



FACULTY OF PSYCHOLOGY AND  
EDUCATIONAL SCIENCES

# Visual-perceptual and perceptual-motor skills in children with Dyslexia and/or Mathematical Learning Disabilities

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## Overview



- Dyslexia and Mathematical Learning Disabilities (MLD)
- Co-morbidity
- Motor, visual-perceptual and perceptual-motor skills
- Study 1: Co-morbidity
- Study 2: Motor, visual-perceptual and perceptual-motor skills in children with Dyslexia and/or MLD

# Dyslexia



- In accordance with DSM-IV-TR and ICD-10:
- **Below-average performances on reading and/or spelling.** Difficulties with reading and/or spelling:  $\leq -2$  SD below the norm
- **RTI-criterion.** Difficulties remain severe, even with remediation
- **Exclusion criterion.** Sensory deficit: reading and/or spelling difficulties in excess of those usually associated with it

## Mathematical Learning Disabilities (MLD)



- In accordance with DSM-IV-TR and ICD-10:
- **Below-average performances on mathematics.** Difficulties with mathematics:  $\leq -2$  SD below the norm
- **RTI-criterion.** Difficulties remain severe, even with remediation
- **Exclusion criterion.** Sensory deficit: mathematical difficulties in excess of those usually associated with it

## Prevalence and gender ratio



- Dyslexia
  - Prevalence: 1 to 33% (~ orthographic consistency)
  - Gender ratio: 1.7 - 2/1
- MLD
  - Prevalence: 5.9 to 13.8%
  - Gender ratio: 1/1

## Developmental Coordination Disorder (DCD)



# Developmental Coordination Disorder (DCD)



- DSM-IV-TR:
  - **Criterion A.** Motor coordination substantially below expected, given the chronological age and intelligence
  - **Criterion B.** Interference with academic achievement or daily living
  - **Criterion C.** No general medical condition, no PDD
  - **Criterion D.** Mental retardation: motor difficulties in excess of those usually associated with it
- Prevalence: 1.7%

## Co-morbidity: in general



- The presence of more than one diagnosis occurring in an individual

- Successive ↔

concurrent

Homotypic / Heterotypic

- Prognosis: isolated diagnosis > co-morbidity

## Co-morbidity: more specific



- Dyslexia:
  - with MLD: 56%
  - with ADHD: 15 - 40%
  - with DCD: (small clinical samples: 33 - 88%)
- MLD:
  - with Dyslexia: 17- 43%
  - with Spelling disorder: 50% (neg. prognosis!)
  - with ADHD: 43% (neg.prognosis!)
  - with DCD: ?

## STUDY 1: Aim



Motor problems in children with learning disabilities (Dyslexia and/or MLD):

Rule or exception?

Pieters et al. (in preparation)

## STUDY 1: Method - Participants



- Profiles of 3608 children between 1 - 21 y (m = 9y 8mo)
- 31 Flemish rehabilitation centers
- Male/female ratio: 2/1
- Education:
  - Regular education: 81.4%
  - Special education: 15.3%
  - Not going to school: 3.3%

## STUDY 1: Method – Rehabilitation centers?



- Diagnostic and therapeutic tasks
- Target groups:
  - PDD
  - ADHD
  - SLI
  - Mental disabilities
  - Learning disorders
  - Conductive and sensorineural hearing loss...
- < pc 3 on a standardized test

## STUDY 1: Method – Rehabilitation centers?



- Team:
  - Physicians
  - Social workers
  - Psychologists
  - Speech therapists
  - Audiologists
  - Occupational therapists
  - Physiotherapists...
- Rehabilitation: 3 different disciplines
- 2 or 3 times/week, 30 to 90 minutes

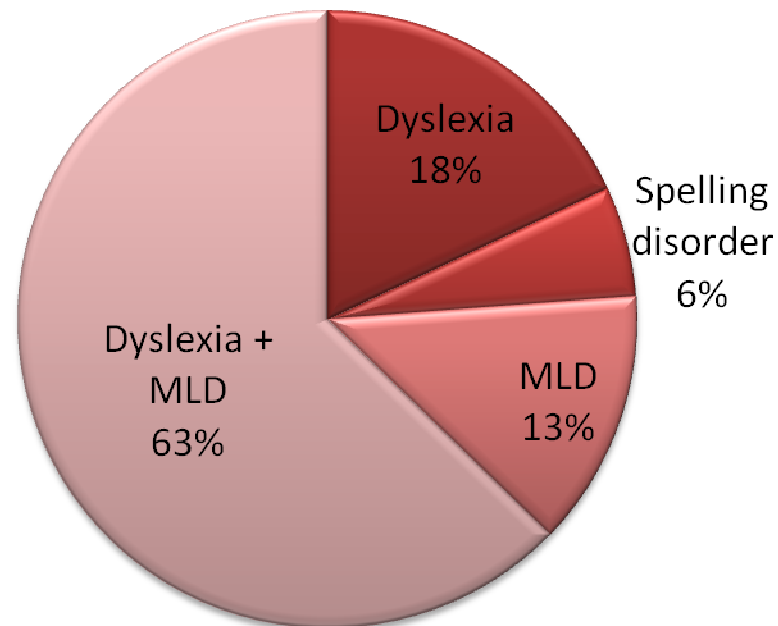
## STUDY 1: Method – Data collection



- Registration of:
  - Gender
  - Main disability (ICD-10) (< pc 10)
  - (Eventually) co-morbid disabilities (ICD-10) (< pc 10)
- Procedure:
  - Six-month training (pilot study)
  - Manual of the registration system
  - Extra support

## STUDY 1: Results

Learning disabilities: n=1243/3608 (34.5%)



## STUDY 1: Results – Dyslexia

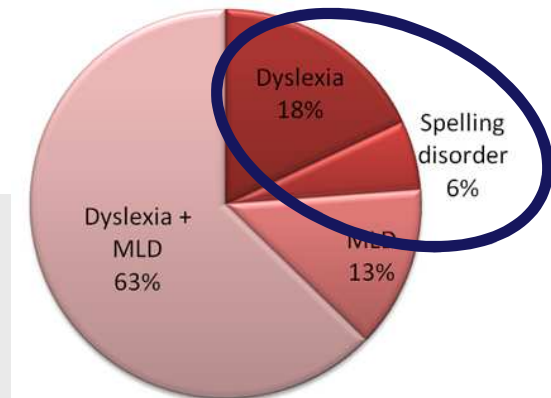


- n=296/3608 (8.2%)
- ICD-10 codes
  - F81.0: Specific reading disorder: n=224 (6.2%)
  - F81.1: Specific spelling disorder: n=72 (2.0%)

