Perceptual and cognitive contributions to early mathematical learning

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Complex skills depend on various building blocks

- present from birth
- gained from experience and interaction with world

Can I benefit from teaching?
How will I benefit from teaching?

Prior knowledge – using it optimally while teaching?

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Spelke, 2000; Butterworth, 1999; Dehaene & Spelke, 2004; Xu, Spelke & Goddard, 2005; Aunola, Leskinen, Lerkkanen & Numi, 2004

A framework for understanding the building blocks

- Biological level

  Brain areas
  Neurological pathways
  Plasticity

- Cognitive level

  Numerosity
  Approximate number system
  Conceptual development
  Working memory
  Fluid intelligence

- Operational level

  Mathematical and arithmetic procedures and operations

Rubinstein & Hennik, 2009

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Cognitive level

Numerosity
Approximate number system
Conceptual development
Working memory
Fluid intelligence

Numerosity & dyscalculia

- causes of dyscalculia
- 3 to 7% of children
- Some studies indicate up to 10%

Benefits of knowing whether a child is dyscalculic or has difficulties with number skills or difficulties with mathematics?

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Butterworth, 2005; Dehaene, 2007; Gillum, 2012; Fritz, Ehlert & Balzer, 2013; Arsic, Eminovic & Stankovic, 2011

Fluid intelligence

Think logically and solve problems in novel situations

- Patterns and relationships
- Correlate with quantitative reasoning
- Has a genetic base, but cognitive exercise can result in improvements

Does this relate to teaching in the early grades?

What kind of exercises contributes to reasoning?

- Visual discrimination
- Visual figure-ground
- Visual pattern completion

Cattell, 1971; Qiu, Wei, Qinqin, Liying & Lin, 2009

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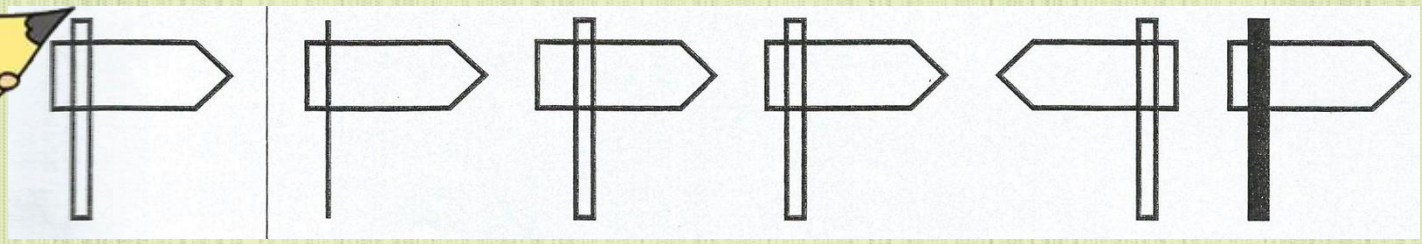

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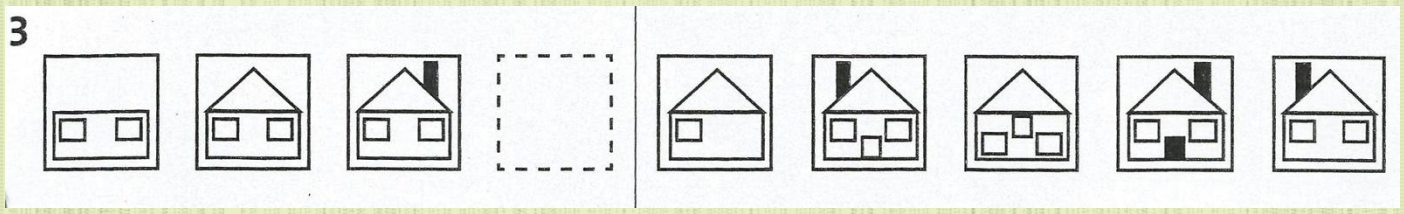

