Working memory in development: Links with learning between typical and atypical populations

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Outline

- Working memory: A definition
- Measuring working memory
- Working memory profiles of typical and atypical groups

What is working memory?

Some key features:

- Capacity to hold material in mind and manipulate for brief period
- Mental workspace
- Limited in capacity

An example

- 25 X 3
- 25 x 39
- 25 x 9 = 225
- 25 x 30 =

An example

- Listening recall
- True or False:

- Lions have four legs
- Fish live in water

- Now, what are the last words in the sentence?

Why is working memory important?

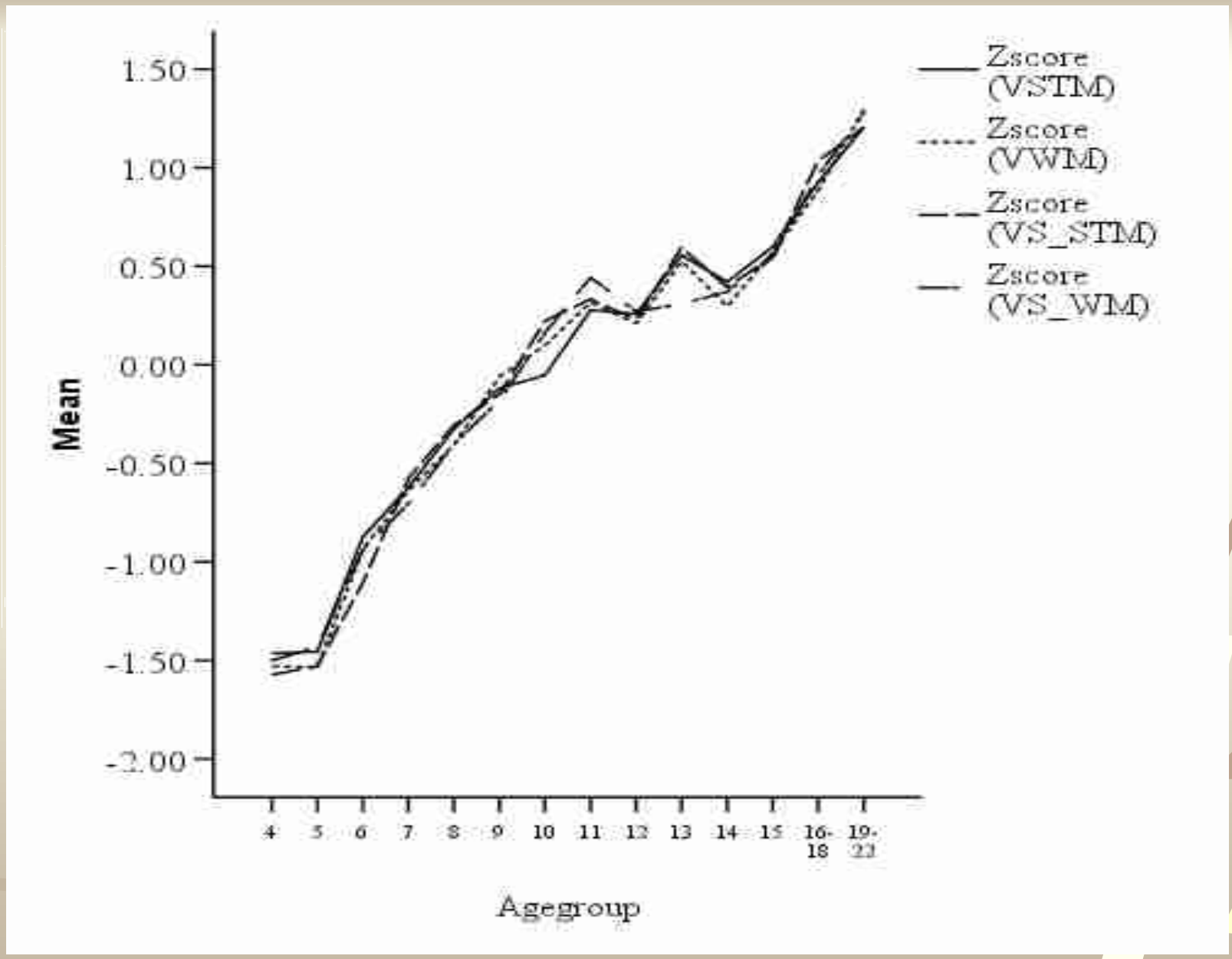
- A ‘pure’ measure of a child’s learning potential
- Measures fluid not crystallized cognitive skills

Working memory & SES

- Not strongly associated with inadequacies in pre-school experiences or education
  - Number of years in nursery
- Nor with the quality of social or intellectual stimulation in the home
  - Maternal education level
  - UK & Netherlands
- Low-income vs high-income families
  - Receptive vocabulary (BPVS) & AWMA

