Seriousness and pervasiveness of impairments: Educational, Clinical, Interpersonal

- **Poor School Performance (90%+)**
  - More failing grades
  - Reduced productivity (greatest problem)
  - Lower GPA (1.7 vs 2.6)
  - Grade retentions (42% vs 13%)
  - Lower class rankings (69% vs 50%)
  - Higher rate of suspensions (60% vs 19%) and expulsions (14% vs 6%)

- **Low Academic Achievement (10-15 pt. deficit)**

- **Low Average Intelligence (7-10 point deficit)**

- **Learning Disabilities (10 to 70%)**
  - Reading (15-30%; 21% in Barkley, 1990)
  - Spelling (26% in Barkley, 1990)
  - Math (10-60%; 28% in Barkley, 1990)
  - Handwriting (common but % unspecified)

- **Academic Outcomes**
  - 23% to 32% fail to complete high school
  - 22% vs 77% enter college
  - 5% vs 35% complete college

[Barkley et al. 2006 Milwaukee Young Adult Outcome Study]

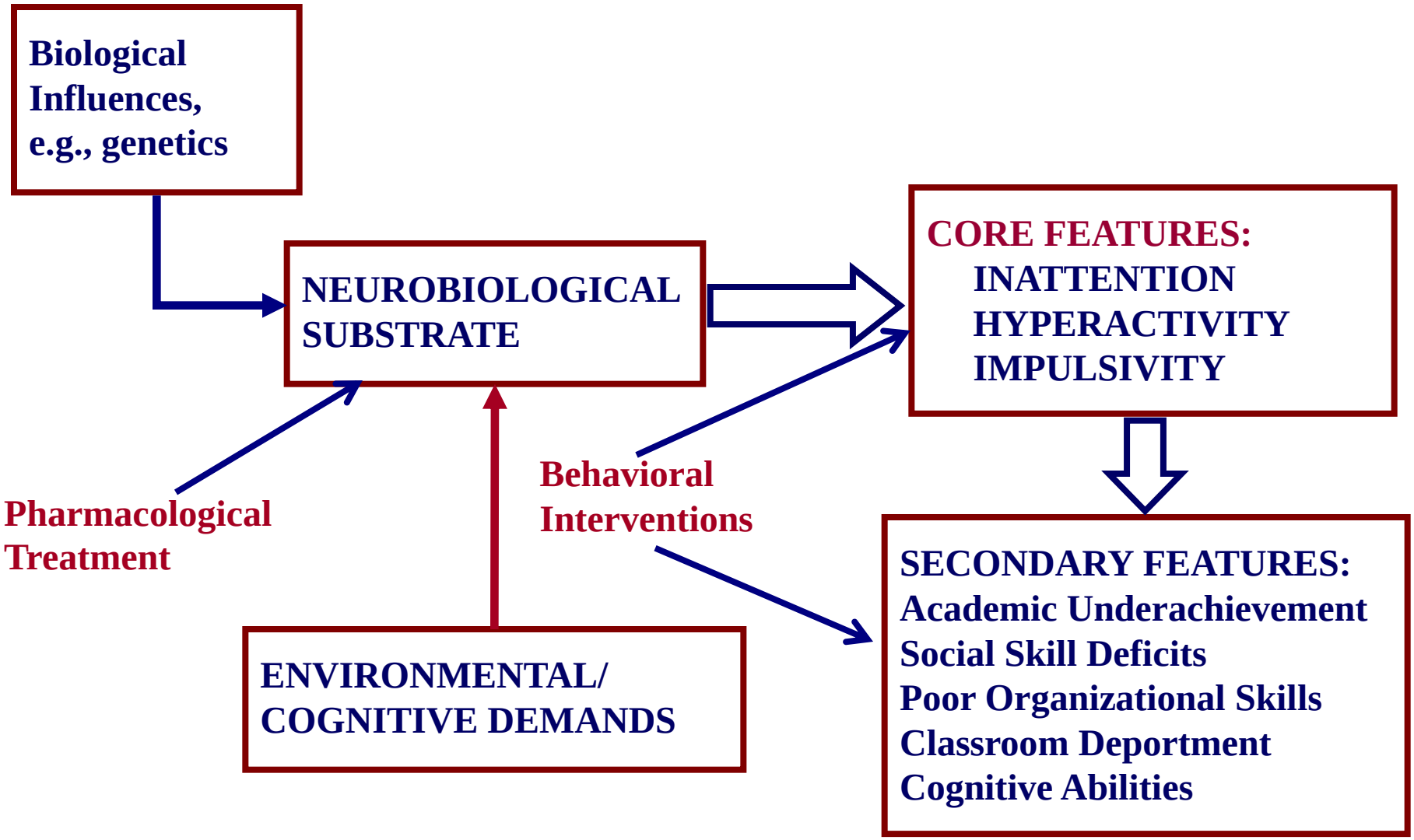
ADHD Cost of Illness (COI) in USA

COI = **Educational accommodations**
Mental health care
Parental work loss
Juvenile justice system involvement

COI = **Mean = $14,576 annually per child (Pelham et al., 2007)**
Range = $12,005 to $17,458

COI = ***$40.8 billion*** **annually (based on assumed 5% prevalence rate and 2.8 million school age children in the United States (National Center for Education Statistics, 2010, enrollment data)**

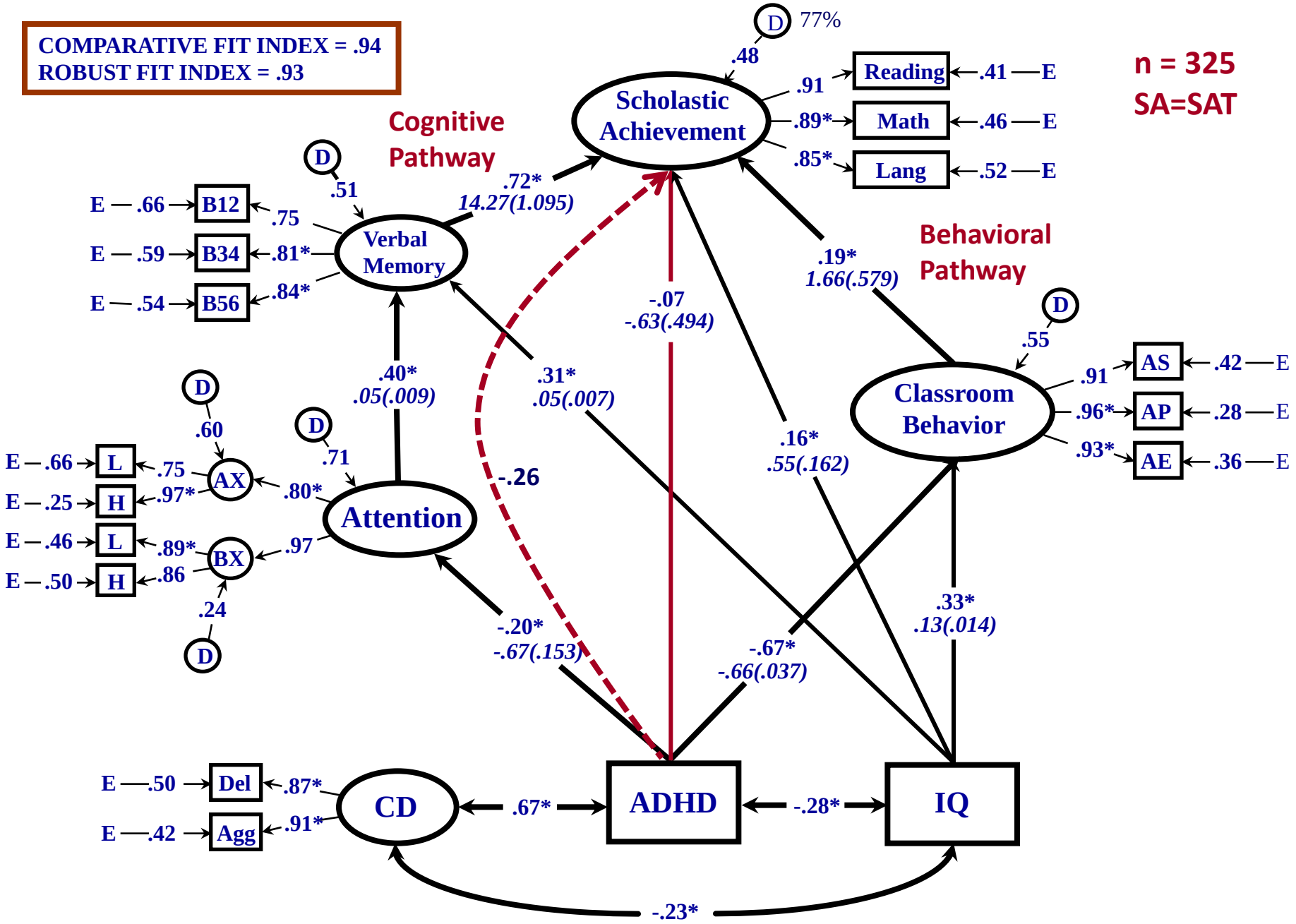
DSM-IV CLINICAL MODEL OF ADHD



The enigma – why do large magnitude changes in core symptoms not translate into sustainable or generalizable changes in treated children?

- Pharmacodynamic studies reveal DA and NA activation of cortical-subcortical pathways involving the frontal/prefrontal, temporal lobe, and basal ganglia – areas that play a critical role in executive functions (EFs)

- Optimal activation of structures underlying EFs and accompanying arousal is necessary but insufficient to facilitate the development of executive function processes supported by these structures and wide range of behaviors dependent upon these processes



Rapport, Scanlan & Denney (1999) J. of Child Psychiatry and Psychology

Overview of Executive Functions (EFs)

Executive Function (EF): an umbrella term used to describe a broad range of 'top-down' cognitive processes and abilities that enable flexible, goal-directed behavior; and represents the dominant paradigm during the past decade following Dr. Barkley's (1997) seminal theoretical paper in 1997.

Ensuing debate focused on two alternative models:

1. **EF viewed as a unitary construct with interrelated sub-processes.**
2. **EF viewed as a componential model of dissociable EF processes**

Accumulating evidence supports an integration of the two approaches (i.e., interrelated sub-processes governed by a domain general executive or attentional controller (e.g., Miyake et al., 2000) emphasizing 3 primary executive functions:

- **Updating: the continuous monitoring and quick addition or deletion of contents within one's working memory**
- **Inhibition: the capacity to supersede responses that are prepotent in a given situation**
- **Shifting: the cognitive flexibility to switch between different tasks or mental states**

Miyake et al. (2000): 3-factor model of executive function based on SEM

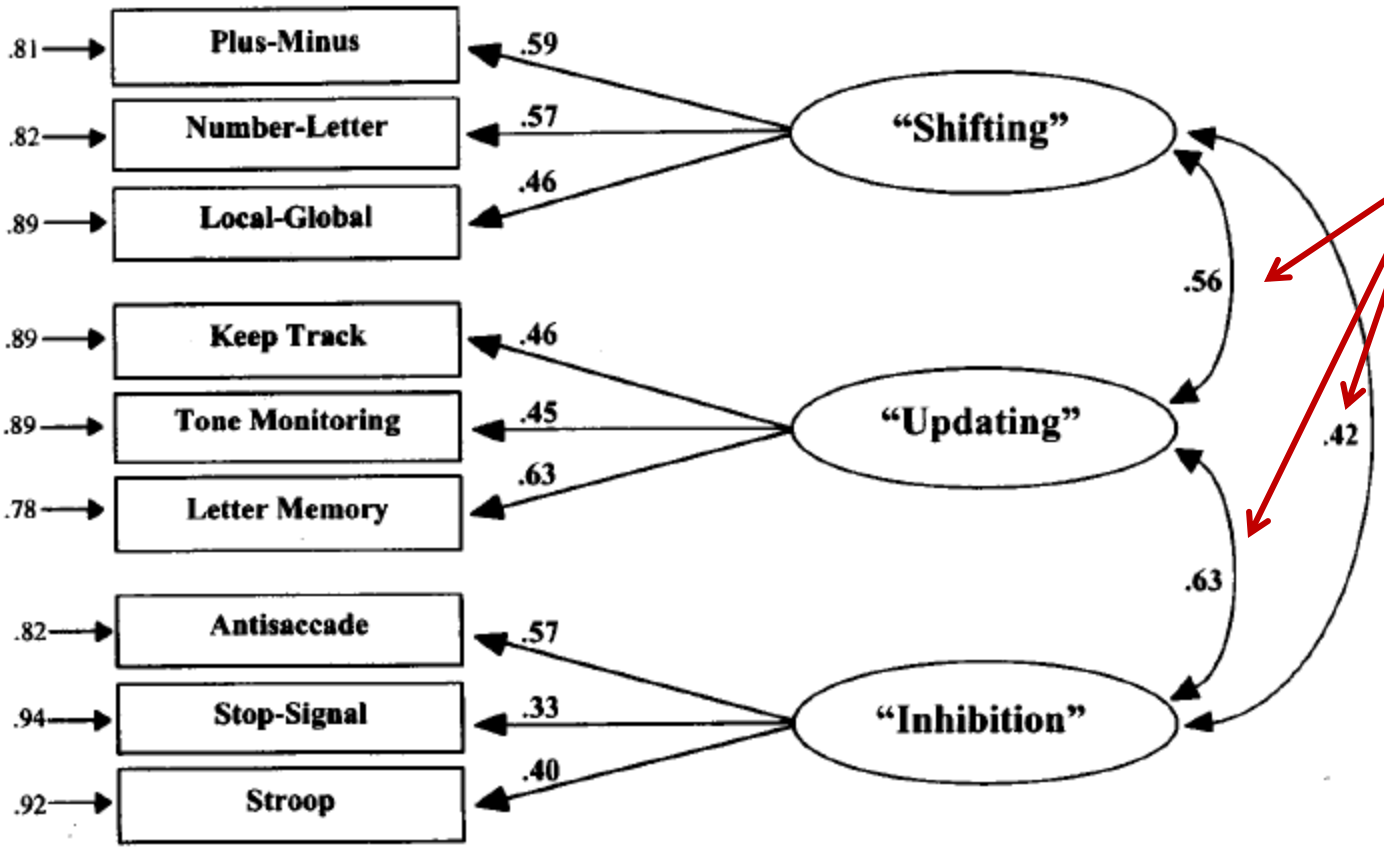
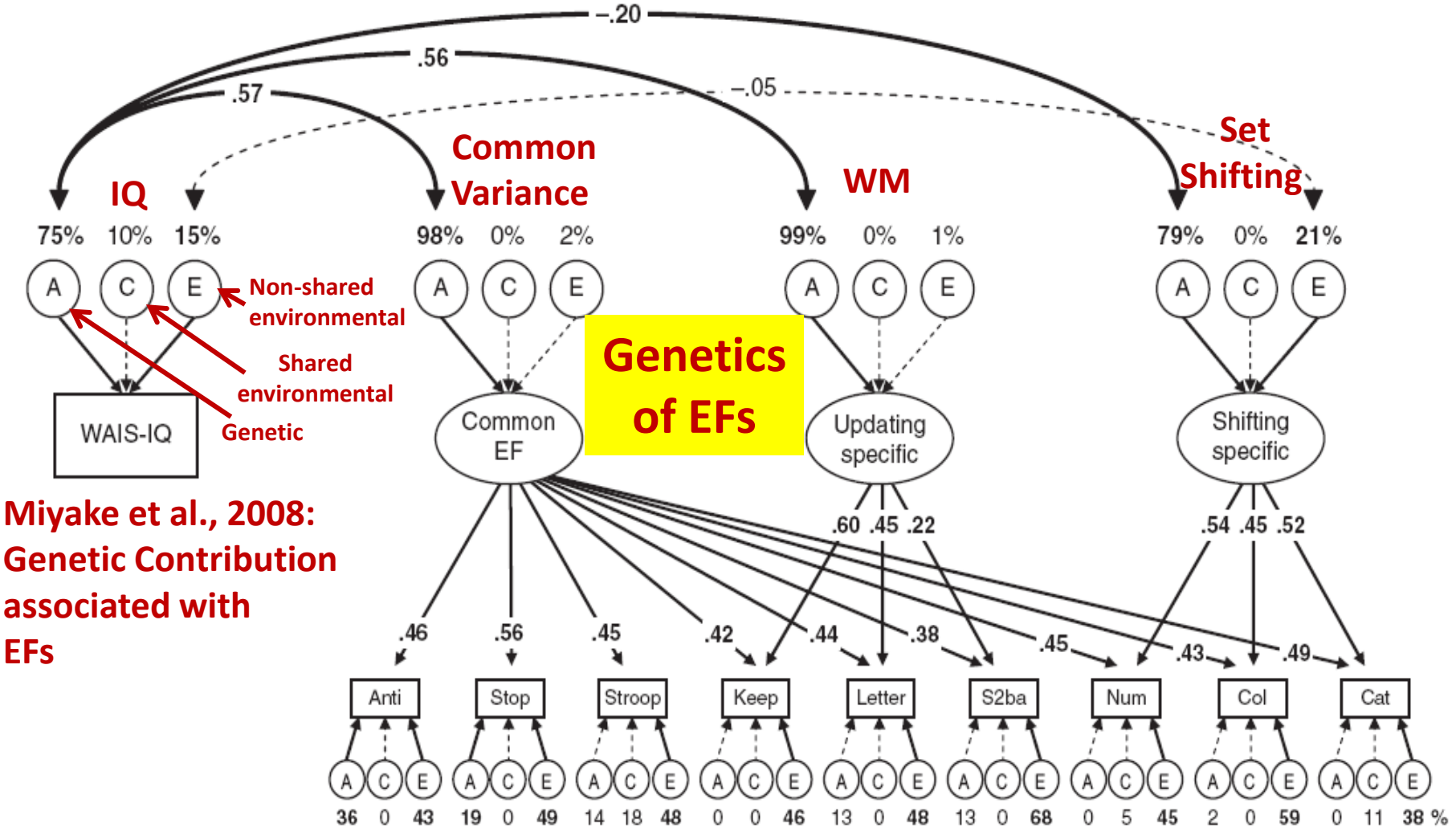


FIG. 2. The estimated three-factor model. Single-headed arrows have standardized factor loadings next to them. The loadings, all significant at the .05 level, are equivalent to standardized regression coefficients (beta weights) estimated with maximum likelihood estimation. The numbers at the ends of the smaller arrows are error terms. Squaring these terms gives an estimate of the variance for each task that is not accounted for by the latent construct. The curved, double-headed arrows have correlation coefficients next to them and indicate significant correlations between the latent variables.

Supports a domain general executive controller

1
Lehto et al. (2003): replicated factor structure in 8-13 year old children

2
Huizinga et al. (2006): WM & set shifting are developmentally contiguous between 7 & 21 years of age

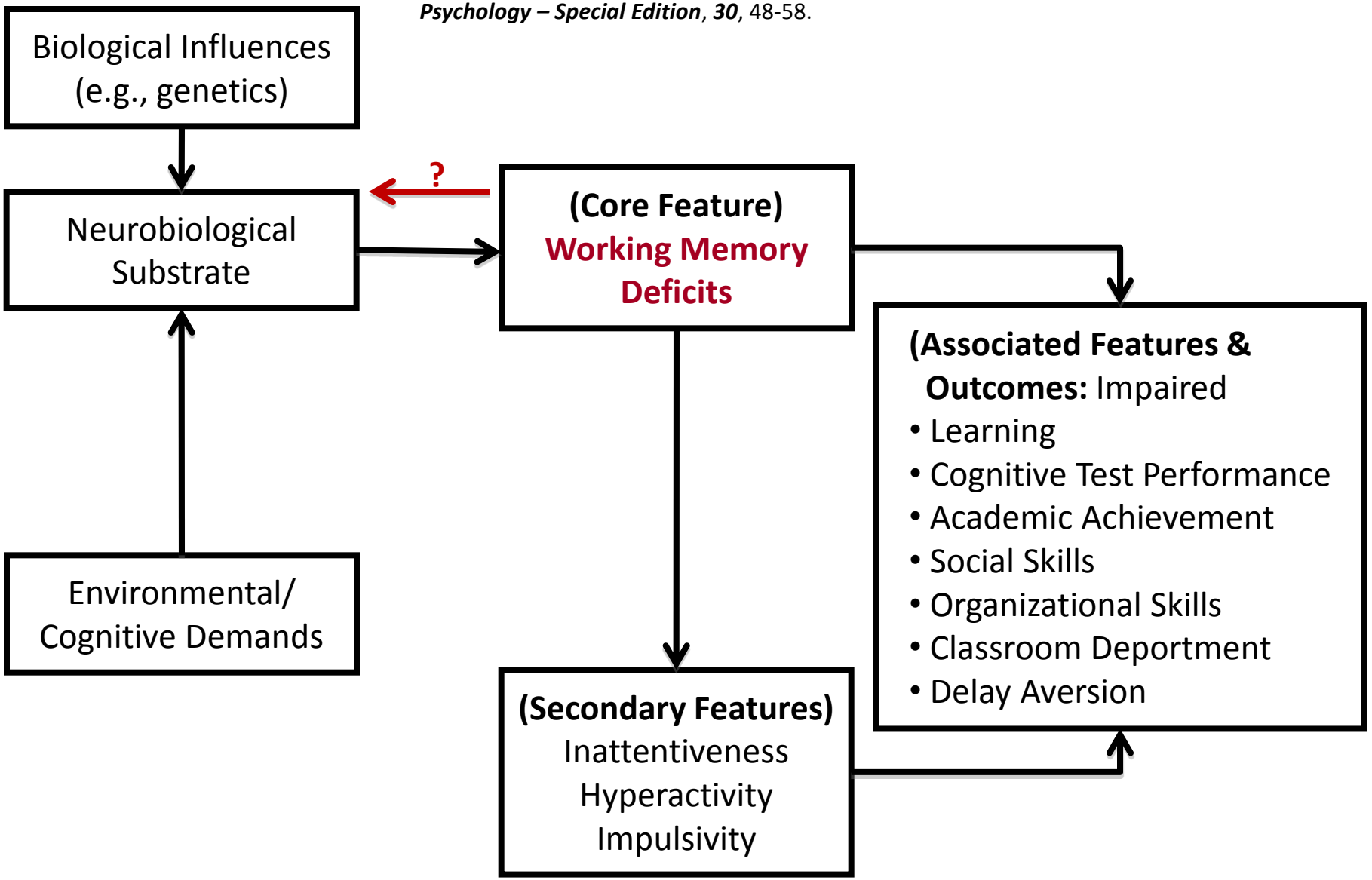


Miyake et al., 2008: Genetic Contribution associated with EFs

Figure 7. Nested factors executive function model with Wechsler Adult Intelligence Scale full-scale IQ (WAIS–IQ). Numbers above the ACEs for the latent variables and WAIS–IQ are the percentages of those variables accounted for by genetic and environmental influences. Numbers occluding the double-headed arrows are correlation coefficients. Correlations for components with zero or near-zero variance were not estimated. Numbers occluding arrows are standardized factor loadings. Numbers under the lower ACEs are estimates for task-specific variances. Boldface type and solid lines indicate $p < .05$. Anti = antisaccade; stop = stop signal; keep = keep track; letter = letter memory; S2ba = spatial 2-back; num = number–letter; col = color–shape; cat = category switch.