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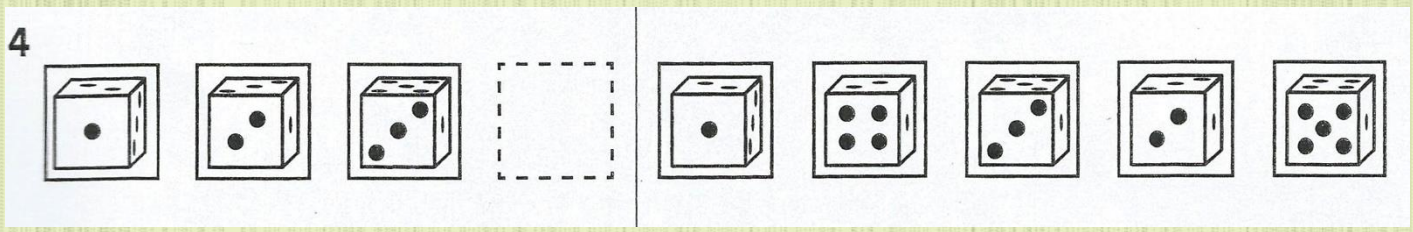

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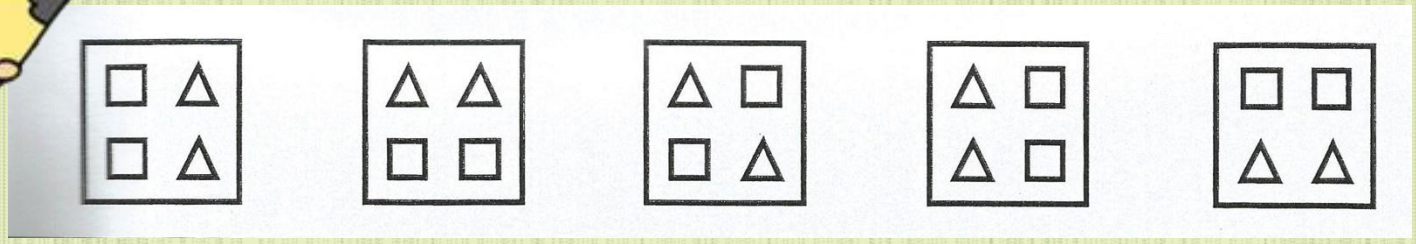

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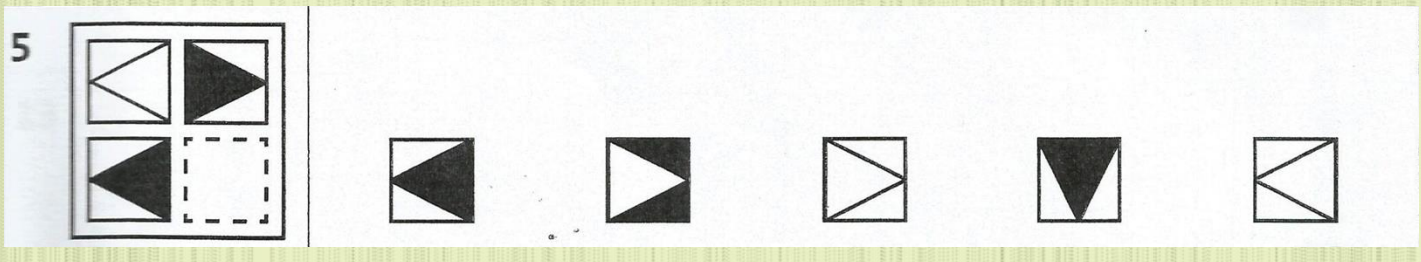