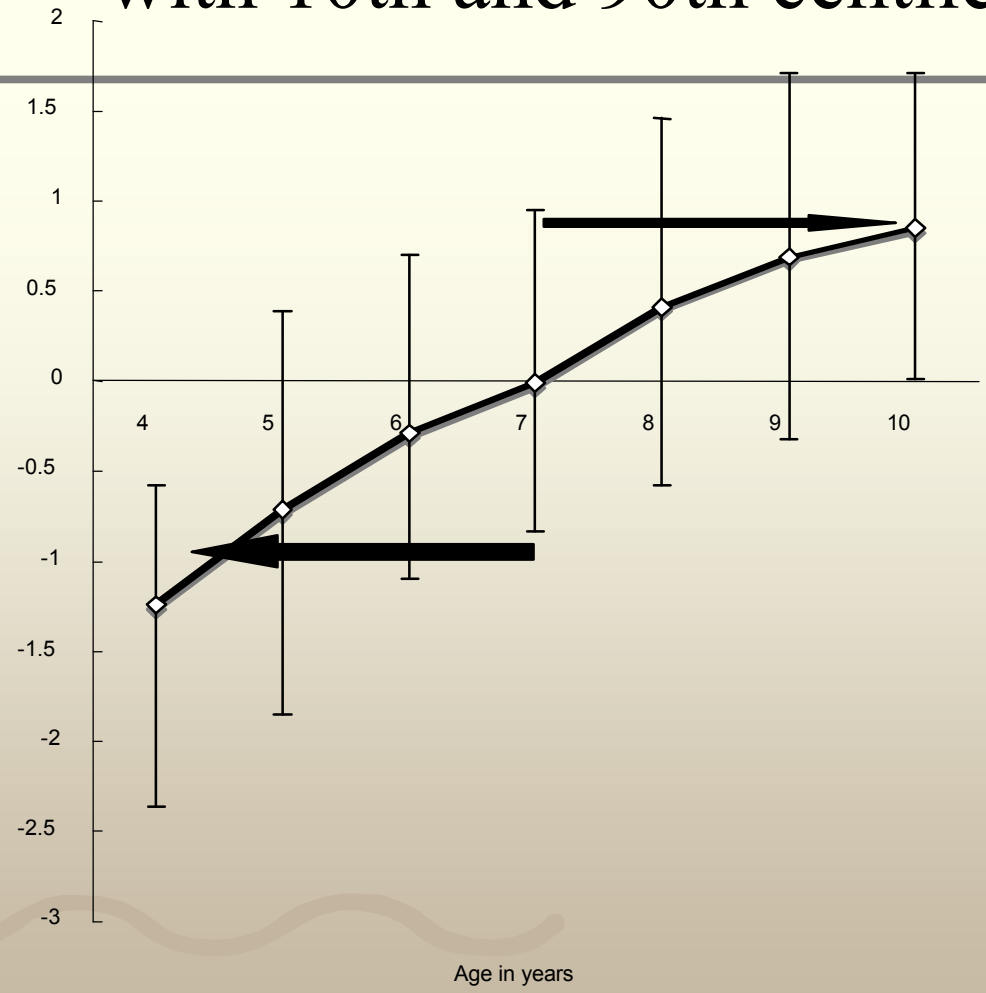
Development of working memory

- Working memory capacity increases steadily with age between 4 and 18 years
- Large degree of individual variation in working memory capacity at each age



Alloway et al (2008) *In preparation*

Age-related increase in working memory scores, with 10th and 90th centile points



Alloway et al (2006) *Child Development*

Measuring working memory

- The Automated Working Memory Assessment (**AWMA) is a computerised tool**

- First standardised tool for educators to screen for working memory impairments

- Standardised for 4-22 years.

Alloway (2007) *Pearson/Harcourt Assessment*

Measuring working memory

- The **AWMA** is standardised for 4-22 years.

- Screener: 5-7 minutes
  - 2 tests
- Short version: 10-15 minutes
  - 4 tests
- Long version: 40 minutes
  - 12 tests

Tests

Verbal short-term
Digit recall
Word recall
Nonword recall

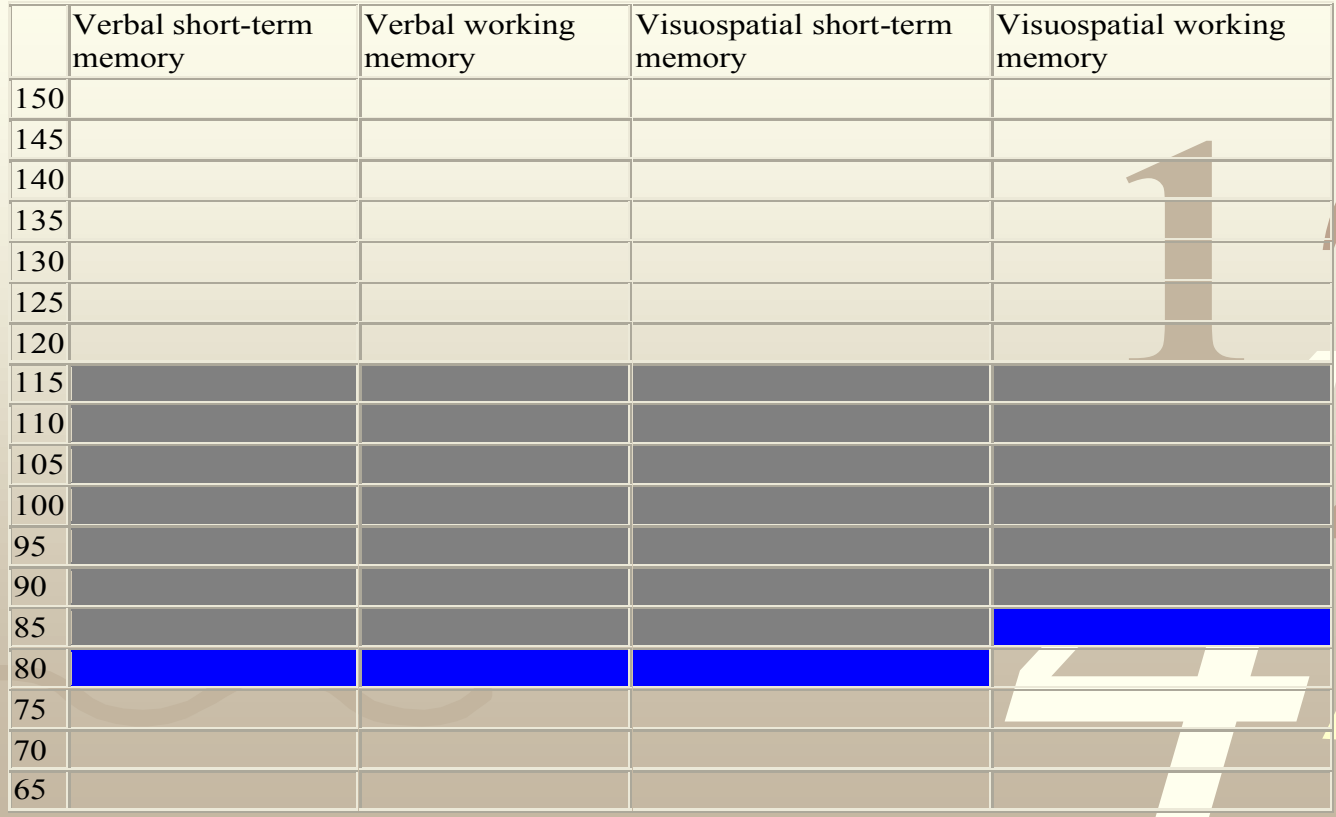
Verbal working memory
Listening recall
Counting recall
Backward digit recall

