quintile (least deprived)	553 (16.7)	525 (17.0)
Missing	45 (1.4)	46 (1.5)
<b>Preterm birth, n (%)</b>		
Term ( $\geq 37$ weeks)	3125 (94.1)	2914 (94.6)
Late & moderately preterm (32-36 weeks)	187 (5.6)	156 (5.1)
Very preterm ( $< 32$ weeks)	9 (0.3)	11 (0.4)
<b>Multiple birth, n (%)</b>		
Singleton	3242 (97.6)	2992 (97.1)
Multiple birth	79 (2.4)	89 (2.9)

IMD: Index of Multiple Deprivation

**Table 2.6** Distribution of socio-demographic and birth characteristics in the standardisation sample between the four age groups.

	24 months n=2185	25 months n=2724	26 months n=1081	27 months n=412
<b>Sex, n (%)</b>				
Males	1136 (52.0)	1395 (51.2)	570 (52.7)	220 (53.4)
Females	1049 (48.0)	1329 (48.8)	511 (47.3)	192 (46.6)
<b>Ethnic background, n (%)</b>				
White	1701 (77.8)	2120 (77.8)	881 (81.5)	307 (74.5)
Other ethnic background	136 (6.2)	237 (8.7)	79 (7.3)	56 (13.6)
Missing	348 (15.9)	367 (13.5)	121 (11.2)	49 (11.9)
<b>IMD Quintiles, n (%)</b>				
1st Quintile (most deprived)	584 (26.7)	672 (24.7)	269 (24.9)	126 (30.6)
2nd Quintile	454 (20.8)	541 (19.9)	197 (18.2)	92 (22.3)
3rd Quintile	350 (16.0)	455 (16.7)	200 (18.5)	76 (18.4)
4th Quintile	433 (19.8)	527 (19.3)	191 (17.7)	66 (16.0)
5th Quintile (least deprived)	344 (15.7)	495 (18.2)	195 (18.0)	44 (10.7)
Missing	20 (0.9)	34 (1.2)	29 (2.7)	8 (1.9)
<b>Preterm birth, n (%)</b>				
Term ( $\geq 37$ weeks)	2099 (96.1)	2554 (93.8)	1004 (92.9)	382 (92.7)
Late & moderately preterm (32-36 weeks)	85 (3.9)	167 (6.1)	65 (6.0)	26 (6.3)
Very preterm ( $< 32$ weeks)	1 (0.05)	3 (0.1)	12 (1.1)	4 (1.0)
<b>Multiple birth, n (%)</b>				
Singleton	2134 (97.7)	2645 (97.1)	1053 (97.4)	402 (97.6)
Multiple birth	51 (2.3)	79 (2.9)	28 (2.6)	10 (2.4)

IMD: Index of Multiple Deprivation

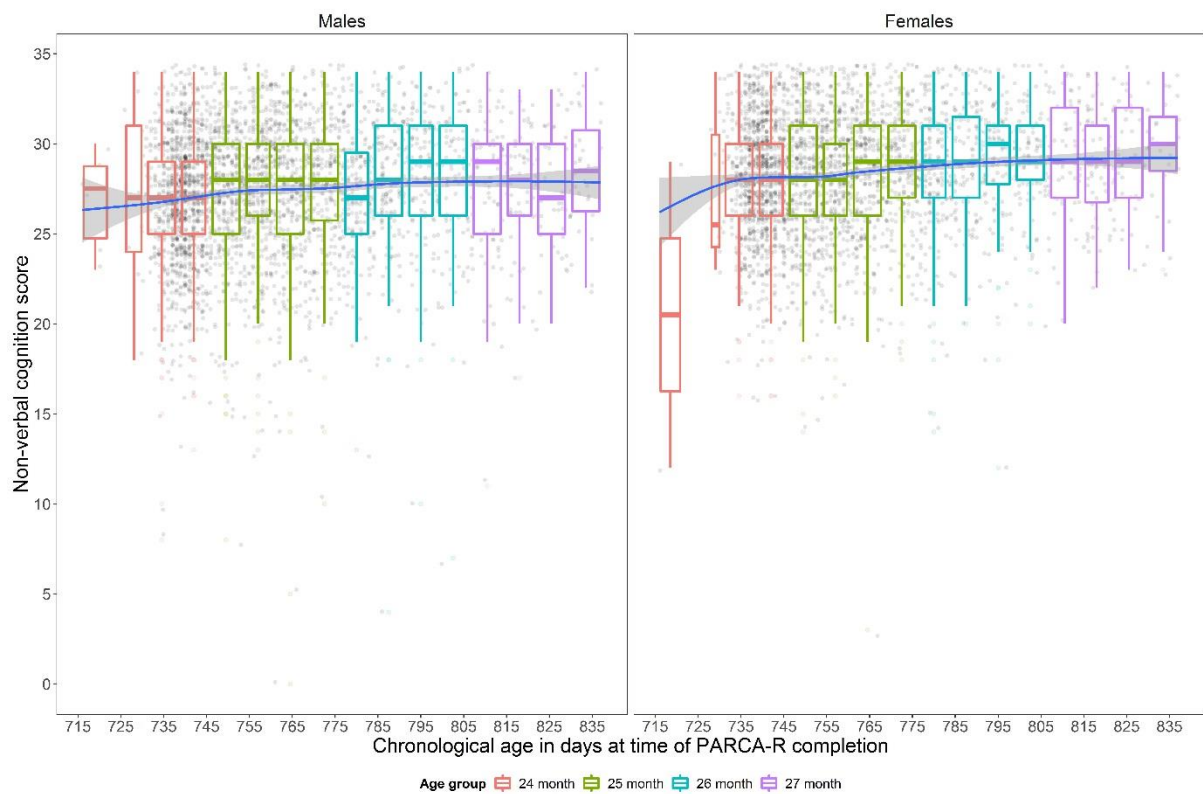
## 2.4 Distribution of PARCA-R raw scores in the standardisation sample

On average, raw scores on both the non-verbal cognitive and language scale were higher among females than males (see Table 2.7).

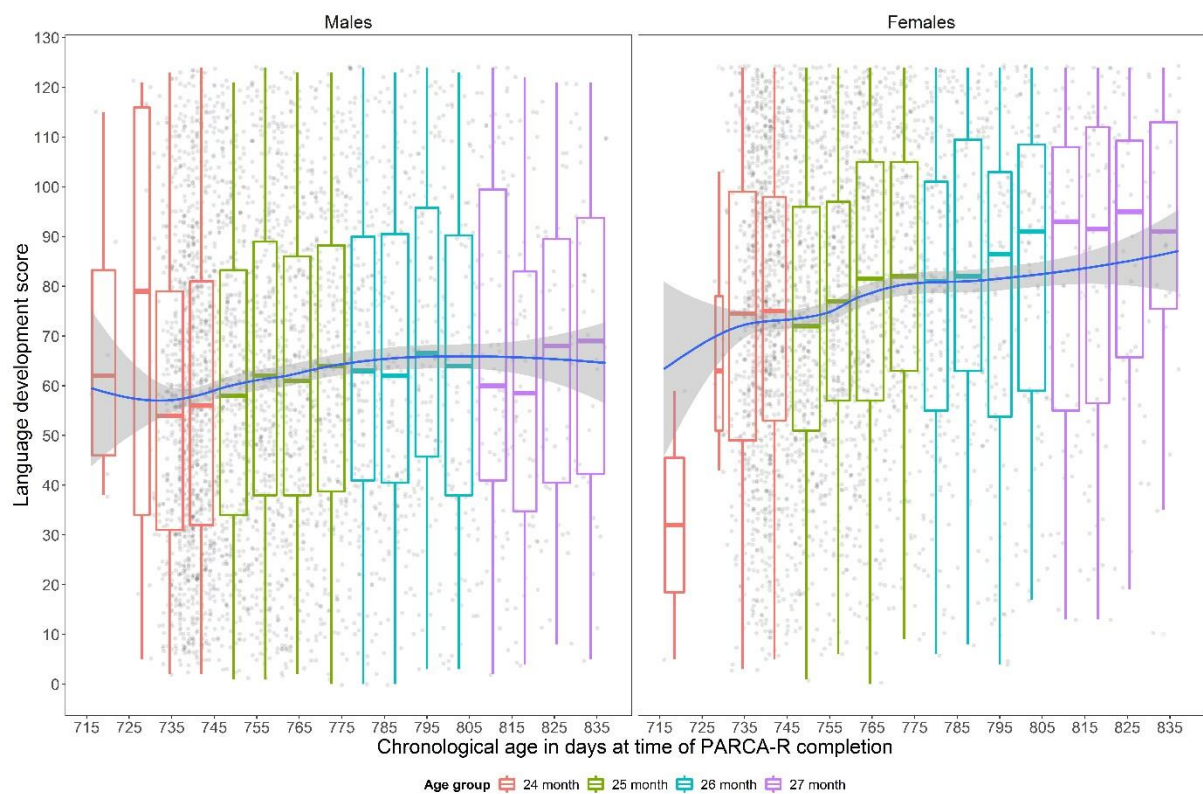
**Table 2.7** Distribution of raw scores on the PARCA-R non-verbal cognitive and language scales in the standardisation sample by sex.

	Non-verbal cognition	Language development
<b>Males, n=3321</b>		
Range	0-34	0-124
Mean (SD)	27.3 (3.6)	61.2 (31.6)
Median (P25; P75)	28 (25; 30)	60 (36; 86)
<b>Females, n=3081</b>		
Range	3-34	0-124
Mean (SD)	28.4 (3.3)	76.5 (30.1)
Median (P25; P75)	29 (26; 31)	78 (55; 102)
P: Percentile		

Raw PARCA-R scores also increased with age in both males and females on both the non-verbal cognitive scale (Figure 2.3) and the language scale (Figure 2.4).



**Figure 2.3** Distribution of non-verbal cognitive scale scores by age for males (left) & females (right).



**Figure 2.4** Distribution of language scale scores by age for males (left) & females (right).

## 2.5 Statistical methods for developing the standard scores

An extension of the Lamda-Mu-Sigma (LMS) method was used to develop the standard scores. The LMS method is commonly used to estimate percentiles and produce age related normalised reference ranges for use in clinical practice. With this method, the skewness (lamda), the median (mu) and the coefficient of variation (sigma) of a distribution are modelled, and it is suitable when the response variable is symmetric and normally distributed. However, this requirement may be violated when age-bounded scales are used, such as the PARCA-R, which are discrete and often show a high concentration of values in the extremes of their range.

To accommodate this limitation, an extension of the LMS method was applied that also allows the kurtosis of the distribution to be modelled. For each of the PARCA-R non-verbal cognitive and language scales, the raw scores were regressed against chronological age, separately for males and females. Then, the predicted values for the median, the coefficient of variation, the skewness and the kurtosis were used to convert individual raw scores to z-scores, which are normally distributed with a mean of 0 and SD of 1, and are equivalent to the percentiles of a distribution. These z-scores were then standardised to a mean of 100 and SD of 15 using the formula:  $100 + 15 * z\text{-score}$ . In order to derive the standard scores from raw scores in practice, norms tables were developed separately for males and females for each of the 4 age bands as follows:

- **24 months:** 23 months 16 days to 24 months 15 days
- **25 months:** 24 months 16 days to 25 months 15 days
- **26 months:** 25 months 16 days to 26 months 15 days
- **27 months:** 26 months 16 days to 27 months 15 days

This was carried out using the z-score corresponding to the median age, which was 24 months 10 days for the 24-month age band, and the midpoint for the other three age bands (i.e. 25 months 0 days, 26 months 0 days, and 27 months 0 days, respectively).

For each of the standard scores, a 95% confidence interval was produced using the formula:  $95\% \text{ CI} = \text{Score} \pm 1.96 * \text{Standard error}$ , where the score is the estimated true score (ETS)<sup>55, 56</sup> and the standard error is equivalent to the standard error of the estimation (SEE).<sup>57</sup> The ETS is produced by the formula  $X_{ETS} = \bar{X} + r_a * (X - \bar{X})$ , where  $\bar{X}$  is the score average (equal to 100 in the standard scale),  $X$  is the observed standard score, and  $r_a$  is the reliability coefficient of the related scale. As observed in the PARCA-R validation studies,  $r_a$  is equal to 0.87 for the non-verbal cognition scale and 0.96 (i.e. the average of 0.98 for the vocabulary sub-scale and 0.93 for the sentence complexity sub-scale) for the language development scale. The SEE is calculated from the formula  $SEE = SD * r_a * \sqrt{(1 - r_a)}$ , where SD is the standard deviation of the scale (equal to 15 in the standard scale) and  $r_a$  as previously described. The 95% CIs for the true standard scores are then calculated and used as the confidence intervals of the observed scores. For example, the ETS for a standard score of 85 on the non-verbal cognition scale is:  $100 + 0.87 * (85 - 100) = 86$ , and the relevant SEE is 4.7 (i.e.,  $15 * 0.87 * \sqrt{(1 - 0.87)}$ ). Thus the lower limit of the 95% CI is 77 (i.e.,  $86 - 1.96 * 4.7$ ) and the upper limit of the 95% CI is 95 (i.e.,  $86 + 1.96 * 4.7$ ). Details of the average standard scores and SDs used to calculate the CI for the standard scores for each sex and in each age band have previously been published.<sup>47</sup>

The norms tables for calculating standard scores from raw scores are provided in full in Appendix B.



## CHAPTER 3

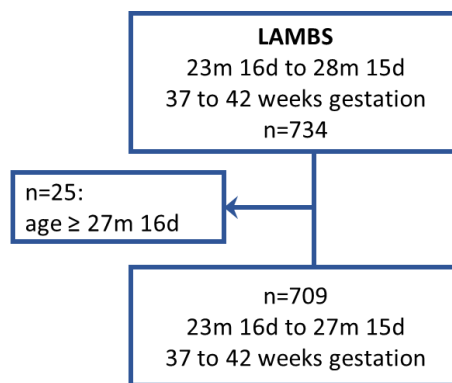
### EXTERNAL VALIDATION

#### 3.1 Introduction

In order to assess external validity, the standard scores were applied to PARCA-R data obtained from a different sample of children who were similar in socio-demographic characteristics to the standardisation sample. To demonstrate external validity, PARCA-R standard scores in the external validation sample would be expected to be similar to those of the standardisation sample, and thus to the general population.

#### 3.2 Composition of the external validation sample

The external validation sample comprised anonymised PARCA-R data for children born at 37 to 42 weeks of gestation who were recruited to a term-born reference group in LAMBS, a population-based geographical cohort study of outcomes following late and moderately preterm birth<sup>10, 50</sup>. Complete PARCA-R data were available for 734 term-born children. Data for 25 children assessed after 27 months 15 days of age were excluded, leaving 709 children who were assessed within the same age range as the standardisation sample (i.e., 23 months 16 days to 27 months 15 days chronological age) (see Figure 3.1).



**Figure 3.1** Data available for the external validation sample.

Characteristics of the external validation sample are shown in Table 3.1. The distribution of socio-demographic and birth characteristics was similar between boys and girls in the external validation sample.

**Table 3.1** Distribution of socio-demographic and birth characteristics in the external validation sample, overall and by sex.

	Total n=709	Males n=350	Females n=359
<b>Chronological age, n (%)</b>			
24 months	382 (53.9)	184 (52.6)	198 (55.2)
25 months	253 (35.7)	128 (36.6)	125 (34.8)
26 months	52 (7.3)	25 (7.1)	27 (7.5)
27 months	22 (3.1)	13 (3.7)	9 (2.5)
<b>Ethnic background, n (%)</b>			
White	591 (83.4)	289 (82.6)	302 (84.1)
Other ethnic background	118 (16.6)	61 (17.4)	57 (15.9)
<b>IMD Quintile, n (%)</b>			
1st Quintile (most deprived)	133 (18.8)	71 (20.3)	62 (17.3)
2nd Quintile	151 (21.3)	66 (18.9)	85 (23.7)
3rd Quintile	115 (16.2)	61 (17.4)	54 (15.0)
4th Quintile	143 (20.2)	69 (19.7)	74 (20.6)
5th Quintile (least deprived)	167 (23.6)	83 (23.7)	84 (23.4)
<b>Multiple birth, n (%)</b>			
Singleton	570 (80.4)	277 (79.1)	293 (81.6)
Multiple birth	139 (19.6)	73 (20.9)	66 (18.4)

IMD: Index of Multiple Deprivation

Compared with the standardisation sample, more children in the external validation sample were in the youngest age band (54% in the 24 month age range in the external validation sample vs. 34% in the 24 month age band in the standardisation sample), were of white ethnicity (83% in the external validation sample vs. 78% in the standardisation sample), from the least deprived areas (44% in the 4<sup>th</sup> and 5<sup>th</sup> quintiles in the external validation sample vs. 36% in the standardisation sample) and were a multiple birth (20% in the external validation sample vs. 3% in the standardisation sample) (see Table 3.2). The higher proportion of multiple births in the external validation sample was expected as a result of the LAMBS study design in which a randomly selected sample of term-born babies was recruited in addition to all term-born multiples during the study period.<sup>10</sup>

**Table 3.2** Distribution of socio-demographic and birth characteristics in the standardisation sample compared with the external validation sample.

