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## Supporting Online Material for

### **Interventions Shown to Aid Executive Function Development in Children 4 to 12 Years Old**

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#### **This PDF file includes:**

Tables S1 to S3

References

**Correction:** Minor changes to table S2 (p. S-6, row “Bergman-Nutley *et al.*” and p. S-7, row “Davis *et al.*”) have been made to clarify the text.

## Supplementary Online Materials

A. Diamond & K. Lee

### Table of Contents

- i. Table S1: Details about Participants and Interventions shown to aid  
Executive Function Development in Children 4-12 years old . . . . . S-2
  - covers intervention details (e.g., dosage, frequency, and duration)
  - covers participant details (e.g., age, SES, if known, and gender)
- ii. Table S2: Executive Function Outcomes:  
Including Assessment Measures Used and Effect Sizes . . . . . S-6
- iii. Table S3: Other Cognitive & Non-Cognitive Outcomes and  
Long-term Assessments . . . . . S-10
- iv. Supplementary Online References and Notes . . . . . S-14

i. Table S1: Details about Participants and Interventions shown to aid Executive Function Development in Children 4-12 years old

Ref #	Author/ Year	Number of Subjects		Subject Characteristics			Intervention			Active Control Group?	Dosage, Frequency & Duration			
		Ttl	Per Group	Age (yrs)	Sex	Other	Kind	Incremental increases in difficulty?	What EF skills were targeted?		Session Duration (in minutes)	# of Sessions per Week	Total Time Period (in weeks)	Total # of Hours
<b>Computerized Training: Cogmed Training System (S1)</b>														
10	Holmes et al. (2009)	42	1) Working memory (WM) = 22 2) Active control (non-incrementing version of training games) = 20	8-11	M & F	All had poor initial working memory (low working memory span).	Working memory training: Cogmed computerized training system	Yes	- verbal WM - visuospatial WM	Yes	30-45	~2-5	5-8	15-17 (S2)
11	Klingberg et al. (2005)	53	1) Working memory (WM) = 27 2) Active control (non-incrementing version of training games) = 26	7-12	M & F	All were diagnosed with ADHD & non-medicated.	Working memory training: Cogmed computerized training system	Yes	- verbal WM - visuospatial WM	Yes	40	~4-5	5-6	17
12	Bergman-Nutley et al. (2011)	101	1) Working memory (WM) = 24 2) Non-verbal reasoning (NVR) = 25 3) Combined (CB) = 27 4) Placebo (PL) (non-incrementing version of training games) = 25	4	M & F	All families needed to have access to a PC computer & internet (parents supervised the training at home).	1) Working memory training: Cogmed computerized training system 2) Non-verbal reasoning training: 3 Leiter battery tests (RP,SO,CL [S4]) 3) Combined training: combination of NVR and WM training 4) Placebo training: combined, lowest level of difficulty	Yes	1) WM training - verbal WM - visuospatial WM 2) NVR training - identifying patterns - deducing rules - matching by ≥1 dimensions & ignoring others	Yes	15	5	5-7	~6
13	Thorell et al. (2009)	65	1) Working memory (WM) = 17 2) Inhibition training = 18 3) Active control (computer games [S5]) = 14 4) Passive control (no treatment) = 16	4-5	M & F	None	1) Working memory training: Cogmed computerized training system 2) Inhibition training - Go/No-go task - Flanker task - Stop Signal task	Yes	1) WM training - tasks focused on visuospatial WM 2) Inhibition training - inhibition of a prepotent motor response - interference control - stopping of an ongoing response	Yes	15	~4-5	5	6
14	Holmes et al. (2010)	25	1) Working memory (WM) = 25 T1: Off medication T2: Pre-training, on medication T3: Post-training, on medication T4: 6 months later, on medication	8-11	M & F	All were diagnosed with ADHD & taking stimulant medication.	Working memory training: CogMed computerized training system	Yes	- verbal WM - visuospatial WM	No	30-45	~2-5	5-8	15-17 (S6)



Ref #	Author/ Year	Number of Subjects		Subject Characteristics			Intervention			Active Control Group?	Dosage, Frequency & Duration			
		Ttl	Per Group	Age (yrs)	Sex	Other	Kind	Incremental increases in difficulty?	What EF skills were targeted?		Session Duration (in minutes)	# of Sessions per Week	Total Time Period (in weeks)	Total # of Hours

**Computerized Training: Other**

15	Rueda et al. (2005)	73	4-year-olds 1) Attention training = 24 2) Inactive control (watch videos) = 13 3) No treatment control = 12  6-year-olds 1) Attention training = 12 2) Inactive control (watch videos) = 12	4 & 6	M & F	All were middle-income.	Computerized attention training included: - conflict resolution sets - inhibitory control exercises (4-year-olds on a Stroop-like task, 6-year-olds on a Go/No-go task)	Yes	- attention - memory - inhibitory control	No (S7)	40	~2-3	2-3	~3
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**Hybrids of Computer and Non-computer Games**