Visuo-spatial short-term
Dot matrix
Mazes memory
Block recall

Visuo-spatial working memory
Odd one out
Mister X
Spatial recall

TEST	STANDARD SCORE	PERCENTILES
VERBAL SHORT-TERM MEMORY		
Digit recall	83.0	9.0
VERBAL WORKING MEMORY		
Listening recall	81.0	9.0
Listening recall processing	72.0	2.0
VISUO-SPATIAL SHORT-TERM MEMORY		
Dot matrix	80.0	9.0
VISUO-SPATIAL WORKING MEMORY		
Spatial recall	89.0	22.0
Spatial recall processing	71.0	3.0

This graph indicates whether Jack is at risk for working memory problems. The grey shaded area represents average or typical performance for this age group. The blue area represents Jack's working memory profile.



Learning profile

- **Verbal short-term memory**
  - Jack's performance in the area of verbal short-term memory skills is below average compared to the peers in the same age-group. The scores indicate that Jack is likely to have specific impairments in language learning, and would acquire new vocabulary items at a much slower rate than the peers in the same age-group.

Working memory profiles of different atypical groups

- Children with working memory deficits
- Children with SLI
- Children with DCD
- Children with ADHD
- Children with Asperger syndrome

Children with WM deficits

- N=3189, aged 4-5 yrs & 8-9 yrs
- 25 primary schools in England
- Screened: Backward digit recall & Listening recall
- N=308 with working memory problems
  - 10th percentile on both measures
- None had physical, sensory or behavioural problems

Alloway et al. (in press) *Child Development*

Children with WM deficits

- Standard scores <86 in the AWMA

- Verbal STM = 52%
- Verbal WM = 95%
- Visuo-spatial STM = 50%
- Visuo-spatial WM = 71%

Alloway et al. (in press) *Child Development*

Children with WM deficits

- Standard scores <86
- IQ (WASI): Vocabulary = 89%
- IQ (WASI): Block Design = 45%
- Receptive vocabulary (BPVS): 36%

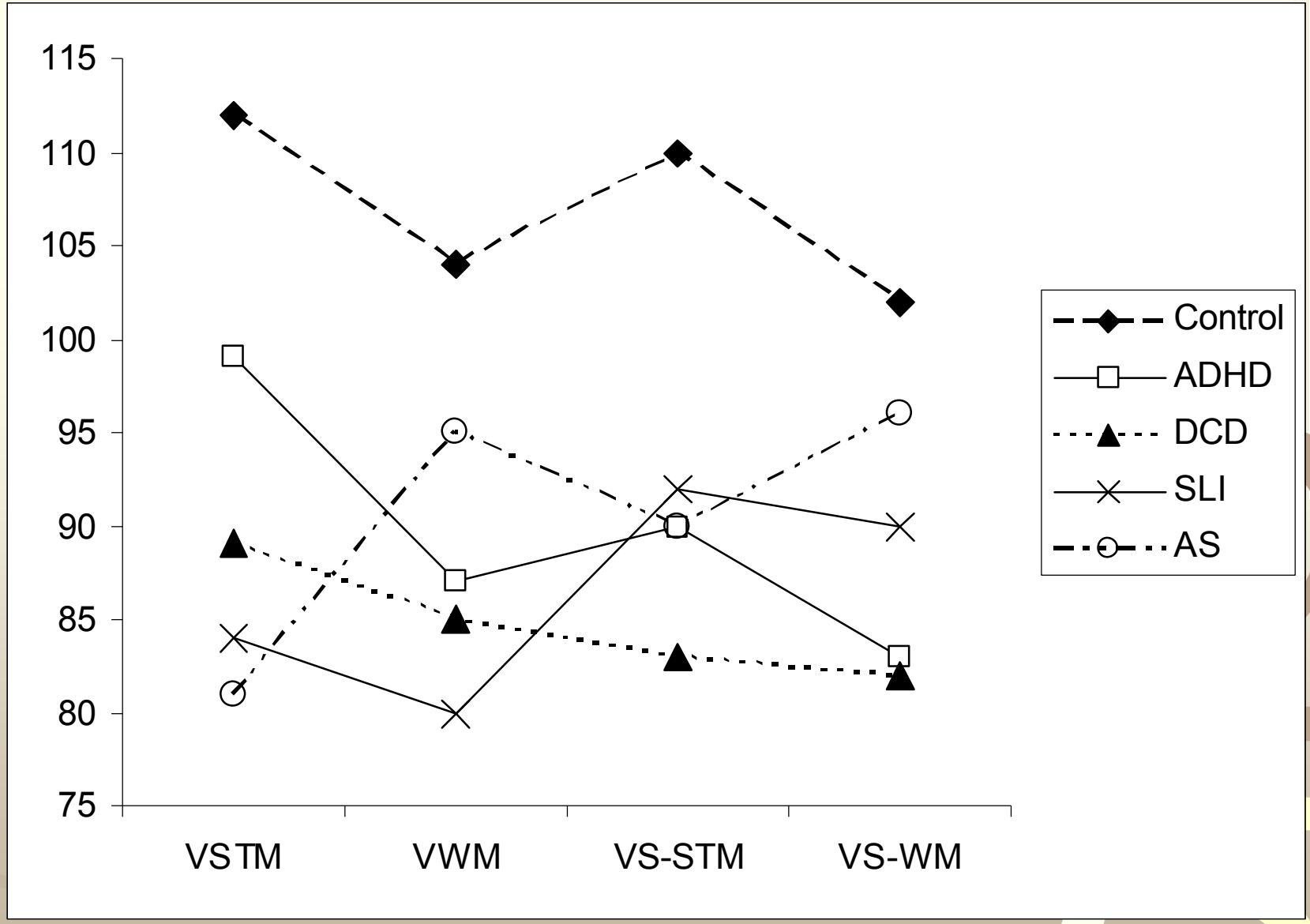
Alloway et al. (in press) *Child Development*