	Standardisation sample n=6402	External validation sample n=709	% difference (95% CI) Standardisation vs. validation sample
<b>Child's sex, n (%)</b>			
Male	3321 (51.9)	350 (49.4)	2.5 (-1.4; 6.4)
Female	3081 (48.1)	359 (50.6)	-2.5 (-6.4; 1.4)
<b>Ethnic background, n (%)</b>			
White	5009 (78.2)	591 (83.4)	-5.1 (-8.0; -2.2)
Other ethnic background	508 (7.9)	118 (16.6)	-8.7 (-11.5; -5.9)
Missing	885 (13.8)	-	-
<b>Chronological age, n (%)</b>			
24 months	2185 (34.1)	382 (53.9)	-20 (-25; -14)
25 months	2724 (42.5)	253 (35.7)	6.9 (0.7; 13)
26 months	1081 (16.9)	52 (7.3)	9.6 (2.1; 17)
27 months	412 (6.4)	22 (3.1)	3.3 (-4.3; 11)
<b>IMD Quintile, n (%)</b>			
1st Quintile (most deprived)	1651 (25.8)	133 (18.8)	7.0 (4.0; 10.1)
2nd Quintile	1284 (20.1)	151 (21.3)	-1.2 (-4.4; 1.9)
3rd Quintile	1081 (16.9)	115 (16.2)	0.7 (-2.2; 3.5)
4th Quintile	1217 (19.0)	143 (20.2)	-1.2 (-4.3; 1.9)
5th Quintile (least deprived)	1078 (16.8)	167 (23.6)	-6.7 (-10.0; -3.5)
Missing	91 (1.4)	-	-
<b>Multiple birth, n (%)</b>			
Singleton	6234 (97.4)	570 (80.4)	17 (14; 20)
Multiple birth	168 (2.6)	139 (19.6)	-17 (-20; -14)

IMD: Index of Multiple Deprivation

### 3.3 Distribution of PARCA-R raw scores in the external validation sample

The distribution of raw PARCA-R scores in the external validation sample is shown in Table 3.3. In general, children in the external validation sample had similar raw scores to children in the standardisation sample, with females having higher scores than males. Females in the external validation sample had, on average, lower raw scores for language development than children in the standardisation sample. However, this should be interpreted with caution given the small sample size in the older age groups in the external validation sample (Table 3.3).

**Table 3.3** Distribution of non-verbal cognitive and language development raw scores in the external validation sample, overall and by age group.

	Total n=350	24 months n=184	Males		
			25 months n=128	26 months n=25	27 months n=13
<b>Non-verbal cognition</b>					
Range	15-34	19-34	15-34	16-34	18-34
Mean (SD)	27.6 (3.6)	27.4 (3.3)	27.8 (3.7)	27.4 (4.3)	28.2 (4.3)
Median (P25; P75)	28 (26; 30)	27 (26; 30)	28 (26; 30)	27 (25; 31)	29 (27; 29)
<b>Language</b>					
Range	1-124	1-124	2-124	2-124	20-120
Mean (SD)	60 (31.5)	58.1 (31.7)	61.3 (31.3)	58.1 (31.1)	79 (27)
Median (P25; P75)	58 (36; 82)	58 (33; 79)	59 (37; 83)	57 (37; 76)	74 (69; 96)
	Total n=359	24 months n=198	Females		
			25 months n=125	26 months n=27	27 months n=9
<b>Non-verbal cognition</b>					
Range	0-34	0-34	17-34	23-34	24-34
Mean (SD)	28.4 (3.7)	28.2 (4)	28.5 (3.3)	29.3 (3.5)	28 (2.9)
Median (P25; P75)	29 (26; 31)	29 (26; 31)	28 (26; 31)	29 (27; 33)	28 (27; 29)
<b>Language</b>					
Range	0-124	0-124	6-124	5-124	32-120
Mean (SD)	72.8 (31.6)	70.3 (31.2)	76.9 (31.7)	71.5 (31.5)	76 (36.2)
Median (P25; P75)	76 (51; 97)	73 (48; 96)	81 (53; 102)	74 (56; 98)	70 (44; 115)

P: Percentile.

### 3.4 External validity

To assess the external validity of the standard scores, the equations derived from the LMS models in the standardisation sample were applied to the PARCA-R data in the external validation sample. Using these equations, z-scores were calculated and rescaled to a Mean of 100 and SD of 15, as described in Chapter 2. In addition, standard scores for the PARCA-R data in the external validation sample were assigned using the norms tables provided in Appendix B. External validity of the standard scores derived using the equations would be demonstrated if the observed scores in the external validation sample were close to the expected mean of 100 and SD of 15. Moreover, if the standard scores derived using the two methods were similar, this would confirm the appropriateness of the norms tables for deriving the standard scores in practice. However it should be noted that small differences were expected given the smaller size of the validation sample relative to the standardisation sample and the differences in socio-demographic characteristics between the two samples (Table 3.2), and thus the differences in raw scores (Table 3.3).

The mean (SD) standard scores in the external validation sample approximated 100 (15) for both the non-verbal cognitive scale and the language development scale (Table 3.4). In addition, the standard scores generated from applying the equations derived during the standardisation process to the validation sample were similar to the standard scores derived using the norms tables (Table 3.4).

This demonstrates both the external validity of the standard scores and the accuracy of using the norms tables for deriving the standard scores in clinical practice.

**Table 3.4** Standard scores in the external validation sample derived using the equations and the norms tables, overall and by sex.

	Overall n=709	Males n=350	Females n=359
<b>Non-verbal cognition, mean (SD)</b>			
Equations	101 (16)	102 (15)	101 (16)
Norm tables	101 (16)	102 (15)	100 (16)
<b>Language, mean (SD)</b>			
Equations	100 (16)	100 (16)	99 (16)
Norm tables	99 (16)	99 (17)	99 (16)



## CHAPTER 4

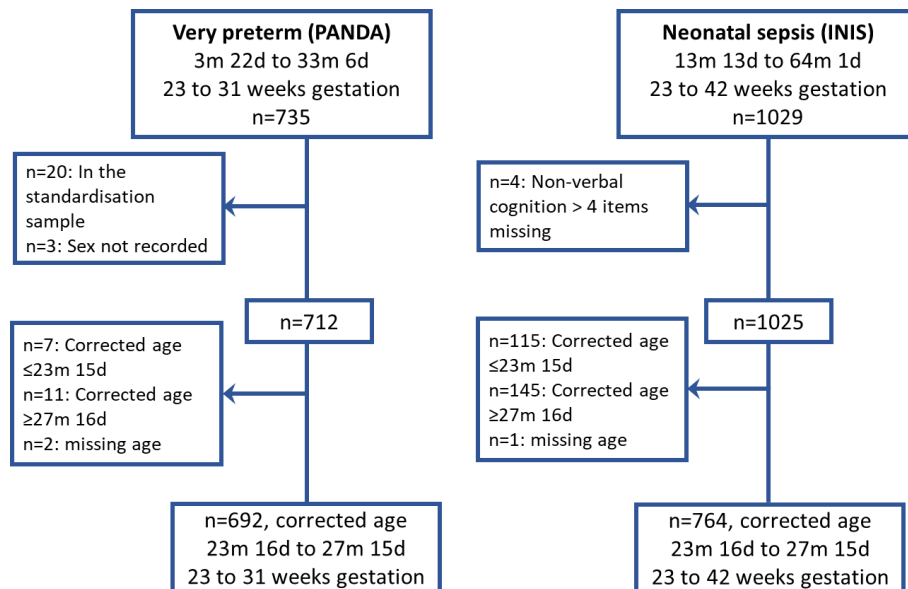
### CLINICAL VALIDATION

#### 4.1 Introduction

In order to assess clinical validity, the standard scores were applied to PARCA-R data obtained from two samples of children known to be at high risk for developmental problems and disorders. To demonstrate clinical validity, PARCA-R standard scores in the clinical validation samples would be expected to be lower than those in the standardisation sample, and thus lower than in the general population.

#### 4.2 Composition of the clinical validation samples

As noted in Chapter 1, children born very preterm, before 32 weeks of gestation, are at increased risk for developmental problems and disorders compared with their term-born peers.<sup>58, 59</sup> In addition, infants with suspected or clinically confirmed sepsis during the neonatal period are at increased risk for developmental problems later in life.<sup>39, 44</sup> Therefore an anonymised extract of PARCA-R data from two samples of children with these risk factors were used to examine the clinical validity of the standard scores (Figure 4.1)



**Figure 4.1** Data available for the clinical validation samples.

First, to examine performance of the standard scores in a very preterm population, anonymised PARCA-R data from PANDA, a study of the use of parent-completed questionnaires for developmental screening in this population, were obtained.<sup>51</sup> This sample comprised data for 735 children, of which data for 43 children were excluded (20 who were included in the standardisation

sample, 3 due to missing data for sex and 20 assessed outside the PARCA-R age range or with missing information), leaving data for 692 very preterm born children who were assessed using the PARCA-R at a corrected age of 23 months 16 days to 27 months 15 days.

The characteristics of this sample are shown in Table 4.1. These were similar between males and females. However, compared with the standardisation sample, children in the clinical validation sample were mainly in the youngest age groups, had white ethnic background and were more often multiple births.

**Table 4.1** Characteristics of children in the very preterm clinical validation sample, overall and by sex.

		<b>Total n=692</b>	<b>Males n=342</b>	<b>Females n=350</b>
<b>Corrected age, n (%)</b>				
	24 months	466 (67.3)	234 (68.4)	232 (66.3)
	25 months	187 (27.0)	91 (26.6)	96 (27.4)
	26 months	32 (4.6)	14 (4.1)	18 (5.1)
	27 months	7 (1.0)	3 (0.9)	4 (1.1)
<b>Ethnic background, n (%)</b>				
	White	585 (84.5)	304 (88.9)	281 (80.3)
	Other ethnic background	106 (15.3)	38 (11.1)	68 (19.4)
	Missing	1 (0.1)	-	1 (0.3)
<b>Multiple birth, n (%)</b>				
	Singleton	479 (69.2)	238 (69.6)	241 (68.9)
	Multiple birth	213 (30.8)	104 (30.4)	109 (31.1)

Second, anonymised PARCA-R data for children with suspected or confirmed sepsis during the neonatal period were obtained from the UK arm of the INIS trial.<sup>37</sup> Of 1,025 children with a completed PARCA-R questionnaire, data for 261 children assessed outside the PARCA-R age range or with missing information were excluded, leaving a total of 764 children who were assessed using the PARCA-R at a corrected age of 23 months 16 days to 27 months 15 days. The characteristics available for this sample are shown in Table 4.2. Similarly, children in this clinical validation sample were predominantly born very preterm, were in the youngest age groups and had a higher proportion of multiple births than in the standardisation sample (Table 4.2).



**Table 4.2** Characteristics of children in the neonatal sepsis clinical validation sample, overall and by sex.

	Total n=764	Males n=437	Females n=327
<b>Corrected age, n (%)</b>			
24 months	546 (71.5)	309 (70.7)	237 (72.5)
25 months	150 (19.6)	88 (20.1)	62 (19)
26 months	40 (5.2)	23 (5.3)	17 (5.2)
27 months	28 (3.7)	17 (3.9)	11 (3.4)
<b>Preterm birth, n (%)</b>			
Full term ( $\geq 37$ weeks)	39 (5.1)	26 (5.9)	13 (4)
Late & moderately preterm (32-36 weeks)	71 (9.3)	41 (9.4)	30 (9.2)
Very preterm ( $< 32$ weeks)	654 (85.6)	370 (84.7)	284 (86.9)
<b>Multiple birth, n (%)</b>			
Singleton	674 (88.2)	379 (86.7)	295 (90.2)
Multiple birth	90 (11.8)	58 (13.3)	32 (9.8)

### 4.3 Distribution of PARCA-R raw scores in the clinical validation samples

As expected, children in the clinical validation samples had, on average, lower raw scores on both the non-verbal cognition scale and the language scale than in the standardisation sample. On both scales, and in both samples, females had higher scores than males (Table 4.3).

**Table 4.3** Distribution of non-verbal cognitive and language development raw scores in the clinical validation samples, overall and by sex.

CHILDREN BORN VERY PRETERM, n=692			
		Non-verbal cognition	Language development
<b>Males, n=342</b>			
	Range	0-33	0-124
	Mean (SD)	24.2 (6.1)	48.8 (34.1)
	Median (P25; P75)	26 (22; 27)	43 (20; 73)
<b>Females, n=350</b>			
	Range	3-34	0-124
	Mean (SD)	25.8 (4.7)	57.8 (32.7)
	Median (P25; P75)	26 (24; 29)	57 (32; 83)
CHILDREN WITH NEONATAL SEPSIS, n=764			
		Non-verbal cognition	Language development
<b>Males, n=437</b>			
	Range	0-34	0-124
	Mean (SD)	22.7 (6.7)	38.9 (33.7)
	Median (P25; P75)	24 (21; 27)	30 (12; 59)
<b>Females, n=327</b>			
	Range	0-34	0-124
	Mean (SD)	24.8 (6.2)	55.4 (36.9)
	Median (P25; P75)	26 (23; 29)	52 (25; 86)

P: Percentile.

#### 4.4 Clinical validity

Standard scores for the clinical validation samples were assigned using the norms tables provided in Appendix B. Clinical validity of the standard scores would be demonstrated if the observed scores in the clinical validation samples were lower than the normative mean of 100 (SD 15).

The mean standard scores in both clinical validation samples were substantially lower than the normative mean of 100 for both PARCA-R scales, both in the total samples and for males and females separately (Table 4.4), thus indicating clinical validity of the PARCA-R. Mean scores for the very preterm sample were 6 to 9 points lower than the normative mean and, for the neonatal sepsis sample, mean scores were 11 to 14 points lower than the normative mean.

**Table 4.4** Standard scores in the clinical validation samples derived using the equations and the norms tables, overall and by sex.

<b>CHILDREN BORN VERY PRETERM</b>			
	<b>Overall n=692</b>	<b>Males n=342</b>	<b>Females n=350</b>
Non-verbal cognition, mean (SD)	91 (17)	91 (17)	90 (17)
Language development, mean (SD)	94 (17)	95 (18)	93 (17)
<b>CHILDREN WITH NEONATAL SEPSIS</b>			
	<b>Overall n=764</b>	<b>Males n=437</b>	<b>Females n=327</b>
Non-verbal cognition, mean (SD)	86 (21)	86 (19)	87 (22)
Language development, mean (SD)	89 (19)	88 (19)	90 (20)

Developmental assessments are frequently used to identify children with developmental delay, either to identify those in need of referral or intervention in clinical services or as a categorical outcome in observational studies or clinical trials.

Conventionally, developmental test scores more than 1 SD below the normative mean (i.e., scores < 85) are used to classify children with mild to severe delay, and scores more than 2 SD below the normative mean (i.e., scores < 70) to classify children with moderate to severe delay. Therefore, in order to further assess clinical validity, the proportion of children with scores below both cut-offs was explored. Clinical validity would be demonstrated if the proportion of children with developmental delay in the clinical validation samples was higher than that expected in the general population (i.e., approximately 2.5% in a normal distribution will have moderate to severe delay [score < -2SD]; approximately 16% in a normal distribution will have mild to severe delay [score < -1 SD]).