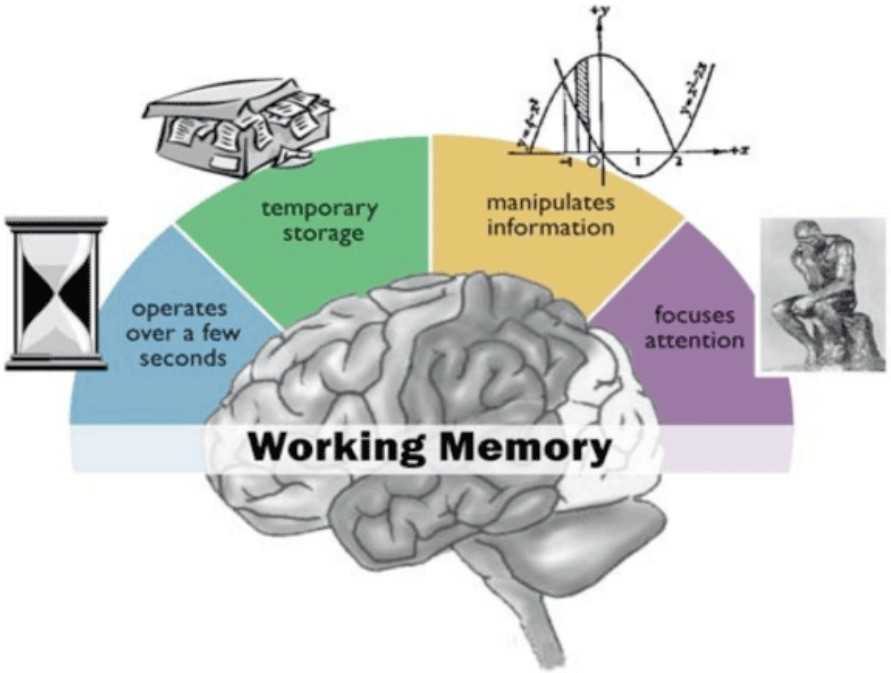
Functional Working Memory Model of ADHD

Rapport, M.D., Chung, K.M., Shore, G., & Isaacs, P. (2001). ***Journal of Clinical Child Psychology – Special Edition***, ***30***, 48-58.



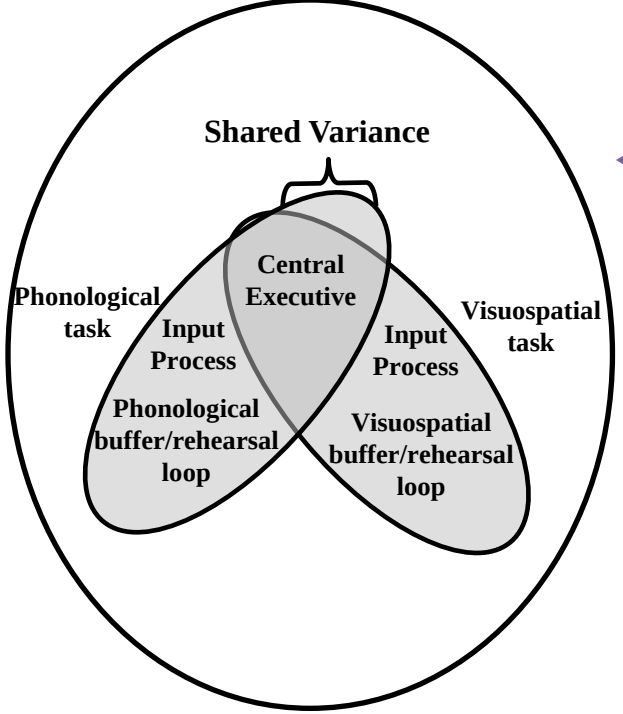
What is Working Memory?

– Working memory is a limited capacity system that enables individuals to store briefly and process information (Baddeley, 2007).



http://usablealgebra.landmark.edu/wp-content/uploads/2008/12/working-memory-2.gif

Alan Baddeley's (2007) WM Model



Domain General

Central Executive

Auditory Input

Visual Input

Visual Input

Phonological Analysis

Visual analysis & STS

Visuospatial Analysis

Phonological

STS

Inferior parietal lobe

Orthographic to phonological recoding

Visuospatial

STS

Right hemisphere

Rehearsal Process

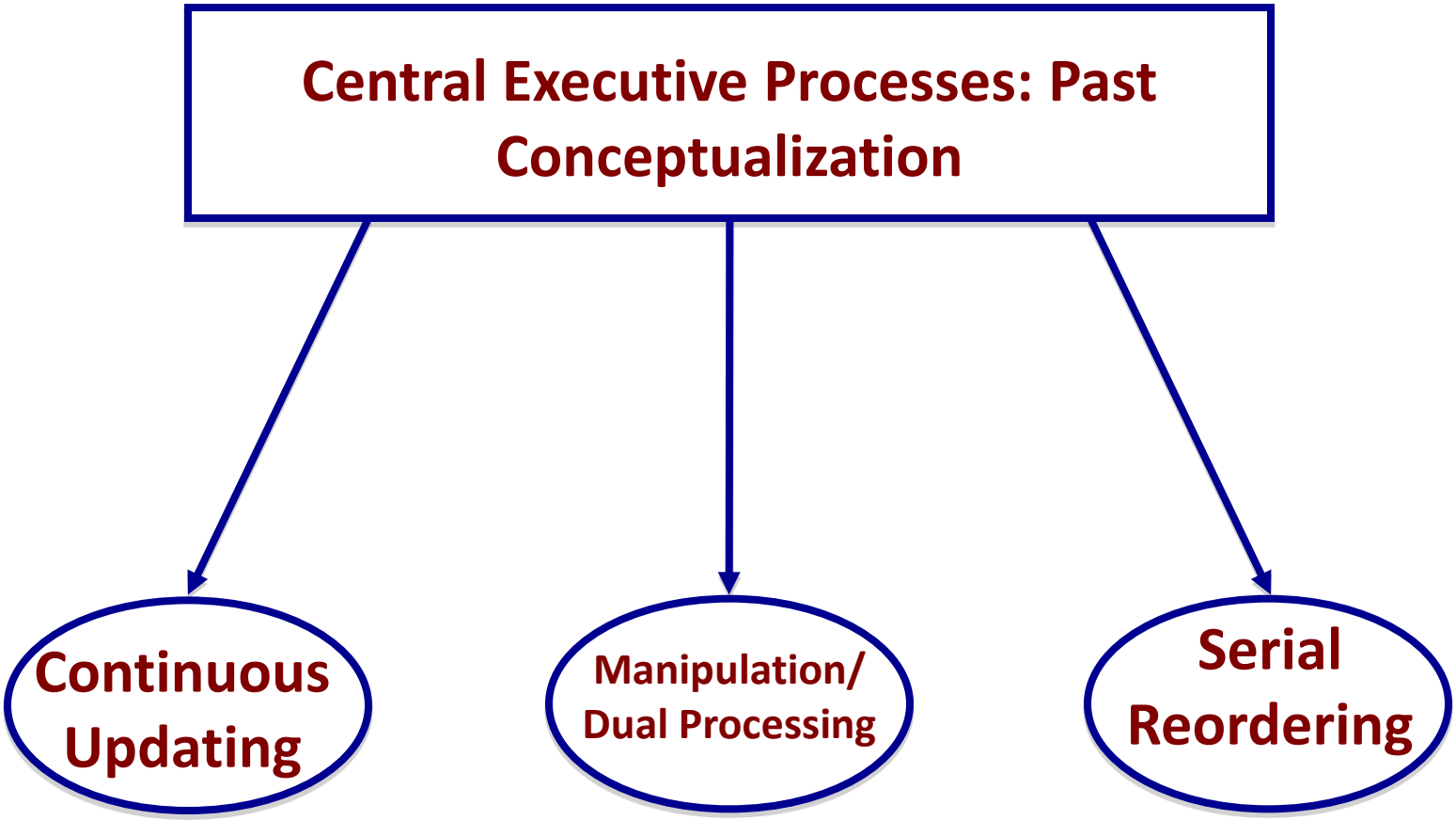
Rehearsal Process

Phonological output buffer
Broca's area-premotor cortex

Visuospatial output buffer
Right premotor cortex

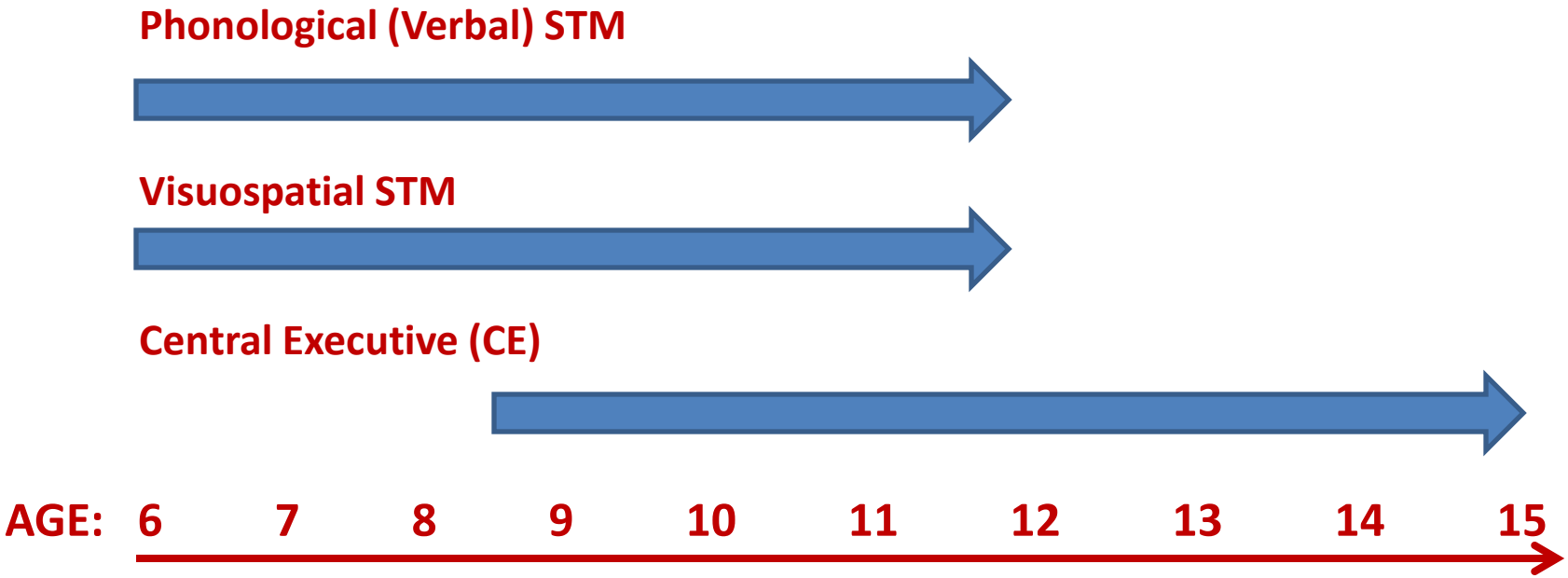
Spoken Output

Motor Output



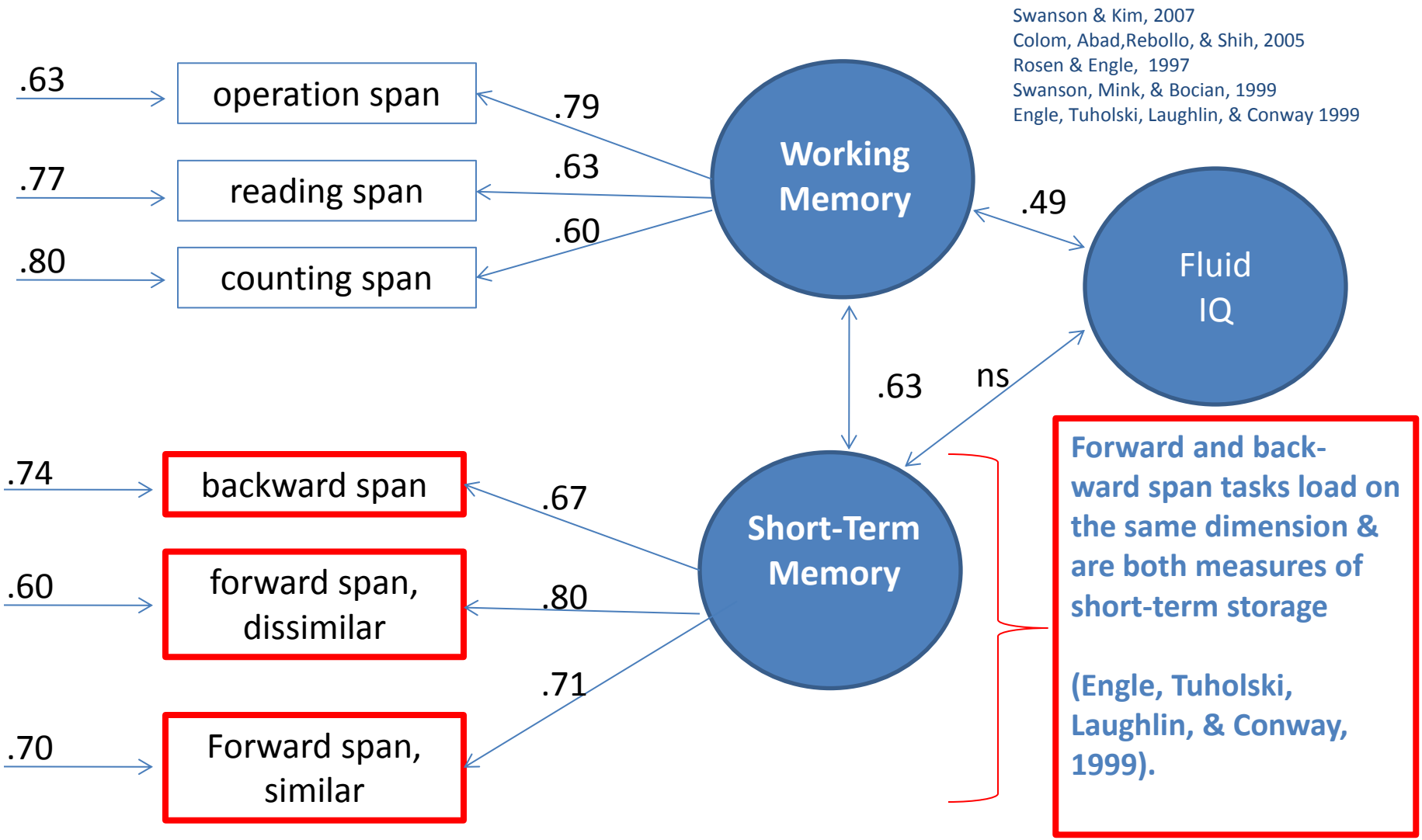
[Baddeley, 2007]

Development of Working Memory in Children: Peak Developmental Periods



Tillman et al. (2011). *Developmental Neuropsychology, 36*, 181-198

Forward and Backward Span Tasks



Journal of Experimental Psychology: General
1999, Vol. 128, No. 3, 309–331

0096-3445/99/$3.00

Working Memory, Short-Term Memory, and General Fluid Intelligence: A Latent-Variable Approach

ENGLE, TUHOLSKI, LAUGHLIN, AND CONWAY

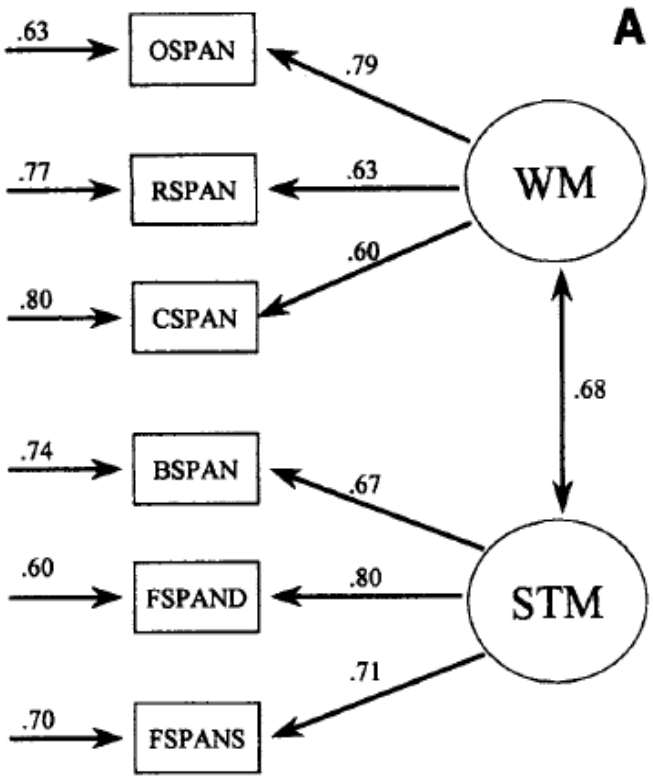


Figure 2. (a) Path model for two-factor model (A_1). All paths are significant at the .05 level. (b) Path model for two-factor model with additional tasks (B_2). Paths significant at the .05 level are indicated by solid lines. OSPAN = operation span; RSPAN = reading span; CSPAN = counting span; BSPAN = backward span; FSPAND = forward span, dissimilar; FSPANS = forward span, similar; KTRACK = keeping track; IFRSM = Immediate Free Recall Secondary Memory; CONTOP = continuous opposites; WM = working memory; STM = short-term memory.

