Dyscalculia in Practice:

From Cognitive Understanding and Assessment to Effective Clinical Intervention

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Université catholique de Louvain UCL IPSY
Institut de recherches en sciences psychologiques-Psychological Sciences Research Institute

DSM V- dyscalculia

- Substantial difficulties in mathematics learning and using academic skills
- difficulties mastering
  - number sense
  - calculation
  - mathematical reasoning
- have persisted for at least 6 months, despite the provision of targeted interventions
- cannot be explained by low IQ, neurological disorder ....

Prevalence



- 7.7% in G3 (8 y.o) and 6.6% in G4 (9 y.o.) among 3978 Belgian children (Desoete et al., 2004)
- 6.5 % among 3029 children 10 y.o. in Israel (Gross-Tsur, et al. 1996)

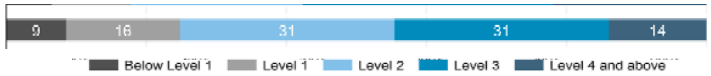
Persistent difficulties

- 6.5% of G4 children are dyscalculic: 2-years behind despite normal intelligence and schooling (Gross-Tsur et al. ,1996)
- 6 years later, 95% of them are still performing in the lower quarter of a math test (Shalev & al. , 2005)

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OECD survey of numeracy skills in adults

- Below Level 1 : can add and subtract small numbers.
- Level 1 : they can do basic maths with whole numbers or money, understand decimals, and find single pieces of information in tables or charts, but may struggle with tasks needing multiple steps (e.g. solving a proportion).



- Survey in 2022-2023, 31 countries
- OECD average in numeracy

impact

In children

❖ Impact in school performance

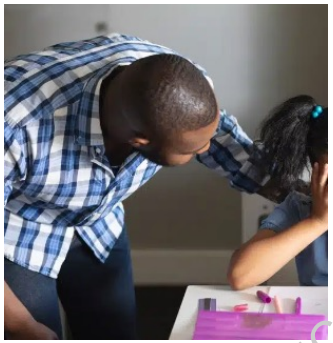
❖ higher math anxiety, lower self-esteem (Fritz, & al., 2019)

In adulthood

❖ people with low numeracy have a lower range of working opportunities, lower salaries, poorer financial well-being (Bruine de Bruin et al. 2021; Parsons & Bynner, 1997, Rivera-Batiz, 1992)

❖ Lower performance in numerical daily activities (Vigna et al., 2022)

- **Time**
- **Measure**
- **General semantic numerical** knowledge
- **Money**



Testimonials

- *Since my childhood, I have suffered excruciatingly when I have to be in contact with numbers and other mathematical languages. I have never been able to remember the multiplication tables or make a double-digit addition without making a mistake. I have a lot of trouble getting through the decades, understanding anything about the problems. I am unable to divide the proportions of a recipe, to calculate mentally and I have a lot of trouble locating myself in space.*
- *I sucked at math. It's a fact, a certainty. No matter how much I calculate, everything is always wrong.*
- Woman of 56 y.o. ...IQ of 140 !



Comorbidities





Dyslexia

- about half of the DD children are poor readers (43% in Badian, 1983, 64% in Lewis et al., 1994, 62% in Luoni & al., 2023)

ADHD

- Between 25% (Gross-Tsur, Manor, & Shalev, 1996; Silva et al., 2015) and 42% (Desoete, 2008) of DD children have attentional problems
  - Ashkenazi and Henik (2010) observed deficient attentional functions in adults diagnosed with DD

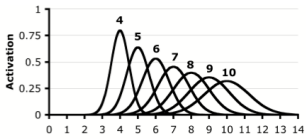
Math anxiety

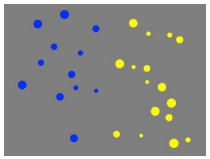
- children with DD are twice as likely to have high mathematics anxiety than typical children (Devine et al., 2018)
- but 77% of children with high mathematics anxiety had typical or high mathematics performance, so DD ≠ math anxiety (Devine et al., 2018)

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What are the causes?

- Hypoth 1 : deficit in the approximate number system - ANS
- A system to process the magnitude of collections in an approximate way, innate, shared with many animal species





Wilson & Dehaene, 2007

What are the causes?

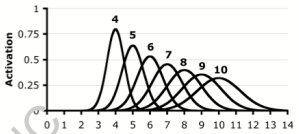
- Hypoth 2 : deficit in the construction of a precise number representation based on the number sequence

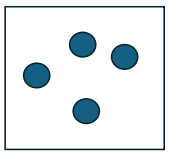


7 6

Rousselle & Noël, 2007; Noël & Rousselle, 2011









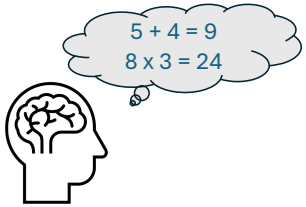
Influence of general cognitive skills

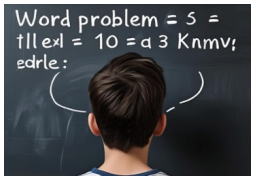
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Language abilities

1,2,3,4,5 ...