As shown in Table 4.5, the proportion of children with developmental delay in both clinical validation samples far exceeded the proportion with delay that would be expected in the general population. For example, 15% of very preterm children and 24% of children with neonatal sepsis had moderate to severe cognitive or language delay compared with 2.5% expected to have scores < -2 SD in the general population. Similarly, 30% of very preterm children and 41% of children with neonatal sepsis had mild to severe cognitive or language delay compared with 16% expected to have scores < -1 SD in the general population. These results show that PARCA-R scores derived using the norms tables have good clinical validity.

**Table 4.5** Proportion of children with developmental delay in the clinical validation samples, overall and by sex.

CHILDREN BORN VERY PRETERM				
	n	Non-verbal cognitive delay n (%)	Language delay n (%)	Non-verbal cognitive or language delay n (%)
<b>Standard score &lt;70</b>				
Total	692	76 (11)	72 (10)	107 (15)
Males	342	39 (11)	39 (11)	56 (16)
Females	350	37 (11)	33 (9)	51 (15)
<b>Standard score &lt;85</b>				
Total	692	235 (34)	210 (30)	311 (45)
Males	342	118 (35)	94 (27)	150 (44)
Females	350	117 (33)	116 (33)	161 (46)
CHILDREN WITH NEONATAL SEPSIS				
	n	Non-verbal cognitive delay n (%)	Language delay n (%)	Non-verbal cognitive or language delay n (%)
<b>Standard score &lt;70</b>				
Total	764	147 (19)	127 (17)	183 (24)
Males	437	93 (21)	74 (17)	111 (25)
Females	327	54 (17)	53 (16)	72 (22)
<b>Standard score &lt;85</b>				
Total	764	327 (43)	311 (41)	423 (55)
Males	437	199 (46)	182 (42)	250 (57)
Females	327	128 (39)	129 (39)	173 (53)

## CHAPTER 5

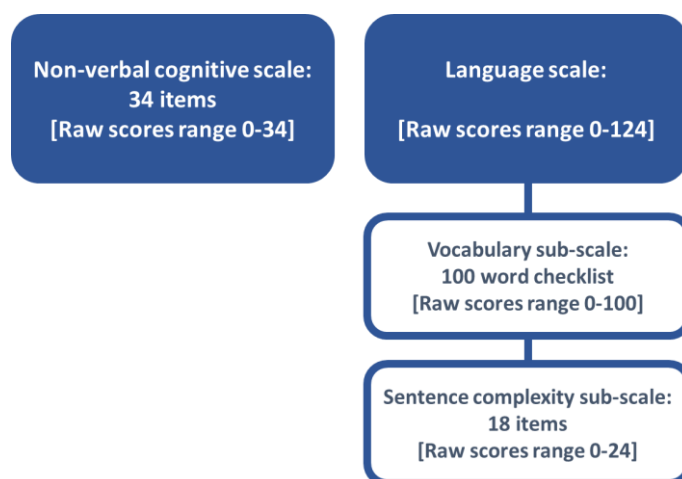
### SCORING THE PARCA-R

#### 5.1 Introduction

This chapter describes the procedure for scoring the non-verbal cognitive and language scales of the PARCA-R, and for deriving the standard scores.

The questionnaire should be completed by the child's parent or main caregiver. Components of the PARCA-R have been translated into 14 different languages to date. These are freely available to download from the PARCA-R website ([www.parca-r.info](http://www.parca-r.info)).

The PARCA-R comprises two scales for which raw scores and age- and sex-standardised scores can be derived (Figure 5.1).



**Figure 5.1** Composition of the PARCA-R raw scores.

## 5.2 Obtaining raw scores

### 5.2.1 Non-verbal cognitive scale raw score

As shown in Appendix A, the non-verbal cognition scale comprises Questions 1-34 in the “Your child’s play” section of the questionnaire.

Responses to each of these items should be scored as follows:

Yes	= 1
No	= 0
Don’t know	= 0

Sum the number of yes responses to give the total raw score for the non-verbal cognition scale. Raw scores for this scale range from 0 to 34.

Scores for missing questions in the non-verbal cognition scale can be substituted with the average of the score for completed questions if  $\leq 4$  questions are missing. If  $> 4$  questions are missing, a non-verbal cognition scale score cannot be calculated.

### 5.2.2 Language scale raw score

As shown in Appendix A, the language scale consists of two sections:

- a) Vocabulary sub-scale, which comprises the 100-word checklist in the “What your child can say” section of the questionnaire.
- b) Sentence complexity sub-scale, which comprises the 18 questions in the “How your child uses words” section of the questionnaire.

Calculating the language scale raw score requires 3 steps, as follows:

**1)** Calculate the raw score for the vocabulary sub-scale by summing the number of words ticked in the “What your child can say” checklist. Vocabulary sub-scale raw scores range from 0 to 100.

Unchecked or unanswered words in the vocabulary sub-scale should be scored zero.

**2)** Calculate the raw score for the sentence complexity sub-scale. Sentence complexity sub-scale raw scores range from 0 to 24.

i) First, score responses to Questions 1 to 6 of the “How your child uses words” section of the questionnaire, as follows:

Often	= 2
Sometimes	= 1
Not Yet	= 0

Sum the item scores to give a total score ranging from 0 to 12.

ii) Second, score Questions 7 to 18 of the “How your child uses words” section of the questionnaire, as follows:

Sentence A	= 0
Sentence B	= 1

Sum the item scores to give a total score ranging from 0 to 12.

iii) Third, sum the scores from Questions 1-6 and Questions 7-18 in order to give a total raw score for the sentence complexity sub-scale, ranging from 0 to 24.

Unchecked or unanswered items for the sentence complexity sub-scale should be scored zero.

**3)** To obtain the raw score for the language scale, sum the vocabulary and sentence complexity sub-scale scores. Language scale raw scores range from 0 to 124.

### 5.3 Obtaining standard scores

#### 5.3.1 Calculating standard scores by hand

Standard scores are obtained from the tables presented in Appendix B.

To derive the standard scores, the child’s age at assessment in months and days, sex and raw scores are needed.

First, identify the appropriate table for the child’s age and sex. Read down the first column to locate the child’s raw score. Then read along the row, to the right, to locate the standard score corresponding to the child’s raw score for each PARCA-R scale.

For example (Figure 5.2), to identify standard scores for a boy assessed at age 25 months and 5 days, with a raw score of 19 on the non-verbal cognitive scale and a raw score of 24 on the language scale:

- i) First, identify the table in Appendix B for males in the appropriate age range, in this case 24 months 16 days to 25 months 15 days (Table B3).
- ii) Second, locate the raw score of 19 in the first column of the table and read across the row to locate the corresponding standard score for the non-verbal cognitive scale, in this case a standard score of 70.
- ii) Third, locate the raw score of 24 in the first column of the table and read across the row to locate the corresponding standard score for the language scale, in this case a standard score of 84.

Percentile ranks and 95% confidence intervals can also be derived for each standard score using the tables in Appendix B. To derive these indicators, locate the child’s raw score in the first column of the age- and sex- appropriate norms table and read across the row to locate the corresponding percentile rank and 95% confidence interval for the non-verbal cognitive scale raw score and the language scale raw score (see Figure 5.2).

	Males: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (raw scale range: 0-34)			Language development (raw scale range: 0-124)		
Raw score	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	49	<0.1	46 - 65	53	<0.1	49 - 61
1	49	<0.1	46 - 65	58	0.2	54 - 65
2	49	<0.1	46 - 65	61	0.5	57 - 68
3	49	<0.1	46 - 65	64	0.8	60 - 71
4	49	<0.1	46 - 65	66	1.2	62 - 73
5	49	<0.1	46 - 65	68	1.6	64 - 75
6	49	<0.1	46 - 65	69	2.0	65 - 76
7	49	<0.1	46 - 65	71	2.5	66 - 77
8	49	<0.1	46 - 65	72	3.1	67 - 79
9	49	<0.1	46 - 65	73	3.6	69 - 80
10	49	<0.1	46 - 65	74	4.2	69 - 81
11	50	<0.1	47 - 66	75	4.8	70 - 82
12	51	<0.1	48 - 67	76	5.4	71 - 82
13	53	0.1	50 - 68	77	6.0	72 - 83
14	55	0.1	52 - 70	77	6.7	73 - 84
15	58	0.2	54 - 73	78	7.3	74 - 85
16	61	0.4	57 - 75	79	8.0	74 - 85
17	64	0.8	59 - 78	80	8.8	75 - 86
18	67	1.3	62 - 81	80	9.5	76 - 87
19	70	2.2	64 - 83	81	10.2	76 - 87
20	73	3.5	67 - 86	82	11.0	77 - 88
21	76	5.5	70 - 89	82	11.7	77 - 89
22	79	8.2	73 - 91	83	12.5	78 - 89
23	82	12.0	75 - 94	83	13.3	78 - 90
24	86	17.0	78 - 97	84	14.1	79 - 90
25	89	23.5	81 - 100	84	15.0	79 - 91
26	93	31.4	84 - 103	85	15.8	80 - 91
27	97	40.9	88 - 106	85	16.6	80 - 92
28	101	51.6	91 - 110	86	17.5	81 - 92
29	105	63.0	95 - 114	86	18.3	81 - 93
30	110	74.5	99 - 118	87	19.2	82 - 93
31	115	84.8	104 - 123	87	20.1	82 - 94
32	122	92.8	110 - 128	88	21.0	83 - 94
33	129	97.3	116 - 135	88	21.9	83 - 94
34	135	99.0	121 - 140	89	22.8	84 - 95
35	-	-	-	89	23.7	84 - 95
36	-	-	-	90	24.6	85 - 96
37	-	-	-	90	25.5	85 - 96
38	-	-	-	91	26.5	85 - 97
39	-	-	-	91	27.4	86 - 97
40	-	-	-	91	28.4	86 - 97
41	-	-	-	92	29.3	87 - 98
42	-	-	-	92	30.3	87 - 98
43	-	-	-	93	31.2	87 - 99
44	-	-	-	93	32.2	88 - 99

Figure 5.2 Obtaining standard scores.



### 5.3.2 Calculating standard scores using the online calculator

Standard scores may be calculated electronically using the PARCA-R online score calculator which can be accessed at [www.parca-r.info](http://www.parca-r.info) (see Figure 5.3). To obtain standard scores using the calculator, the child's sex, date of birth and date of assessment must first be entered, from which the child's chronological age will be automatically calculated. The child's raw scores should then be entered from which the standard scores will be automatically calculated. A summary sheet detailing the child's raw and standard scores is available to print.

UNIVERSITY OF LEICESTER

PARCA-R calculator

action medical research for children

To obtain PARCA-R standard scores, first select the child's sex and then enter the child's date of birth and date of PARCA-R assessment. In order to obtain scores for corrected age for children born preterm, enter the child's expected date of delivery (EDD) instead of date of birth. Next enter the child's raw questionnaire scores for the Non-Verbal Cognition Scale and the Language Development Scale. The calculator will then provide the child's age and sex standardised score for each scale.

Sex  
☒ Boy  
☐ Girl

Date of birth or EDD  
29/07/2015 ✓

Date of assessment  
03/09/2017 ✓

Age at assessment  
25 months 5 days

For preterm born babies, you may use the expected delivery date (EDD) instead of date of birth.

**NON-VERBAL COGNITION SCALE**  
A 25mo 5d old boy with a non-verbal cognition scale of 19 has a standard score of 70. This is on the 2nd percentile. This means that 2% of children in the general population have scores equal to or less than this child's score.

Child's raw score	Standard score	Percentile
19 ✓	70	2

**LANGUAGE DEVELOPMENT SCALE**  
A 25mo 5d old boy with a language development scale of 24 has a standard score of 84. This is on the 14th percentile. This means that 14% of children in the general population have scores equal to or less than this child's score.

Child's raw score	Standard score	Percentile
24 ✓	84	14

Thank you for using the PARCA-R online calculator. If you would like more information on how to use these scores, please contact your child's health professional.

Figure 5.3 Screenshot of the PARCA-R online calculator and illustrative example.

### 5.3.3 Interpreting PARCA-R scores

PARCA-R standard scores are norm-referenced and can therefore be used to determine how far an individual's score differs from the mean of the standardisation sample. That is, standard scores can be used to compare an individual child's development with that of children of the same age and sex in the general population, and to identify children with developmental delay.

Percentile ranks and confidence intervals corresponding with each standard score can also be derived from the tables in Appendix B. Percentile ranks indicate what proportion of the standardisation sample had scores lower than an individual child's observed score and can therefore be used to compare a child's developmental level with that expected for his or her age. For example,

a percentile rank of 45 indicates that 44% of children of the same age and sex in the general population had scores lower than that of the individual child being assessed.

In addition to identifying developmental delay, standard scores can also be used to identify children with advanced development. For example, a percentile rank of 95 indicates that the child being assessed had a score higher than 94% of children of the same age and sex in the general population.

As specific criteria for identifying delay and eligibility for early intervention services may differ between healthcare systems, relevant local or national guidelines for detecting developmental problems and disorders and classifying eligibility for intervention programmes should be consulted. For research purposes, and frequently in developmental follow-up,<sup>24</sup> conventional definitions for identifying developmental delay using standardised test scores are applied using SD-banded cut-offs. For example:

*Development in the average range:* Standardised score -1 SD to < +1 SD; corresponding to standard scores 85 to 114.

*Mild delay:* Standardised score -2 SD to < -1 SD; corresponding to standard scores 70 to 84.

*Moderate delay:* Standardised score -3 SD to < -2 SD; corresponding to standard scores 55 to 69.

*Severe delay:* Standardised score < -3 SD; corresponding to standard scores of 54 or less.

Similarly, standard scores may be used to identify children with development above the average range, for example:

*Above average:* Standardised score +1 SD to < +2 SD; corresponding to standard scores 115 to 129.

*Very above average:* Standardised score  $\geq$  +2 SD; corresponding to standard scores of 130 or above.

Standard scores for the non-verbal cognitive and language scales should be used separately to assess children's development and to classify delay in individual domains.

Eligibility for referral for diagnostic testing or intervention services should ultimately be made taking into account the results of other clinical assessments and in line with relevant local or national guidelines.

## 5.4 Adjusting for prematurity

Standard scores were developed using chronological age for all children in the standardisation sample. For children born at term (i.e., at 37 weeks of gestation or more), the child's chronological age at the time the PARCA-R is completed should be used for deriving standard scores. However, children born preterm, before 37 weeks of gestation, perform more poorly on development tests than children born at term.<sup>58-61</sup> To compare the development of all children at the same post-conceptual age, it is therefore conventional to adjust for prematurity when assessing development during the first few years of life.

Correction for prematurity is commonly applied in practice by subtracting the number of weeks a child was born preterm, before 40 weeks of gestation, from his or her chronological age at the time of testing to account for the degree of immaturity at birth and to compare the child's performance with that of children of a similar post-conceptual age. For example, if the parents of a boy who was born extremely preterm at 26<sup>+0</sup> weeks of gestation completed the PARCA-R when he was 27 months

and 0 days chronological age, his corrected age would be 23 months 24 days. For the same raw non-verbal cognitive score of 29, his standard score would be 103 for chronological age (Table B7) and 107 for corrected age (Table B1), a difference of 4 points in non-verbal cognition. Similarly, for the same raw language score of 46, his standard score would be 92 for chronological age (Table B7) and 95 for corrected age (Table B1), a difference of 3 points in language development.

Recent clinical guidelines for the developmental follow up of children and young people born preterm published by the National Institute for Health and Care Excellence (NICE) recommend using corrected age when assessing children's functional and developmental skills over the first two years.<sup>26</sup> Correcting for prematurity is also recommended for children up to three years of age by the American Academy of Pediatrics.<sup>62</sup> However, these guidelines do not specify the degree of prematurity at which corrected age should cease to be applied. Given that birth at late and moderately preterm gestations has been shown to have an adverse impact on developmental outcomes<sup>9, 10</sup>, corrected age should be applied when assessing development and obtaining standard scores for all children born before 37 weeks of gestation.

In practice, correction for prematurity is operationalised by using the norms table corresponding to the child's corrected age (i.e., age at assessment from his or her expected date of delivery, rather than date of birth) when deriving standard scores. Correction should be applied when using the PARCA-R questionnaire across the full age range for which standard scores are available, that is, for the assessment of preterm born children at a corrected age up to 27 months 15 days. To obtain standard scores for corrected age using the online score calculator, the child's expected date of delivery should be entered instead of the child's date of birth (see Figure 5.3).