16	Mackey et al. (2010)	28	1) Reasoning training = 17 2) Speed training = 11	7-9	M & F	All attended a school with a history of low statewide test scores and a high % of low-income students.	1) Reasoning training (fluid reasoning) 2) Speed training (processing speed)  *combination of 10-12 commercially-available computerized & non-computerized games (S8)	Yes	1) Reasoning training - joint consideration of several task rules, relations, or steps  2) Speed training - rapid visual detection - rapid motor response	Yes	60	2	8	16
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**Aerobic Exercise and Sports**

19	Tuckman & Hinkle (1986)	154	1) Aerobic running = 77 2) Regular Phys. Ed. = 77	8-12	M & F	All attended a university-affiliated "research" school.	Aerobic running	Yes	None	Yes	30	3	12	18
20	Davis et al. (2011)	171	1) High-dose aerobic exercise = 60 2) Low-dose aerobic exercise = 55 3) No program control = 56	7-11	M & F	All were sedentary & overweight or obese (85 <sup>th</sup> percentile body mass index).	Aerobic exercise: - included running games, jump rope, modified basketball and soccer - high-dose was 40 minutes / day - low-dose was 20 minutes / day	Yes	None	No	20 or 40	5	~13	~22 or 43
21	Kamijo et al. (2011)	43	1) Physical activity program = 22 2) No program control = 21	7-9	M & F	None	Physical activity: - aerobic exercises - muscle fitness	Yes	None	No	120	5	36	300



Ref #	Author/ Year	Number of Subjects		Subject Characteristics			Intervention			Active Control Group?	Dosage, Frequency & Duration			
		Ttl	Per Group	Age (yrs)	Sex	Other	Kind	Incremental increases in difficulty?	What EF skills were targeted?		Session Duration (in minutes)	# of Sessions per Week	Total Time Period (in weeks)	Total # of Hours

**Martial Arts and Mindfulness Practices**

28	Lakes & Hoyt (2004)	207	1) LEAD Program Tae-Kwon-Do Martial Arts training (S12) = 105  2) Regular Phys. Ed. classes = 102  *Randomly assigned by homeroom class	5-11	M & F	All attended a private school and most were high-middle or high-income.	Tae-Kwon-Do Martial Arts training: - used traditional Moo Gong Ryu techniques in environment of respect, discipline and self-control - ask self 3 questions: 1. Where am I? 2. What am I doing? 3. What should I be doing?	Yes	- self-control (inhibition) - discipline - sustained concentration - self-monitoring - planning	Yes	45	~2-3	16	~28
30	Flook et al. (2010)	64	1) Mindfulness Awareness Practices (MAPS) = 32  2) Control (silent reading) = 32	7-9	M & F	None	MAPS: - sitting meditation - games to promote sensory awareness, attention regulation, awareness of others and environment - body scans	Yes	- top-down control of attention - monitoring attention	Yes	30	2	8	8
31	Manjunath & Telles (2001)	20	1) Yoga = 10  2) Active control (physical training) = 10	10-13	F only	None	Yoga program: - physical training - relaxation - awareness training	Yes	- top-down control of attention	Yes	75	7	4	~35

**Classroom Curricula**

35	Diamond et al. (2007)	147	1) Tools of the Mind = 85  2) School district curriculum = 62	4-5	M & F	All were low-income & most were Hispanic. Groups were closely matched on demographics.	Tools of the Mind curriculum: - see text & Table 1	Yes	- inhibitory control of behavior & attention - sustained attention - working memory - switching - planning	Yes	Entire school day	5	Entire school year	860
41	Lillard & Else-Quest (2006)	112	5-year-olds 1) Montessori = 30 2) Other school curricula = 25  12-year-olds 1) Montessori = 29 2) Other school curricula = 28  *subjects were not randomly assigned	5 & 12	M & F	All were low-income & had entered lottery for Montessori school. Selection from lottery was random.	Montessori curriculum: - see text & Table 1	Yes	- inhibitory control of behavior & attention - sustained attention - working memory - planning	Yes	Entire school day	5	See footnote section for details (S15)	



Ref #	Author/ Year	Number of Subjects		Subject Characteristics			Intervention			Active Control Group?	Dosage, Frequency & Duration			
		Ttl	Per Group	Age (yrs)	Sex	Other	Kind	Incremental increases in difficulty?	What EF skills were targeted?		Session Duration (in minutes)	# of Sessions per Week	Total Time Period (in weeks)	Total # of Hours