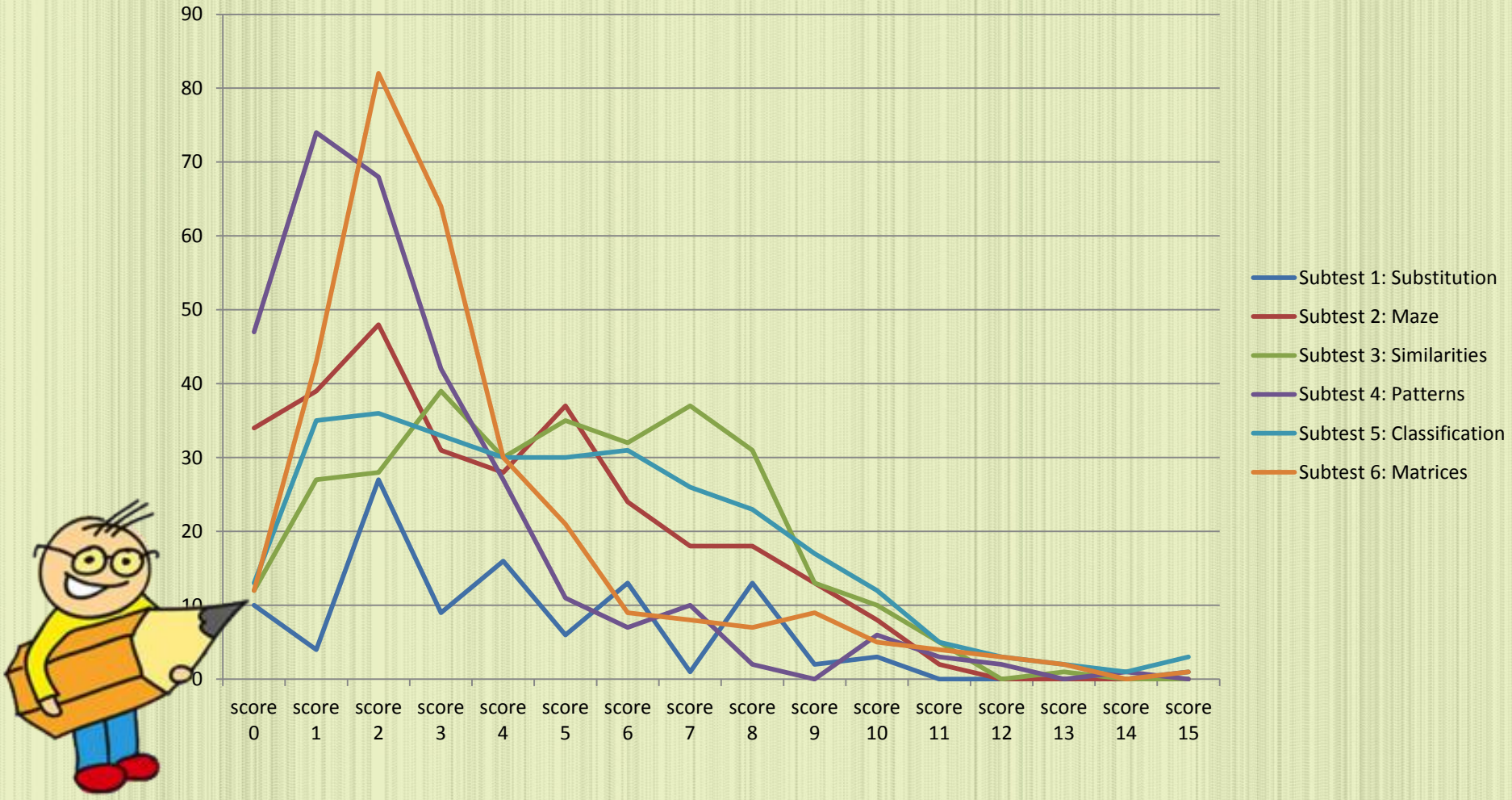
90
80
70
60
50
40
30
20
10
0
score 0
score 1
score 2
score 3
score 4
score 5
score 6
score 7
score 8
score 9
score 10
score 11
score 12
score 13
score 14
score 15
Subtest 1: Substitution
Subtest 2: Maze
Subtest 3: Similarities
Subtest 4: Patterns
Subtest 5: Classification
Subtest 6: Matrices

Still not convinced?

Testing almost 1000 grade 1 learners at end of grade 1 year

- between 1 and 5% reverse/rotate numerals
- between 1 and 5% reverse digits in two-digit numbers
- almost 10% confuses before and after
- 5% of learners confuses less and more

The % reversals and rotations pretty much the same for grade 2 and 3 learners

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Working memory

Multi-component storage and processing unit

- phonological loop – verbal and auditory information, allow understanding of verbal instructions
- visuospatial sketchpad – visual and spatial information, shape and location, visual imagery
- central executive – attentional control system, allow focus of and swifting of attention, evaluation of pieces of information

Most important domain-general predictor of mathematical achievement

Baddeley & Hitch, 1974; Baddeley, 2007; Friso-van den Bos, Kroesenbergen & Van Luit; 2014

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Policy implications

Looking at finer categories of learners struggling

Going back to the real basic building blocks

Making the perceptual and conceptual blocking blocks explicit in the curriculum

Teacher training – remedial teachers and educational psychologists or all teachers?

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Development of materials geared towards grade R and 1 teachers

- meant to become open source material
- stand-alone or as the basis for a training programme
- summary of the key research findings and theories in accessible language
- compatible with CAPS
- practical examples of activities that would work in South African classes, using as far as possible inexpensive and easily obtainable resources
- worksheets for learners, where applicable

Completed so far

- Visual perception (teachers)
- Visual perception worksheets for learners
- Vision, visual impairments and support

In progress

- Difficulties in number skills, mathematics and dyscalculia