- Gender ♂/♀:  
**2.6/1**
- Age: M=10;9

| Co-morbid disorders | n          | %          |
|---------------------|------------|------------|
| 0                   | 55         | 18.6       |
| 1                   | 150        | 50.7       |
| 2                   | 72         | 24.3       |
| 3 or more           | 19         | 6.7        |
| <b>Total</b>        | <b>296</b> | <b>100</b> |

**81.4%**



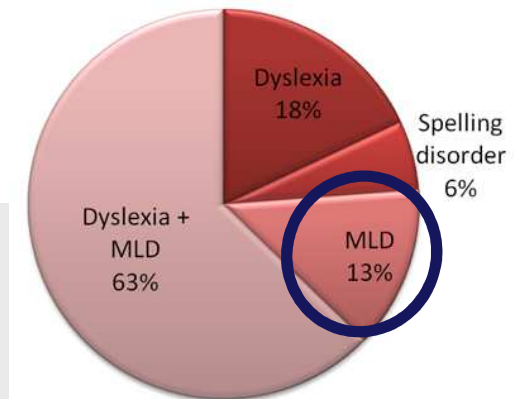
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| 2                   | 72         | 24.3       |
| 3 or more           | 19         | 6.7        |
| <b>Total</b>        | <b>296</b> | <b>100</b> |

**81.4%**



| Dyslexia +   | n         | %           |
|--|-----------|-------------|
| Hyperkinetic disorders (F90) or ADHD                                 | 95        | 32.1        |
| Specific developmental disorder of motor function (F82) or DCD       | <b>67</b> | <b>22.6</b> |
| Pervasive Developmental disorders (F84)                              | 36        | 12.2        |
| Specific developmental disorders of speech and language (F80) or SLI | 33        | 11.1        |

## STUDY 1: Results – MLD



- ICD-10 code
  - F81.2: Specific disorder of arithmetical skills: n=167(4.6%)

- Gender ♂/♀:  
**1/1**

- Age: M=10;7

| Co-morbid disorders | n          | %          |
|---------------------|------------|------------|
| 0                   | 27         | 16.2       |
| 1                   | 75         | 44.9       |
| 2                   | 53         | 31.7       |
| 3 or more           | 12         | 7.2        |
| <b>Total</b>        | <b>167</b> | <b>100</b> |

**83.8%**

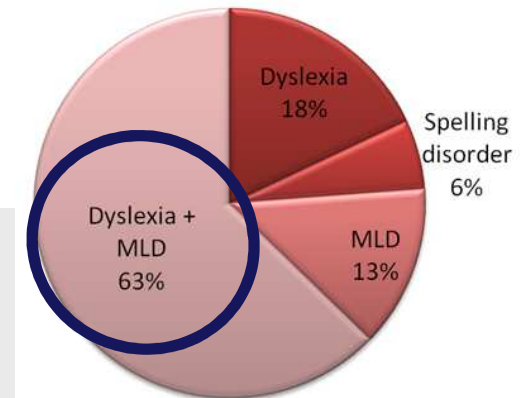
| Co-morbid disorders | n          | %          |
|---------------------|------------|------------|
| 0                   | 27         | 16.2       |
| 1                   | 75         | 44.9       |
| 2                   | 53         | 31.7       |
| 3 or more           | 12         | 7.2        |
| <b>Total</b>        | <b>167</b> | <b>100</b> |

**83.8%**



| MLD +  | n         | %           |
|--|-----------|-------------|
| Hyperkinetic disorders (F90) or ADHD                                 | 53        | 31.7        |
| Specific developmental disorder of motor function (F82) or DCD       | <b>42</b> | <b>25.1</b> |
| Specific developmental disorders of speech and language (F80) or SLI | 32        | 19.2        |
| Pervasive Developmental disorders (F84)                              | 15        | 9.0         |

## STUDY 1: Results – Dyslexia + MLD



- ICD-10 code
  - F81.3: Mixed disorder of scholastic skills: n=780 (21.6%)

- Gender ♂/♀:  
**1.5/1**

- Age: M=10;7

| Co-morbid disorders | n          | %          |
|---------------------|------------|------------|
| 0                   | 166        | 21.3       |
| 1                   | 350        | 44.9       |
| 2                   | 207        | 26.5       |
| 3 or more           | 57         | 7.3        |
| <b>Total</b>        | <b>780</b> | <b>100</b> |

**78.7%**

| Co-morbid disorders | n          | %          |
|---------------------|------------|------------|
| 0                   | 166        | 21.3       |
| 1                   | 350        | 44.9       |
| 2                   | 207        | 26.5       |
| 3 or more           | 57         | 7.3        |
| <b>Total</b>        | <b>780</b> | <b>100</b> |

**78.7%**



| Dyslexia + MLD +   | n          | %           |
|--|------------|-------------|
| Hyperkinetic disorders (F90) or ADHD                                 | 247        | 31.7        |
| Specific developmental disorder of motor function (F82) or DCD       | <b>192</b> | <b>24.6</b> |
| Specific developmental disorders of speech and language (F80) or SLI | 152        | 19.5        |
| Pervasive Developmental disorders (F84)                              | 58         | 7.4         |

## STUDY 1: Results – Motor problems



22.6% motor problems in Dyslexia

25.1% motor problems in MLD

24.6% motor problems in Dyslexia + MLD

Binomial analysis:

→ sign. more motor problems in learning disabilities as opposed to 1.7% in general population

## STUDY 1: Conclusion



- Co-morbid motor problems more than expected by chance
- More rule than exception
- Developmental deviance = seldom specific
- Dyslexia and MLD are common co-morbid disorders
- Dyslexia and/or MLD have heterogeneous other co-morbid disorders