Add-ons to Classroom Curriculum														
43	Riggs et al. (2006)	318	1) PATHS (Promoting Alternative Thinking Strategies) added to school district curriculum = 153 2) School district curriculum = 165	7-9	M & F	All were low or middle-income.	PATHS curriculum: - see text & Table 1	Yes	- inhibitory control (self-control) including waiting before acting - emotion regulation - problem-solving - planning	Yes	20-30	3	24	~30
45 46	Raver et al. (2008, 2011)	467	1) Chicago School Readiness Project (CSRP) added to Head Start = 238 2) Head Start = 229	3-4	M & F	All were low-income, considered at-risk & came from high-poverty neighborhoods.	CSRP: - see text & Table 1	Yes	None	Yes	Entire school day	5	Entire school year	

ii. Table S2: Executive Function Outcomes: Including Assessment Measures Used and Effect Sizes

Ref #	Author/ Year	Executive Function Outcomes						No Transfer on EF Measures
		Positive EF Transfers	Size of Effect	Positive transfers were narrow	Those with worse EFs benefit most	Larger group differences for more EF-demanding conditions	Progressively increasing challenge during training is important for benefits	
<b>Computerized Training: Cogmed Training System (S1)</b>								
10	Holmes et al. (2009)	<p>1) WM training group showed transfers to (S2):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>verbal WM</b> (Counting Recall) . . . . .</li> <li>• <b>verbal STM</b> (Word Recall, Digit Recall) . . . . .</li> <li>• <b>visuospatial WM</b> (Mr. X, Spatial Recall) . . . . .</li> <li>• <b>visuospatial STM</b> (Dot Matrix, Block Recall) . . . . .</li> </ul> </li> <li>- <b>verbal WM task</b> (Following Instructions task) . . . . .</li> </ul> <p>2) Active control group showed transfers to (S2):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>verbal WM</b> (Counting Recall) . . . . .</li> <li>• <b>verbal STM</b> (Word Recall, Digit Recall) . . . . .</li> </ul> </li> </ul> <p>*Based on pre- to post- training comparison</p>	<p>Large Medium Large Large Large</p> <p>Medium Medium</p>	Yes	All started low.	n/a	Yes	<p>1) None; WM training group only showed positive transfers.</p> <p>2) Active control group showed no transfer to (S2):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>visuospatial WM</b> (Mr. X, Spatial Recall)</li> <li>• <b>visuospatial STM</b> (Dot Matrix, Block Recall)</li> </ul> </li> <li>- <b>verbal WM task</b> (Following Instructions task)</li> </ul>
11	Klingberg et al. (2005)	<p>1) WM training group showed transfers to (S3):</p> <ul style="list-style-type: none"> <li>- <b>verbal WM</b> (Digit Span – WISC-III) . . . . .</li> <li>- <b>visuospatial WM</b> (Span Board – WAIS-RNI) . . . . .</li> <li>- <b>inhibition</b> (Stroop task) . . . . .</li> <li>- <b>non-verbal reasoning</b> (Raven's Matrices) . . . . .</li> <li>- parent-reported Conners Rating Scale: <ul style="list-style-type: none"> <li>• <b>inattention decreased</b> . . . . .</li> <li>• <b>hyperactivity/impulsivity decreased</b> . . . . .</li> </ul> </li> </ul> <p>*Based on control group comparison</p>	<p>Medium Large Medium Medium Large Medium</p>	Yes	All had ADHD.	n/a	Yes	<p>1) WM training group showed no transfer to:</p> <ul style="list-style-type: none"> <li>- teacher-reported Conners Rating Scale: <ul style="list-style-type: none"> <li>• <b>inattention</b></li> <li>• <b>hyperactivity/impulsivity</b></li> </ul> </li> </ul>