Children with WM deficits

- Reading (WORD) = 67%
- Math (WOND) = 70%
- Only 2% had SS >96 in BOTH WORD & WOND (n=6)

- Hierarchical regression analysis: WM predicted reading and math scores even after IQ was statistically controlled.

Alloway et al. (in press) *Child Development*

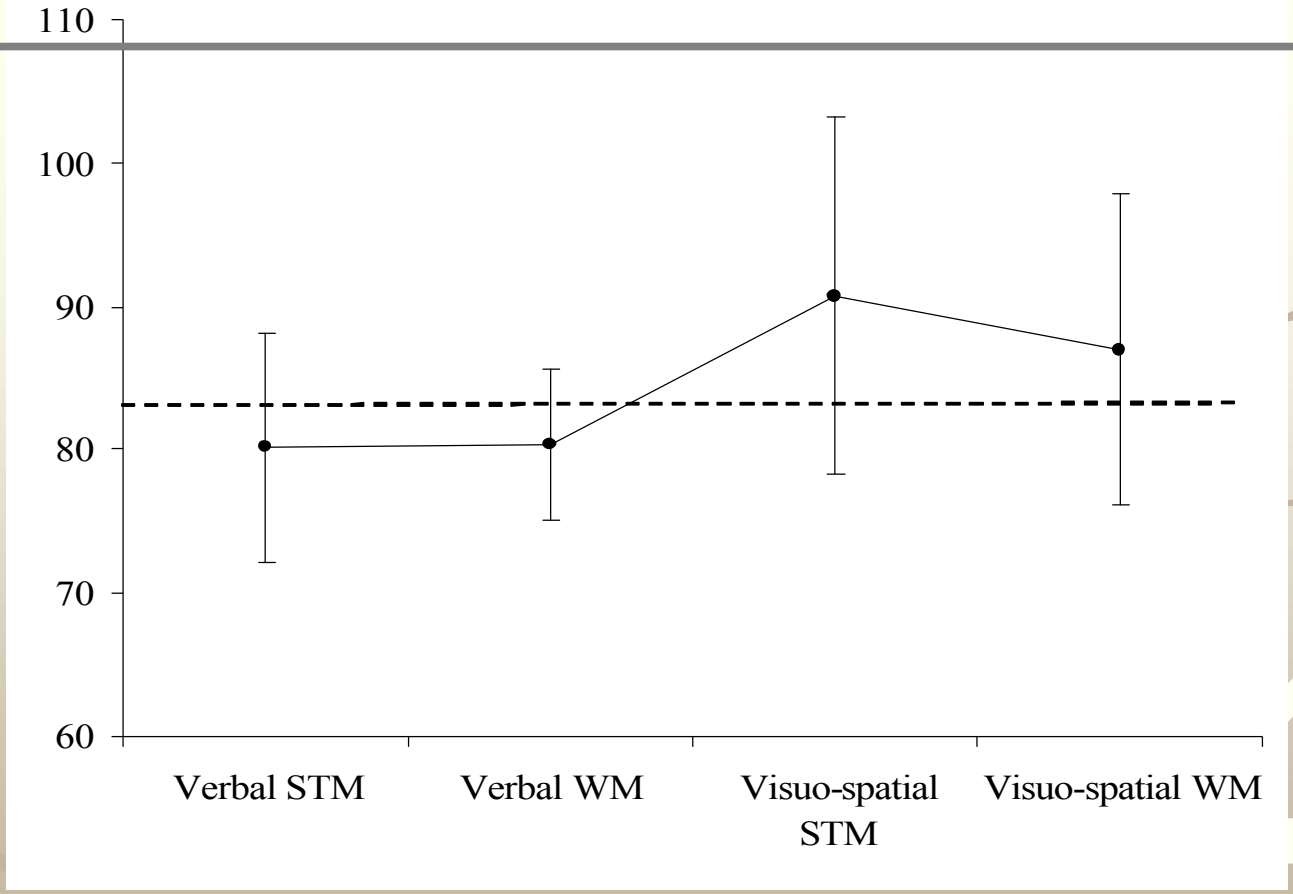


Alloway et al. (2008) *Manuscript submitted*

Specific Language Impairment

- Also known as Developmental language disorder, language delay, or developmental dysphasia
- Delayed or disordered language development in the absence of any obvious cause
- Normal IQ
- Disorder not linked with hearing loss or physical problems such as cerebral palsy
- Prevalence: 7-8% of young children
  - more males than females affected (3/4:1)