## Motor, visual-perceptual, and perceptual-motor skills

## Visual perception and perceptual-motor skills



- “The interpretation and the organization of visual information”  
(Kavale, 1982)
- Different conceptualizations & assessment → confusion
- Visual perception (ICF) (WHO, 2001): “Mental functions involved in discriminating characteristics of objects (shape, size, color...)”
- Perceptual-motor skills: “Ability to use visual information in order to realize a motor activity”
- Close link with motor problems or DCD

## ... in children with Dyslexia



- Visual perception: needed for reading and spelling  
For example: visual discrimination of letters: shape, detail, orientation... (d p w m)
- Predicting reading performance
- Disabilities in visual perception ~ Dyslexia

## ... in children with MLD



- Visual perception: needed for mathematics  
For example: visual discrimination of numbers: shape, detail, orientation... (2 - 5    6 - 9)
- Correlation between mathematical and visual-perceptual skills
- Subtype of MLD with visuospatial difficulties
- Visuospatial learning disability (VSLD)
- Conflicting results

... in children with co-morbid Dyslexia and MLD



?



*Purpose of STUDY 2:*

To investigate visual-perceptual and perceptual-motor skills in children with Dyslexia and/or MLD

## STUDY 2: Participants



- 69 children:
  - ▶ 21 children with Dyslexia (20 male)
  - ▶ 10 children with MLD (3 male)
  - ▶ 15 children with co-morbid Dyslexia + MLD (8 male)
  - ▶ 23 typically achieving (TA) children (9 male)
- Dyslexia – MLD group recruited in:
  - ▶ Rehabilitation centers
  - ▶ Special education
  - ▶ Private speech therapy

## STUDY 2: Inclusion criteria



- Inclusion criteria **all children:**

- Age between 7;0 – 11;11 years
- TIQ > 80

→ USED TESTS:

IQ: Short version of the WISC-III: (Grégoire, 2000; Wechsler et al., 2002)

4 subtests:            Similarities  
                              Picture Arrangement  
                              Block Design  
                              Vocabulary

Reliability: .92

Validity: .93

Correlation with total IQ full form WISC-III: .92

## STUDY 2: Inclusion criteria



- Inclusion criteria **Dyslexia** group:
  - Clinical diagnosis of Dyslexia (= pretest in setting  $\leq -2$  SD)
  - Retest score  $\leq -1$  SD
  
- USED TESTS for retesting (confirming the diagnosis):
  - Reading:
    - One Minute Test (Eén Minuut Test, EMT; Brus & Voeten, 1999)
    - Klepel (van den Bos, Spelberg, Scheepstra, & de Vries, 1994)
  - Spelling:
    - PI-dictation (PI dictee, Geelhoed & Reitsma, 2000)

## Study 2: Inclusion criteria - assessment

One Minute Test (Eén Minuut Test, EMT; Brus & Voeten, 1999)

|        |            |              |                 |
|--------|------------|--------------|-----------------|
| waar   | zijpad     | priemen      | struikgewas     |
| kar    | inham      | getik        | speelvergunning |
| been   | stoutheid  | oertijd      | hernieuwen      |
| min    | proefstuk  | aanplanten   | berging         |
| vos    | lapje      | slopen       | nanacht         |
| net    | doch       | vooruitduwen | uitspuwen       |
| bruin  | vegen      | steigeren    | herplaatsing    |
| hand   | koplamp    | opsparen     | onnozel         |
| morgen | koelte     | handelaar    | medelid         |
| eten   | rekenen    | diamant      | zijrivier       |
| mak    | verdieping | bezig        | vermindering    |

## Study 2: Inclusion criteria - assessment

Klepel (van den Bos, Spelberg, Scheepstra, & de Vries, 1994)

|        |           |              |                 |
|--------|-----------|--------------|-----------------|
| taaf   | zapod     | briekem      | stroukgewep     |
| vas    | ijnhas    | gelup        | stoolvordanning |
| deek   | stuikhaut | oeltijk      | lerdieuwen      |
| nim    | truufstin | aafplenton   | dergonk         |
| gol    | kepjo     | drepes       | nonochd         |
| vek    | roch      | keenantluwer | outpluwijn      |
| fruim  | veben     | steiperan    | derkraatsong    |
| jund   | fiplemp   | ipsporel     | annasel         |
| nargel | goelte    | hosdelaar    | sederab         |

## Study 2: Inclusion criteria - assessment

### PI-dictation (PI dictee, Geelhoed & Reitsma, 2000)

#### A blok 5

|    |   |        |
|----|---|--------|
| 1  | De koe loopt <i>in</i> de wei.                  | in     |
| 2  | Door de <i>bui</i> werden we erg nat.           | bui    |
| 3  | <i>Jaap</i> kan al goed schrijven.              | jaap   |
| 4  | Mijn <i>voet</i> doet pijn.                     | voet   |
| 5  | Deze fiets is erg <i>duur</i> .                 | duur   |
| 6  | De tafel is van <i>hout</i> gemaakt.            | hout   |
| 7  | Het <i>mos</i> groeit onder de bomen.           | mos    |
| 8  | De <i>pijl</i> wijst naar rechts.               | pijl   |
| 9  | Hij loopt met een <i>boog</i> om de hond heen.  | boog   |
| 10 | Mijn <i>fiets</i> is stuk.                      | fiets  |
| 11 | Het <i>hert</i> schrok van de jager.            | hert   |
| 12 | Hij eet zijn bord zo <i>vlug</i> mogelijk leeg. | vlug   |
| 13 | Met een <i>dreun</i> kwam hij op de grond neer. | dreun  |
| 14 | Een <i>kreeft</i> leeft in zee.                 | kreeft |
| 15 | Deze kast is <i>zwart</i> .                     | zwart  |

## STUDY 2 : Inclusion criteria



- Inclusion criteria **MLD** group:
  - Clinical diagnosis of MLD (= pretest in setting  $\leq -2$  SD)
  - Retest score  $\leq -1$  SD
  
- USED TESTS for retesting (confirming the diagnosis):
  - Arithmetic Number Facts Test (Tempo Test Rekenen, TTR, De Vos, 1992)
  - Kortrijk Arithmetic Test (Kortrijkse Rekeningtest, KRT; Cracco et al. 1995)