12	Bergman-Nutley et al. (2011)	<p>1) Non-verbal WM training group showed transfer to (S4):</p> <ul style="list-style-type: none"> <li>- <b>non-verbal memory / reasoning</b> (Odd One Out - AWMA)</li> </ul> <p>2) NV analogical reasoning training showed transfer to (S4):</p> <ul style="list-style-type: none"> <li>- <b>non-verbal analogical reasoning &amp; problem solving</b> (Raven's Matrices B, Block Design - WPPSI) . . . . .</li> <li>- <b>non-verbal memory / reasoning</b> (Odd One Out - AWMA)</li> </ul> <p>3) CB training group showed transfers to (S4):</p> <ul style="list-style-type: none"> <li>- <b>non-verbal memory / reasoning</b> (Odd One Out - AWMA)</li> </ul> <p>*Odd One Out had a reasoning component and reasoning training tended to aid its performance</p> <p>*Based on control group (PL) comparison</p>	<p>Large</p> <p>Large Small (trend only)</p> <p>Small</p>	Yes	n/a	n/a	Yes	<p>1) WM training group showed no transfer to (S4):</p> <ul style="list-style-type: none"> <li>- <b>problem solving</b> (Leiter tests, Raven's Matrices, Block Design - WPPSI)</li> <li>- <b>verbal WM</b> (Word Span)</li> </ul> <p>2) NVR training group showed no transfer to (S4):</p> <ul style="list-style-type: none"> <li>- <b>problem solving</b> (non-verbal Gestalt completion on Raven's Matrices A &amp; AB)</li> <li>- <b>verbal WM</b> (Word Span)</li> </ul> <p>3) CB training group showed no transfer to (S4):</p> <ul style="list-style-type: none"> <li>- <b>problem solving</b> (Raven's Matrices, Block Design - WPPSI)</li> <li>- <b>verbal WM</b> (Word Span)</li> </ul>
13	Thorell et al. (2009)	<p>1) WM training group showed transfers to (S5):</p> <ul style="list-style-type: none"> <li>- <b>visuospatial WM</b> (Span Board – WAIS-RNI) . . . . .</li> <li>- <b>verbal WM</b> (Word Span) . . . . .</li> <li>- <b>auditory attention</b> (Auditory Continuous Performance task - NEPSY) . . . . .</li> </ul> <p>*Based on comparison with the 2 control groups combined</p> <p>*Based on change x group comparison (change over time in intervention group was greater than change over time in control group)</p>	<p>Large Large</p> <p>Medium</p>	Yes	n/a	n/a	n/a	<p>1) WM training group showed no transfer to (S5):</p> <ul style="list-style-type: none"> <li>- <b>response inhibition</b> (Go/No-go)</li> <li>- <b>inhibition &amp; WM</b> (Day-Night Stroop task)</li> <li>- <b>problem solving</b> (Block Design – WPPSI-R)</li> <li>- <b>inhibitory control</b> (Go/No-go)</li> <li>- <b>sustained attention</b> (Go/No-go)</li> </ul> <p>2) Inhibition training group showed no transfer.</p>
14	Holmes et al. (2010)	<p>1) From T1 to T2, WM training group showed transfers to (S6):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>visuospatial WM</b> (Mr. X, Spatial Span) . . . . .</li> </ul> </li> </ul> <p>2) From T2 to T3, WM training group showed transfers to (S6):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>verbal WM</b> (Backward Digit Recall, Listening Recall)</li> <li>• <b>verbal STM</b> (Digit Recall) . . . . .</li> <li>• <b>visuospatial WM</b> (Mr. X, Odd One Out) . . . . .</li> <li>• <b>visuospatial STM</b> (Dot Matrix, Mazes Memory) . . . . .</li> </ul> </li> </ul> <p>*Based on comparisons across time</p>	<p>Medium</p> <p>Medium Medium Small Large</p>	Yes	All had ADHD.	n/a	n/a	<p>1) From T1 to T2, WM training group showed no transfer to (S6):</p> <ul style="list-style-type: none"> <li>- subtests from the AWMA: <ul style="list-style-type: none"> <li>• <b>verbal WM</b> (Backward Digit Recall, Counting Recall)</li> <li>• <b>verbal STM</b> (Digit Recall, Word Recall)</li> <li>• <b>visuospatial STM</b> (Dot Matrix)</li> </ul> </li> </ul>