## REFERENCES

1. Twins Early Development Study. *Twins Early Development Study*. London, UK: King's College London, 2019.
2. Saudino KJ, Dale PS, Oliver B, et al. The validity of parent-based assessment of the cognitive abilities of 2-year-olds. *Brit J Dev Psychol* 1998; 16: 349-363. DOI: DOI 10.1111/j.2044-835X.1998.tb00757.x.
3. Fenson L, Dale PS, Reznick JS, et al. *MacArthur Communicative Development Inventories: User's Guide and Technical Manual*. San Diego, California, USA: Singular Publishing Group, 1993.
4. Fenson L, Dale PS, Reznick JS, et al. Variability in Early Communicative Development. *Monogr Soc Res Child Dev* 1994; 59: R5-+.
5. Fenson L, Pethick S and Cox JL. The MacArthur Communicative Development Inventories: Short Form Versions. San Diego State University. Unpublished manuscript.
6. Bayley N. *Bayley Scales of Infant Development, 2nd Edition*. San Antonio, TX, USA: Psychological Corporation, 1993.
7. Moore T, Hennessy EM, Myles J, et al. Neurological and developmental outcome in extremely preterm children born in England in 1995 and 2006: the EPICure studies. *Brit Med J* 2012; 345: e7961. DOI: 10.1136/bmj.e7961.
8. Wood NS, Marlow N, Costeloe K, et al. Neurologic and developmental disability after extremely preterm birth. *N Engl J Med* 2000; 343: 378-384. DOI: 10.1056/Nejm200008103430601.
9. Cheong JL, Doyle LW, Burnett AC, et al. Association Between Moderate and Late Preterm Birth and Neurodevelopment and Social-Emotional Development at Age 2 Years. *JAMA Pediatr* 2017; 171: e164805. DOI: 10.1001/jamapediatrics.2016.4805.
10. Johnson S, Evans TA, Draper ES, et al. Neurodevelopmental outcomes following late and moderate prematurity: a population-based cohort study. *Arch Dis Child Fetal Neonatal Ed* 2015; 100: F301-F308. DOI: 10.1136/archdischild-2014-307684.
11. Johnson S, Fawke J, Hennessy E, et al. Neurodevelopmental disability through 11 years in children born before 26 weeks of gestation: The EPICure Study. *Pediatr* 2009: e249-e257.
12. Johnson S and Marlow N. Preterm Birth and Childhood Psychiatric Disorders. *Pediatr Res* 2011; 69: 11r-18r.
13. Johnson S, Matthews R, Draper ES, et al. Early Emergence of Delayed Social Competence in Infants Born Late and Moderately Preterm. *J Dev Behav Pediatr* 2015; 36: 690-699. DOI: 10.1097/DBP.0000000000000222.
14. Johnson S, Hollis C, Kochhar P, et al. Psychiatric Disorders in Extremely Preterm Children: Longitudinal Finding at Age 11 Years in the EPICure Study. *J Am Acad Child Adolesc Psychiatry* 2010; 49: 453-463.e451. doi: DOI: 10.1016/j.jaac.2010.02.002.
15. Burnett AC, Anderson PJ, Cheong J, et al. Prevalence of psychiatric diagnoses in preterm and full-term children, adolescents and young adults: A meta-analysis. *Psychol Med* 2011; 41: 2463-2474. DOI: 10.1017/s003329171100081x.
16. Johnson S, Hennessy E, Smith R, et al. Academic attainment and special educational needs in extremely preterm children at 11 years. The EPICure Study. *Arch Dis Child Fetal Neonatal Ed* 2009; 94: F283-F289.
17. Hutchinson EA, De Luca CR, Doyle LW, et al. School-age outcomes of extremely preterm or extremely low birth weight children. *Pediatr* 2013; 131: e1053-1061. 2013/03/20. DOI: 10.1542/peds.2012-2311.

18. Breeman LD, Jaekel J, Baumann N, et al. Preterm Cognitive Function Into Adulthood. *Pediatr* 2015; 136: 415-423. DOI: 10.1542/peds.2015-0608.
19. Breeman LD, Jaekel J, Baumann N, et al. Attention problems in very preterm children from childhood to adulthood: the Bavarian Longitudinal Study. *J Child Psychol Psychiatry* 2016; 57: 132-140. DOI: 10.1111/jcpp.12456.
20. Linsell L, Johnson S, Wolke D, et al. Cognitive trajectories from infancy to early adulthood following birth before 26 weeks of gestation: a prospective, population-based cohort study. *Arch Dis Child* 2018; 103: 363-370. DOI: 10.1136/archdischild-2017-313414.
21. Linsell L, Johnson S, Wolke D, et al. Trajectories of behavior, attention, social and emotional problems from childhood to early adulthood following extremely preterm birth: a prospective cohort study. *Eur Child Adolesc Psychiatry* 2019; 28: 531-542. DOI: 10.1007/s00787-018-1219-8.
22. MacKay DF, Smith GC, Dobbie R, et al. Gestational age at delivery and special educational need: retrospective cohort study of 407,503 schoolchildren. *PLoS Med* 2010; 7: e1000289.
23. Wolke D, Strauss VY, Johnson S, et al. Universal gestational age effects on cognitive and basic mathematic processing: 2 cohorts in 2 countries. *J Pediatr* 2015; 166: 1410-1416 e1411-1412. DOI: 10.1016/j.jpeds.2015.02.065.
24. British Association of Perinatal Medicine. *Report of a BAPM/RCPCH Working Group: Classification of health status at 2 years as a perinatal outcome*. 2008. London: BAPM.
25. NHS & Department for Health. *Toolkit for High Quality Neonatal Services*. London, UK: Department of Health, 2009.
26. National Institute for Health and Care Excellence. *Developmental follow-up of children and young people born preterm. Full Guideline. NG72*. 2017.
27. Marlow N. Measuring neurodevelopmental outcome in neonatal trials: a continuing and increasing challenge. *Arch Dis Child Fetal Neonatal Ed* 2013 2013/07/11. DOI: 10.1136/archdischild-2012-302970.
28. Marlow N. Is survival and neurodevelopmental impairment at 2 years of age the gold standard outcome for neonatal studies? *Arch Dis Child Fetal Neonatal Ed* 2015; 100: F82-84. DOI: 10.1136/archdischild-2014-306191.
29. Marlow N, Doyle LW, Anderson P, et al. Assessment of long-term neurodevelopmental outcome following trials of medicinal products in newborn infants. *Pediatr Res* 2019. DOI: 10.1038/s41390-019-0526-1.
30. Johnson A, Clavert S, Marlow N, et al. Multicentre trial of high frequency ventilation. UKOS Study Group. *Arch Dis Child Fetal Neonatal Ed* 1999; 81: F160. DOI: 10.1136/fn.81.2.f159c.
31. Griffiths R. *The Griffiths Mental Development Scales from birth to 2 years Manual. The 1996 Revision*. Henley: The Test Agency, 1996.
32. Johnson S, Marlow N, Wolke D, et al. Validation of a parent report measure of cognitive development in very preterm infants. *Dev Med Child Neurol* 2004; 46: 389-397.
33. Johnson S, Wolke D, Marlow N, et al. Developmental assessment of preterm infants at 2 years: validity of parent reports. *Dev Med Child Neurol* 2008; 50: 58-62. 2008/01/05. DOI: 10.1111/j.1469-8749.2007.02010.x.
34. Liao H, Wang T, Yao G, et al. Concurrent validity of the Comprehensive Developmental Inventory for Infants and Toddlers with the Bayley Scales of Infant Development-II in preterm infants. *J Formos Med Assoc* 2005; 104: 731-737.
35. Vincer MJ, Cake H, Graven M, et al. A population-based study to determine the performance of the Cognitive Adaptive Test/Clinical Linguistic and Auditory Milestone Scale to predict the Mental Development Index at 18 months on the Bayley Scales of Infant Development-II in very preterm infants. *Pediatr* 2005; 116: 864-867.

36. Voight RG, Brown FR, K. FJ, et al. Concurrent and predictive validity of the cognitive adaptive test/clinical linguistic and auditory milestone scale (CAT/CLAMS) and the Mental Development Index of the Bayley Scales of Infant Development. *Clin Pediatr* 2003; 42: 427-432.
37. Brocklehurst P, Farrell B, King A, et al. Treatment of neonatal sepsis with intravenous immune globulin. *N Engl J Med* 2011; 365: 1201-1211. 2011/10/04. DOI: 10.1056/NEJMoa1100441.
38. Bayley N. *Bayley Scales of Infant and Toddler Development, 3rd Edition*. San Antonio, TX, USA: Harcourt Assessment Inc, 2006.
39. Martin AJ, Darlow BA, Salt A, et al. Performance of the Parent Report of Children's Abilities-Revised (PARCA-R) versus the Bayley Scales of Infant Development III. *Arch Dis Child* 2013; 98: 955-958. 2013/09/14. DOI: 10.1136/archdischild-2012-303288.
40. Blaggan S, Guy A, Boyle EM, et al. A parent questionnaire for developmental screening in infants born late and moderately preterm. *Pediatr* 2014; 134: e55-62. DOI: 10.1542/peds.2014-0266.
41. Cuttini M, Ferrante P, Mirante N, et al. Cognitive assessment of very preterm infants at 2-year corrected age: performance of the Italian version of the PARCA-R parent questionnaire. *Early Hum Dev* 2012; 88: 159-163. 2011/08/25. DOI: 10.1016/j.earlhumdev.2011.07.022.
42. Beardsall K, Vanhaesebrouck S, Ogilvy-Stuart AL, et al. Early insulin therapy in very-low-birth-weight infants. *N Engl J Med* 2008; 359: 1873-1884. DOI: 10.1056/NEJMoa0803725.
43. Vanhaesebrouck S, Theyskens C, Vanhole C, et al. Cognitive assessment of very low birth weight infants using the Dutch version of the PARCA-R parent questionnaire. *Early Hum Dev* 2014; 90: 897-900. DOI: 10.1016/j.earlhumdev.2014.10.004.
44. Martin AJ, Darlow BA, Salt A, et al. Identification of infants with major cognitive delay using parental report. *Dev Med Child Neurol* 2012; 54: 254-259. 2011/12/23. DOI: 10.1111/j.1469-8749.2011.04161.x.
45. Glascoe FP. Screening for developmental and behavioural problems. *Mental Retardation and Developmental Disabilities Research Reviews* 2005; 11: 173-109.
46. Glascoe FP. Are overreferrals on developmental screening tests really a problem? *Arch Pediatr Adolesc Med* 2001; 155: 54-59.
47. Johnson S, Bountziouka V, Brocklehurst P, et al. Standardisation of the Parent Report of Children's Abilities-Revised (PARCA-R): a norm-referenced assessment of cognitive and language development at age 2 years. *Lancet Child Adolesc Health* 2019; 3: 705-712. DOI: 10.1016/S2352-4642(19)30189-0.
48. Infant Collaborative Group. Computerised interpretation of fetal heart rate during labour (INFANT): a randomised controlled trial. *Lancet* 2017; 389: 1719-1729. DOI: 10.1016/S0140-6736(17)30568-8.
49. Office for National Statistics. Gestation-specific infant mortality in England and Wales: 2011 <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/causesofdeath/bulletins/pregnancyandethnicfactorsinfluencingbirthsandinfantmortality/2013-10-10#background-notes> (2011, accessed May 10, 2018).
50. Boyle EM, Johnson S, Manktelow B, et al. Neonatal outcomes and delivery of care for infants born late preterm or moderately preterm: a prospective population-based study. *Arch Dis Child Fetal Neonatal Ed* 2015; 100: F479-485. DOI: 10.1136/archdischild-2014-307347.
51. Field D, Spata E, Davies T, et al. Evaluation of the use of a parent questionnaire to provide later health status data: the PANDA study. *Arch Dis Child Fetal Neonatal Ed* 2016; 101: F304-308. DOI: 10.1136/archdischild-2015-309247.
52. Office for National Statistics. The English Indices of Deprivation 2010 [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\\_data/file/6871/1871208.pdf](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/6871/1871208.pdf) (2011, accessed Sept 5, 2018).

53. Office for National Statistics. Census 2011 table links, [https://www.nomisweb.co.uk/census/2011/detailed\\_characteristics](https://www.nomisweb.co.uk/census/2011/detailed_characteristics) (2012, accessed May 10, 2018).
54. Information Services Division Scotland. Data tables: maternity and births, <https://www.isdscotland.org/Health-Topics/Maternity-and-Births/Publications/data-tables.asp> (2016, accessed May 10, 2018).
55. Dudek FJ. Continuing Misinterpretation of the Standard Error of Measurement. *Psychol Bull* 1979; 86: 335-337. DOI: Doi 10.1037/0033-2909.86.2.335.
56. Glutting JJ, Mcdermott PA and Stanley JC. Resolving Differences among Methods of Establishing Confidence-Limits for Test-Scores. *Educ Psychol Meas* 1987; 47: 607-614. DOI: Doi 10.1177/001316448704700307.
57. Stanley JC. Reliability. In: Thorndike RL (ed) *Educational Measurement*. Washington, DC: American Council on Education, 1971, pp.356-442.
58. Johnson S and Marlow N. Early and long-term outcome of infants born extremely preterm. *Arch Dis Child* 2017; 102: 97-102. DOI: 10.1136/archdischild-2015-309581.
59. Saigal S and Doyle L. An overview of mortality and sequelae of preterm birth from infancy to adulthood. *Lancet* 2008; 371: 261-269.
60. Draper ES, Zeitlin J, Manktelow BN, et al. EPICE cohort: two-year neurodevelopmental outcomes after very preterm birth. *Arch Dis Child Fetal Neonatal Ed* 2019 2019/11/07. DOI: 10.1136/archdischild-2019-317418.
61. Ene D, Der G, Fletcher-Watson S, et al. Associations of Socioeconomic Deprivation and Preterm Birth With Speech, Language, and Communication Concerns Among Children Aged 27 to 30 Months. *JAMA Netw Open* 2019; 2: e1911027. 2019/09/12. DOI: 10.1001/jamanetworkopen.2019.11027.
62. American Academy of Pediatrics Medical Home Initiatives for Children With Special Needs Project Advisory Committee. Policy statement: organizational principles to guide and define the child health care system and/or improve the health of all children. *Pediatr* 2004; 113: 1545-1547. DOI: 10.1542/peds.2004-1915.



**APPENDIX A**

**PARCA-R QUESTIONNAIRE**



## Parent Report of Children's Abilities – Revised

### (PARCA-R Questionnaire)

### Your child's health and development at 2 years

In this form we ask you to answer some questions about your child.

This information is used to work out how your child is developing now that she/he is two years old.

**Please complete all the questions as accurately as possible.**

If you need any help completing the questionnaire, or have any queries about the questions, please do not hesitate to ask the doctor about these at your appointment.

#### **Permissions:**

The PARCA questionnaire was adapted for use with infants born preterm (Johnson et al., Dev Med Child Neurol 2004, 46;389-397) with permission from Saudino, Dale, Oliver, Petrill, Richardson, Rutter, Simonoff, Stevenson & Plomin (1998). The language measures included in this questionnaire are used with permission from the MacArthur-Bates CDI Advisory Board, Chair: Larry Fenson (2016).

**For more information:** Visit the PARCA-R website at [www.parca-r.info](http://www.parca-r.info)

## Your child's play

As a parent, you will have a good idea of what your child can and can't do. Listed below are a number of activities. Please indicate whether or not your child can do the activity. That is, if you have seen your child do the activity (or something similar) then tick the box under "YES". If you know that your child would not be able to do it, then tick the box under "NO". If you are not sure whether or not your child can do it, then tick the box under "DON'T KNOW". Please answer every question.

Please keep in mind that these questions are for children ranging from 18 months to 4 years. Some activities may be easy for your child, others may be difficult. Most children of your child's age will not be able to do some of the activities.