## STUDY 2 : Inclusion criteria - assessment

Arithmetic Number Facts Test (Tempo Test Rekenen, TTR, De Vos, 1992)

|    | 1           | 2           | 3            | 4            | 5           |
|----|-------------|-------------|--------------|--------------|-------------|
|    | 1+1 = _____ | 2-1 = _____ | 1x4 = _____  | 4:2 = _____  | 2+1 = _____ |
|    | 2+1 = _____ | 3-2 = _____ | 2x2 = _____  | 5:1 = _____  | 2-1 = _____ |
|    | 3+0 = _____ | 4-2 = _____ | 1x7 = _____  | 12:2 = _____ | 2x5 = _____ |
|    | 4+1 = _____ | 3-0 = _____ | 0x5 = _____  | 15:3 = _____ | 4:2 = _____ |
| 5  | 2+3 = _____ | 5-2 = _____ | 8x1 = _____  | 10:5 = _____ | 3+2 = _____ |
|    | 7+2 = _____ | 8-3 = _____ | 3x10 = _____ | 6:3 = _____  | 8-4 = _____ |
|    | 3+5 = _____ | 6-0 = _____ | 2x9 = _____  | 20:2 = _____ | 9:3 = _____ |
|    | 0+7 = _____ | 9-2 = _____ | 4x4 = _____  | 24:3 = _____ | 4x5 = _____ |
|    | 2+5 = _____ | 7-5 = _____ | 5x8 = _____  | 36:6 = _____ | 7+2 = _____ |
| 10 | 4+6 = _____ | 8-6 = _____ | 6x0 = _____  | 9:3 = _____  | 9-5 = _____ |

# Current study: Inclusion criteria - assessment

Kortrijk Arithmetic Test (Kortrijkse Rekeningtest, KRT; Cracco et al., 1995)

|  |                      |                                   |    |
|--|----------------------|-----------------------------------|----|
| 7 min 4 is <input type="text"/>                                | G1<br>G2<br>G3<br>G4 | $3 + 4 =$ <input type="text"/>    | H1 |
| het dubbel van 7 is <input type="text"/>                       |                      | $13 + 6 =$ <input type="text"/>   | H2 |
| de helft van 8 is <input type="text"/>                         |                      | $4 + 8 =$ <input type="text"/>    | H3 |
| vul het juiste teken in : = of > of < 3 <input type="text"/> 8 |                      | $12 =$ <input type="text"/> $+ 8$ | H4 |
| 15 komt net voor <input type="text"/>                          |                      | $39 + 60 =$ <input type="text"/>  | H5 |

**number system knowledge**

**mental computation**

## STUDY 2: Inclusion criteria



- Inclusion criteria **co-morbid Dyslexia + MLD** group:
  - Criteria Dyslexia + Criteria MLD
- Inclusion criteria **TA** group:
  - Normal scores for reading, spelling and mathematics

No significant differences between groups (IQ and age)

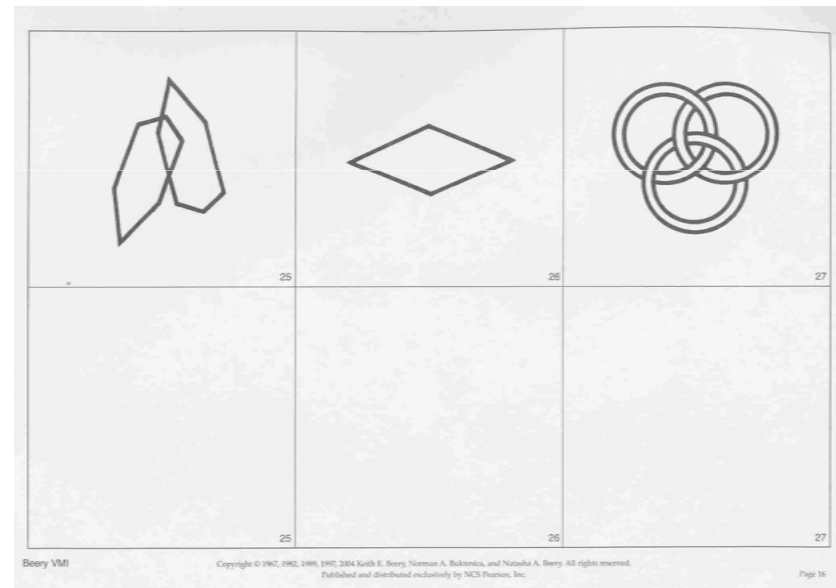
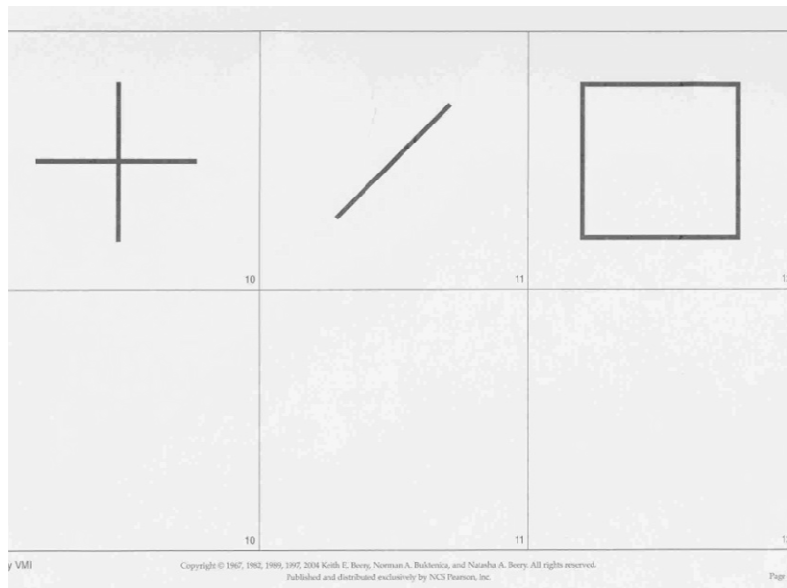
## STUDY 2: Tests



- Beery visual motor integration (VMI) (Beery, Buktenicka, & Beery, 2004)
  - Copy test
  - Visual perception
  - Motor coordination
- Movement Assessment Battery for Children 2 (M-ABC 2) (Henderson & Sugden, 2007)
- Subtest 'Block Design' (WISC-III) (Barnes et al. , 2002; Cirino et al. , 2007; Wechsler et al., 2002)