Ref #	Author/ Year	Executive Function Outcomes					
		Positive EF Transfers	Size of Effect	Positive transfers were narrow	Those with worse EFs benefit most	Larger group differences for more EF-demanding conditions	Progressively increasing challenge during training is important for benefits

**Computerized Training: Other**

15	Rueda et al. (2005)	<p>4-year-olds: Attention training showed transfers to (S7):  <b>- abstract reasoning</b> (Matrices – K-BIT) . . . . .</p> <p>6-year-olds: Attention training showed no transfers but showed more efficient adult-like ERPs during attention task.</p> <p>*Based on change x group comparison (change over time in intervention group was greater than change over time in control group)</p>	?	Yes	All were middle-income.	n/a	n/a	<p>4-year-olds showed no transfer to (S7):  <b>- selective attention</b> (Flanker task)  <b>- parent-reported temperament</b> (CBQ)</p> <p>6 year-olds showed no transfer to (S7):  <b>- selective attention</b> (Flanker task)  <b>- parent-reported effortful control</b> (CBQ)</p>
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**Hybrids of Computer and Non-computer Games**

16	Mackey et al. (2010)	<p>1) Reasoning training showed transfers to (S8):  <b>- fluid reasoning</b> (Matrix task – TONI-3) . . . . .  <b>- processing speed</b> (Cross-Out – WJ-R) . . . . .  <b>- working memory</b> (Spatial Span - WMS) . . . . .</p> <p>2) Speed training showed transfers to (S8):  <b>- processing speed</b> (Coding B – WISC-IV, Cross-Out - WJ-R) . . . . .</p> <p>*Based on pre- to post- training comparison</p>	<p>Large Medium Medium</p> <p>Large</p>	Yes	All were low-income.	n/a	n/a	<p>1) Reasoning training showed no transfer to (S8):  <b>- processing speed</b> (Coding B – WISC-IV)  <b>- working memory</b> (Digit Span - WMS)</p> <p>2) Speed training showed no transfer to (S8):  <b>- fluid reasoning</b> (Matrix task – TONI-3)  <b>- working memory</b> (Digit Span - WMS, Spatial Span - WMS)</p>
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**Aerobic Exercise and Sports**

19	Tuckman & Hinkle (1986)	<p>Aerobic running benefitted:  <b>- creativity &amp; cognitive flexibility</b> (Alternate Uses test) . . .          - girls reported to show more creative involvement in class</p> <p>*Based on control group comparison</p>	Large	n/a	n/a	n/a	n/a	None; only benefits reported.
20	Davis et al. (2011)	<p>High-dosage Aerobics benefitted (S10):  <b>- strategy generation &amp; application, self-regulation, intentionality, utilization of knowledge</b> (CAS Planning scale) . . . . .</p> <p>*Dose-response effect demonstrated          *Based on control group comparison</p>	Small	n/a	All were sedentary & overweight.	Yes	n/a	<p>Aerobics did not benefit (S10):  <b>- focused attention, resistance to distraction</b> (CAS Attention scale)  <b>- spatial/logical reasoning</b> (CAS Simultaneous scale)  <b>- analysis/recall of stimuli arranged in sequence</b> (CAS Successive scale)</p>
21	Kamijo et al. (2011) (S11)	<p>Aerobics benefitted (S11):  <b>- working memory</b> (modified Sternberg task) . . . . .</p> <p>*Based on pre- to post- training comparison</p>	Small	n/a	n/a	n/a	n/a	None; only benefits reported.





Ref #	Author/ Year	Executive Function Outcomes						No Transfer on EF Measures
		Positive EF Transfers	Size of Effect	Positive transfers were narrow	Those with worse EFs benefit most	Larger group differences for more EF-demanding conditions	Progressively increasing challenge during training is important for benefits	

**Martial Arts and Mindfulness Practices**

28	Lakes & Hoyt (2004)	Tae-Kwon-Do Martial Arts benefitted (S12): - subtests from the Response to Challenge Scale: • <b>cognitive self-regulation (focused attention)</b> . . . . . • <b>affective self-regulation (not quitting)</b> . . . . .  *Effect greater for boys than girls *Effect greater for older kids (grades 4 and 5) and smaller for younger kids (grade 1)  *Based on change x group comparison (change over time in intervention group was greater than change over time in control group)	Medium Medium	n/a	All were middle-high or high income.  Yes; Boys benefitted more than girls.	n/a	n/a	None; only benefits reported.
30	Flook et al. (2010)	Mindfulness benefitted (S13): - parent ratings on the BRIEF: • <b>shifting (cognitive flexibility)</b> . . . . . • <b>emotion regulation</b> . . . . . • <b>WM</b> . . . . . • <b>monitoring</b> . . . . .  -teacher ratings on the BRIEF: • <b>shifting (cognitive flexibility)</b> . . . . . • <b>planning / organizing</b> . . . . . • <b>monitoring</b> . . . . .  *Teachers were not blind to group assignment  *Based on change x group comparison (change over time in intervention group was greater than change over time in control group)	Large Large Medium Large  Medium Medium Medium	n/a	Yes	n/a	n/a	Mindfulness did not benefit (S13): - parent ratings on the BRIEF: • <b>inhibition</b> • <b>planning / organizing</b> • <b>organization of materials</b>  - teacher ratings on the BRIEF: • <b>inhibition</b> • <b>emotion regulation</b> • <b>WM</b> • <b>organization of materials</b>
31	Manjunath & Telles (2001)	Yoga benefitted (S14): - <b>planning</b> (Tower of London) . . . . . • faster & in fewer moves  *Based on pre- to post-training comparison	?	n/a	n/a	Yes	n/a	None; only benefits reported.