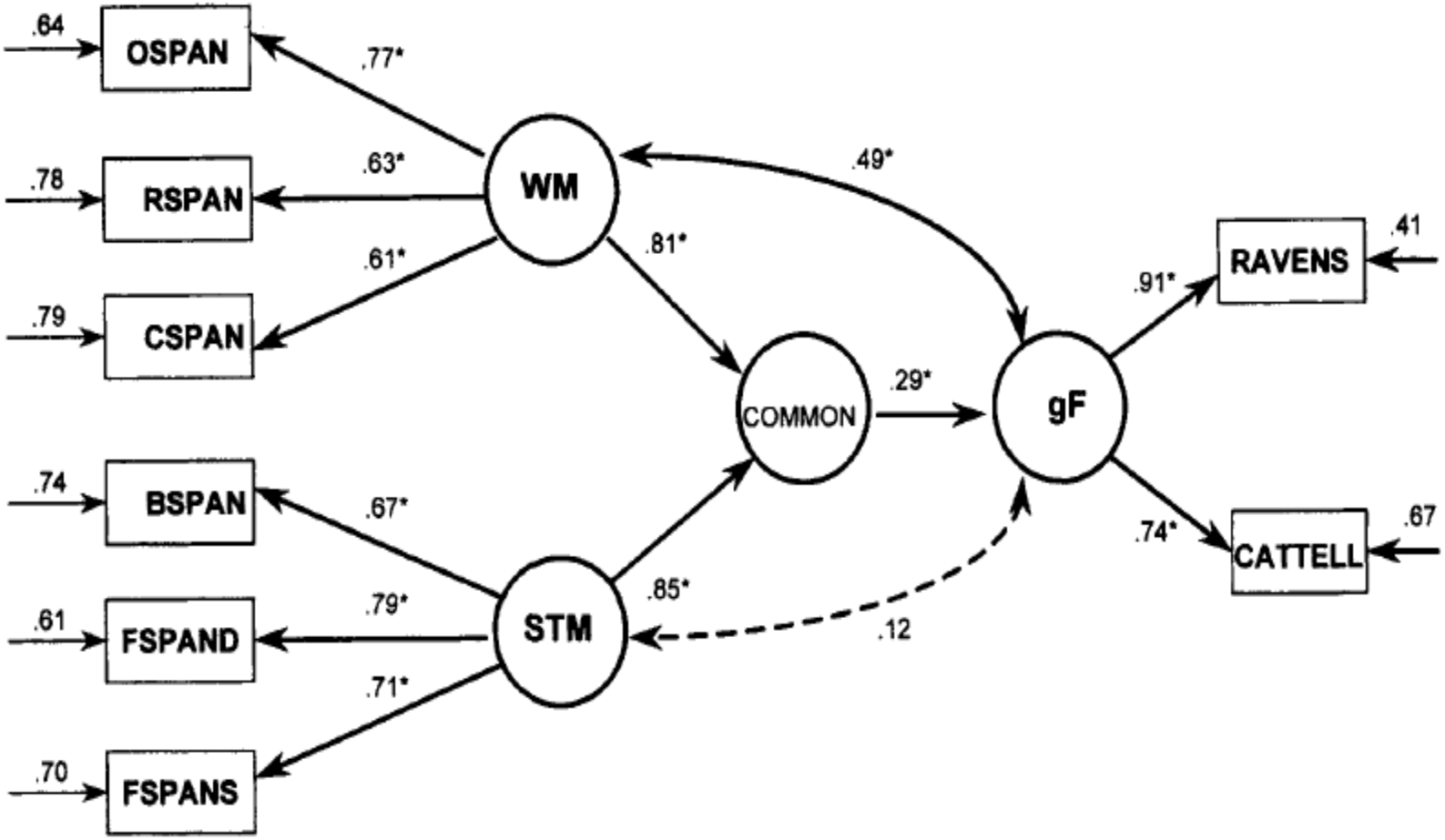
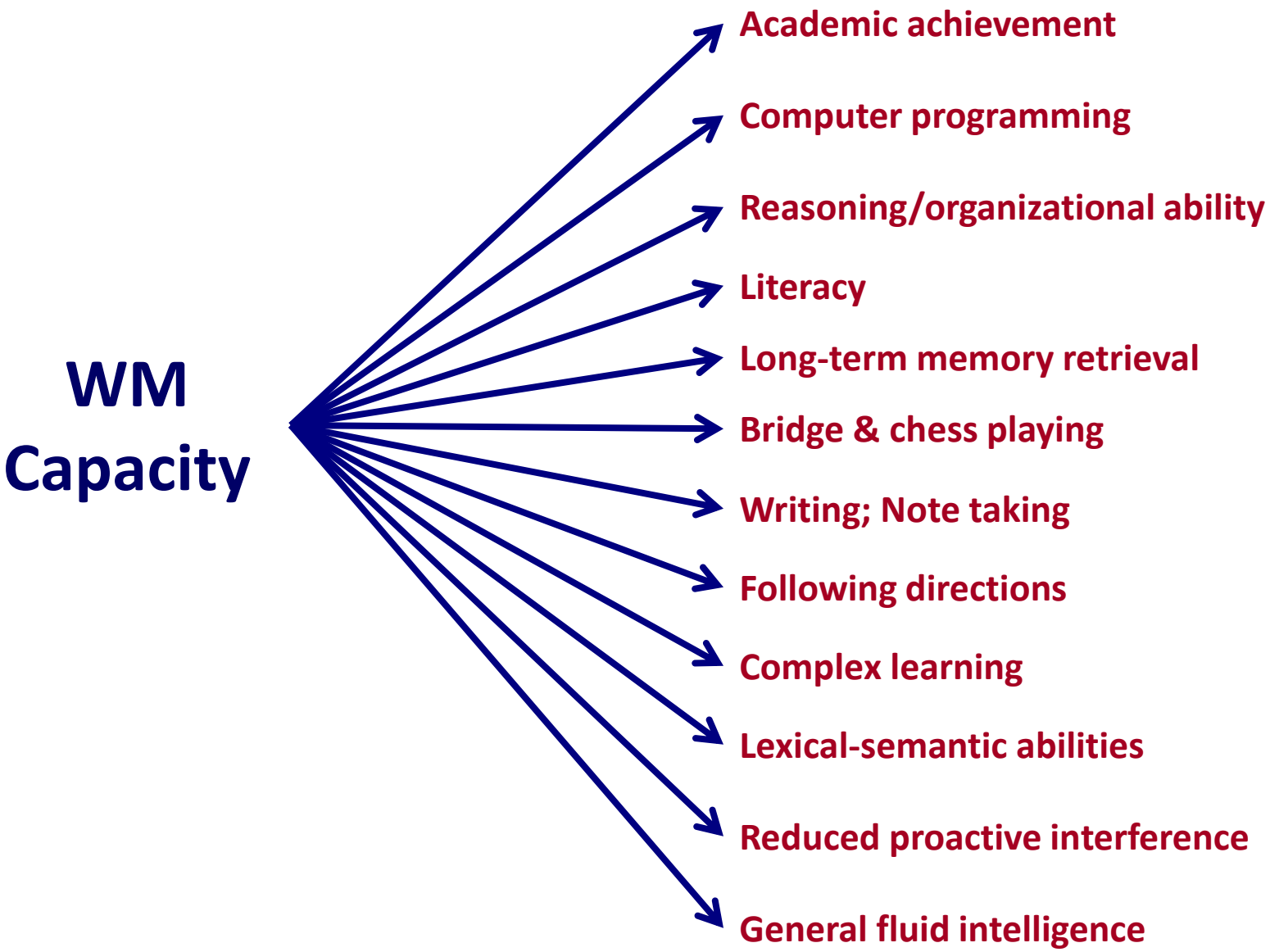
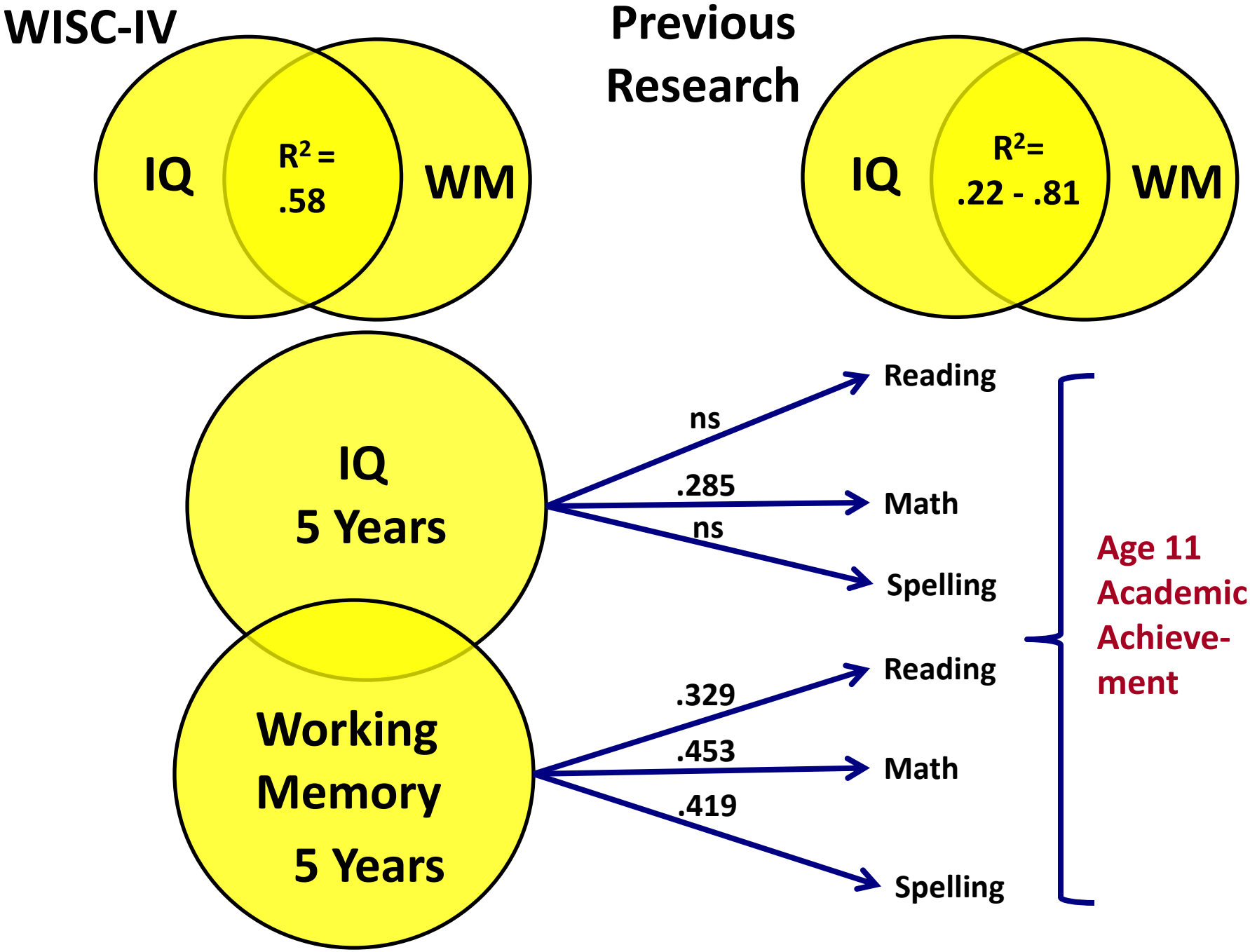


Figure 4. Path model for Model D. Significant paths are indicated by an asterisk. OSPAN = operation span; RSPAN = reading span; CSPAN = counting span; BSPAN = backward span; FSPAND = forward span, dissimilar; FSPANS = forward span, similar; WM = working memory; STM = short-term memory; *gF* = fluid intelligence.

Higher –order cognitive tasks, skills, and abilities dependent on working memory components

Central Executive	Phonological Storage/Rehearsal	Visuospatial Storage/Rehearsal
• General fluid intelligence		
• Verbal and visual reasoning	• Verbal reasoning	• Visual reasoning
• Vocabulary learning	• Vocabulary learning	• Speech production
• Literacy	• Word recognition	
• Arithmetic		
• Reading comprehension		
• Listening comprehension		
• Ability to follow directions		
• Note taking		
• Writing		
• Bridge playing		
• Chess playing		
• Learning to program computers		
• Verbal achievement	• Verbal achievement	
• Math achievement	• Math achievement	• Math achievement
• Lexical-semantic abilities		
• Orthographic abilities	• Phonological/ syntactic abilities	
• Complex learning		
• Motor activity		
• Attentive behavior	• Attentive behavior	• Attentive behavior


WM Capacity
Academic achievement
Computer programming
Reasoning/organizational ability
Literacy
Long-term memory retrieval
Bridge & chess playing
Writing; Note taking
Following directions
Complex learning
Lexical-semantic abilities
Reduced proactive interference
General fluid intelligence



Alloway and Gathercole, 2008 (Nature)

Working memory impairments in children with ADHD

	WM Systems		WM Components		
	VS Working Memory	PH Working Memory	VS Storage/ Rehearsal	PH Storage/ Rehearsal	CE
Meta-analyses					
Martinussen et al. (2005)	--	--	0.85	0.47	0.43-1.06
Willcutt et al. (2005)	0.63	0.55	--	--	--
Brocki et al. (2008)	0.60	0.85	--	--	--
Martinussen & Tannock, (2006)	--	--	0.70	0.04	0.60-1.10
Marzocchi et al. (2008)	1.00	--	0.74	--	

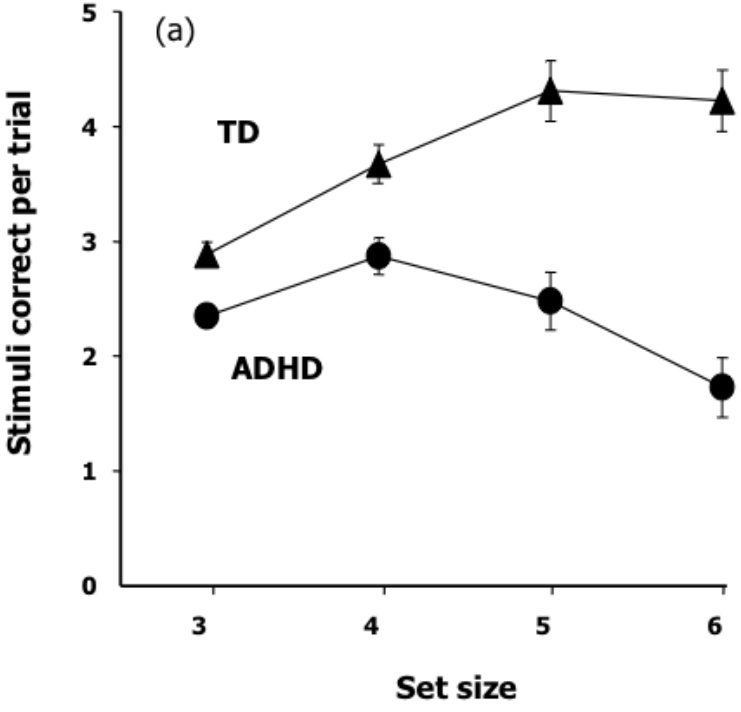
Trends: (a) Deficits in both systems/all three subcomponents
(b) Deficits in CE > VS > PH

Participants and Inclusion Criteria

- **Diagnostic Procedures**
  - **Extensive child histories (pre, pari, post-natal; early developmental; medical; educational; psychiatric; parent/family)**
  - **K-SADS Semi-Structured Clinical Interview, Lifetime Version [parent and child interviewed separately]**
- **Parent Rating Scales [ADHD factor in clinical range; DSM criteria]**
  - **Child Symptom Inventory – 4 Parent Form (DSM-IV criteria)**
  - **Child Behavior Checklist – Parent Form (ADHD factor in clinical range)**
- **Teacher Rating Scales [ADHD factor in clinical range; DSM criteria]**
  - **Child Symptom Inventory – 4 Teacher Report Form (DSM-IV criteria)**
  - **Child Behavior Checklist – Teacher Report Form (TRF)**

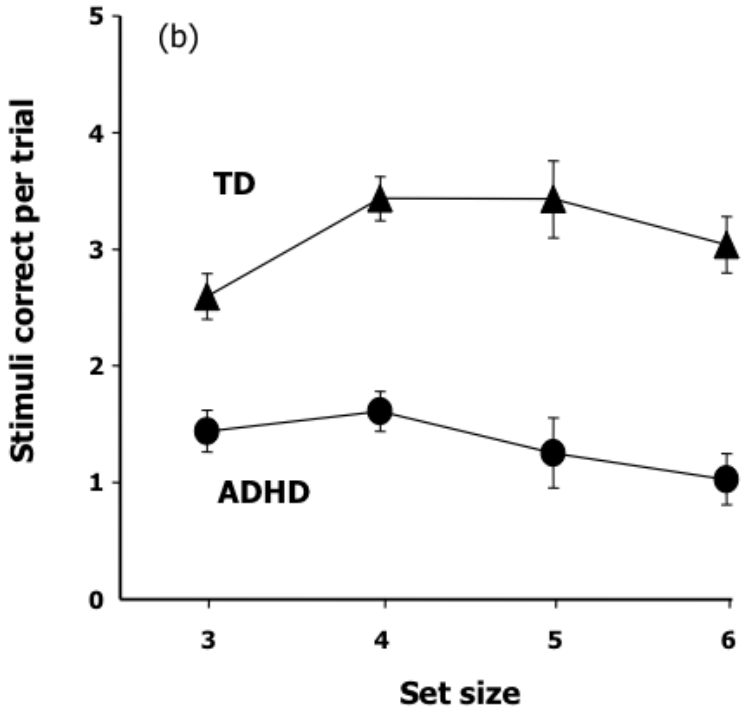
Phonological and Visuospatial WM Deficits in boys with ADHD

ES = 1.89



Phonological WM

ES = 2.31

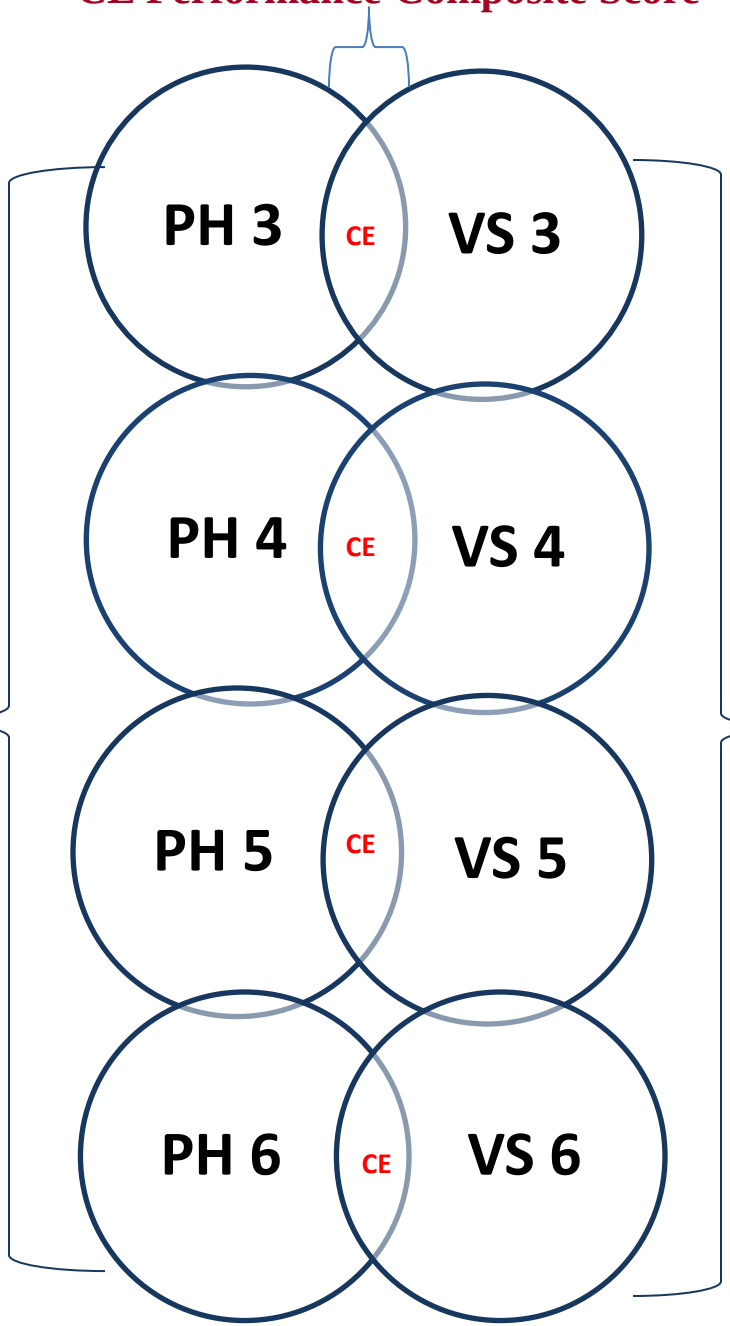


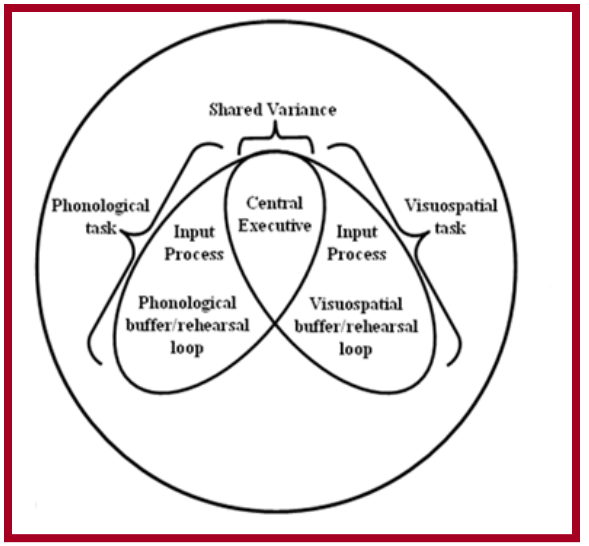
Visuospatial WM

Rapport, Alderson, Kofler, Sarver, Bolden, & Sims (2008).
***J of Abnormal Child Psychology*, *36*, 825-837.**

