

D-score for measuring neurocognitive development 0-4  
years

*Stef van Buuren*

*2018-04-04*



# Contents

<b>Preface</b>	<b>5</b>
<b>1 Introduction</b>	<b>7</b>
1.1 First 1000 days . . . . .	7
1.2 Relevance of child development . . . . .	7
1.3 Limitations of stunting . . . . .	7
1.4 Measuring neurocognitive development . . . . .	7
<b>2 Short history</b>	<b>9</b>
2.1 Growth and development . . . . .	9
2.2 Gesell maturation theory, Piaget stages, Kohlberg stages . . . . .	9
2.3 One number for development . . . . .	9
2.4 Current situation: Bayley, Griffiths, IQ, domains . . . . .	9
<b>3 Comparisons</b>	<b>11</b>
3.1 Types of comparisons needed . . . . .	11
3.2 Problems of age-based measurement . . . . .	11
3.3 What is a latent variable . . . . .	11
3.4 Item response functions . . . . .	11
3.5 Person response functions . . . . .	11
3.6 Family of IRT models . . . . .	11
<b>4 Methods</b>	<b>13</b>
<b>5 Rasch model</b>	<b>15</b>
5.1 Rasch model . . . . .	15
5.2 Perfect symmetry . . . . .	15
5.3 Parameter separation . . . . .	15
5.4 The model as ideal . . . . .	15
<b>6 Items</b>	<b>17</b>
6.1 SMOCC data: design . . . . .	17
6.2 Empirical and fitted item response curves . . . . .	17
6.3 Item fit . . . . .	17
6.4 Item information at a given ability . . . . .	17
6.5 Item information at a given age . . . . .	17
<b>7 Persons</b>	<b>19</b>
7.1 Empirical and fitted person response curves . . . . .	19
7.2 Person fit . . . . .	19
7.3 Ability estimation . . . . .	19
7.4 Measurement precision . . . . .	19
7.5 Distribution of ability against age . . . . .	19

<b>8</b>	<b>Validity</b>	<b>21</b>
8.1	Role of validity . . . . .	21
8.2	Discriminatory validity . . . . .	21
8.3	Concurrent validity . . . . .	21
8.4	Predictive validity . . . . .	21
<b>9</b>	<b>Outcome</b>	<b>23</b>
9.1	Application I: D-score as neurocognitive outcome at 1000 days . . . . .	23
9.2	D-score of reference children at 2 years . . . . .	23
9.3	D-score of pre-terms at 2 years . . . . .	23
9.4	D-score of children in LMIC at 2 years . . . . .	23
9.5	Comparison . . . . .	23
<b>10</b>	<b>Delay</b>	<b>25</b>
10.1	Application II: D-score to identify delayed development . . . . .	25
10.2	Longitudinal D-score patterns in different populations . . . . .	25
10.3	Issues in defining developmental delay . . . . .	25
10.4	Specificity in reference, pre-term and LMIC populations . . . . .	25
10.5	Practical implications . . . . .	25
<b>11</b>	<b>Consequences</b>	<b>27</b>
11.1	Application III: Long-term health consequences of delay in pre-terms . . . . .	27
11.2	Relevance of long-term health outcomes . . . . .	27
11.3	Predictive power of D-score . . . . .	27
11.4	Practical implications . . . . .	27
11.5	Opportunities and impact of early intervention . . . . .	27
<b>12</b>	<b>Discussion</b>	<b>29</b>
12.1	Usefulness of D-score for monitoring child health . . . . .	29
12.2	Opportunities for early intervention . . . . .	29
12.3	D-score for international settings . . . . .	29
12.4	D-score from existing instruments . . . . .	29
12.5	Creating new instruments for D-score . . . . .	29

# Preface

This is an introductory booklet on the measurement of child development by means of the D-score. The D-score is a one-number summary that quantifies generic neurocognitive development for children with ages 0-4 years.

This is the first in a series of three booklets. The series consists of the following titles:

1. D-score for measuring neurocognitive development 0-4 years (this booklet)
2. D-score for international comparisons
3. D-score for creating better instruments

The development of this series was kindly supported by the Bill & Melinda Gates Foundation.



# Chapter 1

## Introduction

1.1 First 1000 days

1.2 Relevance of child development

1.3 Limitations of stunting

1.4 Measuring neurocognitive development





## Chapter 2

# Short history

2.1 Growth and development

2.2 Gesell maturation theory, Piaget stages, Kohlberg stages

2.3 One number for development

2.4 Current situation: Bayley, Griffiths, IQ, domains



## Chapter 3

# Comparisons

- 3.1 Types of comparisons needed
- 3.2 Problems of age-based measurement
- 3.3 What is a latent variable
- 3.4 Item response functions
- 3.5 Person response functions
- 3.6 Family of IRT models



## Chapter 4

# Methods

We describe our methods in this chapter.



## Chapter 5

# Rasch model

### 5.1 Rasch model

### 5.2 Perfect symmetry

### 5.3 Parameter separation

### 5.4 The model as ideal





## Chapter 6

# Items

6.1 SMOCC data: design

6.2 Empirical and fitted item response curves

6.3 Item fit

6.4 Item information at a given ability

6.5 Item information at a given age



## Chapter 7

# Persons

7.1 Empirical and fitted person response curves

7.2 Person fit

7.3 Ability estimation

7.4 Measurement precision

7.5 Distribution of ability against age



## Chapter 8

# Validity

8.1 Role of validity

8.2 Discriminatory validity

8.3 Concurrent validity

8.4 Predictive validity



## Chapter 9

# Outcome

9.1 Application I: D-score as neurocognitive outcome at 1000 days

9.2 D-score of reference children at 2 years

9.3 D-score of pre-terms at 2 years

9.4 D-score of children in LMIC at 2 years

9.5 Comparison





## Chapter 10

# Delay

- 10.1 Application II: D-score to identify delayed development
- 10.2 Longitudinal D-score patterns in different populations
- 10.3 Issues in defining developmental delay
- 10.4 Specificity in reference, pre-term and LMIC populations
- 10.5 Practical implications



## Chapter 11

# Consequences

- 11.1 Application III: Long-term health consequences of delay in pre-terms
- 11.2 Relevance of long-term health outcomes
- 11.3 Predictive power of D-score
- 11.4 Practical implications
- 11.5 Opportunities and impact of early intervention



## Chapter 12

# Discussion

12.1 Usefulness of D-score for monitoring child health

12.2 Opportunities for early intervention

12.3 D-score for international settings

12.4 D-score from existing instruments

12.5 Creating new instruments for D-score