**Classroom Curricula**

35	Diamond et al. (2007)	Tools of the Mind benefitted: - <b>inhibition</b> (Hearts and Flowers-Incongruent) . . . . . - <b>switching / WM / inhibition</b> (Hearts and Flowers-Mixed) - <b>selective attention</b> (Flanker) . . . . . - <b>selective attention/switching</b> (Reverse Flanker) . . . . .  *Based on control group comparison	Small Large Small Large	No	All were low-income & at-risk.	Yes	n/a	None; only benefits reported.
41	Lillard & Else-Quest (2006)	Montessori benefits: 1) 5-year-olds - <b>switching / WM / inhibition</b> (Card Sort task) . . . . .  2) 12-year-olds - <b>creativity</b> (Story Completion task) . . . . .  *Based on control group comparison	Medium  Large	n/a	All were low-income.	n/a	n/a	Montessori did not benefit: - <b>delay of gratification assessed at age 5</b>



Ref #	Author/ Year	Executive Function Outcomes					
		Positive EF Transfers	Size of Effect	Positive transfers were narrow	Those with worse EFs benefit most	Larger group differences for more EF-demanding conditions	Progressively increasing challenge during training is important for benefits

Add-ons to Classroom Curriculum								
43	Riggs et al. (2006)	PATHS benefitted: - <b>inhibition &amp; WM</b> (Stroop task) ..... - <b>cognitive flexibility</b> (Verbal Fluency) .....  *Based on control group comparison	Small Small	No	All were low or middle-income.	n/a	n/a	None; only benefits reported.
45 46	Raver et al. (2008, 2011)	CSRP benefitted (S17): - <b>concentration</b> (Balance Beam - PSRA) ..... - <b>inhibition &amp; WM</b> (Pencil Tap - PSRA) ..... - <b>attention &amp; impulsivity</b> (Global Assessor report - PSRA)  *Based on change x group comparison (change over time in intervention group was greater than change over time in control group)	Medium Medium Medium	n/a	All were low-income, at-risk & came from high-poverty areas.	n/a	n/a	CSRP did not benefit (S17): - <b>delay of gratification</b> (PSRA)

iii. Table S3: Other Cognitive & Non-Cognitive Outcomes and Long-term Assessments

Ref #	Author/ Year	Other: Both Cognitive & Non-Cognitive			Results of Assessments $\geq$ 6 Months Later
		Other Cognitive & Non-Cognitive Skills Improved	Size of Effect	Other Cognitive & Non-Cognitive Skills Not Affected	
<b>Computerized Training: Cogmed Training System (S1)</b>					
10	Holmes et al. (2009)	1) WM training group showed no transfer to other cognitive or non-cognitive skills.	n/a	1) WM training group showed no transfer to (S2): - <b>verbal IQ</b> (WASI) - <b>performance IQ</b> (WASI) - <b>basic word reading</b> (WORD) - <b>mathematical reasoning</b> (WOND)	Assessed 6 months later: 1) WM training group showed lasting improvements on (S2): - subtests from the AWMA: • <b>verbal WM</b> (Counting Recall) • <b>visuospatial WM</b> (Mr. X, Spatial Recall) • <b>visuospatial STM</b> (Dot Matrix, Block Recall) - <b>verbal WM task</b> (Following Instructions task) - <b>mathematical reasoning</b> (WOND)
11	Klingberg et al. (2005)	None tested	n/a	None tested	Not tested
12	Bergman-Nutley et al. (2011)	None tested	n/a	None tested	Not tested
13	Thorell et al. (2009)	None tested	n/a	None tested	Not tested
14	Holmes et al. (2010)	1) WM training group showed no transfer to other cognitive or non-cognitive skills.	n/a	1) From T1 to T2, WM training group showed no transfer to (S6): - <b>verbal IQ</b> (WASI) - <b>performance IQ</b> (WASI)  2) From T2 to T3, WM training group showed no transfer to (S6): - <b>verbal IQ</b> (WASI) - <b>performance IQ</b> (WASI)	Assessed 6 months later: From T2 to T4, WM training group showed lasting improvements on (S6): - subtests from the AWMA: • <b>verbal WM</b> (Backward Digit Recall) • <b>visuospatial WM</b> (Mr. X) • <b>visuospatial STM</b> (Dot Matrix)



Ref #	Author/ Year	Other: Both Cognitive & Non-Cognitive			Results of Assessments ≥ 6 Months Later
		Other Cognitive & Non-Cognitive Skills Improved	Size of Effect	Other Cognitive & Non-Cognitive Skills Not Affected	

Computerized Training: Other					
15	Rueda et al. (2005)	4-year-olds: Attention training showed transfers to (S7): - <b>IQ composite score</b> (K-BIT) .....	?	None; only benefits reported.	Not tested
		6-year-olds: Attention training showed transfers to (S7): - <b>verbal IQ</b> (K-BIT vocabulary) .....	?		