		YES	NO	DON'T KNOW
1	Does your child copy things you do such as cuddling a teddy? (Try it out if not sure by cuddling a teddy and then giving it to your child. Say: Now you cuddle teddy)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	When you hide a toy in full view of your child, will s/he look for it and find it? (Try this out by covering a small toy with a cloth or a cup and seeing if s/he uncovers the toy)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Can your child put a simple piece, such as a square or an animal, into the correct place in a puzzle board?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Some toys have several holes or openings with different shapes, such as a circle, triangle, and star. Could your child put the shapes into the right openings?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Can your child stack two small blocks or toys on top of each other?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Can your child put together, by him/herself, a puzzle or something similar where the pieces fit together?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	If so, can s/he do this for a puzzle with ten or more pieces?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	Can your child mark on a piece of paper using the tip of a crayon, pencil, or chalk?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	Can your child draw a more or less straight line on paper?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	Does your child turn, or try to turn, pages of a book one at a time?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	Does your child ever pretend that one object, such as a block, is another object, such as a car or a telephone?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	Can your child stack three small blocks or toys on top of each other by him/herself?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	Does your child ever pretend to do things? For example, riding a horse or making a cup of tea?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		DON'T		
		YES	NO	KNOW
14	Can your child push a car along the floor with the wheels on the floor?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15	Does your child look with interest at pictures in a book?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16	Does your child point to pictures in a book?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	Does your child try to copy things you do, such as stirring with a spoon in a cup?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18	Can your child stack seven small blocks or toys on top of each other by him/herself?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19	Does your child point or show where people or objects are when you ask: "Where is the light?" "Where is Daddy?" or "Where is Teddy?"	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	Does your child ever pretend that two dolls are playing together, or are talking to each other, or one is feeding the other?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21	Does your child ever play pretend games with another child, pretending to be someone else, such as a mummy, daddy, policeman, or nurse?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22	Does your child ever play any game with another child that involves taking turns?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23	Does your child ever copy some action shortly (within a few minutes) after s/he has seen it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24	Can your child fetch something, such as a toy, from another room by him/herself when you ask?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25	Does your child know where some things belong, such as, that his/her toys belong in a box?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26	Does your child ever save or put to one side a biscuit (or snack) for later, on his/her own?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27	Have you ever seen your child get together three or more toys before beginning to play with them?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28	Have you ever seen your child sort things (blocks, other toys) into groups or piles that go together on his/her own?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29	If your child wants something out of reach, does s/he go and find a chair or box to stand on?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30	When your child uses or plays with a telephone, does s/he speak into the mouthpiece not the earpiece?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31	When your child drinks from a cup, is s/he careful about putting it down, trying not to spill it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32	Does your child try to turn doorknobs, twist tops, or screw lids on or off jars?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33	Does your child recognise him/her self when looking in the mirror?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34	Does your child ever use his/her index (first) finger to point to show an interest in something?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## What your child can say

Children understand many more words than they can say. Here, we are only interested in the words your child SAYS. Please tick all the words you have heard your child say. If your child uses a different pronunciation of a word – e.g., “tend” for pretend, or “duce” for juice – tick it anyway. Please keep in mind that this is only a sample of words; your child may know many other words not on this list.

<input type="checkbox"/> Baa baa	<input type="checkbox"/> Cream cracker	<input type="checkbox"/> Bed	<input type="checkbox"/> Carry	<input type="checkbox"/> Last
<input type="checkbox"/> Meow	<input type="checkbox"/> Juice	<input type="checkbox"/> Bedroom	<input type="checkbox"/> Chase	<input type="checkbox"/> Tiny
<input type="checkbox"/> Ouch/ow	<input type="checkbox"/> Meat	<input type="checkbox"/> Settee/sofa	<input type="checkbox"/> Pour	<input type="checkbox"/> Wet
<input type="checkbox"/> Uh-oh/oh dear	<input type="checkbox"/> Milk	<input type="checkbox"/> Oven/cooker	<input type="checkbox"/> Finish	<input type="checkbox"/> After
<input type="checkbox"/> Woof woof	<input type="checkbox"/> Peas	<input type="checkbox"/> Stairs	<input type="checkbox"/> Fit	<input type="checkbox"/> Day
<input type="checkbox"/> Bear	<input type="checkbox"/> Hat	<input type="checkbox"/> Flag	<input type="checkbox"/> Hug/cuddle	<input type="checkbox"/> Tonight
<input type="checkbox"/> Bird	<input type="checkbox"/> Necklace	<input type="checkbox"/> Rain	<input type="checkbox"/> Listen	<input type="checkbox"/> Our
<input type="checkbox"/> Cat	<input type="checkbox"/> Shoe	<input type="checkbox"/> Star	<input type="checkbox"/> Like	<input type="checkbox"/> Them
<input type="checkbox"/> Dog	<input type="checkbox"/> Sock	<input type="checkbox"/> Swing	<input type="checkbox"/> Pretend	<input type="checkbox"/> This
<input type="checkbox"/> Duck	<input type="checkbox"/> Chin	<input type="checkbox"/> School	<input type="checkbox"/> Rip/tear	<input type="checkbox"/> Us
<input type="checkbox"/> Horse	<input type="checkbox"/> Ear	<input type="checkbox"/> Sky	<input type="checkbox"/> Shake	<input type="checkbox"/> Where
<input type="checkbox"/> Aeroplane	<input type="checkbox"/> Hand	<input type="checkbox"/> Zoo	<input type="checkbox"/> Taste	<input type="checkbox"/> Beside
<input type="checkbox"/> Boat	<input type="checkbox"/> Leg	<input type="checkbox"/> Friend	<input type="checkbox"/> Gentle	<input type="checkbox"/> Down
<input type="checkbox"/> Car	<input type="checkbox"/> Pillow	<input type="checkbox"/> Mummy/mum	<input type="checkbox"/> Think	<input type="checkbox"/> Under
<input type="checkbox"/> Ball	<input type="checkbox"/> Comb	<input type="checkbox"/> Person	<input type="checkbox"/> Wish	<input type="checkbox"/> All
<input type="checkbox"/> Book	<input type="checkbox"/> Lamp/torch	<input type="checkbox"/> Bye/bye bye	<input type="checkbox"/> All gone	<input type="checkbox"/> Much
<input type="checkbox"/> Game	<input type="checkbox"/> Plate	<input type="checkbox"/> Hi/hello	<input type="checkbox"/> Cold	<input type="checkbox"/> Could
<input type="checkbox"/> Sandwich	<input type="checkbox"/> Rubbish	<input type="checkbox"/> No	<input type="checkbox"/> Fast	<input type="checkbox"/> Need to
<input type="checkbox"/> Fish	<input type="checkbox"/> Tray	<input type="checkbox"/> Shopping	<input type="checkbox"/> Happy	<input type="checkbox"/> Would
<input type="checkbox"/> Sauce	<input type="checkbox"/> Towel	<input type="checkbox"/> Thank you	<input type="checkbox"/> Hot	<input type="checkbox"/> If

## How your child uses words

We would like to know how your child uses the words s/he can say. Please tick one box for each question below to tell us whether your child uses words like this often, sometimes, or not yet.

Please keep in mind that these questions are for children up to 4 years of age. Many children of your child's age will not be able say some of the words or sentences below.

		OFTEN	SOMETIMES	NOT YET
1	Does your child ever talk about past events or people who are not present? For example, a child who saw a carnival last week might later say 'carnival', 'clown', or 'band'.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2	Does your child ever talk about something that is going to happen in the future? E.g. saying 'choo-choo' or 'bus' before you leave the house on a trip, or saying 'swing' when you are going to the park?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3	Does your child ever talk about objects that are not present? For example, asking about a missing toy not in the room, or asking about someone not present?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4	Does your child understand if you ask for something that is not in the room? For example, would s/he go to the bedroom to get a teddy bear when you say 'Where's the bear?'	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	Does your child know who things belong to? For example, a child might point to mummy's shoe and say 'Mummy'.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Has your child started to put together words yet, such as 'Daddy gone' or 'Doggie bite'?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

If you answered "Sometimes" or "Often" to question 6 above, please answer all the questions on the next page.

For EACH PAIR of sentences below – A and B – please tick the one that sounds MOST like the way your child talks at the moment, even if s/he would not say that EXACT sentence. If your child is saying sentences even more complicated than the two examples provided, tick B.

<b>7</b>	(Talking about something happening right now)	<b>8</b>	(Talking about something that already happened)	<b>9</b>	
A	<input type="checkbox"/> I make tower	A	<input type="checkbox"/> Daddy pick me up	A	<input type="checkbox"/> That my truck
B	<input type="checkbox"/> I making tower	B	<input type="checkbox"/> Daddy picked me up	B	<input type="checkbox"/> That's my truck
<b>10</b>		<b>11</b>		<b>12</b>	
A	<input type="checkbox"/> Baby crying	A	<input type="checkbox"/> There a doggie	A	<input type="checkbox"/> Coffee hot
B	<input type="checkbox"/> Baby is crying	B	<input type="checkbox"/> There's a doggie	B	<input type="checkbox"/> That coffee hot
<b>13</b>		<b>14</b>		<b>15</b>	
A	<input type="checkbox"/> I no do it	A	<input type="checkbox"/> I like read stories	A	<input type="checkbox"/> Biscuit mummy
B	<input type="checkbox"/> I can't do it	B	<input type="checkbox"/> I like to read stories	B	<input type="checkbox"/> Biscuit for mummy
<b>16</b>		<b>17</b>		<b>18</b>	
A	<input type="checkbox"/> Don't read book	A	<input type="checkbox"/> Baby want eat	A	<input type="checkbox"/> Look at me
B	<input type="checkbox"/> Don't want you read that book	B	<input type="checkbox"/> Baby want to eat	B	<input type="checkbox"/> Look at me dancing

Thank you very much for your time



## APPENDIX B

### STANDARD SCORE CONVERSION TABLES

To obtain the standard scores, locate the appropriate table for the child's age and sex from the following tables:

**Table B1** Standard score conversion table for males aged 23 months 16 days to 24 months 15 days, page 53

**Table B2** Standard score conversion table for females aged 23 months 16 days to 24 months 15 days, page 57

**Table B3** Standard score conversion table for males aged 24 months 16 days to 25 months 15 days, page 61

**Table B4** Standard score conversion table for females aged 24 months 16 days to 25 months 15 days, page 65

**Table B5** Standard score conversion table for males aged 25 months 16 days to 26 months 15 days, page 69

**Table B6** Standard score conversion table for females aged 25 months 16 days to 26 months 15 days, page 73

**Table B7** Standard score conversion table for males aged 26 months 16 days to 27 months 15 days, page 77

**Table B8** Standard score conversion table for females aged 26 months 16 days to 27 months 15 days, page 81



**Table B1** Standard score conversion table for males aged 23 months 16 days to 24 months 15 days

Raw score	Males: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	49	<0.1	47 - 64	53	0.1	49 - 61
1	49	<0.1	47 - 64	59	0.3	55 - 66
2	49	<0.1	47 - 64	63	0.6	59 - 70
3	49	<0.1	47 - 64	65	1.0	61 - 72
4	49	<0.1	47 - 64	68	1.5	63 - 74
5	49	<0.1	47 - 64	69	2.0	65 - 76
6	49	<0.1	47 - 64	71	2.6	66 - 78
7	49	<0.1	47 - 64	72	3.2	68 - 79
8	49	<0.1	47 - 64	73	3.8	69 - 80
9	49	<0.1	47 - 64	74	4.4	70 - 81
10	49	<0.1	47 - 65	75	5.1	71 - 82
11	50	<0.1	48 - 65	76	5.8	72 - 83
12	52	0.1	49 - 67	77	6.5	73 - 84
13	54	0.1	51 - 69	78	7.2	73 - 85
14	57	0.2	53 - 71	79	8.0	74 - 85
15	59	0.3	56 - 73	80	8.7	75 - 86
16	62	0.6	59 - 76	80	9.5	76 - 87
17	65	1.1	61 - 79	81	10.3	76 - 87
18	68	1.8	64 - 81	82	11.1	77 - 88
19	72	2.9	66 - 84	82	12.0	78 - 89
20	75	4.5	69 - 87	83	12.8	78 - 89
21	78	6.9	72 - 89	84	13.7	79 - 90
22	81	10.2	75 - 92	84	14.5	79 - 90
23	84	14.5	77 - 95	85	15.4	80 - 91
24	87	20.2	80 - 98	85	16.3	80 - 91
25	91	27.3	83 - 101	86	17.2	81 - 92
26	95	35.9	87 - 104	86	18.1	81 - 92
27	98	45.7	90 - 107	87	19.0	82 - 93
28	102	56.5	93 - 111	87	19.9	82 - 93
29	107	67.7	97 - 115	88	20.9	83 - 94
30	112	78.4	102 - 119	88	21.8	83 - 94
31	117	87.6	106 - 124	89	22.7	84 - 95
32	124	94.2	112 - 129	89	23.7	84 - 95
33	130	97.6	117 - 135	90	24.6	85 - 96
34	137	99.4	124 - 141	90	25.6	85 - 96
35	-	-	-	91	26.6	85 - 97
36	-	-	-	91	27.5	86 - 97
37	-	-	-	91	28.5	86 - 97

Raw score	Males: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	92	29.5	87 - 98
39	-	-	-	92	30.5	87 - 98
40	-	-	-	93	31.5	88 - 99
41	-	-	-	93	32.5	88 - 99
42	-	-	-	94	33.5	88 - 99
43	-	-	-	94	34.4	89 - 100
44	-	-	-	94	35.4	89 - 100
45	-	-	-	95	36.5	89 - 101
46	-	-	-	95	37.5	90 - 101
47	-	-	-	96	38.5	90 - 101
48	-	-	-	96	39.5	91 - 102
49	-	-	-	96	40.5	91 - 102
50	-	-	-	97	41.5	91 - 102
51	-	-	-	97	42.5	92 - 103
52	-	-	-	98	43.5	92 - 103
53	-	-	-	98	44.5	92 - 104
54	-	-	-	98	45.5	93 - 104
55	-	-	-	99	46.5	93 - 104
56	-	-	-	99	47.5	94 - 105
57	-	-	-	99	48.5	94 - 105
58	-	-	-	100	49.6	94 - 105
59	-	-	-	100	50.6	95 - 106
60	-	-	-	101	51.6	95 - 106
61	-	-	-	101	52.6	95 - 106
62	-	-	-	101	53.6	96 - 107
63	-	-	-	102	54.6	96 - 107
64	-	-	-	102	55.6	96 - 108
65	-	-	-	102	56.6	97 - 108
66	-	-	-	103	57.5	97 - 108
67	-	-	-	103	58.5	98 - 109
68	-	-	-	104	59.5	98 - 109
69	-	-	-	104	60.5	98 - 109
70	-	-	-	104	61.5	99 - 110
71	-	-	-	105	62.4	99 - 110
72	-	-	-	105	63.4	99 - 110
73	-	-	-	106	64.4	100 - 111
74	-	-	-	106	65.3	100 - 111
75	-	-	-	106	66.3	101 - 112
76	-	-	-	107	67.2	101 - 112
77	-	-	-	107	68.2	101 - 112

Raw score	Males: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	107	69.1	102 - 113
79	-	-	-	108	70.0	102 - 113
80	-	-	-	108	71.0	102 - 114
81	-	-	-	109	71.9	103 - 114
82	-	-	-	109	72.8	103 - 114
83	-	-	-	110	73.7	104 - 115
84	-	-	-	110	74.6	104 - 115
85	-	-	-	110	75.5	104 - 115
86	-	-	-	111	76.4	105 - 116
87	-	-	-	111	77.2	105 - 116
88	-	-	-	112	78.1	106 - 117
89	-	-	-	112	79.0	106 - 117
90	-	-	-	113	79.8	106 - 118
91	-	-	-	113	80.6	107 - 118
92	-	-	-	113	81.5	107 - 118
93	-	-	-	114	82.3	108 - 119
94	-	-	-	114	83.1	108 - 119
95	-	-	-	115	83.9	109 - 120
96	-	-	-	115	84.7	109 - 120
97	-	-	-	116	85.5	110 - 121
98	-	-	-	116	86.2	110 - 121
99	-	-	-	117	87.0	111 - 122
100	-	-	-	117	87.7	111 - 122
101	-	-	-	118	88.4	112 - 123
102	-	-	-	119	89.1	112 - 123
103	-	-	-	119	89.8	113 - 124
104	-	-	-	120	90.5	113 - 124
105	-	-	-	120	91.2	114 - 125
106	-	-	-	121	91.8	115 - 126
107	-	-	-	122	92.5	115 - 126
108	-	-	-	122	93.1	116 - 127
109	-	-	-	123	93.7	116 - 128
110	-	-	-	124	94.3	117 - 128
111	-	-	-	124	94.8	118 - 129
112	-	-	-	125	95.4	119 - 130
113	-	-	-	126	95.9	119 - 131
114	-	-	-	127	96.4	120 - 131
115	-	-	-	128	96.9	121 - 132
116	-	-	-	129	97.3	122 - 133
117	-	-	-	130	97.7	123 - 134

