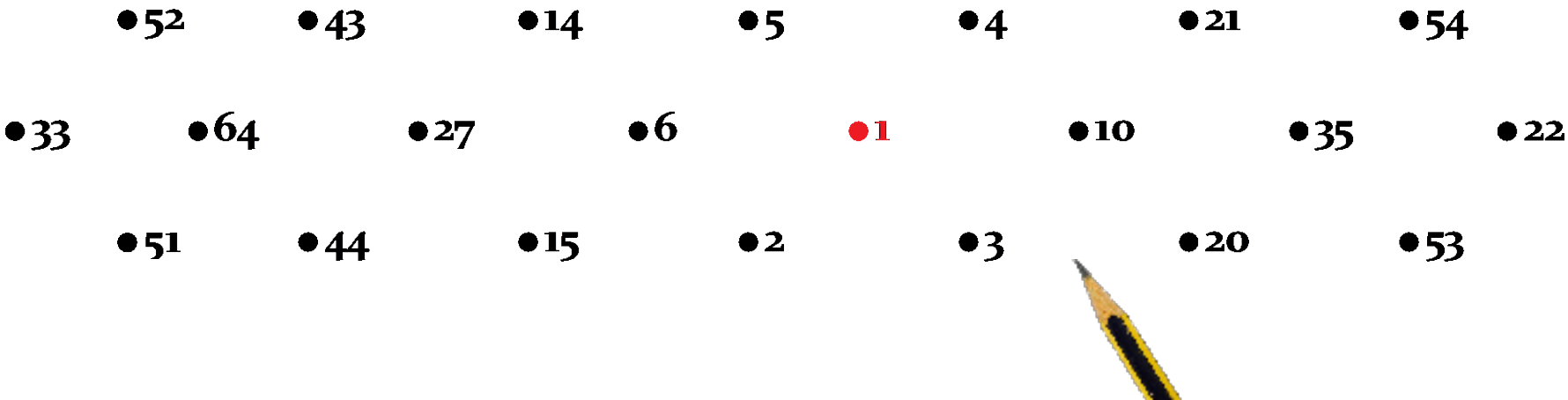
Developmental dyscalculia & order processing

Bianca van Bers, Kinga Morsanyi, and Teresa McCormack, Queen's University Belfast



What is

Developmental dyscalculia?

- Mathematics difficulties are common in both children and adults and they can have a large impact on people's lives
- A specific learning disorder in maths (SLDM or developmental dyscalculia) is a special case of persistent mathematics difficulties where the problems with maths cannot be attributed to environmental factors or a general learning difficulty

Aims

of the project

1) Demographic study to establish the prevalence of DD, gender differences in DD and comorbidities
2) Study with children with DD to test the hypothesis that DD is characterized by order processing deficits
3) Investigating the role of ordering abilities in the development of maths in typically developing children

Study 1

Demographic study of developmental dyscalculia

- Prevalence rate of DD
- Gender differences
- Comorbidities

Methods

Study 1

- 2,421 primary school children, age 7-11 years, 52.5% girls
- Schools' records of children's performance on standardized tests of mathematics, English and intelligence over several school years
- Details about children's demographic characteristics

Findings

Study 1

- 146 children had persistent maths difficulties
  - average maths score of 78 or below
- 139 were identified as having a DD profile according to DSM-5
  - IQ < 70 and moderate hearing loss
- 27 were identified as having DD according to DSM-IV
  - significant discrepancy between IQ and maths

Findings

Study 1

- Only 1 child received an official diagnosis of DD
  - Although no persistent maths difficulties
- 109 children received an official diagnosis of dyslexia, although the two conditions are expected to be equally common
  - A child with dyslexia was more than 100 times more likely to obtain an official diagnosis and receive support

Recommendations

Study 1

- Educational professionals should receive up-to-date information about diagnostic criteria for DD
- DD is not a very rare condition but underdiagnosed
- Diagnosis should be obtained, even if currently there is no specific support available (as a first step, these children should appear in the official statistics to highlight this issue)

Findings

Study 1

- Children with persistent maths difficulties were more likely to:
  - Live in deprived areas
  - Be eligible to free school meals
  - Not speak English as their first language
  - Have relatively low IQ and English performance
  - Have lower school attendance rates
  - Have special educational needs

Recommendations

Study 1

- Teachers should be made aware of the importance of environmental risk factors, in particular, the importance of socio-economic background and newcomer status (the achievement gap between newcomer and NI-born children has increased greatly in the past 10 years)
- Children who are at risk of developing mathematics difficulties should be offered additional support in the first school years

Findings

Study 1

- Persistent maths difficulties and DD were equally common among boys and girls
- Girls were more likely to underperform in maths relative to boys with a similar IQ and similar special educational needs

Recommendations

Study 1

- More research is needed to better understand the reasons for relative underperformance in the case of girls, and the most efficient intervention methods
- Maths difficulties in otherwise high-achieving girls should not be ignored
- Girls should be supported to reach their full educational potential

Findings

Study 1

- About half of the children with DD had some form of language or communication difficulty
- Some children with DD also had a diagnosis of autism, social, emotional and behavioural difficulties or attention deficit hyperactivity disorder