Hybrids of Computer and Non-computer Games					
16	Mackey et al. (2010)	None tested	n/a	None tested	Not tested

Aerobic Exercise and Sports					
19	Tuckman & Hinkle (1986)	Aerobic running showed no benefits to other cognitive or non-cognitive skills.	n/a	Aerobic running did not benefit (S9): - <b>classroom behavior</b> (Devereaux behavior scale) - <b>self-concept</b> (Piers-Harris scale) - <b>perceptual-motor ability</b> (Bender-Gestalt test) - <b>planning ability &amp; visual-motor coordination</b> (Maze Tracing Speed test)	Not tested
20	Davis et al. (2011)	Aerobics benefitted (S10): - <b>mathematics achievement</b> (WJ-III) .....	Small	Aerobics did not benefit (S10): - <b>reading achievement</b> (WJ-III)	Not tested
21	Kamijo et al. (2011)	None tested	n/a	None tested	Not tested



Ref #	Author/ Year	Other: Both Cognitive & Non-Cognitive			Results of Assessments ≥ 6 Months Later
		Other Cognitive & Non-Cognitive Skills Improved	Size of Effect	Other Cognitive & Non-Cognitive Skills Not Affected	

Martial Arts and Mindfulness Practices					
28	Lakes & Hoyt (2004)	Tae-Kwon-Do Martial Arts benefitted (S12): - <b>prosocial behavior</b> (SDQT) ..... - <b>mathematics</b> (WISC-III) ..... - <b>conduct</b> (SDQT) .....  *Improvement in conduct significant for boys only	Small Small Medium	Tae-Kwon-Do Martial Arts did not benefit (S12): - <b>emotional symptoms</b> (SDQT) - <b>hyperactivity</b> (SDQT) - <b>peer problems</b> (SDQT) - <b>digit span</b> (WISC-III) - <b>self-esteem</b> (Self-Esteem Inventory)	Not tested
30	Flook et al. (2010)	Mindfulness benefitted (S13): - parent ratings on the BRIEF: • <b>initiate</b> .....  -teacher ratings on the BRIEF: • <b>initiate</b> .....	Large  Medium	None tested	Not tested
31	Manjunath & Telles (2001)	None tested	n/a	None tested	Not tested

Classroom Curricula					
35	Diamond et al. (2007)	None tested	n/a	None tested	Not tested
41	Lillard & Else-Quest (2006)	Montessori benefits (S15): 1) 5-year-olds - <b>letter-word ID</b> (WJ-III) ..... - <b>phonological decoding ability</b> (WJ-III) ..... - <b>math skills</b> (WJ-III) ..... - <b>higher level of reasoning referring to justice/ fairness</b> (Social problem-solving) ..... - <b>more positive shared play</b> (playground observation) - <b>less ambiguous rough play</b> (playground observation)  2) 12-year-olds - <b>sophisticated sentence structure</b> (Narrative Composition) ..... - <b>positive social strategies</b> (Social problem-solving) ..... - <b>sense of school as community</b> (questionnaire) .....	Medium Medium Medium  Large Medium Large  Medium Large Medium	Montessori did not benefit (S15): 1) 5-year-olds - <b>vocabulary</b> (WJ-III) - <b>spatial reasoning</b> (WJ-III) - <b>concept formation</b> (WJ-III)  2) 12-year-olds - <b>any cognitive / academic measures</b> (WJ-III)	Not tested



Ref #	Author/ Year	Other: Both Cognitive & Non-Cognitive			Results of Assessments $\geq$ 6 Months Later
		Other Cognitive & Non-Cognitive Skills Improved	Size of Effect	Other Cognitive & Non-Cognitive Skills Not Affected	

Add-ons to Classroom Curriculum					
43	Riggs et al. (2006)	None tested	n/a	None tested	- EFs predicted fewer internalizing or externalizing behavior problems 1 year later (CBCL) (S16)
45 46	Raver et al. (2008, 2011)	CSRP benefitted (S17): - <b>vocabulary</b> (PPVT) ..... - <b>letter-naming</b> (Letter-Naming task) ..... - <b>mathematics skills</b> (Early Math Skills) .....	Small Small Small	None; only benefits reported.	- EFs predicted academic achievement up to 3 years later on math and reading

#### iv. Supplementary Online References and Notes

S1. Cogmed Training has two different working memory training programs for children

- a) CogMed JM for preschoolers used by Thorell et al. (2009) & Bergman Nutley et al. (2011)
- b) CogMed RM for school-age children used by Klingberg et al. (2005) & Holmes et al. (2009, 2010)

S2. Holmes et al. (2009)

**Dosage & Duration:** Difficult to be specific about dosage and duration because an adaptive paradigm was used which necessarily differs for each child depending on ability level.

**AWMA** - Automated Working Memory Assessment [T.P. Alloway, *Automated working memory assessment* (Harcourt, Oxford, 2007).]

**Following Instructions task** - a practical assessment of working memory use in the classroom [S.E. Gathercole et al. *Applied Cog. Psychol.* **22**, 1019 (2008).]