PH, VS, and CE Performance Composite Scores

CE Performance Composite Score





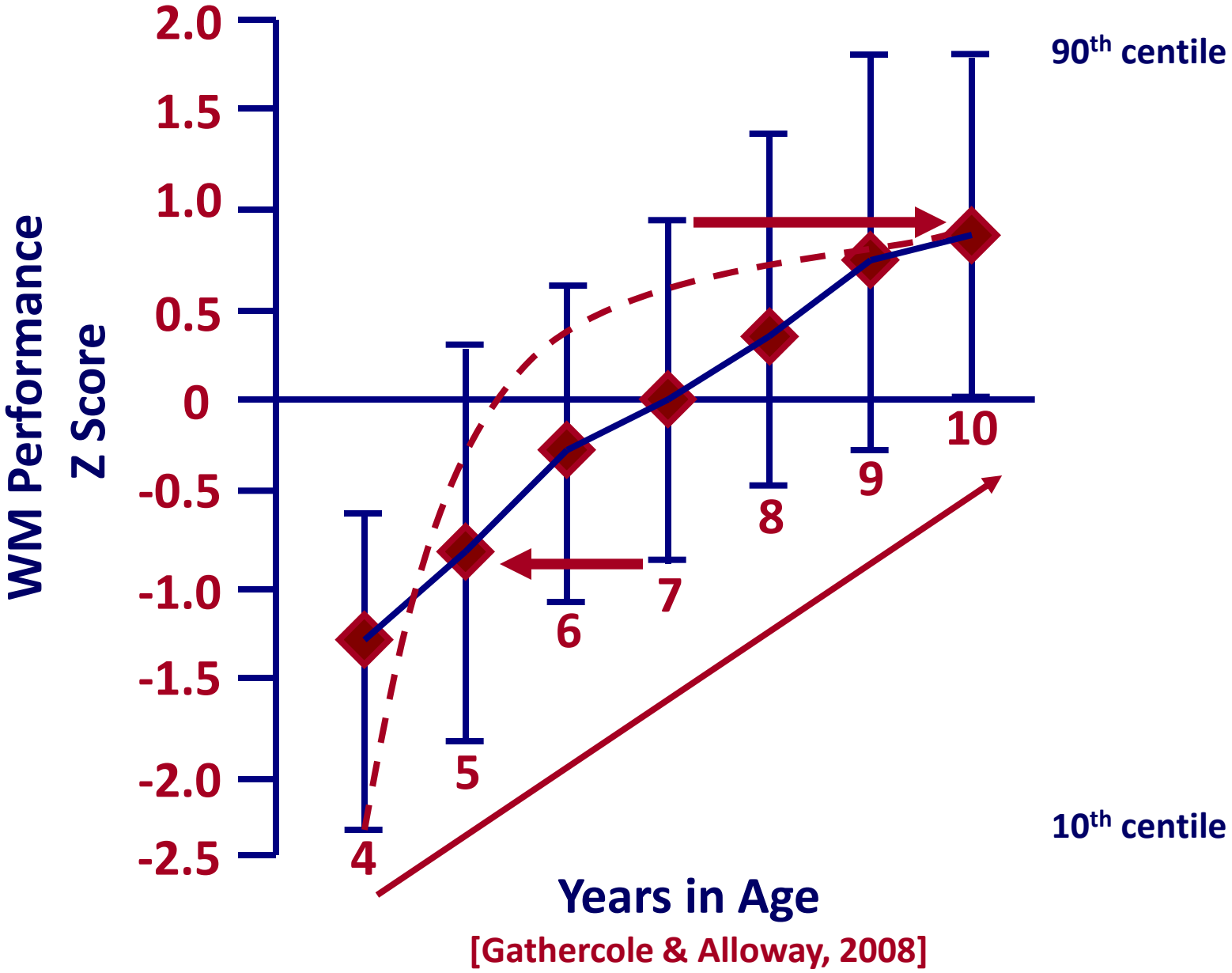
CE ES = 2.76

PH Storage/Rehearsal Performance Composite Score

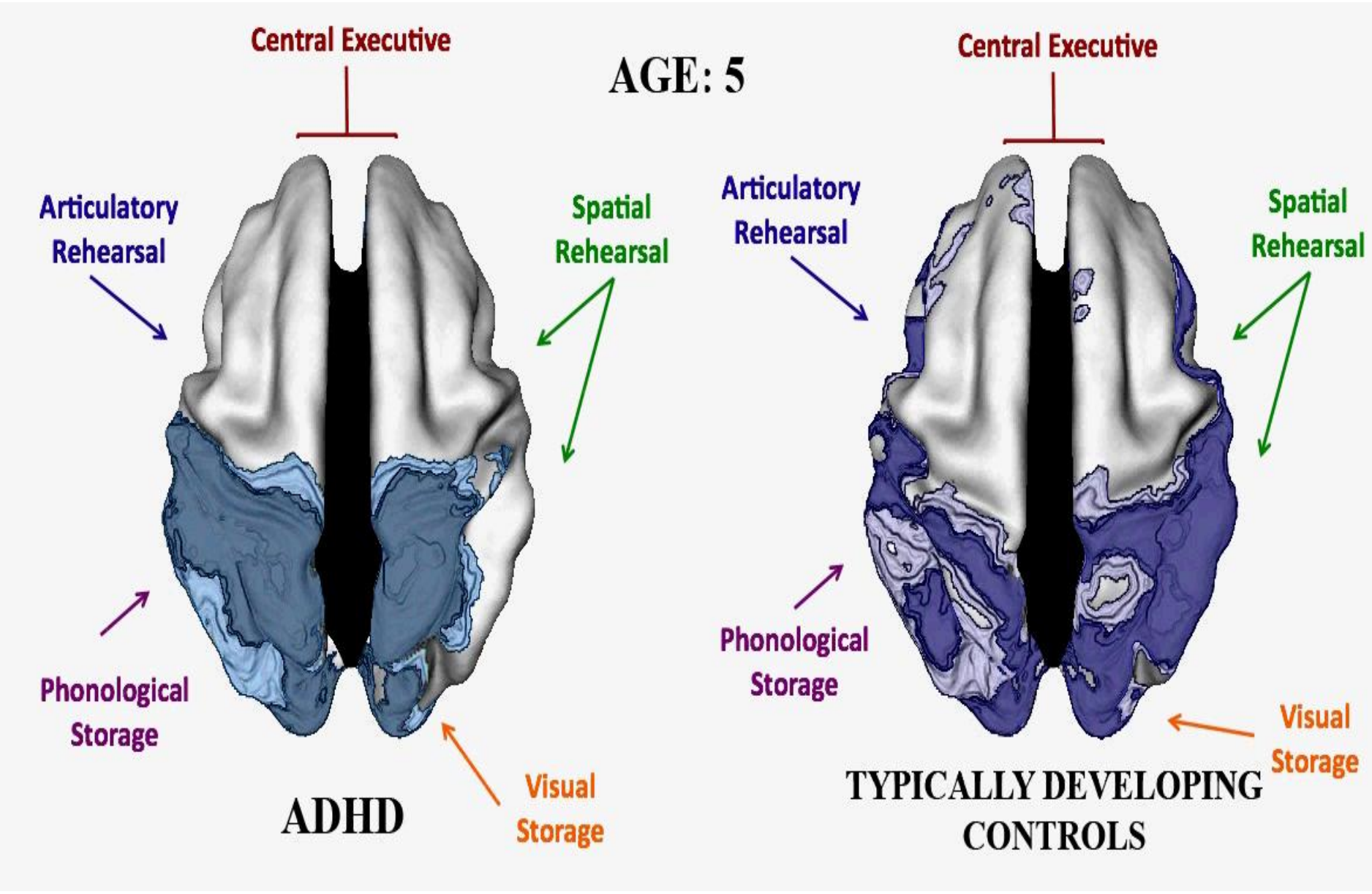
PH ES = .55
[1.89 w/CE]

VS Storage/Rehearsal Performance Composite Score

VS ES = .89
[2.31 w/CE]



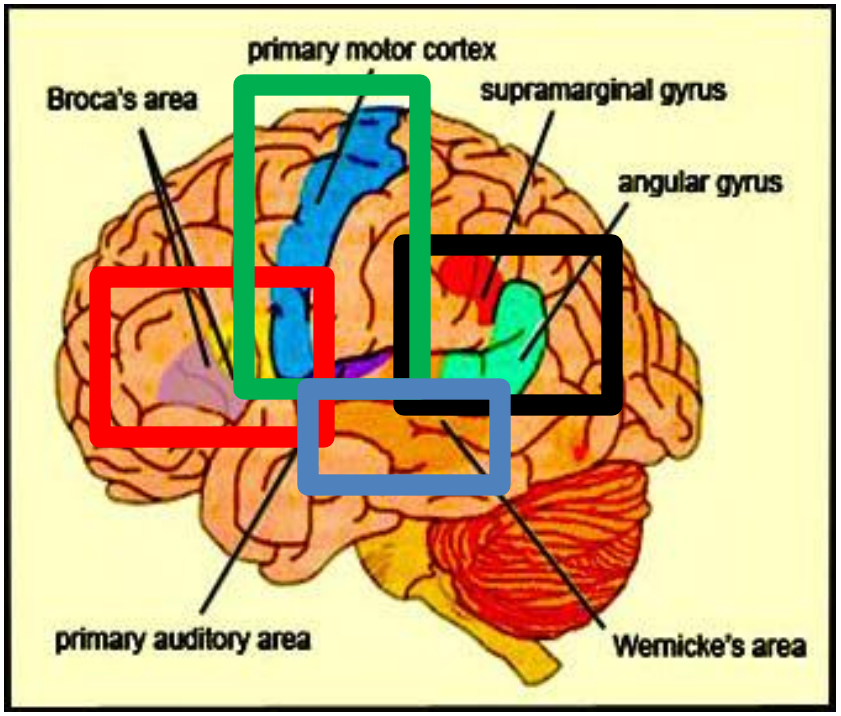
[Gathercole & Alloway, 2008]


AGE: 5
Central Executive
Articulatory Rehearsal
Spatial Rehearsal
Phonological Storage
Visual Storage
ADHD
Central Executive
Articulatory Rehearsal
Spatial Rehearsal
Phonological Storage
Visual Storage
TYPICALLY DEVELOPING CONTROLS

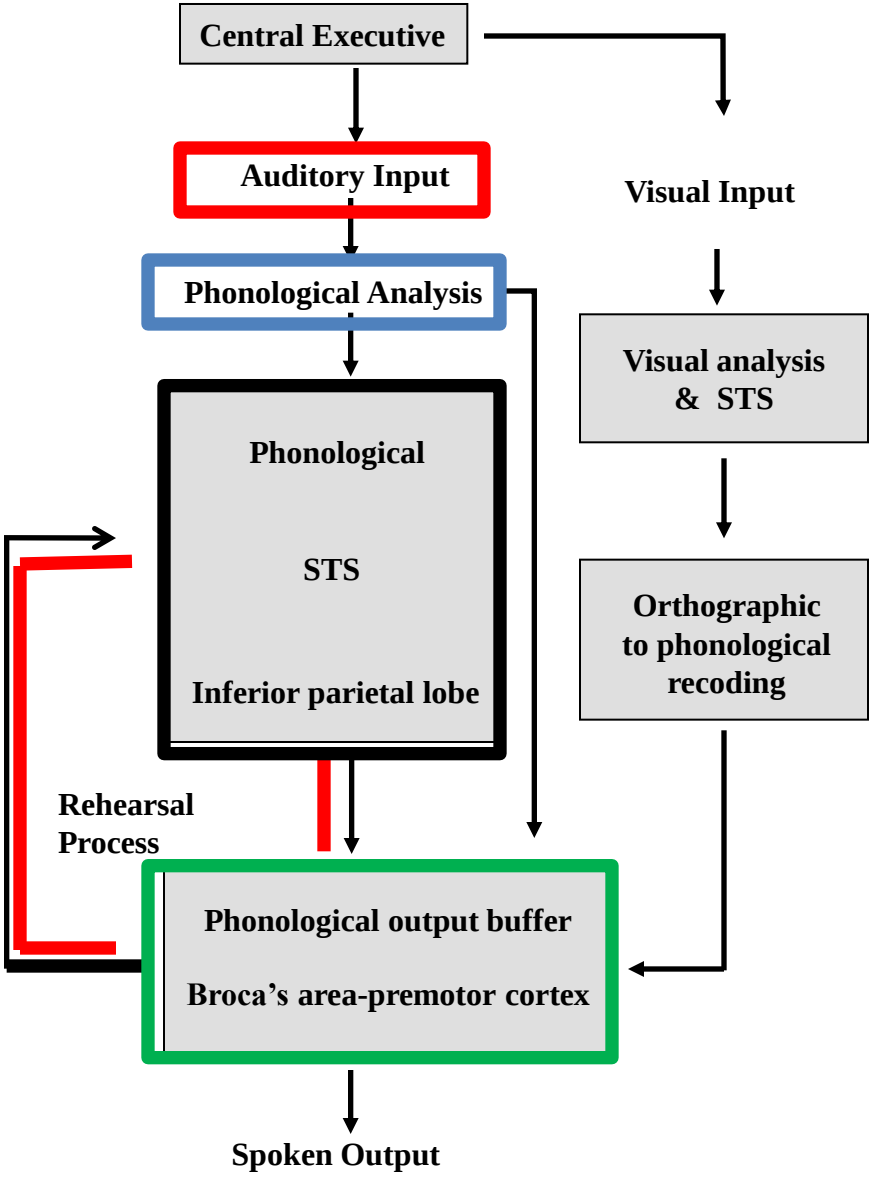
To what extent do WM related phonological (PH) deficits reflect short-term storage as opposed to articulatory (covert) rehearsal deficiencies?

Bolden, J., Rapport, M.D., Raiker, J.S., Sarver, D.E., & Kofler, M.J. (2012). Understanding Phonological Memory Deficits in Boys with Attention-Deficit/Hyperactivity Disorder (ADHD): Dissociation of Short-term Storage and Articulatory Rehearsal Processes. *Journal of Abnormal Child Psychology, 40*, 999-1011.

Phonological Working Memory

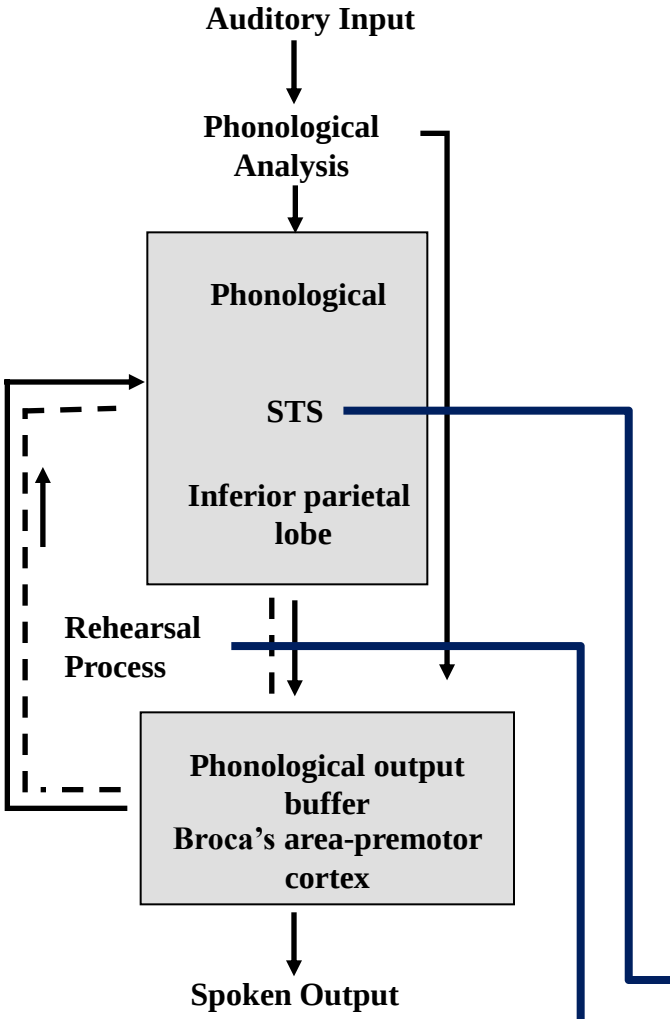


http://docsbrainblocks.com/images/dyslexia_1.jpg



Baddeley, 2007

Contribution of Phonological Processing to other abilities



Language Processing (Adams & Gathercole, 1995)

Math Achievement (Gathercole, Alloway, Willis, & Adams, 2006)

Reading Decoding and Reading Comprehension (Swanson & Howell, 2001)

Understanding Classroom Instructions (Gathercole & Alloway, 2008)

Left, temporo-parietal cortex (Jonides et al., 1998)

Left, prefrontal region (Broca's area) Awh et al., 1996; Smith & Jonides, 1999)

Phonological Memory Task

Presentation Phase

2-Words
4-Words
6-Words

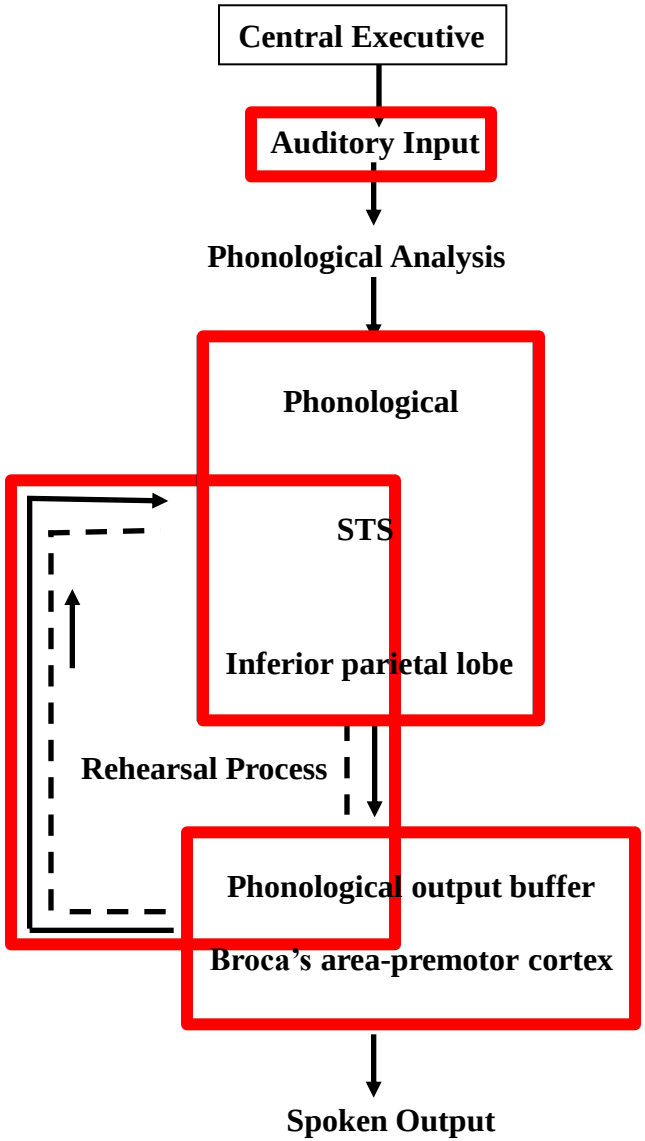
Storage/Rehearsal

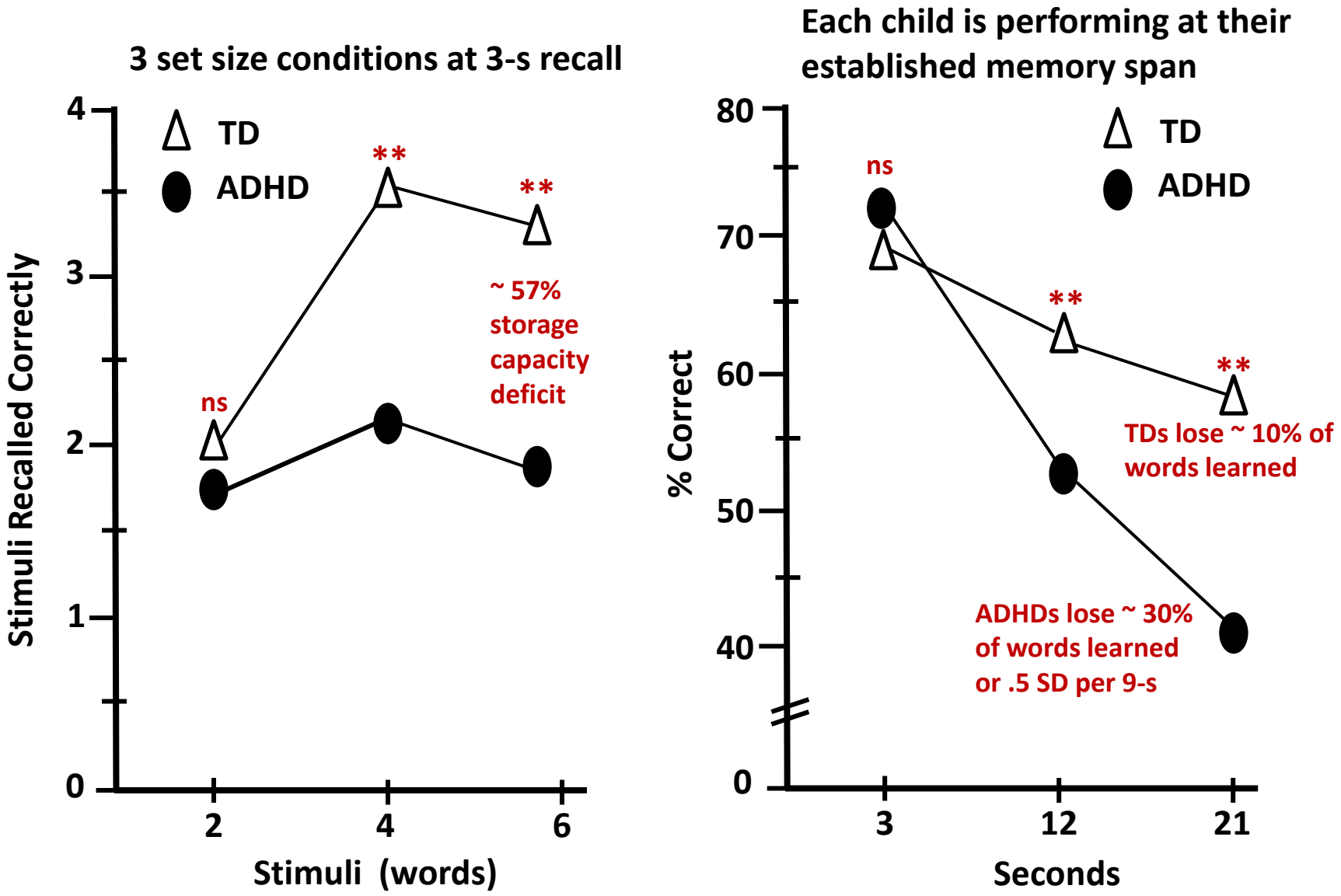
3-seconds delay
12-seconds delay
21-seconds delay