Working memory

1,2,3,...

26 x 4 =

20 x 4 = 80
6 x 4 = 24
80 + 24 = 104

David, 2013 for a meta-analysis

Inhibition

$\frac{1}{2} < \frac{3}{8}$

0.345 > 0.67

$4+5^2x(5/3)=$

Zhang & Wu, 2011; Van Hoof & al., 2017

Hypersensitivity to interference in memory

3×8 = 24
4×8 = 32

$3 \times 2 \neq 3^2$

$(a+b)x2 \neq (a+b)^2$

$(\pi r^2) \neq (2\pi r)$

De Visscher & Noël, 2014

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Cognitive flexibility

27 + 99 =

		1	
		9	9
+		2	7
	1	2	6

27 + 100 -1

20+90+7+9

0.5 ½



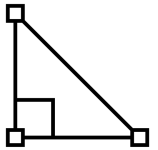
Visuospatial processing

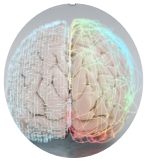
5 2

24 ≠ 42

	1	2	5	3
+		3	9	2
	1	6	4	5







Fluid intelligence



Combination of these different factors in most of the numerical tasks

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Combination of these different factors in most of the numerical tasks

48 ⟷ 62

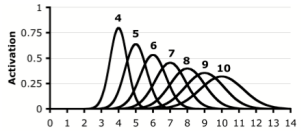
0.0705 ⟷ 0.12





26 ?

0 100





EDA, Dyscalculia Working Definition - Karagiannakis, G., Noël, M-P. & Gilmore C

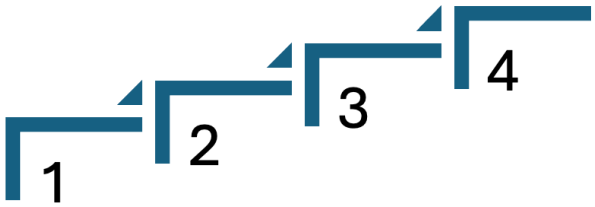
Dyscalculia is a neurodevelopmental disorder characterised by persistent and unexpected difficulty in: *understanding of numbers and mathematical symbols, mathematical fact retrieval, calculations, mathematical reasoning or geometry*

despite the provision of effective classroom instruction.

*These difficulties typically result from **domain specific** deficits in:* *numerical and mathematical symbol processing and understanding (core dyscalculia)*

*These difficulties can also result from **domain general** deficits* *in executive functions (working memory, inhibition, flexibility), hypersensitivity to interference in memory, visual-spatial processing or reasoning, or language.*

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What Does a Comprehensive Assessment for Dyscalculia Involve?



Math Skills Assessment & Dyscalculia Diagnosis

Identify of students at risk of dyscalculia through a math skills screening or teacher observation

↓ YES

Identify deficits of at least one of the following domains:
A) Number-Symbol Understanding B) Math facts C) Calculations D) Math reasoning E) Geometry

↓ YES

Mild difficulties - Response to intervention

↓ YES

No further action at this stage

NO →

Differential Diagnosis of Dyscalculia
- inadequate educational instruction
- uncorrected visual/auditory deficits
- mental or neurological disorders
- *low intelligence (e.g. IQ <85)*

↓ NO

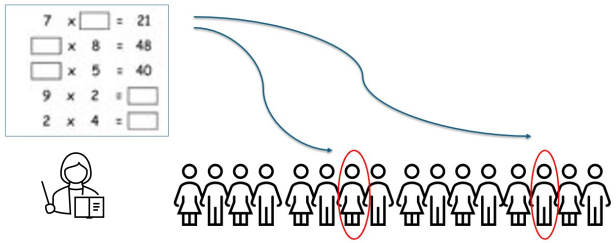
Dyscalculia
Consider the following areas to establish a comprehensive individual profile

Mathematical Profile	Cognitive Profile	Affective Factors
A. Number-Symbol Understanding **(Core Dyscalculia)** B. Math facts C. Calculations D. Math reasoning E. Geometry	• *Executive functions (working memory, inhibition, flexibility)* • *Hypersensitivity to interference in memory* • *Visuo-spatial processing or reasoning* • *Language* • *Comorbidity AD(H)D, Dyslexia, DLD, DCD*	• Socio-affective factors • Math anxiety

(Karagiannakis, G., Noël, M-P. & Gilmore C., EDA Dyscalculia Academical Committee)

Math Skills Assessment & Dyscalculia Diagnosis

Students at risk of dyscalculia identified through a **mathematical skills screening tool**.



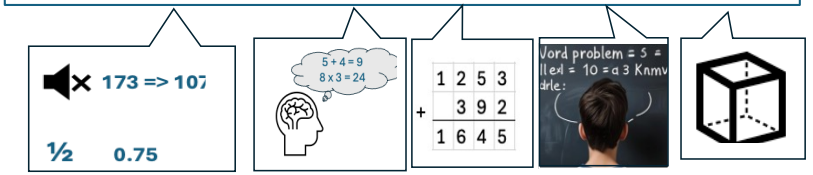
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Thanks very much for your attention !



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