Raw score	Males: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	131	98.1	124 - 135
119	-	-	-	132	98.5	126 - 137
120	-	-	-	134	98.8	127 - 138
121	-	-	-	135	99.1	128 - 140
122	-	-	-	137	99.3	130 - 141
123	-	-	-	139	99.5	132 - 143
124	-	-	-	147	99.9	140 - 151

**Table B2** Standard score conversion table for females aged 23 months 16 days to 24 months 15 days

Raw score	Females: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	10	<0.1	12 - 31	49	<0.1	45 - 57
1	10	<0.1	12 - 31	51	0.1	47 - 59
2	10	<0.1	12 - 31	54	0.1	50 - 61
3	10	<0.1	12 - 31	56	0.2	53 - 64
4	10	<0.1	13 - 31	59	0.3	55 - 66
5	12	<0.1	14 - 33	61	0.4	56 - 68
6	17	<0.1	18 - 37	62	0.6	58 - 69
7	22	<0.1	23 - 41	64	0.8	59 - 71
8	26	<0.1	27 - 45	65	1.0	61 - 72
9	31	<0.1	31 - 49	66	1.2	62 - 73
10	35	<0.1	34 - 52	67	1.4	63 - 74
11	39	<0.1	37 - 56	68	1.7	64 - 75
12	42	<0.1	41 - 59	69	2.0	65 - 76
13	46	<0.1	44 - 62	70	2.3	65 - 77
14	49	<0.1	47 - 65	71	2.6	66 - 78
15	53	0.1	50 - 68	72	2.9	67 - 79
16	56	0.2	52 - 71	72	3.3	68 - 79
17	59	0.3	55 - 74	73	3.7	69 - 80
18	62	0.6	58 - 76	74	4.1	69 - 81
19	66	1.1	61 - 79	75	4.5	70 - 81
20	69	1.9	64 - 82	75	4.9	70 - 82
21	72	3.1	67 - 85	76	5.4	71 - 83
22	75	5.0	69 - 88	76	5.8	72 - 83
23	79	7.8	72 - 91	77	6.3	72 - 84
24	82	11.7	75 - 94	78	6.8	73 - 84
25	86	17.0	78 - 97	78	7.3	73 - 85
26	89	24.0	82 - 100	79	7.8	74 - 85
27	93	32.7	85 - 103	79	8.4	74 - 86
28	97	43.2	89 - 107	80	9.0	75 - 86
29	102	55.1	92 - 111	80	9.5	75 - 87
30	107	67.6	97 - 115	81	10.1	76 - 87
31	112	79.4	102 - 120	81	10.7	76 - 88
32	118	89.0	107 - 125	82	11.4	77 - 88
33	124	94.7	112 - 130	82	12.0	77 - 89
34	133	98.7	120 - 138	83	12.6	78 - 89
35	-	-	-	83	13.3	78 - 90
36	-	-	-	84	14.0	79 - 90
37	-	-	-	84	14.7	79 - 91

Raw score	Females: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	85	15.4	80 - 91
39	-	-	-	85	16.1	80 - 91
40	-	-	-	86	16.8	80 - 92
41	-	-	-	86	17.6	81 - 92
42	-	-	-	86	18.3	81 - 93
43	-	-	-	87	19.1	82 - 93
44	-	-	-	87	19.9	82 - 94
45	-	-	-	88	20.7	83 - 94
46	-	-	-	88	21.5	83 - 94
47	-	-	-	89	22.3	83 - 95
48	-	-	-	89	23.1	84 - 95
49	-	-	-	89	24.0	84 - 96
50	-	-	-	90	24.8	85 - 96
51	-	-	-	90	25.7	85 - 96
52	-	-	-	91	26.6	85 - 97
53	-	-	-	91	27.5	86 - 97
54	-	-	-	91	28.4	86 - 98
55	-	-	-	92	29.3	86 - 98
56	-	-	-	92	30.2	87 - 98
57	-	-	-	93	31.1	87 - 99
58	-	-	-	93	32.0	88 - 99
59	-	-	-	93	33.0	88 - 99
60	-	-	-	94	33.9	88 - 100
61	-	-	-	94	34.9	89 - 100
62	-	-	-	95	35.9	89 - 101
63	-	-	-	95	36.9	89 - 101
64	-	-	-	95	37.9	90 - 101
65	-	-	-	96	38.9	90 - 102
66	-	-	-	96	39.9	91 - 102
67	-	-	-	97	40.9	91 - 102
68	-	-	-	97	41.9	91 - 103
69	-	-	-	97	42.9	92 - 103
70	-	-	-	98	44.0	92 - 104
71	-	-	-	98	45.0	93 - 104
72	-	-	-	99	46.0	93 - 104
73	-	-	-	99	47.1	93 - 105
74	-	-	-	99	48.2	94 - 105
75	-	-	-	100	49.2	94 - 105
76	-	-	-	100	50.3	94 - 106
77	-	-	-	101	51.4	95 - 106



Raw score	Females: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	101	52.5	95 - 107
79	-	-	-	101	53.6	96 - 107
80	-	-	-	102	54.6	96 - 107
81	-	-	-	102	55.7	96 - 108
82	-	-	-	103	56.8	97 - 108
83	-	-	-	103	58.0	97 - 109
84	-	-	-	103	59.1	98 - 109
85	-	-	-	104	60.2	98 - 109
86	-	-	-	104	61.3	98 - 110
87	-	-	-	105	62.4	99 - 110
88	-	-	-	105	63.5	99 - 111
89	-	-	-	106	64.6	100 - 111
90	-	-	-	106	65.8	100 - 112
91	-	-	-	107	66.9	101 - 112
92	-	-	-	107	68.0	101 - 112
93	-	-	-	107	69.1	102 - 113
94	-	-	-	108	70.2	102 - 113
95	-	-	-	108	71.4	102 - 114
96	-	-	-	109	72.5	103 - 114
97	-	-	-	109	73.6	103 - 115
98	-	-	-	110	74.7	104 - 115
99	-	-	-	111	75.8	104 - 116
100	-	-	-	111	76.9	105 - 116
101	-	-	-	112	78.0	105 - 117
102	-	-	-	112	79.1	106 - 117
103	-	-	-	113	80.2	107 - 118
104	-	-	-	113	81.3	107 - 119
105	-	-	-	114	82.4	108 - 119
106	-	-	-	115	83.5	108 - 120
107	-	-	-	115	84.5	109 - 120
108	-	-	-	116	85.6	110 - 121
109	-	-	-	117	86.6	110 - 122
110	-	-	-	117	87.7	111 - 122
111	-	-	-	118	88.7	112 - 123
112	-	-	-	119	89.7	113 - 124
113	-	-	-	120	90.7	113 - 125
114	-	-	-	121	91.6	114 - 126
115	-	-	-	122	92.6	115 - 127
116	-	-	-	123	93.5	116 - 128
117	-	-	-	124	94.4	117 - 129

Raw score	Females: 23mo 16d to 24mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	125	95.3	118 - 130
119	-	-	-	126	96.1	120 - 131
120	-	-	-	128	96.9	121 - 133
121	-	-	-	130	97.6	123 - 134
122	-	-	-	132	98.3	125 - 136
123	-	-	-	134	98.9	127 - 139
124	-	-	-	140	99.6	132 - 144

**Table B3** Standard score conversion table for males aged 24 months 16 days to 25 months 15 days

Raw score	Males: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	49	<0.1	46 - 65	53	0.1	49 - 61
1	49	<0.1	46 - 65	58	0.2	54 - 65
2	49	<0.1	46 - 65	61	0.5	57 - 68
3	49	<0.1	46 - 65	64	0.8	60 - 71
4	49	<0.1	46 - 65	66	1.2	62 - 73
5	49	<0.1	46 - 65	68	1.6	64 - 75
6	49	<0.1	46 - 65	69	2.0	65 - 76
7	49	<0.1	46 - 65	71	2.5	66 - 77
8	49	<0.1	46 - 65	72	3.1	67 - 79
9	49	<0.1	46 - 65	73	3.6	69 - 80
10	49	<0.1	46 - 65	74	4.2	69 - 81
11	50	<0.1	47 - 66	75	4.8	70 - 82
12	51	0.1	48 - 67	76	5.4	71 - 82
13	53	0.1	50 - 68	77	6.0	72 - 83
14	55	0.1	52 - 70	77	6.7	73 - 84
15	58	0.2	54 - 73	78	7.3	74 - 85
16	61	0.4	57 - 75	79	8.0	74 - 85
17	64	0.8	59 - 78	80	8.8	75 - 86
18	67	1.3	62 - 81	80	9.5	76 - 87
19	70	2.2	64 - 83	81	10.2	76 - 87
20	73	3.5	67 - 86	82	11.0	77 - 88
21	76	5.5	70 - 89	82	11.7	77 - 89
22	79	8.2	73 - 91	83	12.5	78 - 89
23	82	12.0	75 - 94	83	13.3	78 - 90
24	86	17.0	78 - 97	84	14.1	79 - 90
25	89	23.5	81 - 100	84	15.0	79 - 91
26	93	31.4	84 - 103	85	15.8	80 - 91
27	97	40.9	88 - 106	85	16.6	80 - 92
28	101	51.6	91 - 110	86	17.5	81 - 92
29	105	63.0	95 - 114	86	18.3	81 - 93
30	110	74.5	99 - 118	87	19.2	82 - 93
31	115	84.8	104 - 123	87	20.1	82 - 94
32	122	92.8	110 - 128	88	21.0	83 - 94
33	129	97.3	116 - 135	88	21.9	83 - 94
34	135	99.0	121 - 140	89	22.8	84 - 95
35	-	-	-	89	23.7	84 - 95
36	-	-	-	90	24.6	85 - 96
37	-	-	-	90	25.5	85 - 96

Raw score	Males: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	91	26.5	85 - 97
39	-	-	-	91	27.4	86 - 97
40	-	-	-	91	28.4	86 - 97
41	-	-	-	92	29.3	87 - 98
42	-	-	-	92	30.3	87 - 98
43	-	-	-	93	31.2	87 - 99
44	-	-	-	93	32.2	88 - 99
45	-	-	-	93	33.2	88 - 99
46	-	-	-	94	34.1	89 - 100
47	-	-	-	94	35.1	89 - 100
48	-	-	-	95	36.1	89 - 101
49	-	-	-	95	37.1	90 - 101
50	-	-	-	95	38.1	90 - 101
51	-	-	-	96	39.0	90 - 102
52	-	-	-	96	40.0	91 - 102
53	-	-	-	97	41.0	91 - 102
54	-	-	-	97	42.0	92 - 103
55	-	-	-	97	43.0	92 - 103
56	-	-	-	98	44.0	92 - 103
57	-	-	-	98	45.0	93 - 104
58	-	-	-	99	46.0	93 - 104
59	-	-	-	99	47.0	93 - 105
60	-	-	-	99	48.0	94 - 105
61	-	-	-	100	49.0	94 - 105
62	-	-	-	100	50.0	94 - 106
63	-	-	-	100	51.0	95 - 106
64	-	-	-	101	52.0	95 - 106
65	-	-	-	101	53.0	96 - 107
66	-	-	-	102	54.1	96 - 107
67	-	-	-	102	55.1	96 - 107
68	-	-	-	102	56.1	97 - 108
69	-	-	-	103	57.1	97 - 108
70	-	-	-	103	58.0	97 - 109
71	-	-	-	103	59.0	98 - 109
72	-	-	-	104	60.0	98 - 109
73	-	-	-	104	61.0	98 - 110
74	-	-	-	105	62.0	99 - 110
75	-	-	-	105	63.0	99 - 110
76	-	-	-	105	64.0	100 - 111
77	-	-	-	106	65.0	100 - 111

Raw score	Males: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	106	65.9	100 - 112
79	-	-	-	107	66.9	101 - 112
80	-	-	-	107	67.9	101 - 112
81	-	-	-	107	68.8	101 - 113
82	-	-	-	108	69.8	102 - 113
83	-	-	-	108	70.7	102 - 113
84	-	-	-	109	71.7	103 - 114
85	-	-	-	109	72.6	103 - 114
86	-	-	-	109	73.5	103 - 115
87	-	-	-	110	74.5	104 - 115
88	-	-	-	110	75.4	104 - 116
89	-	-	-	111	76.3	105 - 116
90	-	-	-	111	77.2	105 - 116
91	-	-	-	112	78.1	106 - 117
92	-	-	-	112	79.0	106 - 117
93	-	-	-	113	79.9	106 - 118
94	-	-	-	113	80.7	107 - 118
95	-	-	-	114	81.6	107 - 119
96	-	-	-	114	82.5	108 - 119
97	-	-	-	114	83.3	108 - 120
98	-	-	-	115	84.1	109 - 120
99	-	-	-	116	85.0	109 - 121
100	-	-	-	116	85.8	110 - 121
101	-	-	-	117	86.6	110 - 122
102	-	-	-	117	87.4	111 - 122
103	-	-	-	118	88.1	111 - 123
104	-	-	-	118	88.9	112 - 123
105	-	-	-	119	89.7	113 - 124
106	-	-	-	120	90.4	113 - 124
107	-	-	-	120	91.1	114 - 125
108	-	-	-	121	91.8	114 - 126
109	-	-	-	122	92.5	115 - 126
110	-	-	-	122	93.2	116 - 127
111	-	-	-	123	93.8	117 - 128
112	-	-	-	124	94.4	117 - 129
113	-	-	-	125	95.0	118 - 129
114	-	-	-	126	95.6	119 - 130
115	-	-	-	127	96.2	120 - 131
116	-	-	-	128	96.7	121 - 132
117	-	-	-	129	97.2	122 - 133

Raw score	Males: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	130	97.7	123 - 134
119	-	-	-	131	98.1	124 - 136
120	-	-	-	133	98.5	126 - 137
121	-	-	-	134	98.9	127 - 139
122	-	-	-	136	99.2	129 - 140
123	-	-	-	138	99.5	131 - 142
124	-	-	-	145	99.9	137 - 149

**Table B4** Standard score conversion table for females aged 24 months 16 days to 25 months 15 days

Raw score	Females: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	10	<0.1	12 - 31	49	<0.1	45 - 56
1	10	<0.1	12 - 31	50	<0.1	47 - 58
2	10	<0.1	12 - 31	53	0.1	49 - 60
3	10	<0.1	12 - 31	55	0.1	51 - 62
4	10	<0.1	12 - 31	57	0.2	53 - 64
5	12	<0.1	14 - 32	59	0.3	55 - 66
6	16	<0.1	18 - 36	60	0.4	56 - 67
7	21	<0.1	22 - 40	62	0.5	58 - 69
8	25	<0.1	26 - 44	63	0.7	59 - 70
9	30	<0.1	30 - 48	64	0.8	60 - 71
10	34	<0.1	33 - 52	65	1.0	61 - 72
11	38	<0.1	36 - 55	66	1.2	62 - 73
12	41	<0.1	40 - 58	67	1.4	63 - 74
13	45	<0.1	43 - 61	68	1.7	64 - 75
14	48	<0.1	46 - 64	69	1.9	65 - 76
15	52	0.1	49 - 67	70	2.2	65 - 77
16	55	0.1	51 - 70	71	2.5	66 - 77
17	58	0.3	54 - 73	71	2.8	67 - 78
18	61	0.5	57 - 76	72	3.1	68 - 79
19	64	0.9	60 - 78	73	3.4	68 - 79
20	68	1.6	63 - 81	73	3.8	69 - 80
21	71	2.6	65 - 84	74	4.1	69 - 81
22	74	4.3	68 - 87	75	4.5	70 - 81
23	78	6.7	71 - 90	75	4.9	71 - 82
24	81	10.3	74 - 93	76	5.3	71 - 82
25	85	15.1	77 - 96	76	5.7	72 - 83
26	88	21.6	80 - 99	77	6.2	72 - 83
27	92	30.0	84 - 102	77	6.6	73 - 84
28	96	40.1	87 - 106	78	7.1	73 - 84
29	101	51.9	91 - 110	79	7.6	74 - 85
30	106	64.6	96 - 114	79	8.1	74 - 85
31	111	77.1	100 - 119	80	8.6	75 - 86
32	117	87.6	106 - 124	80	9.2	75 - 86
33	124	94.3	111 - 130	81	9.7	76 - 87
34	132	98.3	118 - 137	81	10.3	76 - 87
35	-	-	-	81	10.8	77 - 88
36	-	-	-	82	11.4	77 - 88
37	-	-	-	82	12.0	78 - 89