Recall Phase

21 distinct trials at each list length

List length set based on each child's span



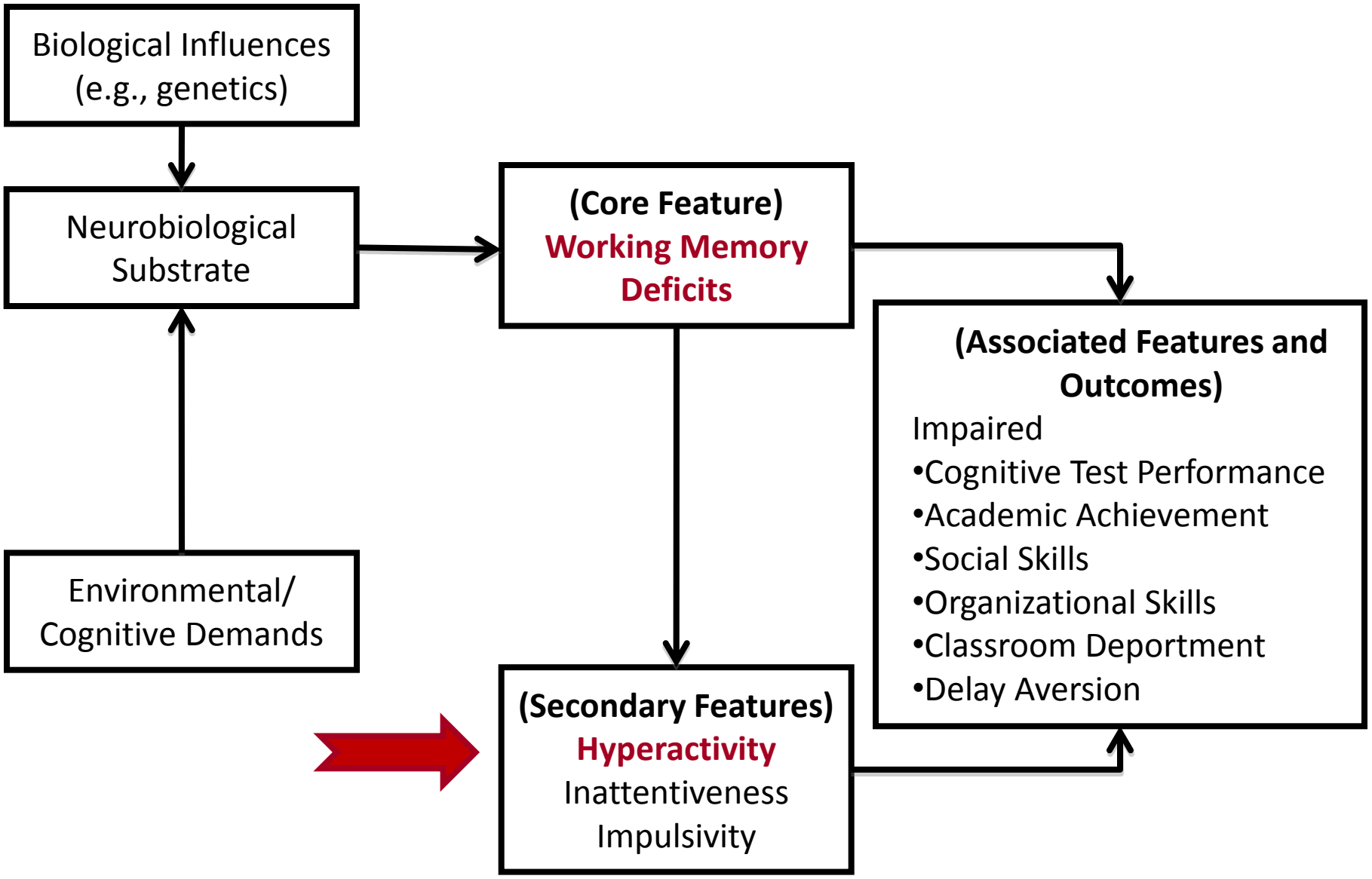


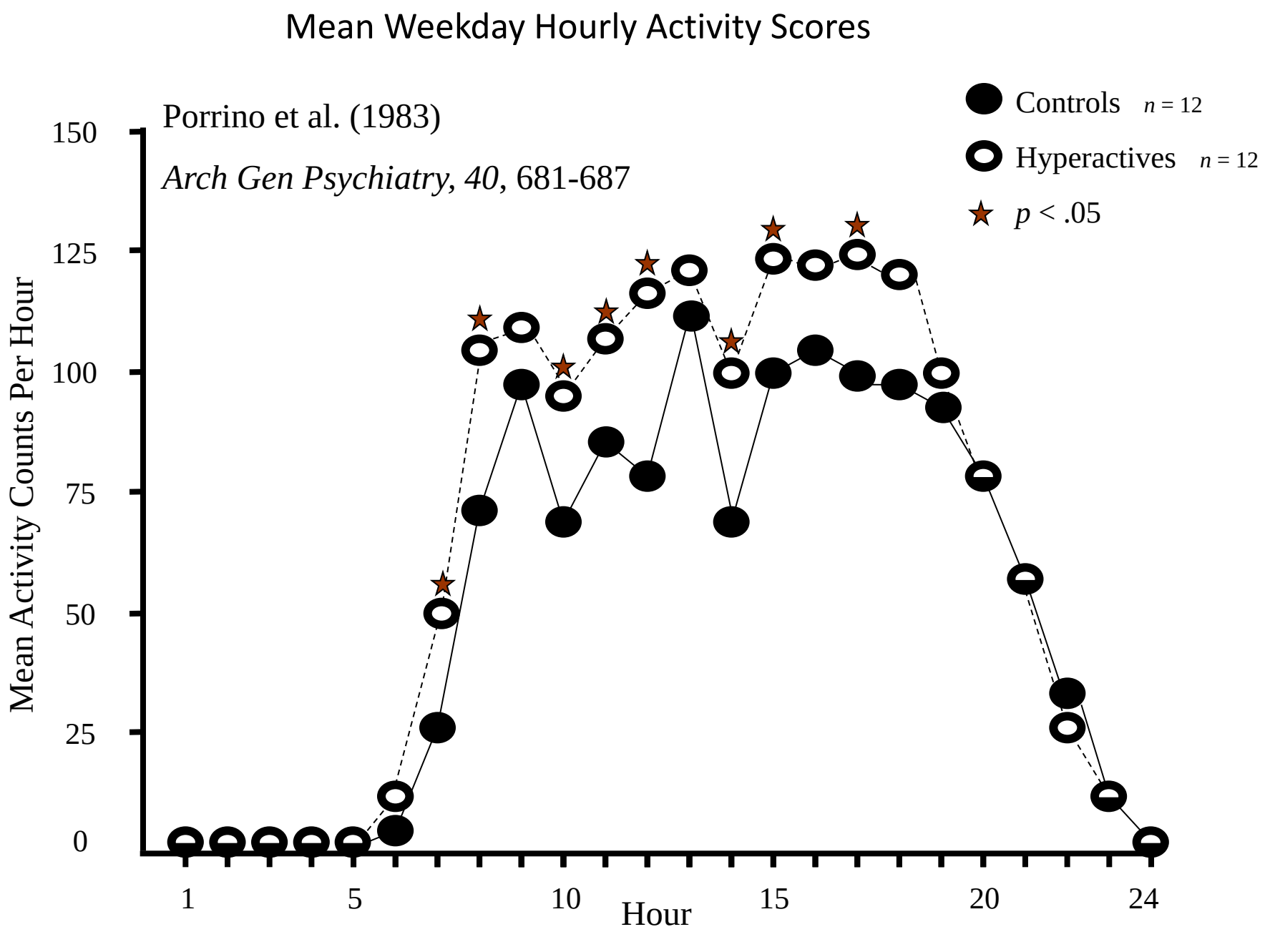
Short-term storage capacity ES = 1.15 to 1.98
Articulatory rehearsal ES = .47 to 1.02

Are components of working memory functionally related to hyperactivity?

Rapport, M.D., Bolden, J., Kofler, M.J., Sarver, D.E., Raiker, J.S., Alderson, R.M. (2009). Hyperactivity in Boys with Attention-Deficit/Hyperactivity Disorder (ADHD): A Ubiquitous Core Symptom or Manifestation of Working Memory Deficits? *Journal of Abnormal Child Psychology*, *37*, 521-534.

Working Memory Model of ADHD




Mean Weekday Hourly Activity Scores
Porrino et al. (1983)
Arch Gen Psychiatry, 40, 681-687
Controls n = 12
Hyperactives n = 12
p < .05
Mean Activity Counts Per Hour
150
125
100
75
50
25
0
1
5
10
15
20
24
Hour

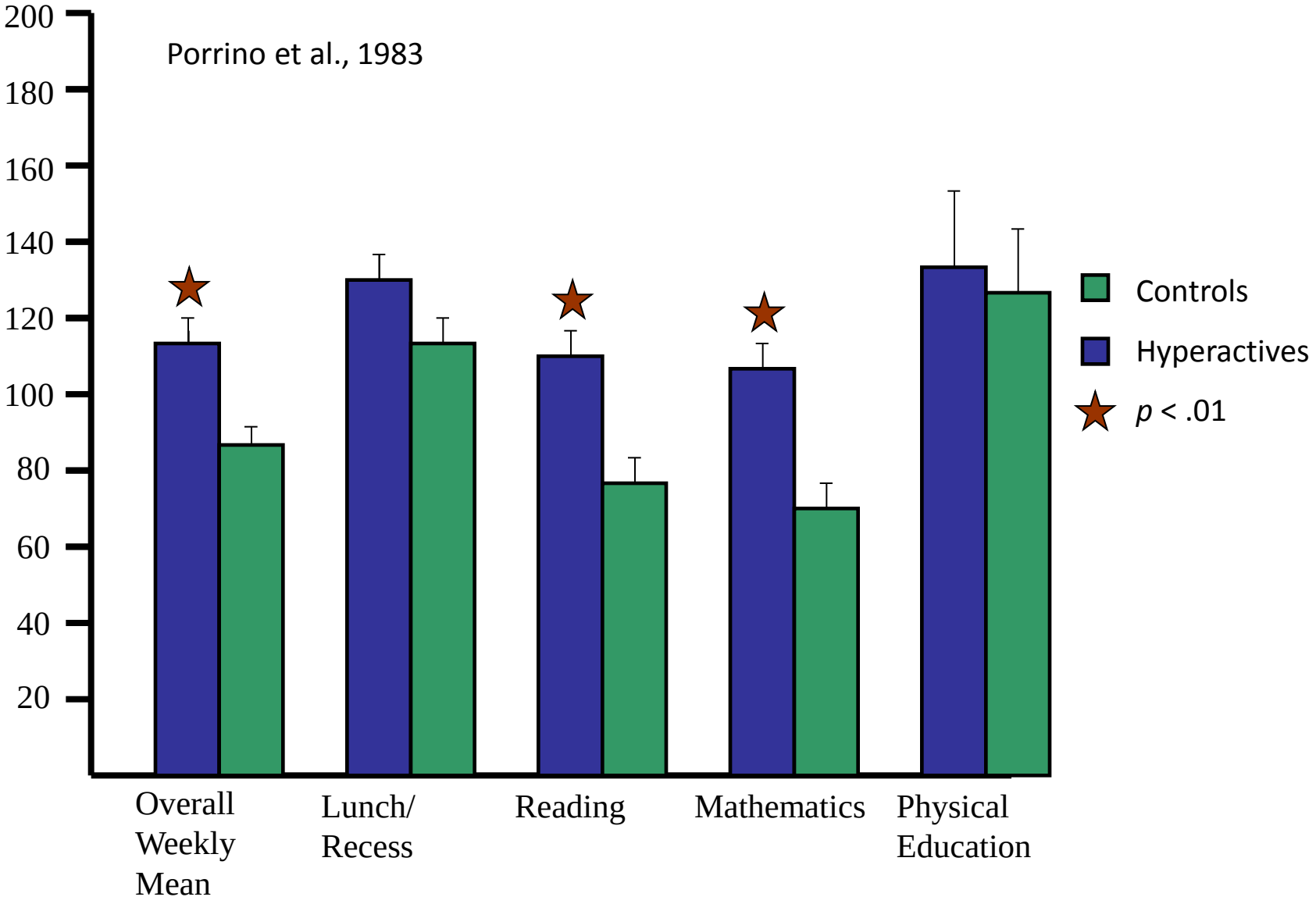
“Little evidence was found, however, to support the hypothesis that hyperactivity is simply an artifact of the structure and attentional demands of a given setting.” p.681

“… a substantial ubiquitous increase in simple motor behavior is a clear characteristic of this group.” p. 685

“In a variety of situations with differing degrees of structure and attentional demand, hyperactives showed consistently higher levels of motor movement than did their normal controls.” p. 686

Porrino et al. (1983). *Archives of General Psychiatry, 40*, 681-687.

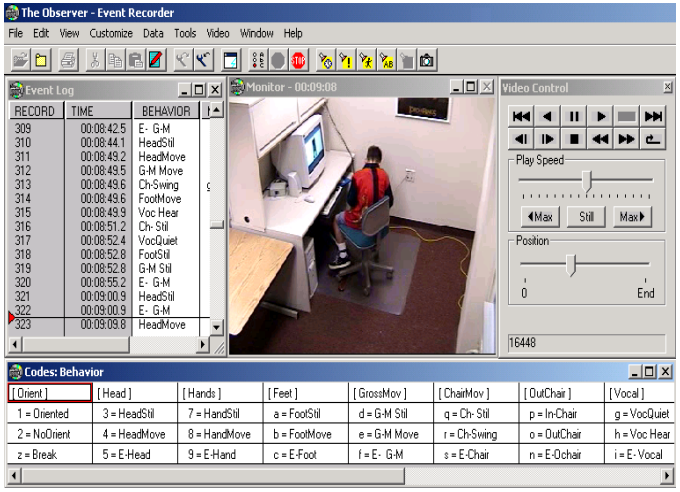
Mean Hourly Activity Scores During the Week



DEPENDENT MEASURES AND TECHNIQUES

ACTIGRAPHS

- Ambulatory Monitoring, Inc. MicroMini Motionlogger®
- SETTING: Low PIM Mode [intensity of movement] [Proportional Integrating Measure]
- SAMPLING RATE = 16 samples per second collapsed into 1-minute epochs
- Placement: both ankles; non-dominant wrist

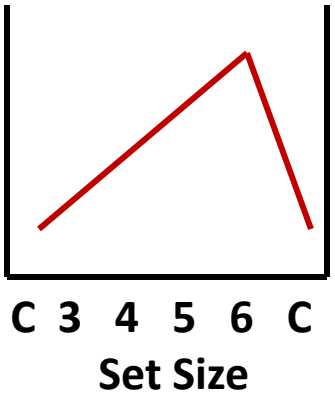


Experimental Design

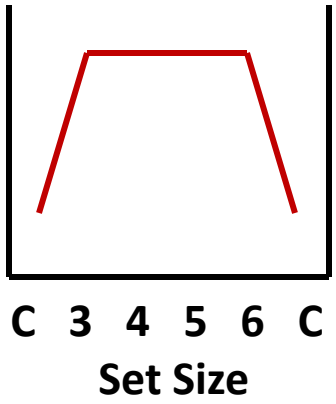
- Phonological WM (21 consecutive trials) at 4 set sizes (3, 4, 5, 6) [programmed using SuperLab 2.0]
- Visuospatial WM (21 consecutive trials) at 4 set sizes (3, 4, 5, 6) [programmed using SuperLab 2.0]
- All tasks administered in counterbalanced order across 4-week Saturday assessment sessions.

Primary Hypothesis

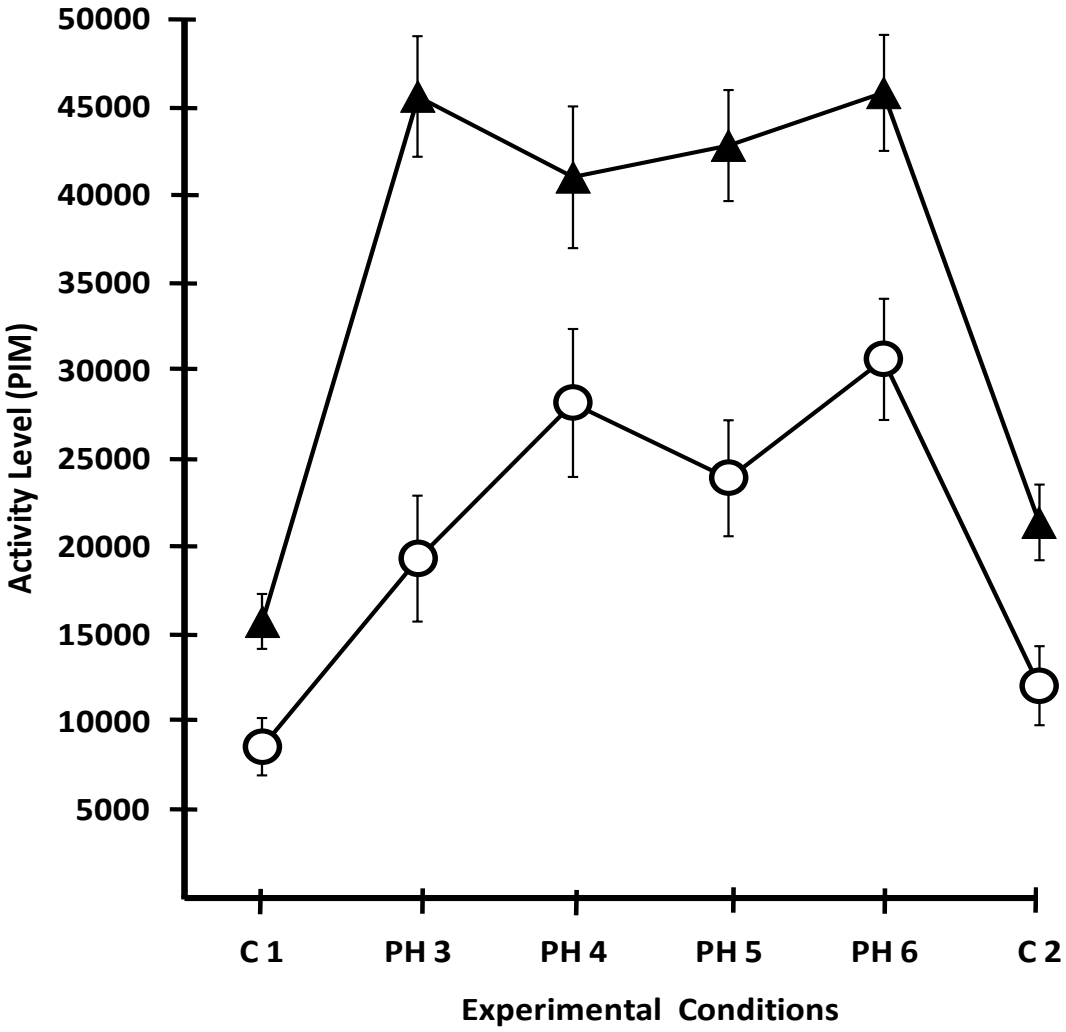
- If activity level is functionally related to PH/VS subsidiary system processes, we would expect movement to vary systematically as greater demands are imposed on the storage/rehearsal systems.



- If activity level is functionally related to Central Executive processes, we would expect movement to increase from control (minimal CE or storage demands) to WM demand conditions, but not vary between set size conditions because no additional demands are placed on the CE when only the number of stimuli increase (i.e., no additional processing demands are imposed).