Specific Language Impairment

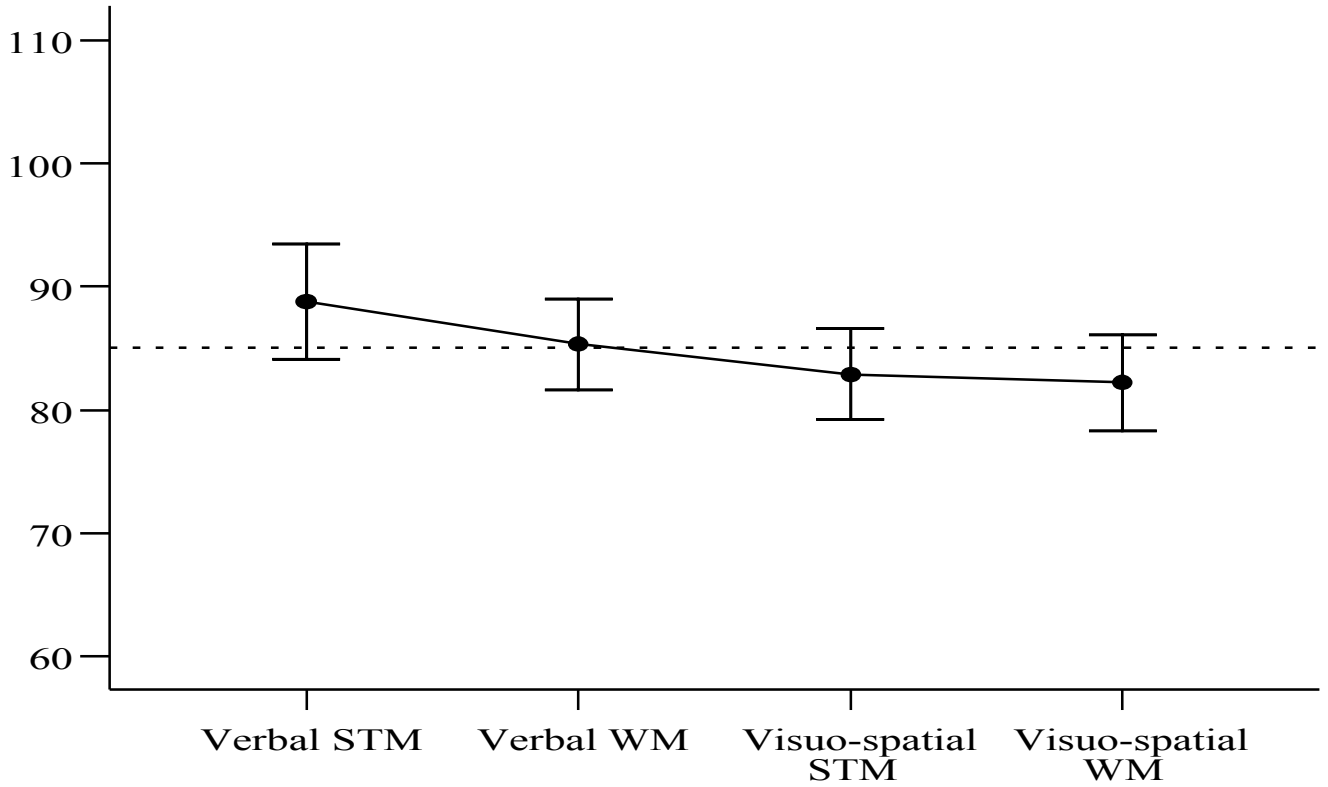


Alloway & Archibald (2008) *Journal of Learning Disabilities*

Developmental coordination disorder

- Motor Dyspraxia and "Clumsy Child"
- Children who have "a marked impairment in the development of motor coordination…that significantly interferes with academic achievement or activities of daily living" (APA, 1994)
- A neurologically based disorder of motor planning present from birth.
- Believed to be an immaturity of parts of the motor cortex that prevents messages from being properly transmitted to the body.
- Prevalence 6%, with more males than females (between 5 – 11 years)

DCD



Alloway (2007) *Journal of Experimental Child Psychology*

DCD

- Two groups:
  - High VS-Memory (SS>85, n=20)
  - Low VS-Memory (SS<86, n=35)
- Low VS group was worse in all areas of learning (reading & maths)
- Even after controlling for IQ

Alloway (2007) *Journal of Experimental Child Psychology*

DCD

- DCD children struggle with visuospatial memory tasks
  - Difficulties with **movement planning:** mentally rotating objects and tracking movement.
- They also perform poorly as a result of the **combined processing and storage demands** of these tasks.

Alloway (2007) *Journal of Experimental Child Psychology*

DCD and SLI

Group	BPVS	TROG	CELF (raw scores)
SLI (*n=20)*	80^	80	3.43*^
DCD: normal language (*n=11)*	101*^	98	6.91*
DCD: Language Impairment (LI) (*n=12*)	87*		5.92^
DCD all	94		6.39

Archibald & Alloway (2008) *Intl. Journal of Communication and Language Disorders*

DCD and SLI

Group	Verbal STM	Verbal WM	VS* STM	VS* WM
SLI	83	81	92*	90*^
DCD: normal language	80	80	82	78^
DCD: Language Impairment (LI)	79	81	78*	70*
DCD all	79	80	80	74