Recommendations

Study 1

- Educational professionals should be made aware that comorbidity is very common and, in these cases, the child should receive multiple diagnoses and educational support targeted at both conditions
- The cognitive profiles of children with DD with various co-morbid conditions (and targeted interventions) should be investigated further in future studies

Study 2

Order processing and developmental dyscalculia

- What are the problems underlying developmental dyscalculia?
- In past decades much focus on magnitude processing
- Alternative proposal: ordering abilities

Methods

Study 2

- 20 children with developmental dyscalculia and a closely matched control group of 20 children without special educational needs
- Several tasks measuring order processing, magnitude processing, and response inhibition.
- Children's level of intelligence and their basic reaction times

Methods

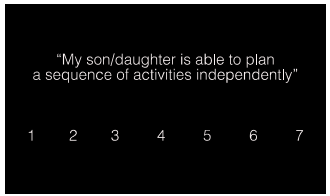
Study 2

- Order processing tasks

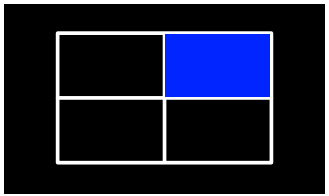
Number ordering task

Annual event ordering task

Order working memory task



Parental order processing questionnaire



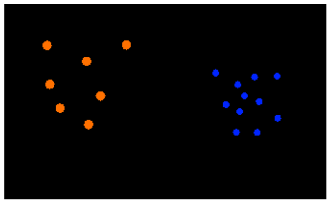
Visual-spatial working memory task

Methods

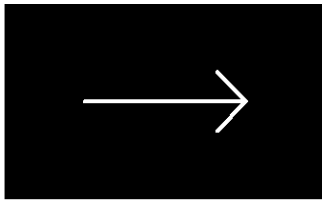
Study 2

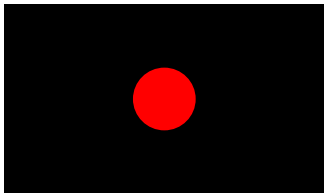
- Other computer tasks

Number comparison task


Dot comparison task

Number line estimation task


Response inhibition task


Choice reaction time task

Findings

Study 2

- There was evidence of impaired performance of children with DD on all order processing tasks
  - They obtained lower scores on the parental order processing questionnaire, order working memory and backward matrices task
  - They were less able to recognize incorrectly ordered triads in the number ordering and yearly event ordering tasks

Recommendations

Study 2

- Activities to improve ordering abilities should be utilized in early mathematics education
- The potential to use ordering tasks for diagnostic purposes (or to establish at-risk status) should also be explored further in future studies

Recommendations

Study 2

- At-risk status could be established before children start formal maths learning
- A warning sign in younger children who did not start formal schooling yet might be that they struggle with everyday activities that require sequential actions in a fixed order, or cannot recall the order of past events (we have already developed questionnaires to assess these problems)

Findings

Study 2

- Selecting best predictors of group membership
- Best model which only included significant predictors comprised of:
  - Order working memory task
  - Parental order processing questionnaire
  - Number line estimation task
- This model was able to categorize correctly 80% of the participants as DD/non-DD

Recommendations

Study 2

- Two of the tasks that best discriminated the two groups did not include numbers! Challenges the domain-specific account of DD.
- Future studies should explore the role of ordering skills in mathematics and reading together. Such studies might also shed light on the reason for the high comorbidity between mathematics and reading difficulties (see results of Study 3)

Study 3

Order processing in typical maths development

- The role of ordering abilities in typical mathematics development
- 100 primary school children, age 5-7 years, without special educational needs
- Same tasks and demographic characteristics as study 1 & 2

Findings

Study 3

- Just as in DD, order processing tasks are also very important in typical development (but the key tasks are not exactly the same)
- Number ordering skills play a particularly important role in the typical development of maths skills
- Basic tasks that are supposed to tap into numerical skills explain a large proportion of variance in reading ability. We need to understand better the underlying cognitive processes.

Future focus

Study 1

- Practice
  - up-to date info about diagnostic criteria for DD
  - importance of environmental risk factors
  - girls should be supported to reach their full educational potential
  - comorbidity is very common -> multiple diagnoses
- Research
  - reasons for relative underperformance of girls
  - cognitive profile of children with various comorbid conditions

Future focus

Study 2&3

- Practice
  - activities to improve ordering abilities utilized in early maths education
  - at-risk status could be established before children start formal maths learning
- Research
  - potential to use ordering tasks for diagnostic purposes
  - explore role of ordering skills in mathematics and reading together

Thanks!

- Kinga Morsanyi and Teresa McCormack
- Nuffield foundation

Thank you

References:

Morsanyi, K., van Bers, B. M., McCormack, T., & McGourty, J. (2018). The prevalence of specific learning disorder in mathematics and comorbidity with other developmental disorders in primary school-age children. *British Journal of Psychology*, *109*(4), 917-940.

Morsanyi, K., van Bers, B. M., O'Connor, P. A., & McCormack, T. (2018). Developmental dyscalculia is characterized by order processing deficits: Evidence from numerical and non-numerical ordering tasks. *Developmental Neuropsychology*, *43*(7), 595-621.