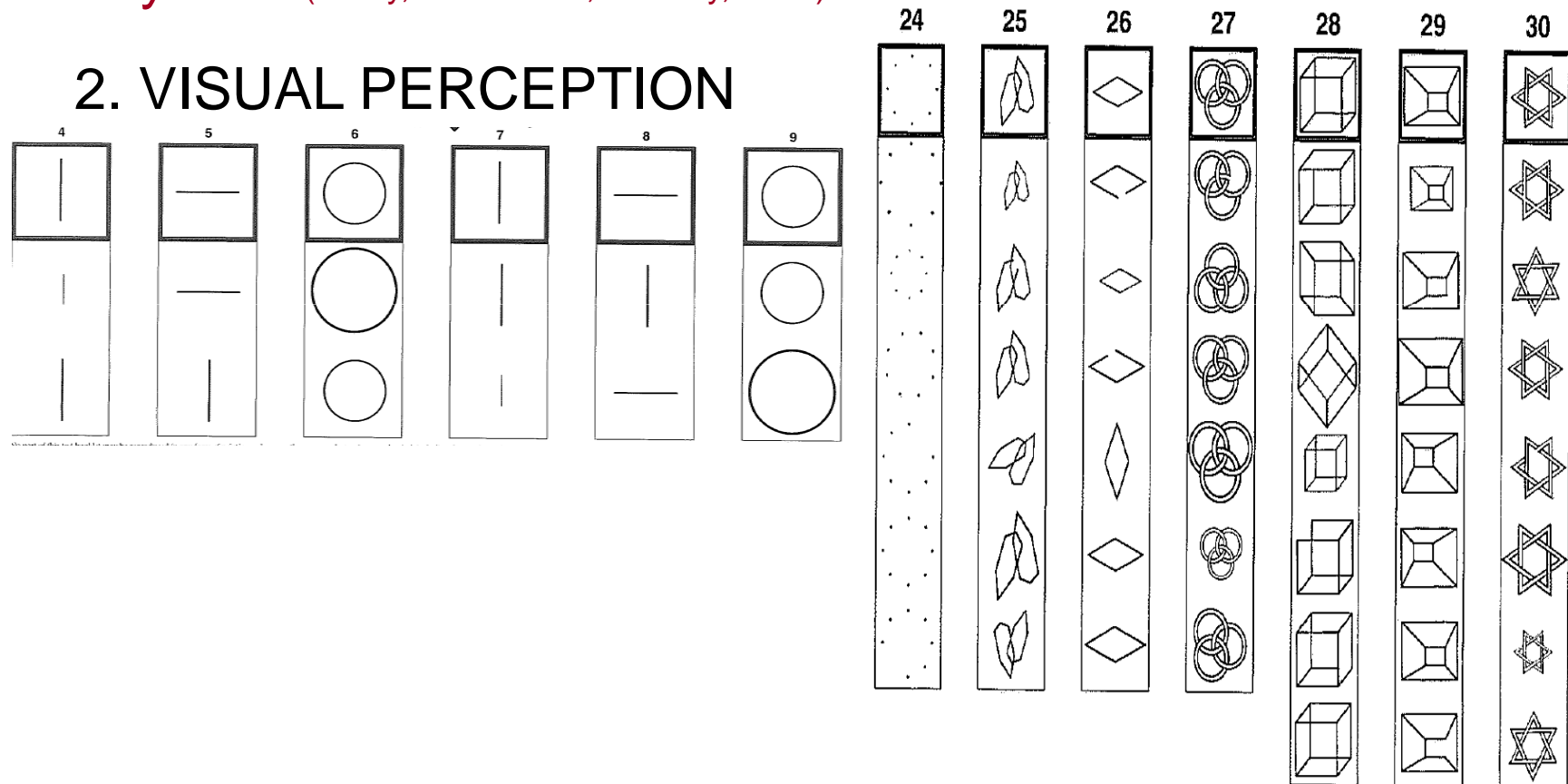
## Beery VMI (Beery, Buktenicka, & Beery, 2004)

### 1. COPY TEST



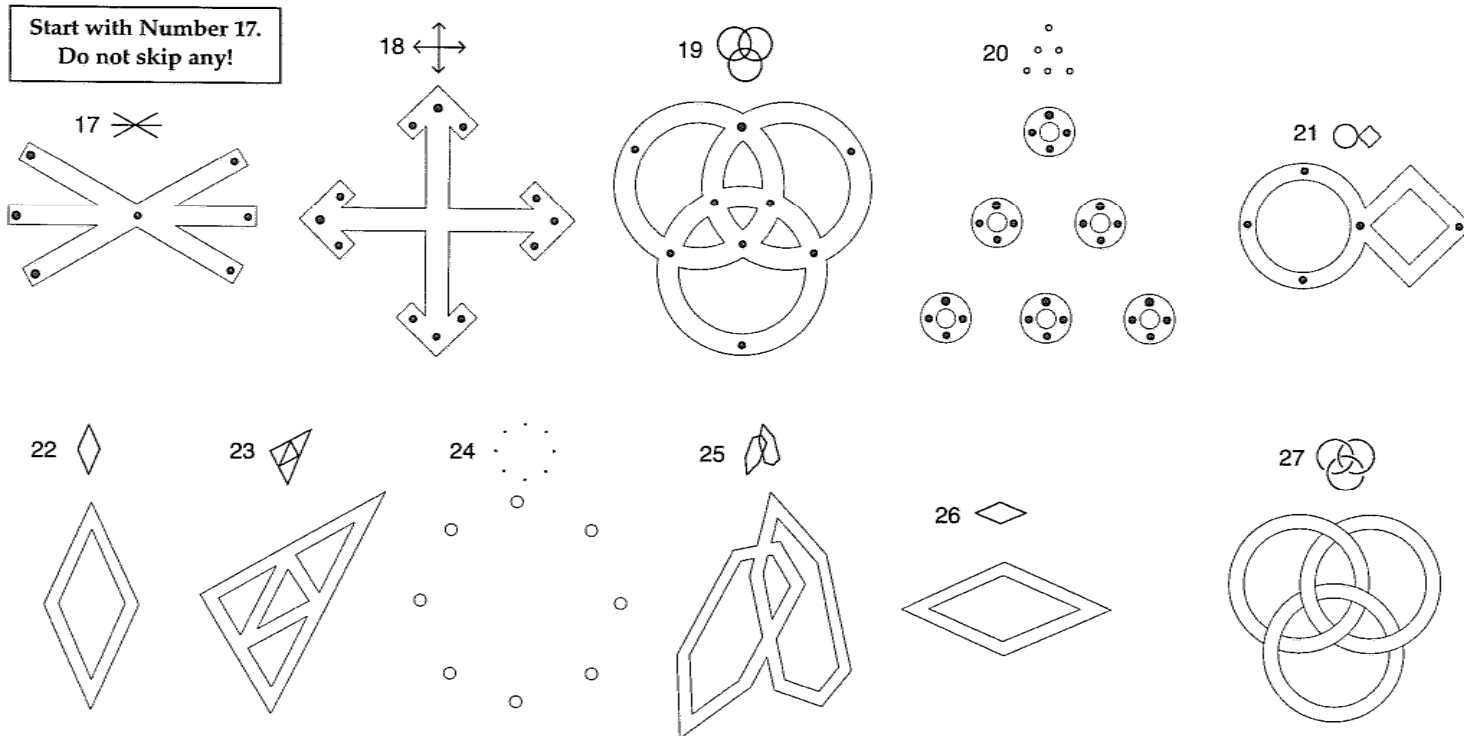
## Beery VMI (Beery, Buktenicka, & Beery, 2004)