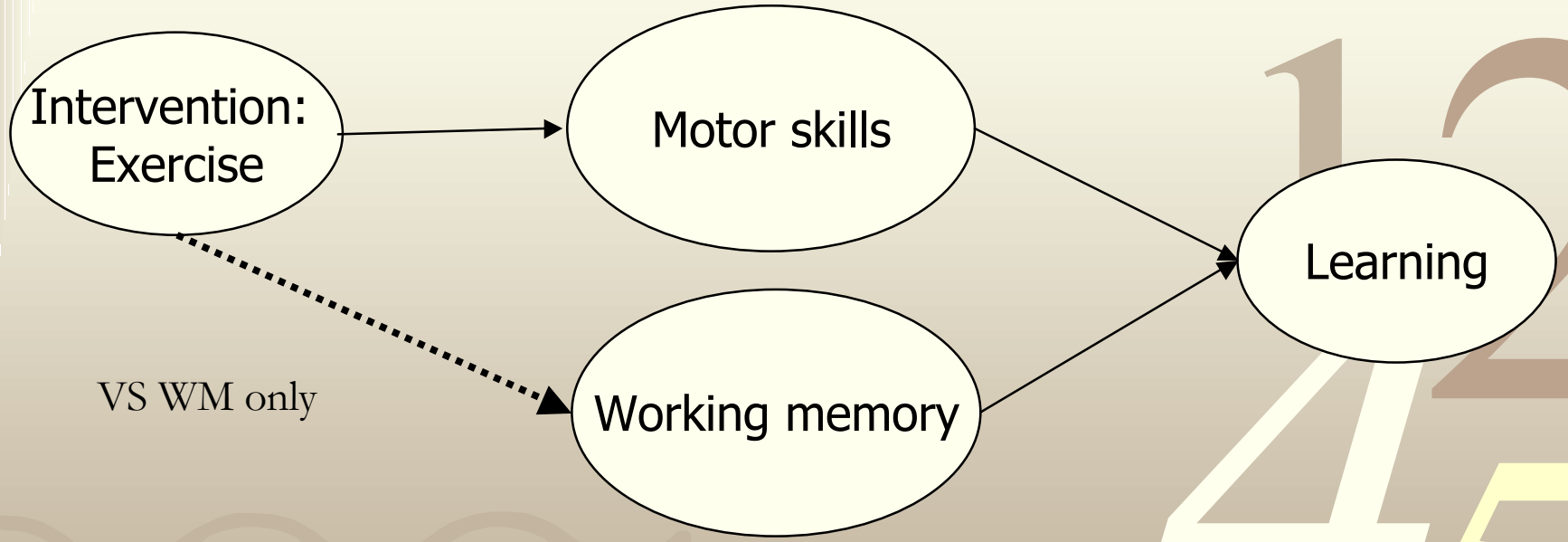
Alloway & Archibald. (2008) *Journal of Learning Disabilities*

DCD and SLI

Group	Numeracy	Reading	Spelling
SLI	87	88	91
DCD: normal language	88	85	86
DCD: Language Impairment (LI)	83	81	80
DCD all	86	83	83