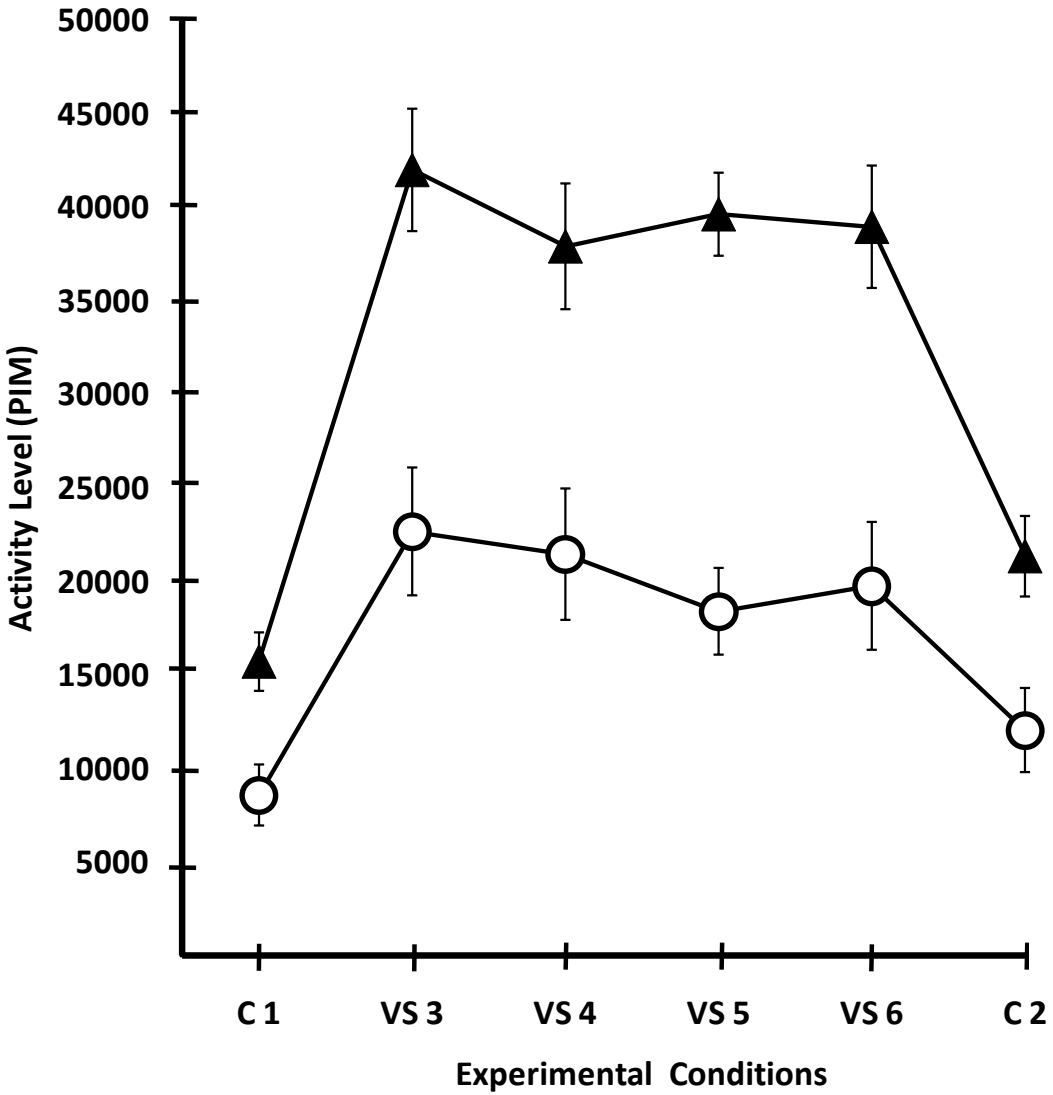
Activity Level Assessed During the PH and Control Conditions



Computation of Hedges' g indicated that the average magnitude difference between children with ADHD and TD children was 1.49 standard deviation units (range: 0.93 to 2.10).

Total extremity activity level (right foot, left foot, and non-dominant hand) expressed in PIM (Proportional Integrated Measure) units for children with ADHD (*triangles*) and typically developing children (*circles*) under control (C1, C2) and four phonological set size (PH 3, 4, 5, 6) working memory task conditions. *Vertical bars* represent standard error.

Activity Level Assessed During the VS and Control Conditions

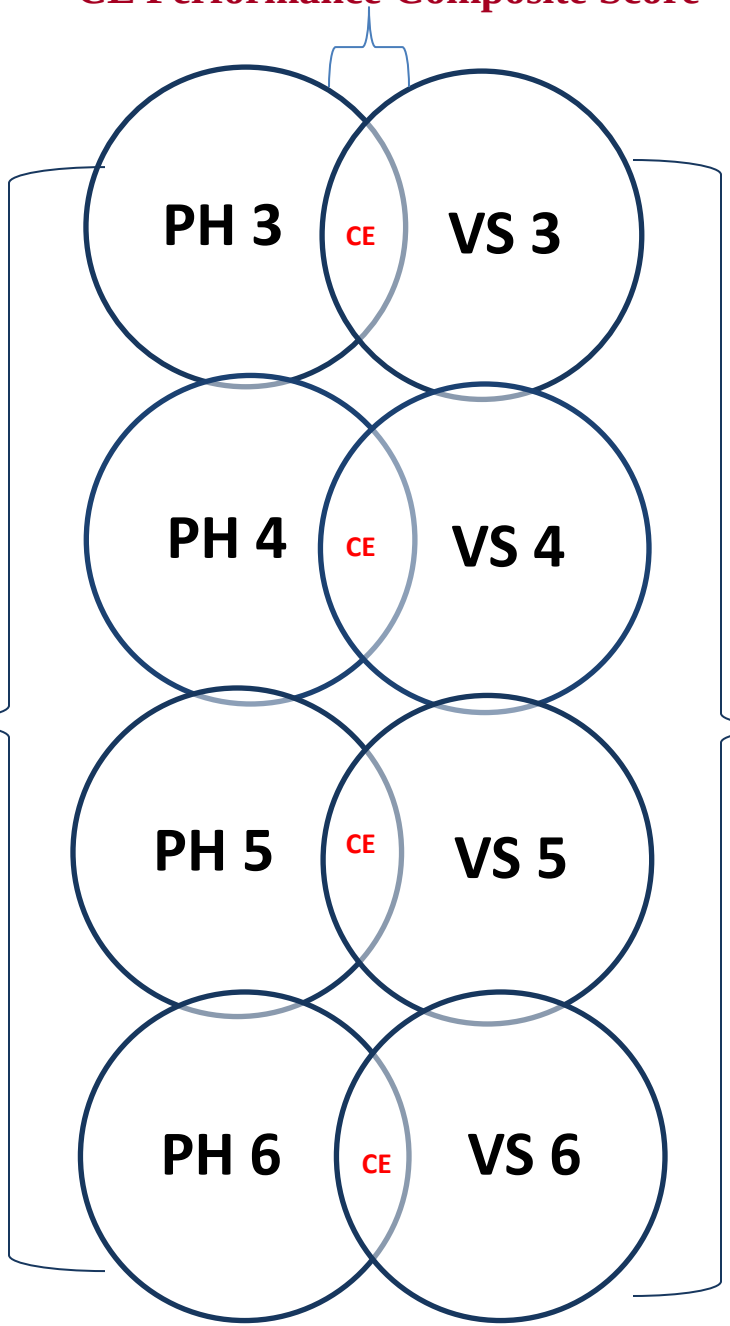


Hedges' *g* effect size indicated that the average magnitude difference in activity level between children with ADHD and TD children during visuospatial WM tasks was 1.83 standard deviation units (range=1.47 to 2.67).

Total extremity activity level (right foot, left foot, and non-dominant hand) expressed in PIM (Proportional Integrated Measure) units for children with ADHD (*triangles*) and typically developing children (*circles*) under control (C1, C2) and four visuospatial set size (VS 3, 4, 5, 6) working memory task conditions. *Vertical bars* represent standard error.

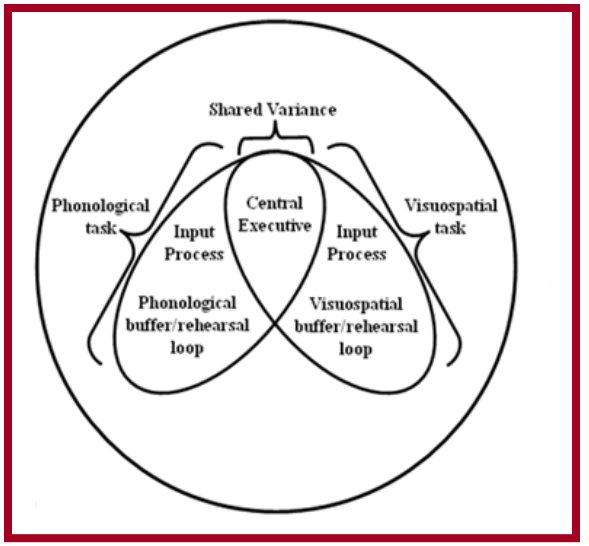
STEP 1:
PH, VS, and CE Performance Composite Scores

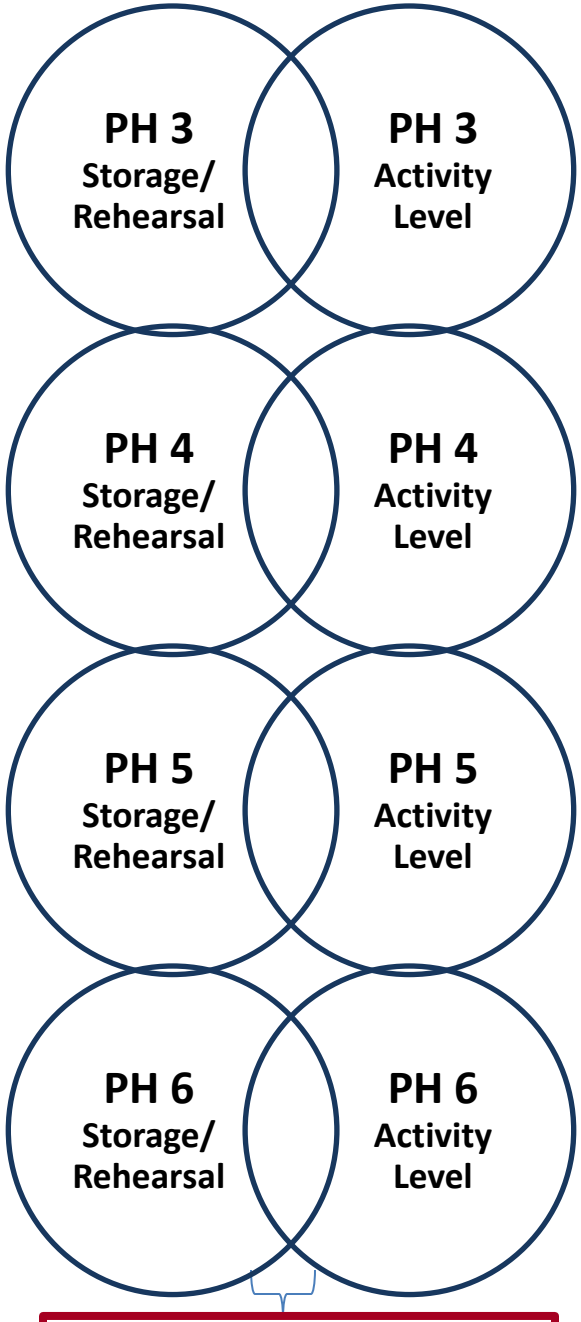
CE Performance Composite Score



PH Storage/Rehearsal Performance Composite Score

VS Storage/Rehearsal Performance Composite Score



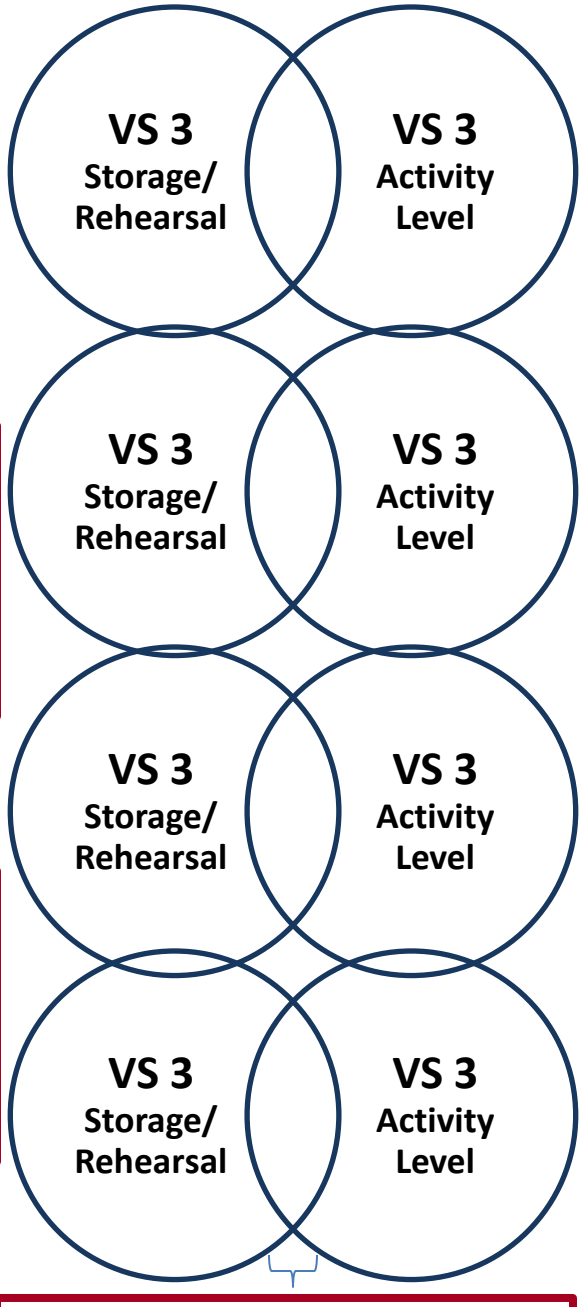


Activity level directly related to PH Storage/Rehearsal

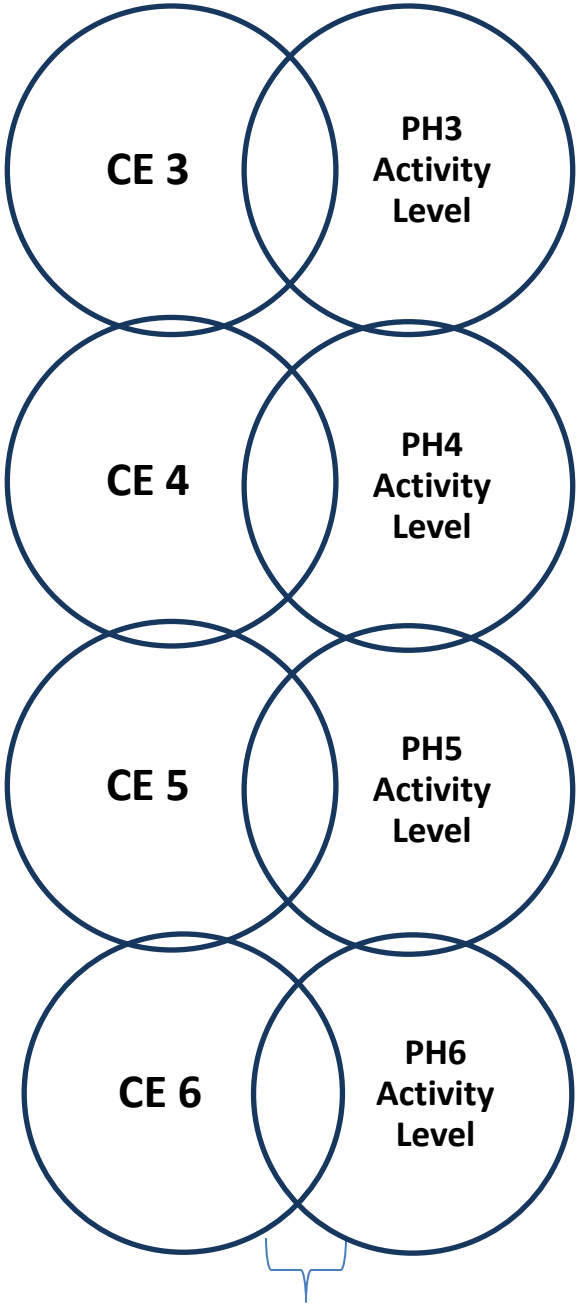
STEP 2:
Activity Level Directly Related to PH and VS Storage/Rehearsal Functioning

Results indicated that PH functioning was NOT a significant contributor to objectively measured activity level (average R^2 = .10; values ranged from .06 to .21 and were all non-significant with one exception).

Results indicated that VS functioning was NOT a significant contributor to objectively measured activity level (average R^2 = .07; values ranged from less than .001 to .14 and were all non-significant).



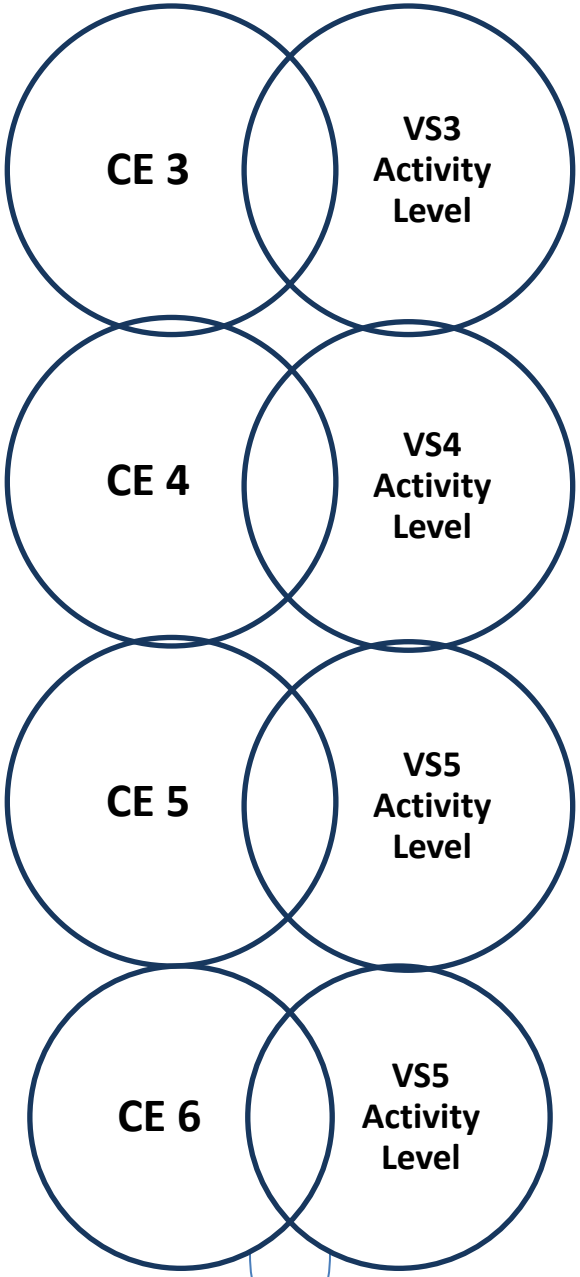
Activity level directly related to VS Storage/Rehearsal functioning



Results indicated that CE functioning **WAS A SIGNIFICANT CONTRIBUTOR** of objectively measured activity level (average R^2 = .32; values ranged from .17 to .61; all $p \leq .04$).

An independent samples t-test on the derived CE-activity level variable indicated a significant between-group difference, $t(21)=7.54$, $p<0.0005$, with children with ADHD evincing higher rates of activity directly associated with CE functioning relative to TD children.

Hedges' g effect size indicated that the average magnitude difference between children with ADHD and TD children was **3.03 standard deviation units** (SE=0.60).

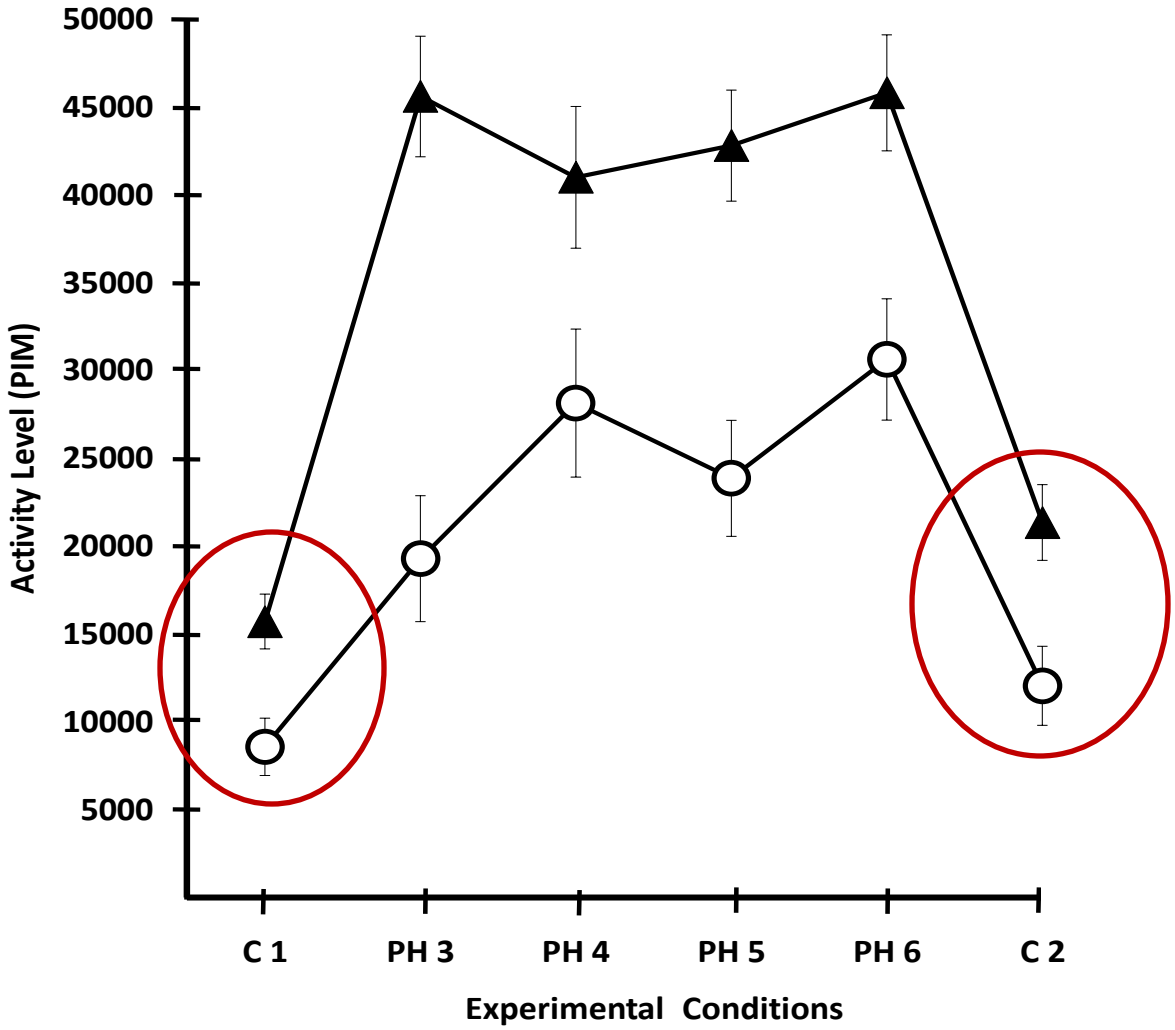


STEP 3: Activity Level Directly Related to CE Functioning

Activity level during the PH task that is directly related to CE functioning

Activity level during the VS task that is directly related to CE functioning

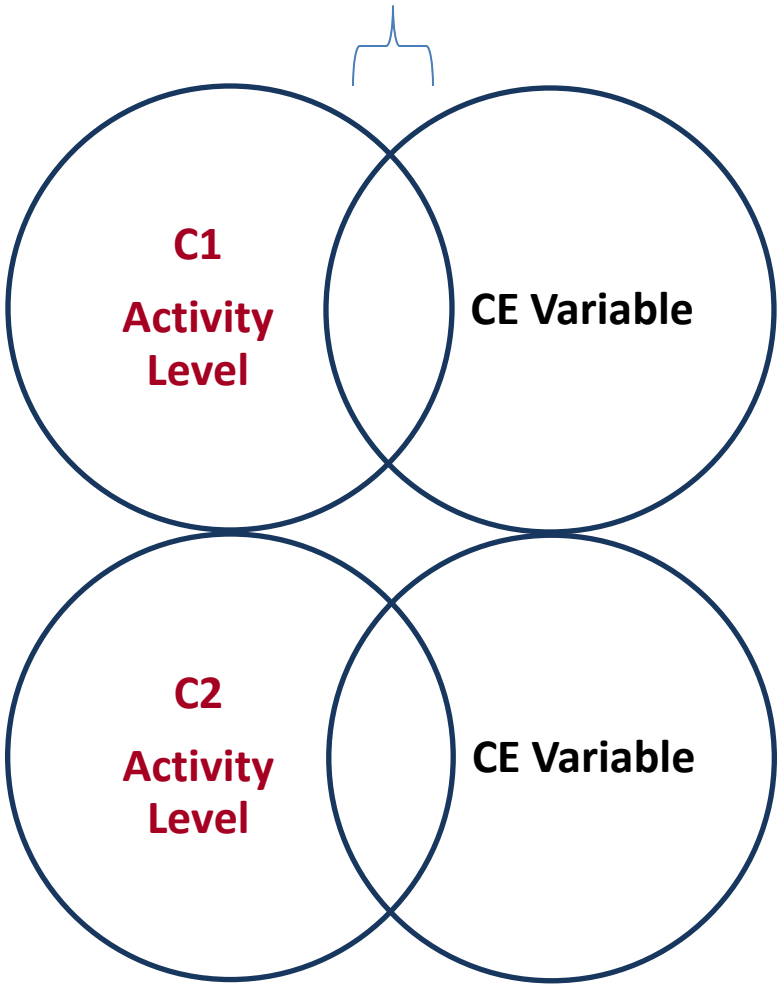
Activity Level Assessed During the PH and Control Conditions