### 2. VISUAL PERCEPTION



## Beery VMI (Beery, Buktenicka, & Beery, 2004)

### 3. MOTOR COORDINATION



## M-ABC 2: Age Band II (Henderson & Sugden, 2007)

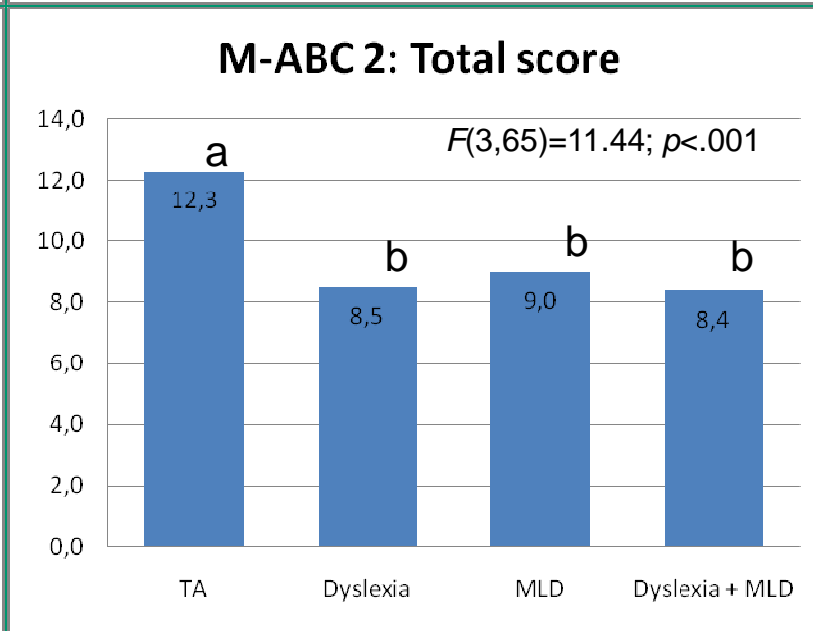
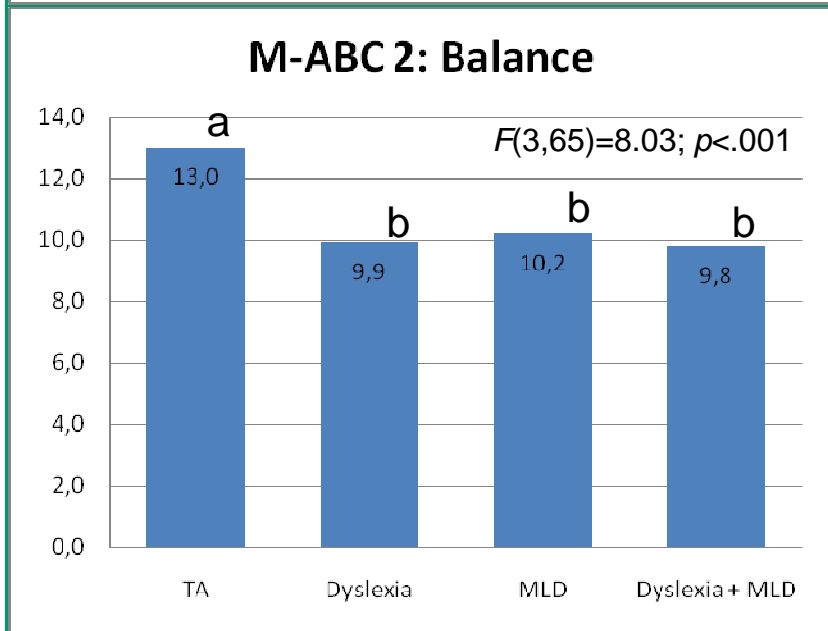
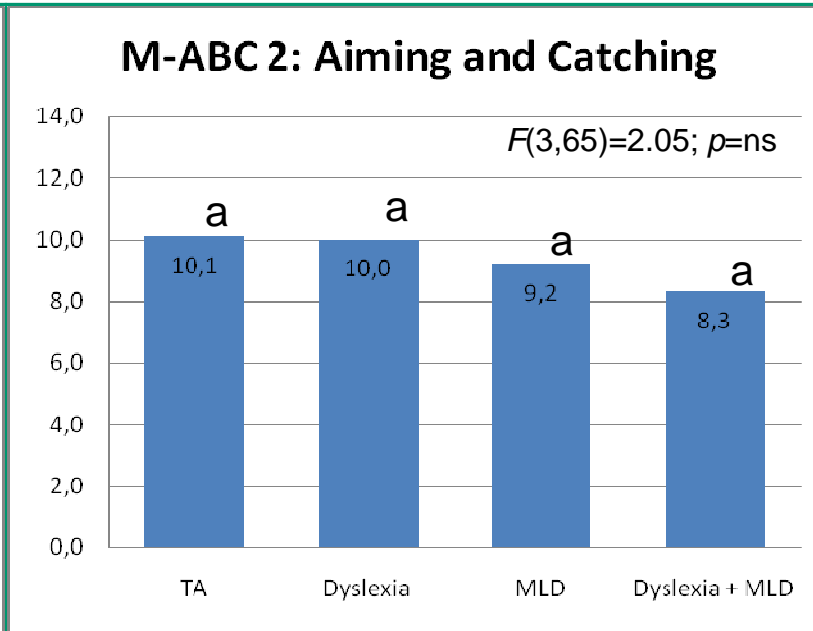
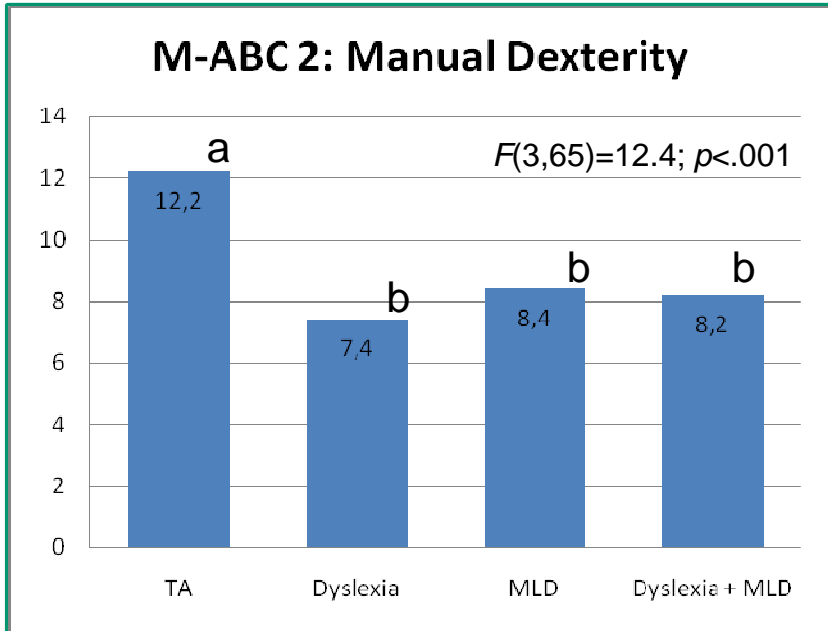
|                            | <i>Subtests</i>                 |
|----------------------------|---------------------------------|
| <b>MANUAL DEXTERITY</b>    | 1. Placing pegs                 |
|                            | 2. Threading lace               |
|                            | 3. Drawing trail                |
| <b>AIMING AND CATCHING</b> | 4. Catching with two hands      |
|                            | 5. Throwing beanbag onto mat    |
| <b>BALANCE</b>             | 6. One-board balance            |
|                            | 7. Walking heel-to-toe forwards |
|                            | 8. Hopping on mats              |