Raw score	Females: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	83	12.6	78 - 89
39	-	-	-	83	13.3	78 - 90
40	-	-	-	84	13.9	79 - 90
41	-	-	-	84	14.6	79 - 90
42	-	-	-	85	15.3	80 - 91
43	-	-	-	85	15.9	80 - 91
44	-	-	-	85	16.6	81 - 92
45	-	-	-	86	17.3	81 - 92
46	-	-	-	86	18.1	81 - 92
47	-	-	-	87	18.8	82 - 93
48	-	-	-	87	19.6	82 - 93
49	-	-	-	88	20.3	83 - 94
50	-	-	-	88	21.1	83 - 94
51	-	-	-	88	21.9	83 - 94
52	-	-	-	89	22.7	84 - 95
53	-	-	-	89	23.5	84 - 95
54	-	-	-	90	24.3	84 - 96
55	-	-	-	90	25.2	85 - 96
56	-	-	-	90	26.0	85 - 96
57	-	-	-	91	26.9	86 - 97
58	-	-	-	91	27.7	86 - 97
59	-	-	-	92	28.6	86 - 97
60	-	-	-	92	29.5	87 - 98
61	-	-	-	92	30.4	87 - 98
62	-	-	-	93	31.3	87 - 99
63	-	-	-	93	32.3	88 - 99
64	-	-	-	93	33.2	88 - 99
65	-	-	-	94	34.1	89 - 100
66	-	-	-	94	35.1	89 - 100
67	-	-	-	95	36.1	89 - 100
68	-	-	-	95	37.1	90 - 101
69	-	-	-	95	38.0	90 - 101
70	-	-	-	96	39.0	90 - 102
71	-	-	-	96	40.1	91 - 102
72	-	-	-	97	41.1	91 - 102
73	-	-	-	97	42.1	92 - 103
74	-	-	-	97	43.1	92 - 103
75	-	-	-	98	44.2	92 - 103
76	-	-	-	98	45.2	93 - 104
77	-	-	-	99	46.3	93 - 104



Raw score	Females: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	99	47.4	94 - 105
79	-	-	-	99	48.5	94 - 105
80	-	-	-	100	49.5	94 - 105
81	-	-	-	100	50.6	95 - 106
82	-	-	-	101	51.7	95 - 106
83	-	-	-	101	52.8	95 - 107
84	-	-	-	101	54.0	96 - 107
85	-	-	-	102	55.1	96 - 107
86	-	-	-	102	56.2	97 - 108
87	-	-	-	103	57.4	97 - 108
88	-	-	-	103	58.5	98 - 109
89	-	-	-	104	59.7	98 - 109
90	-	-	-	104	60.8	98 - 110
91	-	-	-	105	62.0	99 - 110
92	-	-	-	105	63.1	99 - 110
93	-	-	-	105	64.3	100 - 111
94	-	-	-	106	65.5	100 - 111
95	-	-	-	106	66.7	101 - 112
96	-	-	-	107	67.8	101 - 112
97	-	-	-	107	69.0	102 - 113
98	-	-	-	108	70.2	102 - 113
99	-	-	-	108	71.4	103 - 114
100	-	-	-	109	72.6	103 - 114
101	-	-	-	110	73.8	104 - 115
102	-	-	-	110	75.0	104 - 115
103	-	-	-	111	76.2	105 - 116
104	-	-	-	111	77.4	105 - 116
105	-	-	-	112	78.5	106 - 117
106	-	-	-	112	79.7	106 - 118
107	-	-	-	113	80.9	107 - 118
108	-	-	-	114	82.1	108 - 119
109	-	-	-	114	83.3	108 - 119
110	-	-	-	115	84.5	109 - 120
111	-	-	-	116	85.6	110 - 121
112	-	-	-	117	86.8	111 - 122
113	-	-	-	118	87.9	111 - 122
114	-	-	-	118	89.1	112 - 123
115	-	-	-	119	90.2	113 - 124
116	-	-	-	120	91.3	114 - 125
117	-	-	-	121	92.4	115 - 126

Raw score	Females: 24mo 16d to 25mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	123	93.5	116 - 127
119	-	-	-	124	94.5	117 - 129
120	-	-	-	125	95.5	119 - 130
121	-	-	-	127	96.5	121 - 132
122	-	-	-	129	97.4	122 - 134
123	-	-	-	131	98.2	125 - 136
124	-	-	-	137	99.4	130 - 141

**Table B5** Standard score conversion tables for males aged 25 months 16 days to 26 months 15 days.

Raw score	Males: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	49	<0.1	46 - 65	53	0.1	49 - 61
1	49	<0.1	46 - 65	56	0.2	52 - 64
2	49	<0.1	46 - 65	60	0.4	56 - 67
3	49	<0.1	46 - 65	62	0.6	58 - 70
4	49	<0.1	46 - 65	64	0.9	60 - 72
5	49	<0.1	46 - 65	66	1.2	62 - 73
6	49	<0.1	46 - 65	68	1.6	63 - 75
7	49	<0.1	46 - 65	69	2.0	64 - 76
8	49	<0.1	46 - 65	70	2.4	66 - 77
9	49	<0.1	46 - 65	71	2.8	67 - 78
10	49	<0.1	46 - 65	72	3.3	68 - 79
11	49	<0.1	47 - 65	73	3.8	69 - 80
12	50	<0.1	48 - 66	74	4.3	69 - 81
13	52	0.1	49 - 68	75	4.8	70 - 82
14	54	0.1	51 - 69	76	5.4	71 - 83
15	57	0.2	53 - 72	77	6.0	72 - 83
16	59	0.3	56 - 74	77	6.6	72 - 84
17	62	0.6	58 - 77	78	7.2	73 - 85
18	65	1.0	61 - 79	79	7.8	74 - 85
19	68	1.7	63 - 82	79	8.4	74 - 86
20	71	2.8	66 - 85	80	9.1	75 - 87
21	75	4.5	69 - 87	81	9.8	76 - 87
22	78	6.8	71 - 90	81	10.5	76 - 88
23	81	10.1	74 - 93	82	11.2	77 - 88
24	84	14.5	77 - 96	82	11.9	77 - 89
25	88	20.4	80 - 99	83	12.6	78 - 89
26	91	27.8	83 - 102	83	13.4	78 - 90
27	95	36.7	86 - 105	84	14.1	79 - 90
28	99	47.2	90 - 108	84	14.9	79 - 91
29	103	58.8	94 - 112	85	15.7	80 - 91
30	108	70.7	98 - 117	85	16.5	80 - 92
31	114	82.0	103 - 121	86	17.3	81 - 92
32	120	91.2	108 - 127	86	18.1	81 - 93
33	128	96.8	115 - 134	87	18.9	82 - 93
34	133	98.6	119 - 138	87	19.8	82 - 94
35	-	-	-	88	20.6	82 - 94
36	-	-	-	88	21.5	83 - 95
37	-	-	-	89	22.3	83 - 95

Raw score	Males: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	89	23.2	84 - 95
39	-	-	-	89	24.1	84 - 96
40	-	-	-	90	25.0	84 - 96
41	-	-	-	90	25.9	85 - 97
42	-	-	-	91	26.8	85 - 97
43	-	-	-	91	27.7	86 - 97
44	-	-	-	92	28.6	86 - 98
45	-	-	-	92	29.5	86 - 98
46	-	-	-	92	30.4	87 - 99
47	-	-	-	93	31.4	87 - 99
48	-	-	-	93	32.3	88 - 99
49	-	-	-	94	33.3	88 - 100
50	-	-	-	94	34.2	88 - 100
51	-	-	-	94	35.2	89 - 100
52	-	-	-	95	36.1	89 - 101
53	-	-	-	95	37.1	89 - 101
54	-	-	-	95	38.1	90 - 102
55	-	-	-	96	39.0	90 - 102
56	-	-	-	96	40.0	91 - 102
57	-	-	-	97	41.0	91 - 103
58	-	-	-	97	42.0	91 - 103
59	-	-	-	97	43.0	92 - 103
60	-	-	-	98	44.0	92 - 104
61	-	-	-	98	45.0	92 - 104
62	-	-	-	98	46.0	93 - 104
63	-	-	-	99	47.0	93 - 105
64	-	-	-	99	48.0	93 - 105
65	-	-	-	100	49.0	94 - 106
66	-	-	-	100	50.0	94 - 106
67	-	-	-	100	51.0	95 - 106
68	-	-	-	101	52.0	95 - 107
69	-	-	-	101	53.0	95 - 107
70	-	-	-	102	54.0	96 - 107
71	-	-	-	102	55.0	96 - 108
72	-	-	-	102	56.0	96 - 108
73	-	-	-	103	57.0	97 - 108
74	-	-	-	103	58.0	97 - 109
75	-	-	-	103	59.1	97 - 109
76	-	-	-	104	60.1	98 - 110
77	-	-	-	104	61.1	98 - 110

Raw score	Males: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	105	62.1	99 - 110
79	-	-	-	105	63.1	99 - 111
80	-	-	-	105	64.1	99 - 111
81	-	-	-	106	65.1	100 - 111
82	-	-	-	106	66.1	100 - 112
83	-	-	-	107	67.1	101 - 112
84	-	-	-	107	68.1	101 - 113
85	-	-	-	107	69.1	101 - 113
86	-	-	-	108	70.1	102 - 113
87	-	-	-	108	71.0	102 - 114
88	-	-	-	109	72.0	103 - 114
89	-	-	-	109	73.0	103 - 115
90	-	-	-	110	74.0	103 - 115
91	-	-	-	110	74.9	104 - 116
92	-	-	-	111	75.9	104 - 116
93	-	-	-	111	76.8	105 - 116
94	-	-	-	111	77.8	105 - 117
95	-	-	-	112	78.7	106 - 117
96	-	-	-	112	79.6	106 - 118
97	-	-	-	113	80.6	107 - 118
98	-	-	-	113	81.5	107 - 119
99	-	-	-	114	82.4	108 - 119
100	-	-	-	114	83.3	108 - 120
101	-	-	-	115	84.2	109 - 120
102	-	-	-	116	85.1	109 - 121
103	-	-	-	116	85.9	110 - 121
104	-	-	-	117	86.8	110 - 122
105	-	-	-	117	87.6	111 - 123
106	-	-	-	118	88.5	111 - 123
107	-	-	-	119	89.3	112 - 124
108	-	-	-	119	90.1	113 - 124
109	-	-	-	120	90.9	113 - 125
110	-	-	-	121	91.7	114 - 126
111	-	-	-	121	92.4	115 - 127
112	-	-	-	122	93.1	116 - 127
113	-	-	-	123	93.9	116 - 128
114	-	-	-	124	94.6	117 - 129
115	-	-	-	125	95.2	118 - 130
116	-	-	-	126	95.9	119 - 131
117	-	-	-	127	96.5	120 - 132

Raw score	Males: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	128	97.1	121 - 133
119	-	-	-	130	97.6	123 - 135
120	-	-	-	131	98.2	124 - 136
121	-	-	-	133	98.6	126 - 138
122	-	-	-	135	99.1	128 - 140
123	-	-	-	138	99.4	130 - 142
124	-	-	-	143	99.8	135 - 147

**Table B6** Standard score conversion table for females aged 25 months 16 days to 26 months 15 days

Raw score	Females: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	10	<0.1	12 - 31	49	<0.1	45 - 57
1	10	<0.1	12 - 31	50	<0.1	46 - 57
2	10	<0.1	12 - 31	51	0.1	47 - 59
3	10	<0.1	12 - 31	53	0.1	49 - 61
4	10	<0.1	12 - 31	55	0.1	51 - 63
5	11	<0.1	13 - 32	57	0.2	53 - 64
6	15	<0.1	16 - 35	58	0.3	54 - 66
7	19	<0.1	21 - 39	60	0.4	56 - 67
8	24	<0.1	25 - 43	61	0.5	57 - 69
9	28	<0.1	28 - 47	62	0.6	58 - 70
10	32	<0.1	32 - 50	63	0.7	59 - 71
11	36	<0.1	35 - 54	64	0.9	60 - 72
12	40	<0.1	38 - 57	65	1.0	61 - 73
13	43	<0.1	41 - 60	66	1.2	62 - 73
14	47	<0.1	44 - 63	67	1.4	62 - 74
15	50	<0.1	47 - 66	68	1.6	63 - 75
16	53	0.1	50 - 69	69	1.8	64 - 76
17	57	0.2	53 - 72	69	2.0	65 - 76
18	60	0.4	56 - 74	70	2.3	65 - 77
19	63	0.7	59 - 77	71	2.6	66 - 78
20	66	1.2	61 - 80	71	2.8	67 - 78
21	69	2.1	64 - 83	72	3.1	67 - 79
22	73	3.4	67 - 86	73	3.4	68 - 80
23	76	5.4	70 - 88	73	3.7	68 - 80
24	79	8.4	73 - 91	74	4.1	69 - 81
25	83	12.7	76 - 95	74	4.4	70 - 81
26	87	18.5	79 - 98	75	4.8	70 - 82
27	90	26.1	82 - 101	76	5.1	71 - 82
28	95	35.8	86 - 105	76	5.5	71 - 83
29	99	47.3	90 - 109	77	5.9	72 - 83
30	104	60.2	94 - 113	77	6.4	72 - 84
31	109	73.5	99 - 118	78	6.8	73 - 84
32	116	85.4	105 - 123	78	7.2	73 - 85
33	123	93.5	111 - 129	79	7.7	74 - 85
34	130	97.6	117 - 135	79	8.2	74 - 86
35	-	-	-	80	8.6	75 - 86
36	-	-	-	80	9.1	75 - 87
37	-	-	-	80	9.7	75 - 87

Raw score	Females: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	81	10.2	76 - 88
39	-	-	-	81	10.7	76 - 88
40	-	-	-	82	11.3	77 - 88
41	-	-	-	82	11.8	77 - 89
42	-	-	-	83	12.4	78 - 89
43	-	-	-	83	13.0	78 - 90
44	-	-	-	84	13.6	78 - 90
45	-	-	-	84	14.2	79 - 90
46	-	-	-	84	14.9	79 - 91
47	-	-	-	85	15.5	80 - 91
48	-	-	-	85	16.2	80 - 92
49	-	-	-	86	16.9	80 - 92
50	-	-	-	86	17.6	81 - 92
51	-	-	-	86	18.3	81 - 93
52	-	-	-	87	19.0	81 - 93
53	-	-	-	87	19.7	82 - 94
54	-	-	-	88	20.4	82 - 94
55	-	-	-	88	21.2	83 - 94
56	-	-	-	88	22.0	83 - 95
57	-	-	-	89	22.7	83 - 95
58	-	-	-	89	23.5	84 - 95
59	-	-	-	90	24.3	84 - 96
60	-	-	-	90	25.2	84 - 96
61	-	-	-	90	26.0	85 - 97
62	-	-	-	91	26.8	85 - 97
63	-	-	-	91	27.7	86 - 97
64	-	-	-	92	28.6	86 - 98
65	-	-	-	92	29.5	86 - 98
66	-	-	-	92	30.4	87 - 98
67	-	-	-	93	31.3	87 - 99
68	-	-	-	93	32.2	87 - 99
69	-	-	-	93	33.1	88 - 100
70	-	-	-	94	34.1	88 - 100
71	-	-	-	94	35.0	89 - 100
72	-	-	-	95	36.0	89 - 101
73	-	-	-	95	37.0	89 - 101
74	-	-	-	95	38.0	90 - 101
75	-	-	-	96	39.0	90 - 102
76	-	-	-	96	40.0	90 - 102
77	-	-	-	97	41.0	91 - 103