Total extremity activity level (right foot, left foot, and non-dominant hand) expressed in PIM (Proportional Integrated Measure) units for children with ADHD (*triangles*) and typically developing children (*circles*) under control (C1, C2) and four phonological set size (PH 3, 4, 5, 6) working memory task conditions. *Vertical bars* represent standard error.

STEP 4:
Activity Level Assessed During the Control Conditions that is unrelated to CE Functioning

The 2 (group: ADHD, TD) by 2 (condition: C1, C2) Mixed-model ANOVA was non-significant for group, condition, and the group by condition interaction (all $p \geq .52$), indicating that children with ADHD were not ubiquitously more motorically active than typically developing children during the clinical assessment after accounting for task-related WM demands.



Hedges' *g* effect size indicated that the average magnitude difference between children with ADHD and TD children was 0.20 standard deviation units (*SE*=0.29), with a confidence interval that included 0.0.

Findings Summary

- **All children are significantly more active when engage in tasks requiring working memory.**

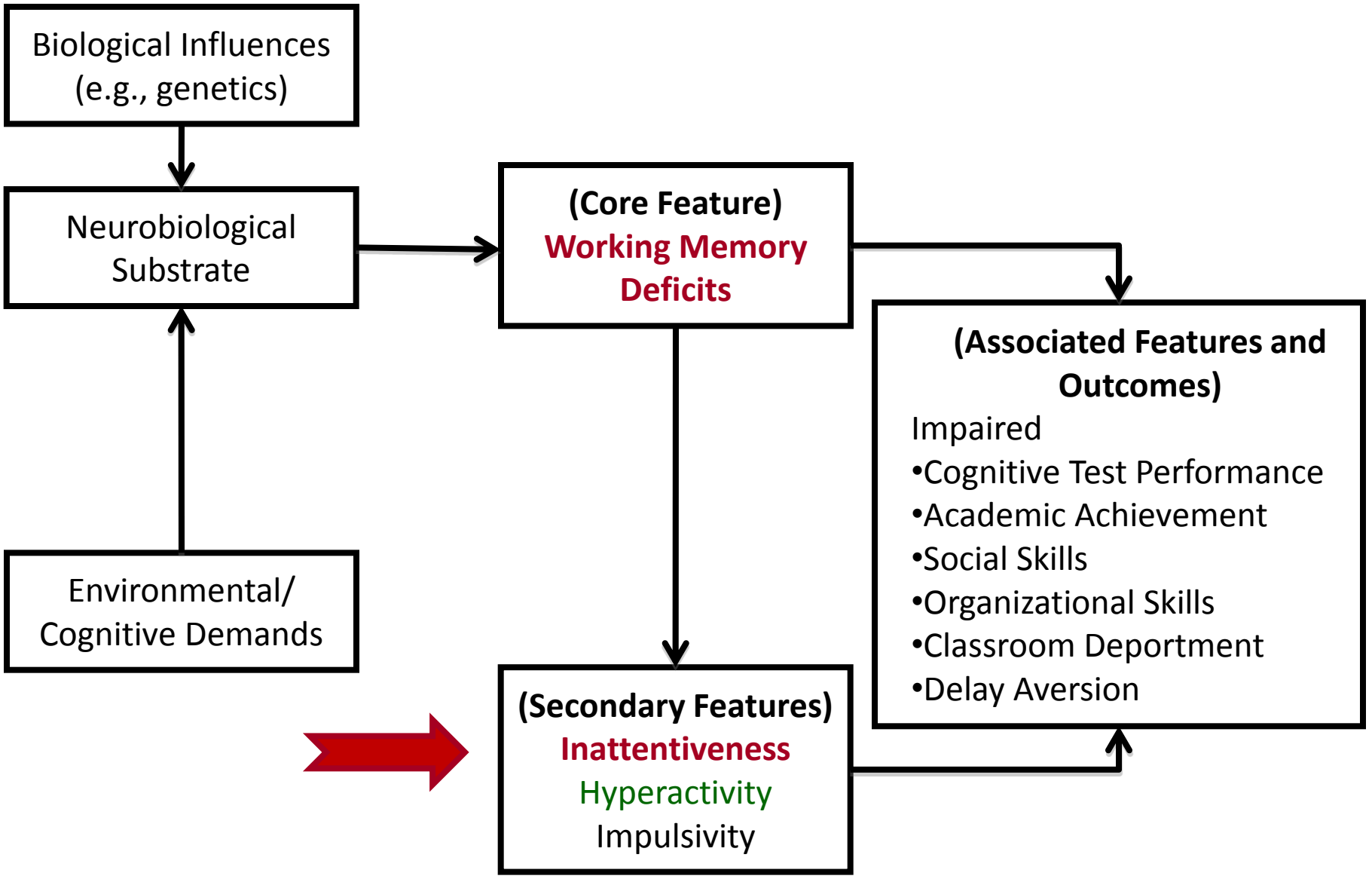
- **Children with ADHD are significantly more active than TDs when engaged in tasks requiring WM.**

- **Children with ADHD are not significantly more active than typically developing children after controlling for the influence of WM [not ubiquitously hyperactive]**

- **Central Executive functioning (not storage/rehearsal) is functionally related to children's activity level.**

- **Differences in children's activity level during WM task may reflect underlying differences in arousal.**

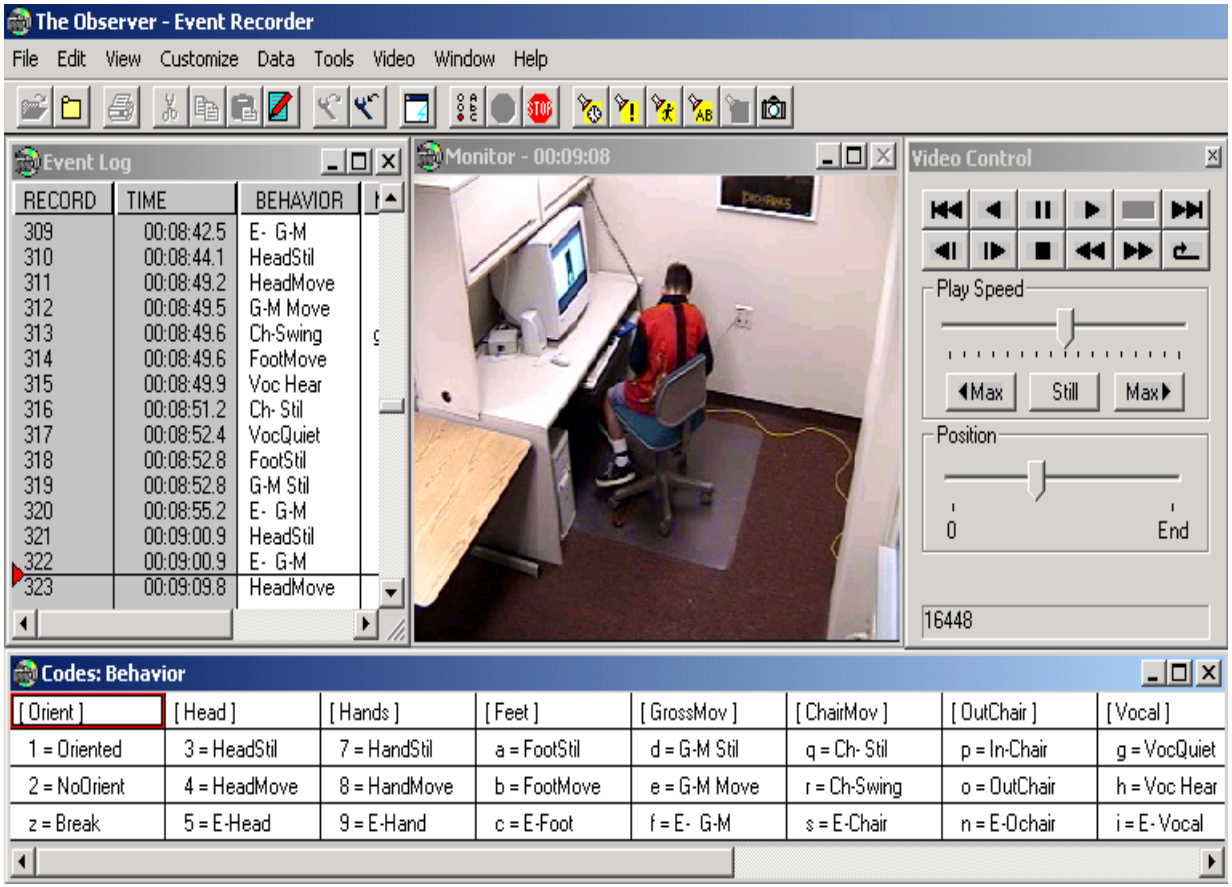
Working Memory Model of ADHD



Dependent Measures and Techniques

Noldus Observer

- Mutually exclusive Behavioral Codes
  - Oriented to task
    - Head is directed within 45° vertically/horizontally of the center of the monitor.
- Observers
  - Two coders per tape
  - Observers pre- trained to exceed 80% agreement
  - Interrater reliability = .94; Kappa = .88



Working Memory and Children's Inattentive behavior

Hypotheses: Inattentiveness may be associated with any of the following deficiencies:

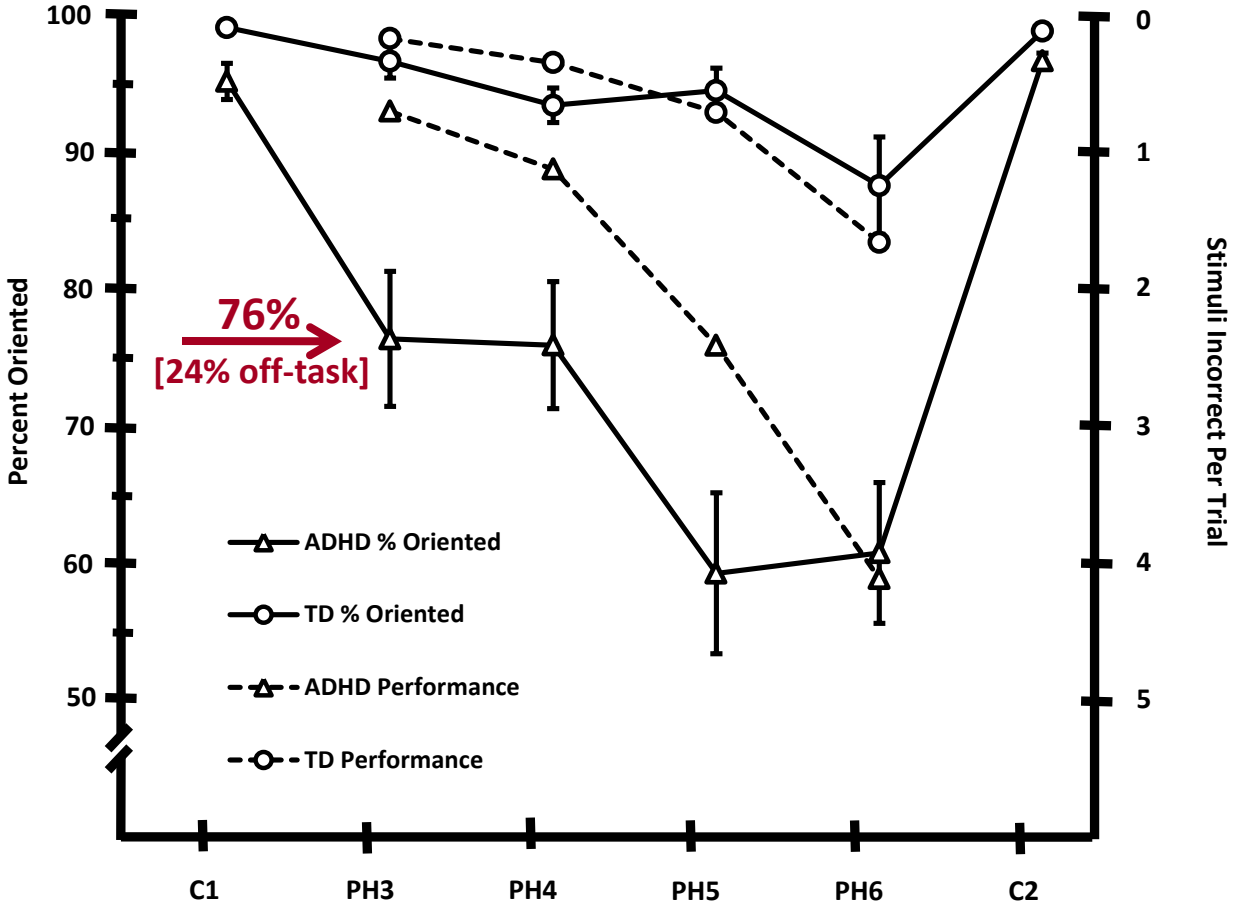
I. **Deficient CE processes [internal focus of attention]**

II. **Exceeding child's storage capacity [STS]**

III. **Deficiencies in both the CE and PH/VS storage capacity**

IV. **Ubiquitous inattentiveness unrelated to WM processes**

Tier I: Attentive behavior and phonological memory load



- Group, set size, and group x set size: all $p <$ .0005
- Post hocs:
  - TDC > ADHD across all conditions (all $p \leq .009$)
  - ADHD: Pre = Post > 3 = 4 > 5 = 6
  - TDC: Pre = Post > 3 = 4 = 5 > 6
  - Pre = Post ($p \geq .18$)
  - Hedges' g = 1.55 (SE = 0.42)

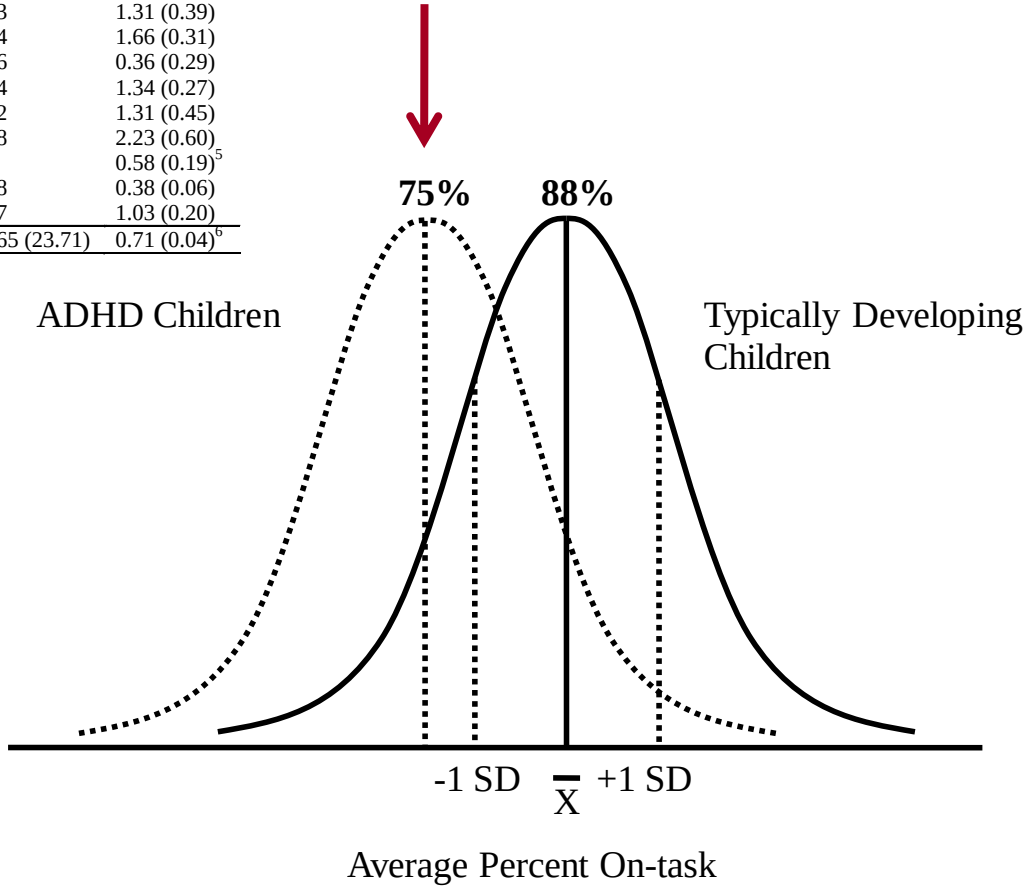
Table 2. Mean Off-task Rates, Standard Difference Scores, and Effect Sizes in Children with ADHD and Typically Developing Children

Study	ADHD % Off-task M (SD)	Control % Off-task M (SD)	Std. Diff. Scores (%)	Hedges' *g* Effect Sizes (Std. Error)
Werry & Quay (1969)	46.3 (12.8)	23 (15.4)	50.3	2.09 (0.53)
Forness & Esveldt (1975)	47.0 (16.5)	34 (12.4)	27.7	0.88 (0.30)
Shecket & Shecket (1976)	*NR*	*NR*	*NR*	0.00[4]
Abikoff et al. (1977)	13.1 (10.0)	2.1 (2.6)	84.2	1.50 (0.21)
Campbell et al. (1978)	16.73 (15.15)	12.41 (10.88)	25.8	0.32 (0.35)
Jacob et al. (1978)	15.8 (NR)	10.5 (NR)	33.3	1.41 (0.53)[3]
Klein & Young (1979)	39.8 (9.0)	26.6 (5.0)	33.1	1.78 (0.40)
Abikoff et al. (1980)	15.1 (23.4)	4.1 (7.8)	72.8	0.62 (0.19)
Zentall (1980)	15.0 (NR)	7.1 (NR)	52.2	0.45 (0.25)
Abikoff & Gittelman (1984)	17.4 (12.3)	3.5 (6.6)	79.7	1.39 (0.29)
Abikoff & Gittelman (1985)	15.7 (10.4)	2.5 (4.6)	84.1	1.71 (0.31)
Atkins et al. (1985)	*NR*	*NR*	*NR*	0.59 (0.30)[1]
Book & Skeen (1987)	5.11 (4.82)	0.78 (1.47)	84.7	1.21 (0.17)
Cunningham & Siegel (1987)	33.0 (NR)	26.4 (NR)	19.9	0.51 (0.26)[2]
Roberts (1990)	39.5 (18.8)	12.9 (20.9)	67.3	1.31 (0.39)
DuPaul & Rapport (1993)	44.26 (16.56)	19.72 (11.56)	55.4	1.66 (0.31)
Lett & Kamphaus (1997)	18.3 (16.5)	12.7 (12.7)	30.6	0.36 (0.29)
Nolan & Gadow (1997)	30.5 (15.9)	13.3 (8.3)	56.4	1.34 (0.27)
DuPaul et al. (1998)	33.0 (19.2)	9.5 (11.9)	71.2	1.31 (0.45)
Skansgaard & Burns (1998)	23.8 (10.3)	4.8 (6.1)	79.8	2.23 (0.60)
Solanto et al. (2001)	*NR*	*NR*	*NR*	0.58 (0.19)[5]
Abikoff et al. (2002)	10.6 (24.0)	3.3 (13.2)	68.8	0.38 (0.06)
Lauth & Mackowiak (2004)	83.0 (12.0)	70.0 (13.0)	15.7	1.03 (0.20)
Column M (SD) =	28.15 (18.28)	14.96 (16.47)	54.65 (23.71)	0.71 (0.04)[6]