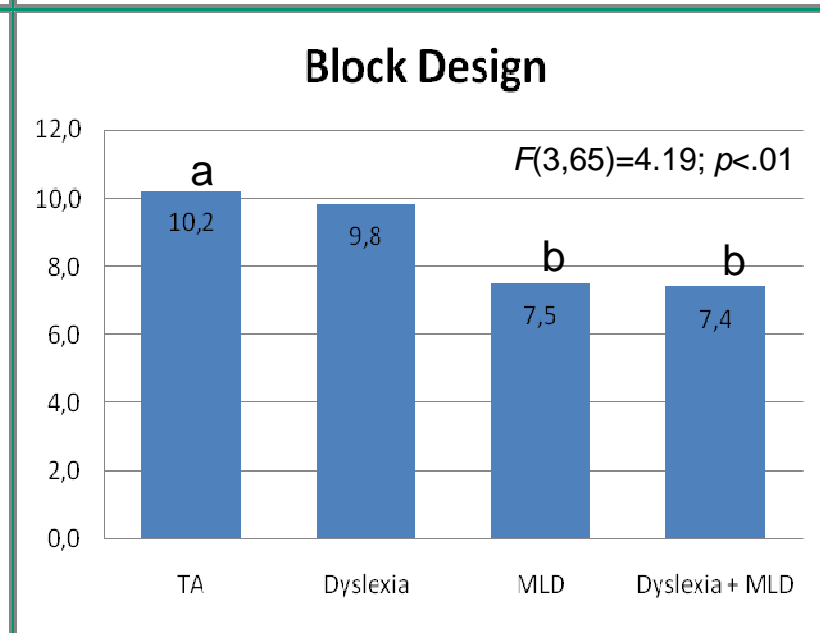
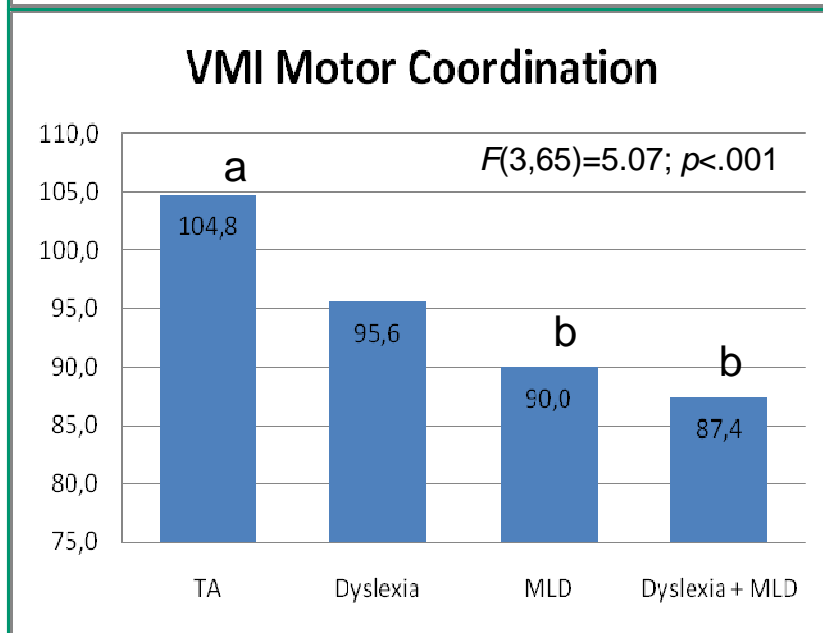
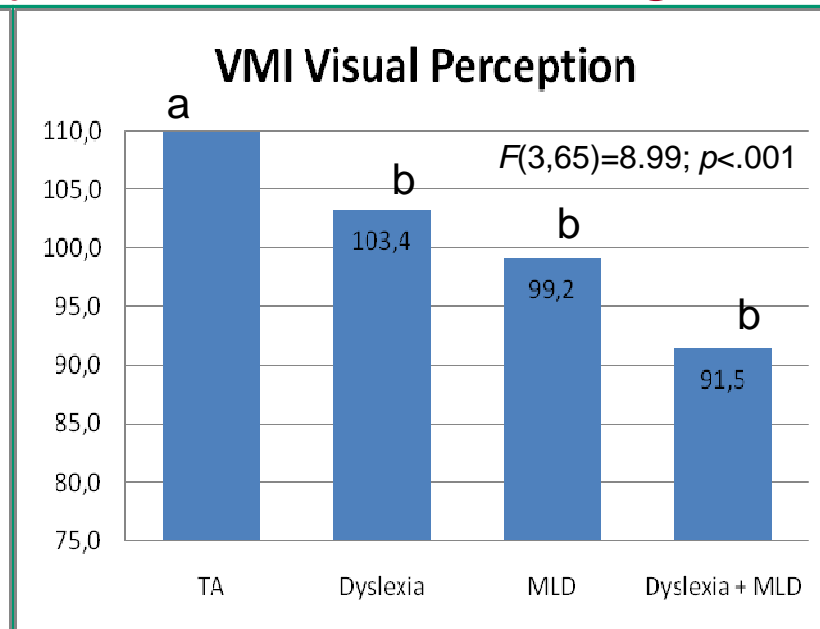
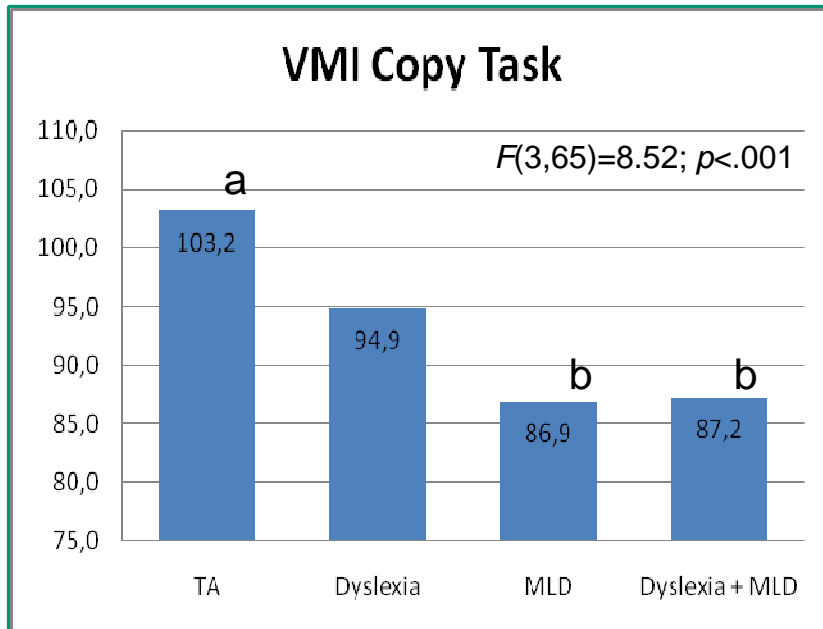
## Block Design (WISC-III) (Wechsler et al., 2002)