Alloway & Archibald. (2008) *Journal of Learning Disabilities*

DCD: Intervention



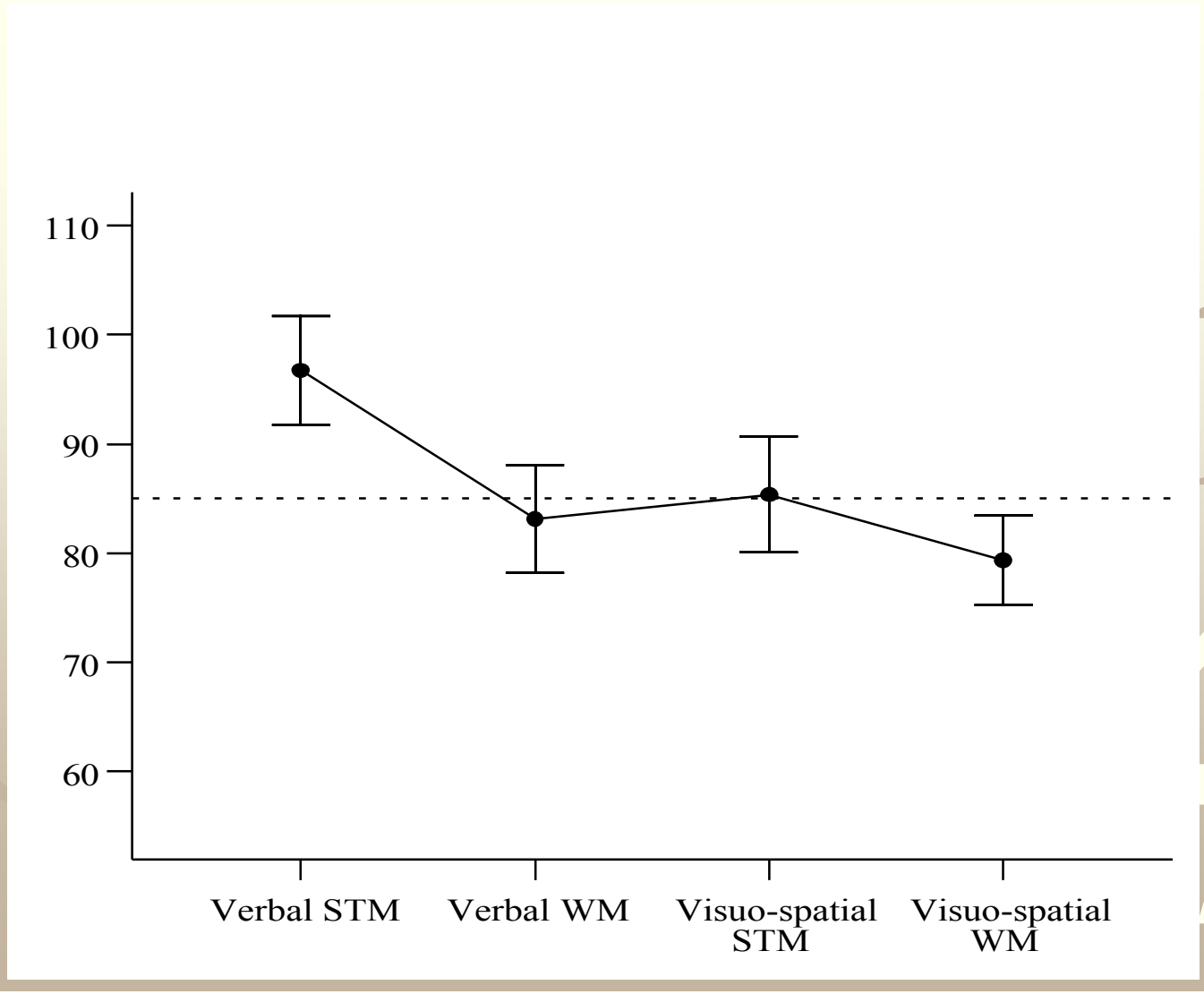
VS WM only

Alloway & Warner (in press) *Perceptual & Motor skills*

ADHD

- Characteristics: inattention, hyperactivity and impulsivity
- Trouble focusing, easily distracted, trouble staying still, frequently unable to control impulsive behaviour
- Must be more frequent than their peers and evident in 2 or more settings (ie school & home)
- Prevalence 3-7% of school children, with more males than females (between 5 – 11 years)

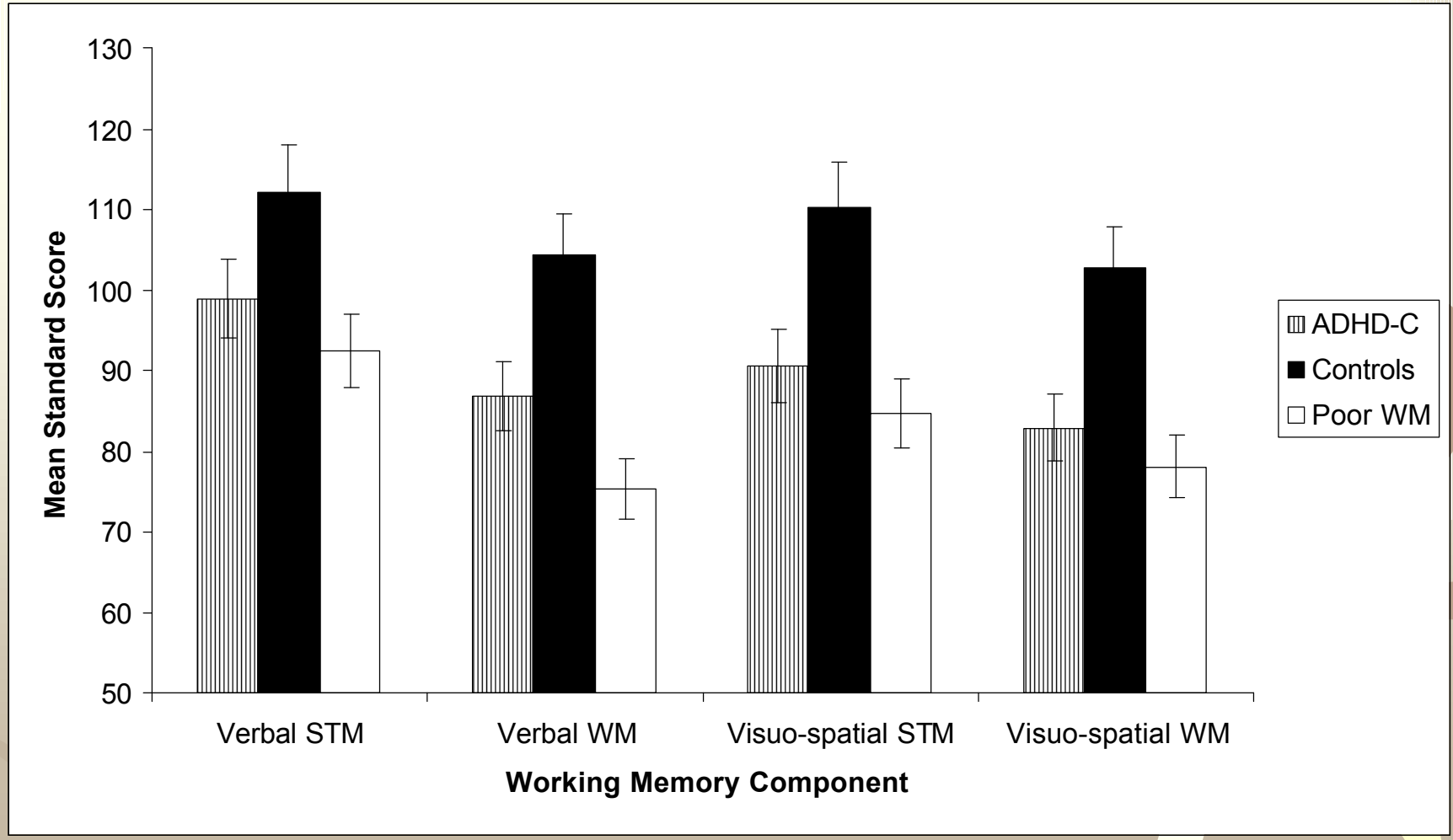
ADHD


110
100
90
80
70
60
Verbal STM
Verbal WM
Visuo-spatial STM
Visuo-spatial WM

ADHD

- No deficit in verbal short-term memory tasks
- Deficits in storage + processing tasks, both verbal and visuo-spatial
- Visuo-spatial tasks less automatic, and so demand more processing than verbal ones.
- Visuo-spatial memory tasks involve the right hemisphere, which has been implicated in ADHD