Raw score	Females: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	97	42.0	91 - 103
79	-	-	-	97	43.1	92 - 103
80	-	-	-	98	44.2	92 - 104
81	-	-	-	98	45.2	92 - 104
82	-	-	-	99	46.3	93 - 105
83	-	-	-	99	47.4	93 - 105
84	-	-	-	99	48.5	94 - 105
85	-	-	-	100	49.6	94 - 106
86	-	-	-	100	50.7	94 - 106
87	-	-	-	101	51.9	95 - 107
88	-	-	-	101	53.0	95 - 107
89	-	-	-	102	54.2	96 - 107
90	-	-	-	102	55.4	96 - 108
91	-	-	-	102	56.5	97 - 108
92	-	-	-	103	57.7	97 - 109
93	-	-	-	103	58.9	97 - 109
94	-	-	-	104	60.1	98 - 110
95	-	-	-	104	61.3	98 - 110
96	-	-	-	105	62.6	99 - 110
97	-	-	-	105	63.8	99 - 111
98	-	-	-	106	65.0	100 - 111
99	-	-	-	106	66.3	100 - 112
100	-	-	-	107	67.5	101 - 112
101	-	-	-	107	68.8	101 - 113
102	-	-	-	108	70.1	102 - 113
103	-	-	-	108	71.3	102 - 114
104	-	-	-	109	72.6	103 - 115
105	-	-	-	110	73.9	103 - 115
106	-	-	-	110	75.2	104 - 116
107	-	-	-	111	76.5	105 - 116
108	-	-	-	111	77.8	105 - 117
109	-	-	-	112	79.1	106 - 118
110	-	-	-	113	80.4	106 - 118
111	-	-	-	114	81.7	107 - 119
112	-	-	-	114	83.1	108 - 120
113	-	-	-	115	84.4	109 - 120
114	-	-	-	116	85.7	109 - 121
115	-	-	-	117	87.0	110 - 122
116	-	-	-	118	88.3	111 - 123
117	-	-	-	119	89.6	112 - 124

Raw score	Females: 25mo 16d to 26mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	120	90.9	113 - 125
119	-	-	-	121	92.2	115 - 126
120	-	-	-	123	93.5	116 - 128
121	-	-	-	124	94.7	117 - 129
122	-	-	-	126	95.9	119 - 131
123	-	-	-	128	97.1	121 - 133
124	-	-	-	135	99.0	128 - 139

**Table B7** Standard score conversion table for males aged 26 months 16 days to 27 months 15 days

Raw score	Males: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	49	<0.1	46 - 64	53	0.1	49 - 61
1	49	<0.1	46 - 64	56	0.2	52 - 64
2	49	<0.1	46 - 64	59	0.3	55 - 67
3	49	<0.1	46 - 64	62	0.5	57 - 69
4	49	<0.1	46 - 64	64	0.8	59 - 71
5	49	<0.1	46 - 64	65	1.0	61 - 73
6	49	<0.1	46 - 64	67	1.4	62 - 74
7	49	<0.1	46 - 64	68	1.7	63 - 76
8	49	<0.1	46 - 64	69	2.1	65 - 77
9	49	<0.1	46 - 65	71	2.5	66 - 78
10	49	<0.1	46 - 65	72	2.9	67 - 79
11	49	<0.1	47 - 65	72	3.3	67 - 80
12	50	<0.1	47 - 66	73	3.8	68 - 81
13	52	0.1	49 - 67	74	4.3	69 - 81
14	54	0.1	50 - 69	75	4.8	70 - 82
15	56	0.2	53 - 71	76	5.3	71 - 83
16	59	0.3	55 - 73	77	5.9	71 - 84
17	62	0.5	57 - 76	77	6.4	72 - 84
18	65	0.9	60 - 78	78	7.0	73 - 85
19	68	1.6	63 - 81	79	7.6	73 - 86
20	71	2.6	65 - 84	79	8.2	74 - 86
21	74	4.1	68 - 86	80	8.9	74 - 87
22	77	6.3	71 - 89	80	9.5	75 - 87
23	80	9.4	73 - 92	81	10.2	76 - 88
24	84	13.6	76 - 95	81	10.8	76 - 88
25	87	19.1	79 - 98	82	11.5	77 - 89
26	90	26.3	82 - 101	83	12.2	77 - 89
27	94	35.0	86 - 104	83	12.9	78 - 90
28	98	45.3	89 - 108	84	13.7	78 - 90
29	103	56.9	93 - 111	84	14.4	79 - 91
30	107	69.1	97 - 116	85	15.2	79 - 91
31	113	80.7	102 - 121	85	15.9	80 - 92
32	120	90.5	108 - 126	86	16.7	80 - 92
33	127	96.6	115 - 133	86	17.5	80 - 93
34	132	98.4	119 - 137	86	18.3	81 - 93
35	-	-	-	87	19.1	81 - 94
36	-	-	-	87	19.9	82 - 94
37	-	-	-	88	20.7	82 - 94

Raw score	Males: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	88	21.6	83 - 95
39	-	-	-	89	22.4	83 - 95
40	-	-	-	89	23.3	83 - 96
41	-	-	-	89	24.1	84 - 96
42	-	-	-	90	25.0	84 - 96
43	-	-	-	90	25.9	85 - 97
44	-	-	-	91	26.8	85 - 97
45	-	-	-	91	27.7	85 - 98
46	-	-	-	92	28.6	86 - 98
47	-	-	-	92	29.5	86 - 98
48	-	-	-	92	30.4	87 - 99
49	-	-	-	93	31.3	87 - 99
50	-	-	-	93	32.2	87 - 99
51	-	-	-	93	33.2	88 - 100
52	-	-	-	94	34.1	88 - 100
53	-	-	-	94	35.1	88 - 101
54	-	-	-	95	36.0	89 - 101
55	-	-	-	95	37.0	89 - 101
56	-	-	-	95	37.9	89 - 102
57	-	-	-	96	38.9	90 - 102
58	-	-	-	96	39.9	90 - 102
59	-	-	-	97	40.9	91 - 103
60	-	-	-	97	41.8	91 - 103
61	-	-	-	97	42.8	91 - 104
62	-	-	-	98	43.8	92 - 104
63	-	-	-	98	44.8	92 - 104
64	-	-	-	98	45.8	92 - 105
65	-	-	-	99	46.8	93 - 105
66	-	-	-	99	47.8	93 - 105
67	-	-	-	100	48.8	93 - 106
68	-	-	-	100	49.8	94 - 106
69	-	-	-	100	50.8	94 - 106
70	-	-	-	101	51.8	95 - 107
71	-	-	-	101	52.9	95 - 107
72	-	-	-	101	53.9	95 - 108
73	-	-	-	102	54.9	96 - 108
74	-	-	-	102	55.9	96 - 108
75	-	-	-	103	56.9	96 - 109
76	-	-	-	103	58.0	97 - 109
77	-	-	-	103	59.0	97 - 109

Raw score	Males: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	104	60.0	98 - 110
79	-	-	-	104	61.0	98 - 110
80	-	-	-	105	62.0	98 - 111
81	-	-	-	105	63.0	99 - 111
82	-	-	-	105	64.1	99 - 111
83	-	-	-	106	65.1	99 - 112
84	-	-	-	106	66.1	100 - 112
85	-	-	-	107	67.1	100 - 112
86	-	-	-	107	68.1	101 - 113
87	-	-	-	107	69.1	101 - 113
88	-	-	-	108	70.1	102 - 114
89	-	-	-	108	71.1	102 - 114
90	-	-	-	109	72.1	102 - 115
91	-	-	-	109	73.1	103 - 115
92	-	-	-	110	74.1	103 - 115
93	-	-	-	110	75.1	104 - 116
94	-	-	-	111	76.1	104 - 116
95	-	-	-	111	77.1	105 - 117
96	-	-	-	112	78.0	105 - 117
97	-	-	-	112	79.0	106 - 118
98	-	-	-	113	80.0	106 - 118
99	-	-	-	113	80.9	107 - 119
100	-	-	-	114	81.9	107 - 119
101	-	-	-	114	82.8	108 - 120
102	-	-	-	115	83.7	108 - 120
103	-	-	-	115	84.6	109 - 121
104	-	-	-	116	85.5	109 - 121
105	-	-	-	117	86.4	110 - 122
106	-	-	-	117	87.3	110 - 123
107	-	-	-	118	88.2	111 - 123
108	-	-	-	118	89.1	112 - 124
109	-	-	-	119	89.9	112 - 124
110	-	-	-	120	90.7	113 - 125
111	-	-	-	121	91.6	114 - 126
112	-	-	-	121	92.4	115 - 127
113	-	-	-	122	93.1	115 - 128
114	-	-	-	123	93.9	116 - 128
115	-	-	-	124	94.6	117 - 129
116	-	-	-	125	95.4	118 - 130
117	-	-	-	126	96.0	119 - 131

Raw score	Males: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	128	96.7	120 - 133
119	-	-	-	129	97.3	122 - 134
120	-	-	-	131	97.9	123 - 135
121	-	-	-	132	98.5	125 - 137
122	-	-	-	135	98.9	127 - 139
123	-	-	-	137	99.3	130 - 142
124	-	-	-	142	99.7	134 - 146

**Table B8** Standard score conversion table for females aged 26 months 16 days to 27 months 15 days

Raw score	Females: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
0	10	<0.1	13 - 31	49	<0.1	45 - 57
1	10	<0.1	13 - 31	49	<0.1	45 - 57
2	10	<0.1	13 - 31	51	0.1	47 - 59
3	10	<0.1	13 - 31	52	0.1	48 - 60
4	10	<0.1	13 - 31	54	0.1	50 - 62
5	11	<0.1	13 - 31	56	0.2	51 - 63
6	13	<0.1	16 - 34	57	0.2	53 - 65
7	18	<0.1	19 - 38	58	0.3	54 - 66
8	22	<0.1	23 - 42	60	0.4	55 - 67
9	27	<0.1	27 - 45	61	0.5	56 - 68
10	31	<0.1	31 - 49	62	0.6	58 - 69
11	35	<0.1	34 - 52	63	0.7	58 - 70
12	38	<0.1	37 - 55	64	0.8	59 - 71
13	42	<0.1	40 - 59	65	0.9	60 - 72
14	45	<0.1	43 - 61	66	1.1	61 - 73
15	48	<0.1	46 - 64	66	1.3	62 - 74
16	52	0.1	49 - 67	67	1.4	63 - 75
17	55	0.1	52 - 70	68	1.6	63 - 75
18	58	0.3	54 - 73	69	1.8	64 - 76
19	61	0.5	57 - 76	69	2.0	65 - 77
20	65	0.9	60 - 78	70	2.3	65 - 77
21	68	1.6	63 - 81	71	2.5	66 - 78
22	71	2.6	66 - 84	71	2.8	66 - 78
23	74	4.3	68 - 87	72	3.0	67 - 79
24	78	6.8	71 - 90	72	3.3	68 - 80
25	81	10.5	74 - 93	73	3.6	68 - 80
26	85	15.6	78 - 96	74	3.9	69 - 81
27	89	22.4	81 - 99	74	4.2	69 - 81
28	93	31.4	85 - 103	75	4.5	70 - 82
29	97	42.5	88 - 107	75	4.9	70 - 82
30	102	55.4	93 - 111	76	5.2	71 - 83
31	108	69.3	97 - 116	76	5.6	71 - 83
32	114	82.6	103 - 121	77	6.0	72 - 84
33	122	92.5	110 - 128	77	6.4	72 - 84
34	127	96.6	115 - 133	78	6.8	73 - 85
35	-	-	-	78	7.2	73 - 85
36	-	-	-	79	7.7	73 - 85
37	-	-	-	79	8.1	74 - 86

Raw score	Females: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
38	-	-	-	79	8.6	74 - 86
39	-	-	-	80	9.0	75 - 87
40	-	-	-	80	9.5	75 - 87
41	-	-	-	81	10.0	76 - 88
42	-	-	-	81	10.5	76 - 88
43	-	-	-	82	11.1	76 - 88
44	-	-	-	82	11.6	77 - 89
45	-	-	-	83	12.2	77 - 89
46	-	-	-	83	12.7	78 - 90
47	-	-	-	83	13.3	78 - 90
48	-	-	-	84	13.9	78 - 90
49	-	-	-	84	14.5	79 - 91
50	-	-	-	85	15.1	79 - 91
51	-	-	-	85	15.8	80 - 92
52	-	-	-	85	16.4	80 - 92
53	-	-	-	86	17.1	80 - 92
54	-	-	-	86	17.8	81 - 93
55	-	-	-	87	18.5	81 - 93
56	-	-	-	87	19.2	81 - 93
57	-	-	-	87	19.9	82 - 94
58	-	-	-	88	20.6	82 - 94
59	-	-	-	88	21.3	83 - 95
60	-	-	-	88	22.1	83 - 95
61	-	-	-	89	22.9	83 - 95
62	-	-	-	89	23.6	84 - 96
63	-	-	-	90	24.4	84 - 96
64	-	-	-	90	25.3	84 - 96
65	-	-	-	90	26.1	85 - 97
66	-	-	-	91	26.9	85 - 97
67	-	-	-	91	27.8	86 - 98
68	-	-	-	92	28.6	86 - 98
69	-	-	-	92	29.5	86 - 98
70	-	-	-	92	30.4	87 - 99
71	-	-	-	93	31.3	87 - 99
72	-	-	-	93	32.2	87 - 99
73	-	-	-	93	33.1	88 - 100
74	-	-	-	94	34.1	88 - 100
75	-	-	-	94	35.0	89 - 100
76	-	-	-	95	36.0	89 - 101
77	-	-	-	95	37.0	89 - 101



Raw score	Females: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
78	-	-	-	95	38.0	90 - 102
79	-	-	-	96	39.0	90 - 102
80	-	-	-	96	40.0	90 - 102
81	-	-	-	97	41.1	91 - 103
82	-	-	-	97	42.1	91 - 103
83	-	-	-	97	43.2	92 - 104
84	-	-	-	98	44.3	92 - 104
85	-	-	-	98	45.3	92 - 104
86	-	-	-	99	46.4	93 - 105
87	-	-	-	99	47.6	93 - 105
88	-	-	-	100	48.7	94 - 106
89	-	-	-	100	49.8	94 - 106
90	-	-	-	100	51.0	94 - 106
91	-	-	-	101	52.1	95 - 107
92	-	-	-	101	53.3	95 - 107
93	-	-	-	102	54.5	96 - 108
94	-	-	-	102	55.7	96 - 108
95	-	-	-	103	56.9	97 - 109
96	-	-	-	103	58.2	97 - 109
97	-	-	-	104	59.4	97 - 109
98	-	-	-	104	60.7	98 - 110
99	-	-	-	105	61.9	98 - 110
100	-	-	-	105	63.2	99 - 111
101	-	-	-	106	64.5	99 - 111
102	-	-	-	106	65.8	100 - 112
103	-	-	-	107	67.1	100 - 112
104	-	-	-	107	68.4	101 - 113
105	-	-	-	108	69.8	102 - 113
106	-	-	-	108	71.1	102 - 114
107	-	-	-	109	72.5	103 - 115
108	-	-	-	110	73.9	103 - 115
109	-	-	-	110	75.2	104 - 116
110	-	-	-	111	76.6	105 - 116
111	-	-	-	112	78.0	105 - 117
112	-	-	-	112	79.5	106 - 118
113	-	-	-	113	80.9	107 - 119
114	-	-	-	114	82.3	107 - 119
115	-	-	-	115	83.8	108 - 120
116	-	-	-	116	85.2	109 - 121
117	-	-	-	117	86.7	110 - 122

Raw score	Females: 26mo 16d to 27mo 15d					
	Non-verbal cognitive (range raw scale: 0-34)			Language development (range raw scale: 0-124)		
	Standard	Percentile	95% CI	Standard	Percentile	95% CI
118	-	-	-	118	88.1	111 - 123
119	-	-	-	119	89.6	112 - 124
120	-	-	-	120	91.0	113 - 125
121	-	-	-	122	92.5	115 - 127
122	-	-	-	123	94.0	116 - 128
123	-	-	-	125	95.4	118 - 130
124	-	-	-	133	98.6	126 - 138





UNIVERSITY OF  
**LEICESTER**



**NPEU**  
Clinical Trials Unit



UCL EGA  
Institute for  
Women's  
Health