# STUDY 2: Results - M-ABC 2



# STUDY 2: Results - Beery VMI + Block Design



## STUDY 2: Conclusion



- Children with Dyslexia have:
  - sign. more motor problems (M-ABC 2), except aiming and catching
  - sign. more visual-perceptual problems (VMI VP)
  - no sign. more perceptual-motor problems (VMI Copy and Block Design)

... than age- and intelligence matched TA peers

- Children with MLD have:
  - sign. more motor problems (M-ABC 2), except aiming and catching
  - sign. more visual-perceptual problems (VMI VP)
  - sign. more perceptual-motor problems (VMI Copy and Block Design)

... than age- and intelligence matched TA peers

## STUDY 2: Conclusion



- Children with Dyslexia + MLD have:
  - sign. more motor problems (M-ABC 2), except aiming and catching
  - sign. more visual-perceptual problems (VMI VP)
  - sign. more perceptual-motor problems (VMI Copy and Block Design)

... than age- and intelligence matched TA peers

→ Dyslexia: not associated with perceptual-motor problems, the presence of MLD makes children underachieve

## General conclusion – Diagnostic assessment



- Dyslexia and MLD: common co-morbid + heterogeneous other co-morbid disorders
- Visual-perceptual problems → undiagnosed DCD?
- Diagnostic assessment: wide range of carefully selected measures
- Early diagnosis → early intervention
  - Plasticity of brain and nervous system
  - Awareness of motor problems → self-esteem
  - Signal for other disorders (e.g. PDD)

## General conclusion - Therapy



- Individual assessment → STICORDI advice:  
**S**Timulation, **C**ompensation, **R**emediation and **D**ispensation
- Specific needs of children with motor/visual-perceptual problems:
  - Adjusting the mirror of the page
  - Using squared paper to aid in spatial placement of numbers
  - Replacing complex figures by text
  - Good position (Tripp Trapp)
  - Ergonomic pencils...
- Deficits in visual perception → academic difficulties and reluctance

## Take home message



- Co-morbidity is rather rule than exception
- Research on children with Dyslexia and MLD should take into account co-morbid disorders such as DCD and other developmental disorders

## Take home message





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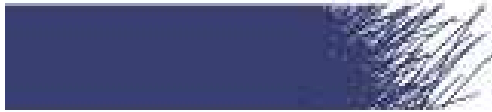
## Acknowledgements



### *Participating children*

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Diana De Graeve and Dirk Deboutte*





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***Thank you for your attention!***



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