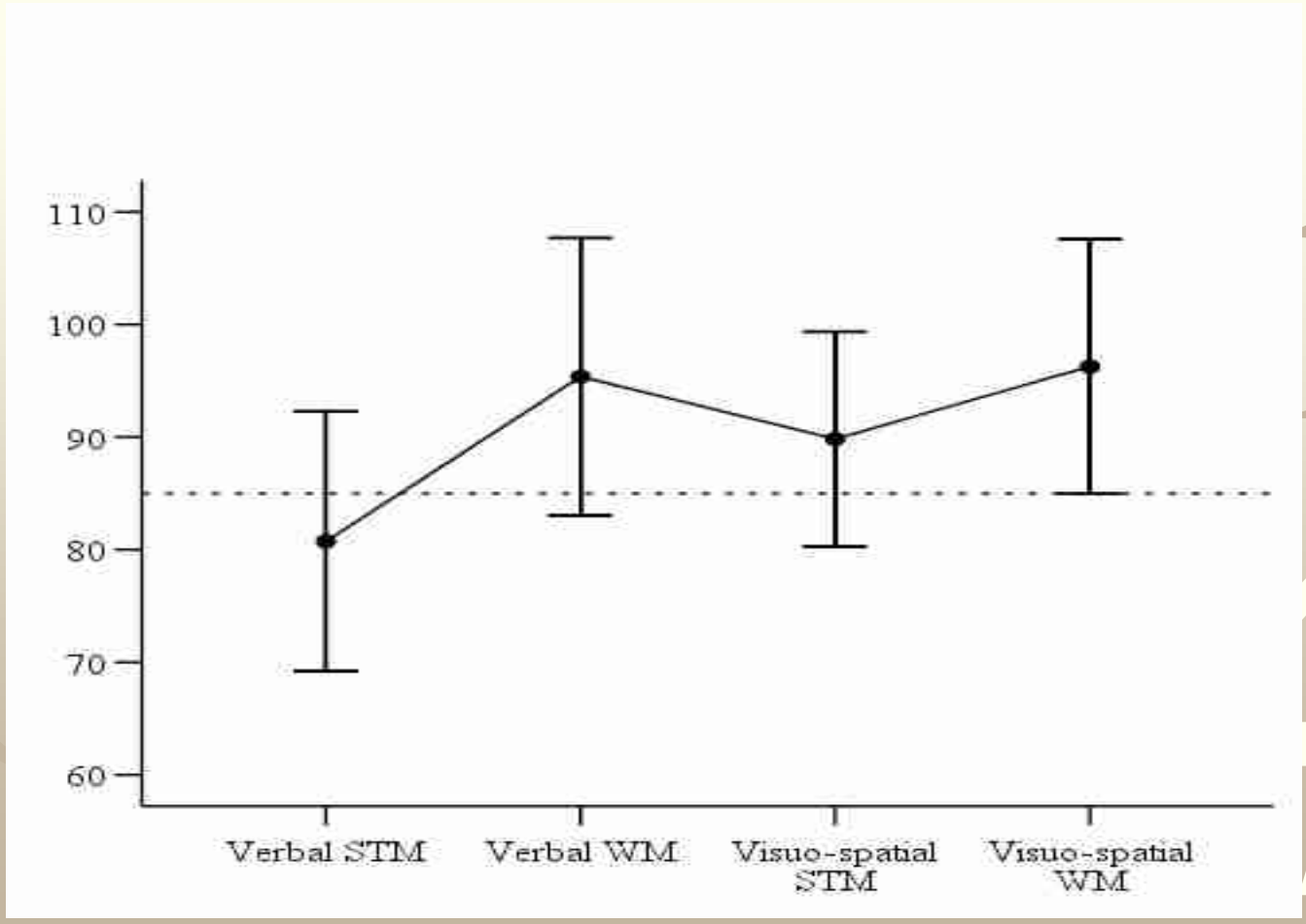
ADHD


130
120
110
100
90
80
70
60
50
Mean Standard Score
Verbal STM
Verbal WM
Visuo-spatial STM
Visuo-spatial WM
Working Memory Component
ADHD-C
Controls
Poor WM

ADHD

	ADHD-C	Controls	Poor WM
Reading	82.60 (16.71)	97.54 (12.05)	78.90 (16.21)
Maths	82.83 (14.69)	97.90 (9.82)	81.58 (16.47)
IQ	89.84 (13.30)	101.08 (11.40)	84.34 (13.30)

Asperger Syndrome



Asperger Syndrome

- Working memory performance depends on IQ
- Low functioning autistic adolescents performed more poorly than chronological age-matched participants, but did not differ from IQ-matched participants on measures of both verbal and visuo-spatial working memory.
- High functioning autistic persons performed in a similar manner as age and IQ matched controls

Asperger Syndrome

- Poor performance restricted to verbal STM
- The result of a computerized presentation of verbal stimuli as the AS children were not able to benefit from phono-articulatory features available in spoken presentation
- Relatively strong performance in verbal WM and visuo-spatial memory suggest that AS children do not struggle with the simultaneous task of processing and storing information.

Findings

- Domain-specific impairments associated with particular developmental disorders can have a cascading effect on other cognitive skills.
- Their cognitive profile may mirror those with domain-general impairments and could explain why ‘pure’ cases of developmental disorders are rare.

Findings

- The memory deficits evidenced in children with developmental disorders may not reflect a separate cognitive deficit.
- The specificity of the poor working memory scores suggest that these impairments may be a secondary consequence of a core deficit that lies elsewhere.
- This impacts the storage and manipulation of information of that particular kind.

Summary

- Distinct memory profiles associated with each disorder reflect the nature of their deficit to some degree.
- The uniqueness of the diagnosis indicated by the AWMA identifies not only areas of deficit, but also areas of strength on which compensatory strategies can be effectively built.

THANK YOU

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