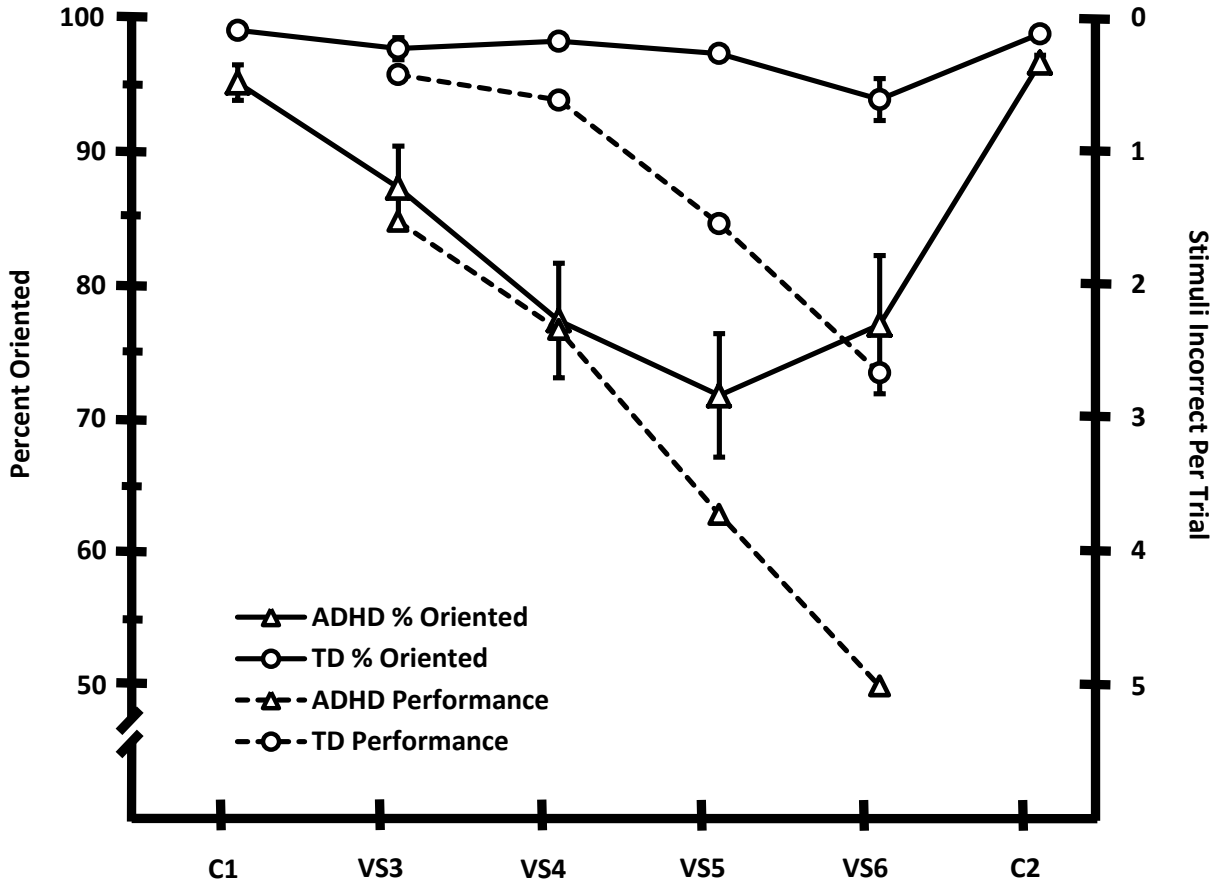
Kofler, Rapport, & Alderson (2008). Quantifying ADHD classroom inattentiveness,its moderators, and variability: a meta-analytic review. *Journal of Child Psychology & Psychiatry* 49, 59–69.

Best case estimation:

ES = 1.40



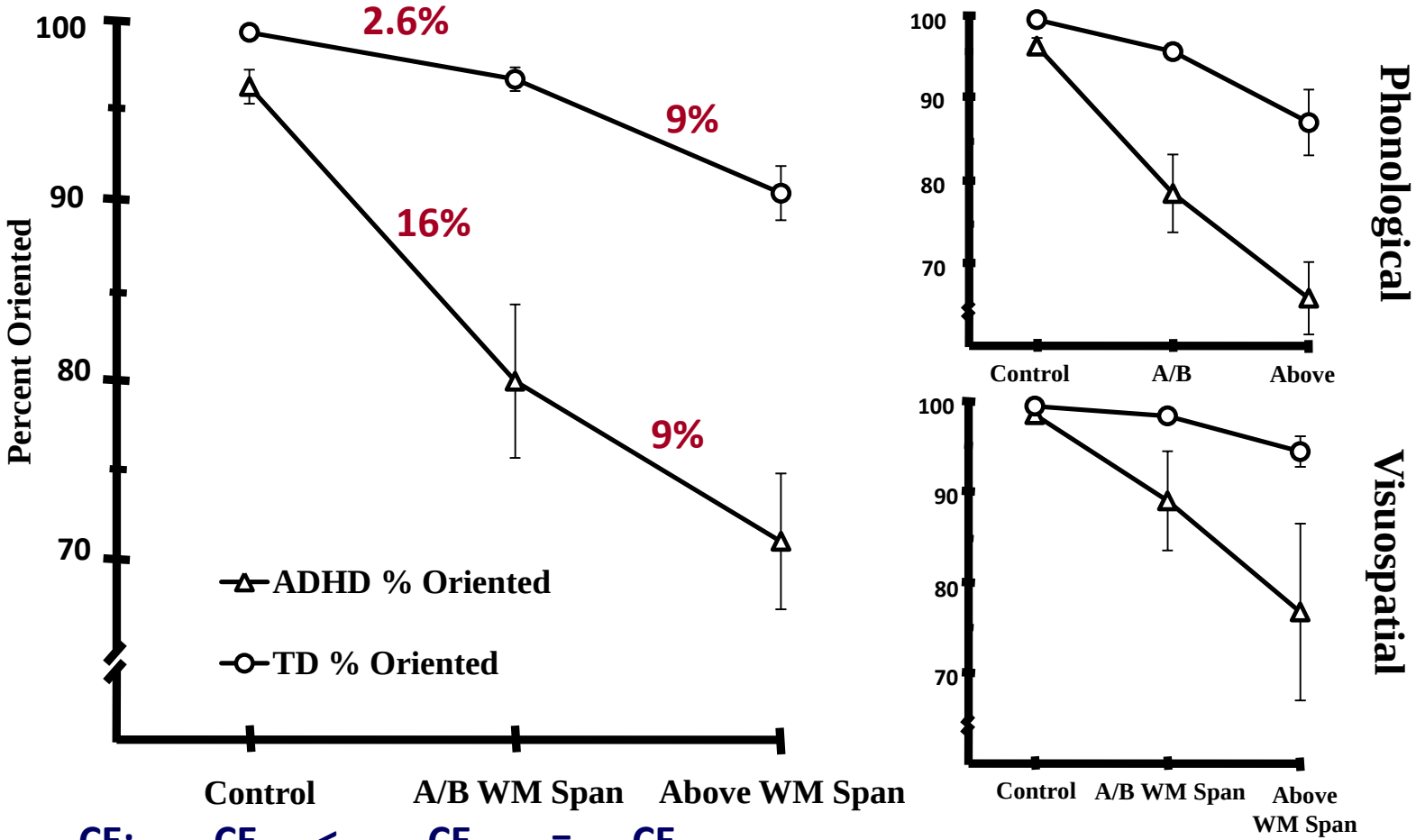
Tier I: Attentive behavior and visuospatial memory load



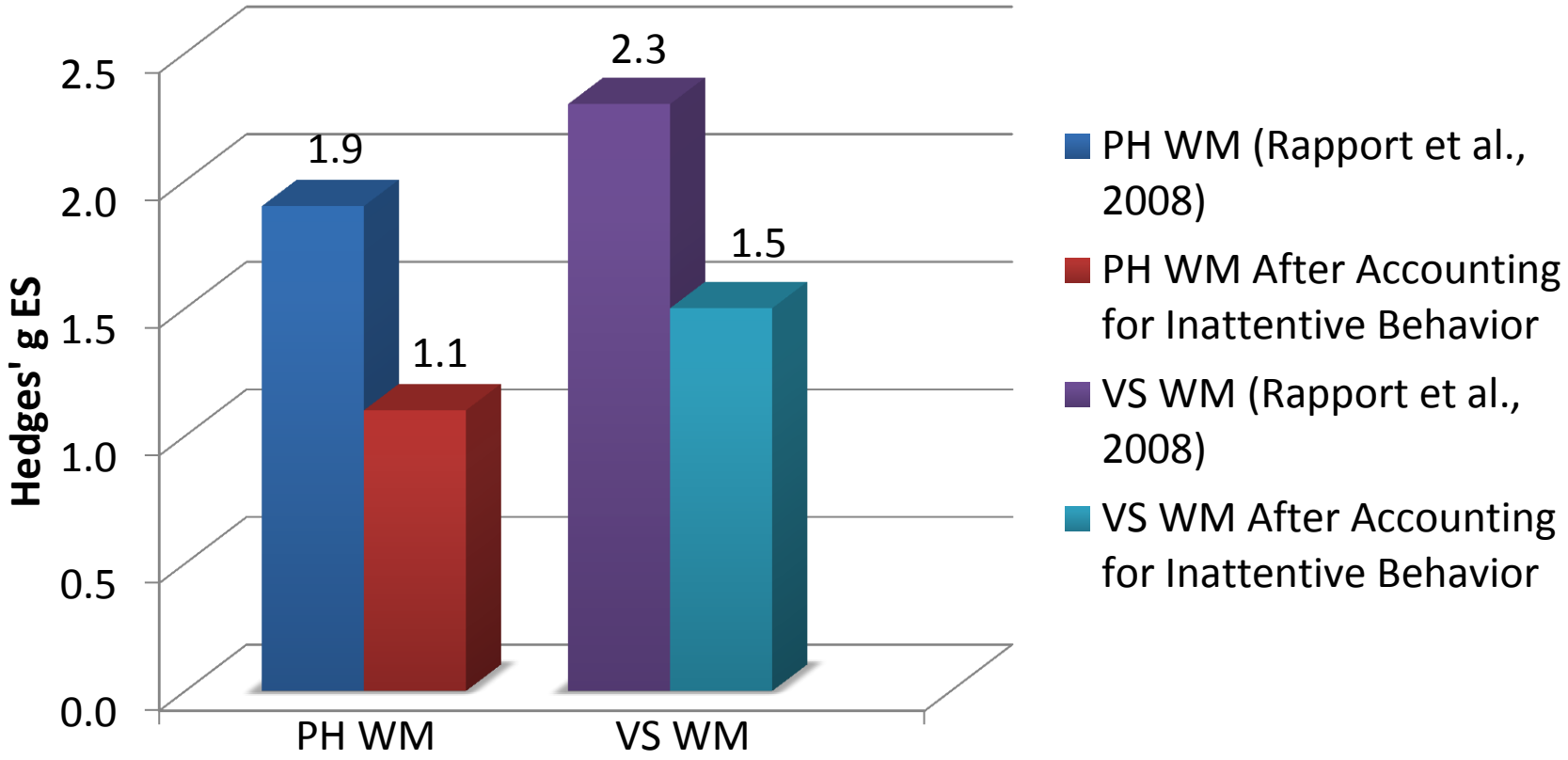
- Group, set size, and group x set size: all $p < .0005$
- Post hocs:
  - TDC > ADHD across all conditions (all $p \leq .009$)
  - ADHD: Pre = Post > 3 > 4 = 5 = 6
  - TDC: Pre = Post = 3 = 4 = 5 > 6
  - Pre = Post ($p \geq .18$)
  - Hedges' g = 1.45 (SE = 0.42)

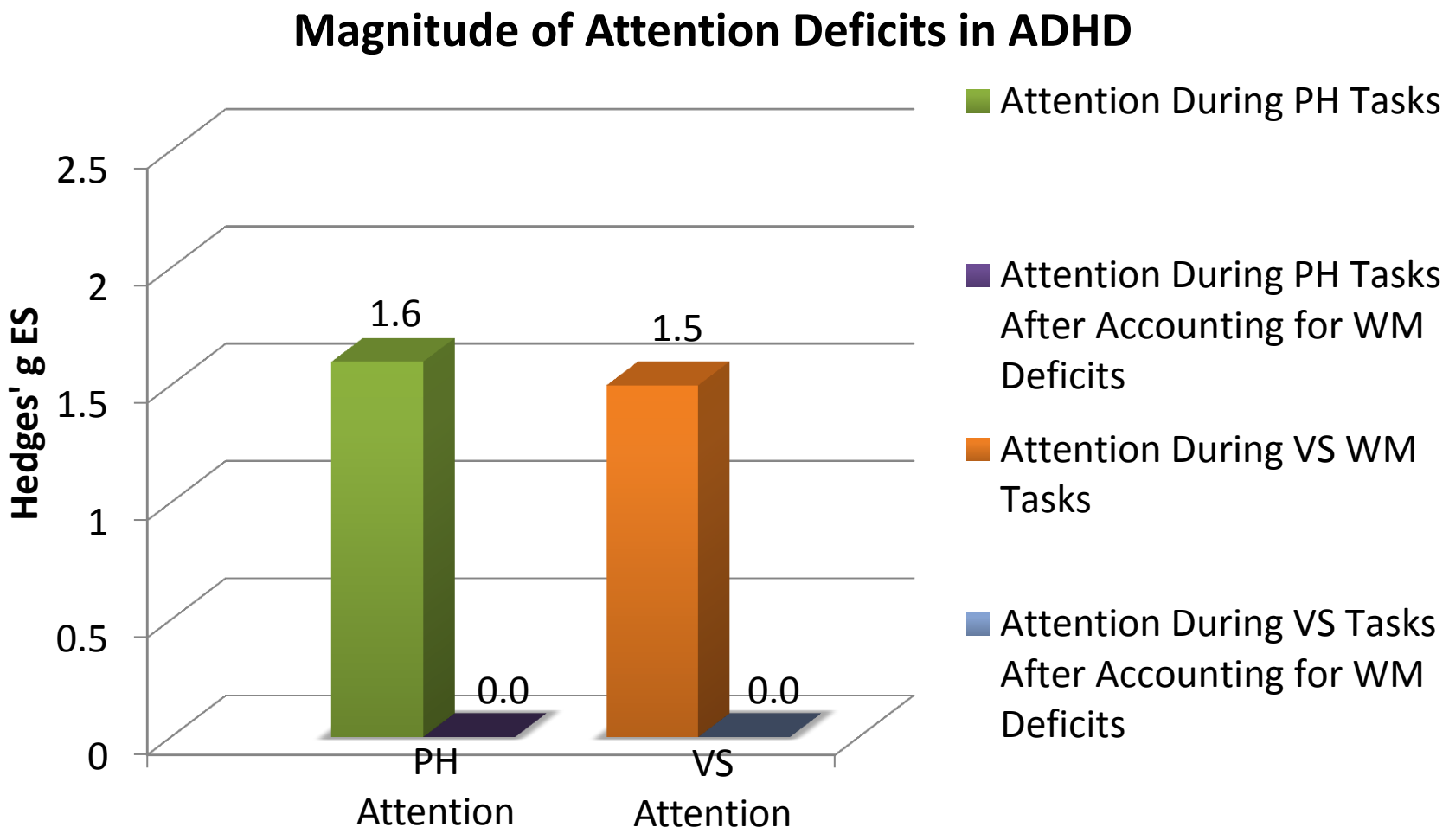
WM Components and Attentive Behavior

[2 (group) x 3 (conditions) mixed-model ANOVA]



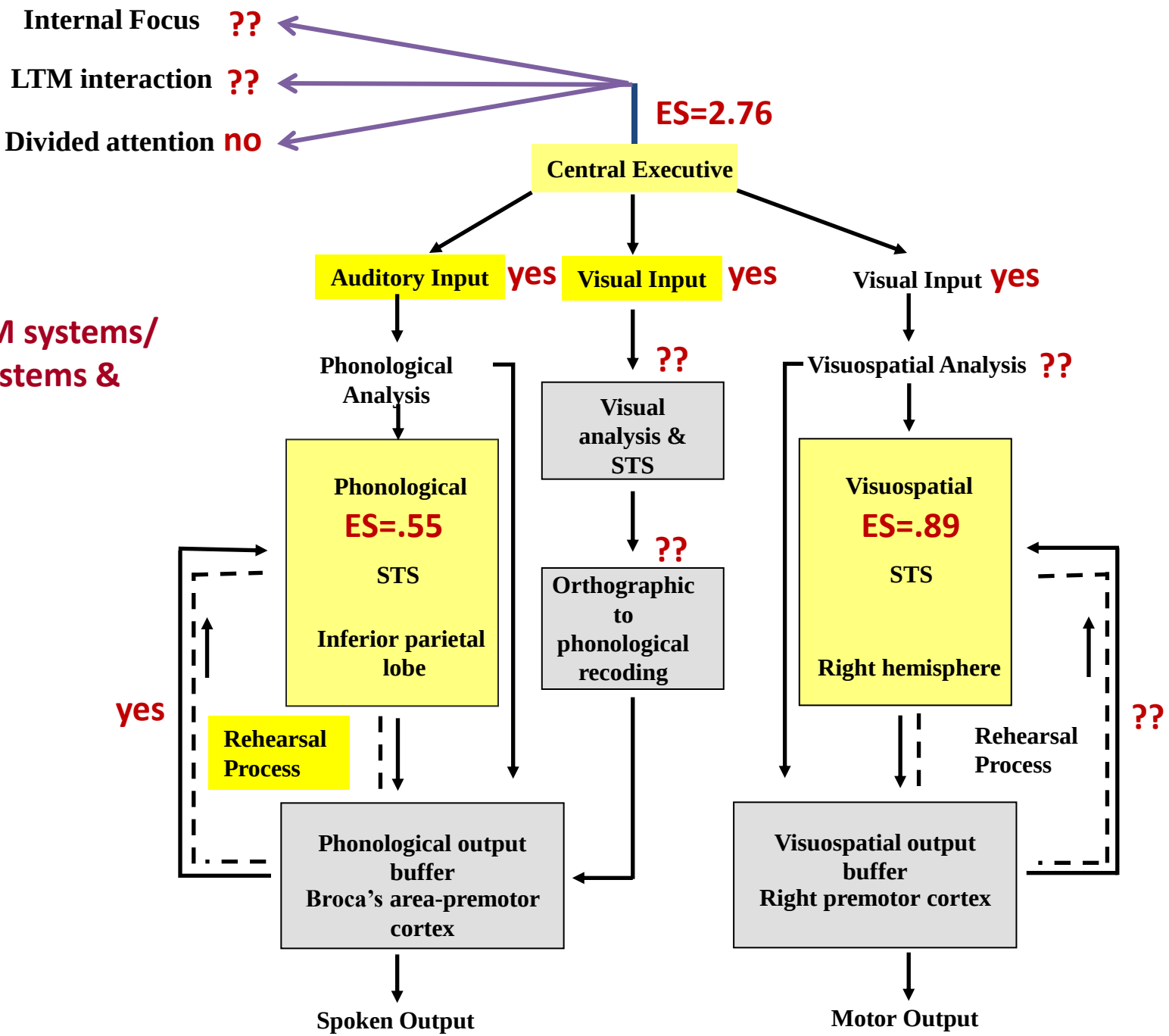
Magnitude of Working Memory Deficits in ADHD




Magnitude of Attention Deficits in ADHD
Hedges' g ES
2.5
2
1.5
1
0.5
0
1.6
0.0
1.5
0.0
PH Attention
VS Attention
Attention During PH Tasks
Attention During PH Tasks After Accounting for WM Deficits
Attention During VS WM Tasks
Attention During VS Tasks After Accounting for WM Deficits

Summary

- Initial inattentiveness in ADHD reflects underlying deficits in CE processes – most likely the internal focus of attention
- Exceeding WM storage capacity results in similar rates of inattentiveness in children with ADHD and typically developing children
- WM deficits remain after accounting for between-group differences in inattentiveness.
- Between-group inattentiveness differences are no longer significant after accounting for WM differences


Internal Focus ??
LTM interaction ??
Divided attention no
ES=2.76
Central Executive
Auditory Input yes
Visual Input yes
Visual Input yes
Deficient WM systems/ subsidiary systems & processes
Phonological Analysis
??
Visuospatial Analysis ??
Visual analysis & STS
Phonological
ES=.55
STS
Inferior parietal lobe
??
Orthographic to phonological recoding
Visuospatial
ES=.89
STS
Right hemisphere
yes
Rehearsal Process
??
Rehearsal Process
Phonological output buffer
Broca's area-premotor cortex
Visuospatial output buffer
Right premotor cortex
Spoken Output
Motor Output