**WASI** - Wechsler Abbreviated Scales of Intelligence [D. Wechsler, *Wechsler abbreviated scale of intelligence* (Harcourt, London, 1999).]

**WORD** - Wechsler Objective Reading Dimensions [D. Wechsler, *Wechsler objective reading dimensions (WORD)* (Psychological Corporation, New York, 1993).]

**WOND** - Wechsler Objective Number Dimensions [D. Wechsler, *Wechsler objective number dimensions (WOND)* (Psychological Corporation, New York, 1996).]

S3. Klingberg et al. (2005)

**WISC-III** - Wechsler Intelligence Scales for Children – III [D. Wechsler, *WISC-III: Wechsler intelligence scale for children* (Psychological Corporation, San Antonio, 1991).]

**WAIS-RNI** - Wechsler Adult Intelligence Scale – Revised [D. Wechsler, *WAIS-R manual* (Psychological Corporation, New York, 1981).]

S4. Bergman-Nutley et al. (2011)

**Intervention:** Non-verbal reasoning training involved 3 Leiter battery tests: 1) RP - Repeated Patterns, 2) SO - Sequential Orders, 3) CL - Classifications

**Leiter Battery:** [G.H. Roid, L.J. Miller, *Leiter international performance scale-revised: Examiner's manual* (Stoelting Co., Wood Dale, 1997).]

**AWMA** - Automated Working Memory Assessment [T.P. Alloway, *Automated working memory assessment* (Harcourt, Oxford, 2007).]

**Raven's Colored Progressive Matrices:** Sets A, B, & AB [J.C. Raven, *Manual for Raven's progressive matrices* (Oxford Psychologists Press, Oxford, 1998).]

**WPPSI** - Wechsler Preschool and Primary Scale of Intelligence

[D. Wechsler, *Wechsler preschool and primary scale of intelligence – third edition (WPPSI-III)* (Psychological Corporation, New York, 2004).]

S5. Thorell et al. (2009)

**Subject Groups:** Active control group played computerized games with little demand on WM & inhibition.

**WAIS-RNI** - Wechsler Adult Intelligence Scale – Revised [D. Wechsler, *WAIS-R manual* (Psychological Corporation, New York, 1981).]

**NEPSY** - Developmental Neuropsychological Assessment

[M. Korkman, S.L. Kemp, U. Kirk, *NEPSY – A developmental neuropsychological assessment* (Psychological Corporation, San Antonio, 1998).]

**WPPSI-R** - Wechsler Preschool and Primary Scale of Intelligence – Revised

[D. Wechsler, *WPPSI-R. Wechsler preschool and primary scale of intelligence – revised* (Psychological Corporation, New York, 1995).]

S6. Holmes et al. (2010)

**Dosage & Duration:** Difficult to be specific about dosage and duration because an adaptive paradigm was used which necessarily differs for each child depending on ability level.

**AWMA** - Automated Working Memory Assessment [T.P. Alloway, *Automated working memory assessment* (Harcourt, Oxford, 2007).]

**WASI** - Wechsler Abbreviated Scale of Intelligence [D. Wechsler, *Wechsler abbreviated scale of intelligence* (Harcourt, London, 1999).]

S7. Rueda et al. (2005)

**Control Group:** Authors consider this an active control condition and note that subjects had to periodically answer questions about the videos they were watching.

**K-BIT** – Kaufman Brief Intelligence Test [A.S. Kaufman, N.L. Kaufman, *Kaufman brief intelligence test – manual* (American Guidance Service, Circle Pines, 1990).]

**CBQ** – Children's Behavior Questionnaire [M.K. Rothbart, S.A. Ahadi, K. Hershey, *Merrill Palmer Quart.* **40**, 21 (1994).]

S8. Mackey et al. (2010)

**Training Games:** List of computerized and non-computerized games

1) Reasoning games: Computerized (Azada, Azada II), Nintendo DS (Big Brain Academy, Picross, Professor Brainium's Games, Neves, Pipe Mania), Non-computerized (Set, Qwirkle, Rush Hour, Tangoes, Chocolate Fix)

2) Processing speed games: Computerized (Feeding Frenzy, Super Cow, Bricks of Atlantis), Nintendo DS (Nervous Brickdown, Super Monkey Ball, Mario Kart, Ratatouille), Non-computerized (Spoons, Pictureka, Speed, Blink, Perfection)

**TONI-3** - Test of Non-verbal Intelligence [L. Brown, R.J. Sherbenou, S.K. Johnsen, *Test of nonverbal intelligence examiner's manual* (Pro. Ed., Austin, ed. 3, 1997).]

**WJ-R** - Woodcock-Johnson Revised [R.W. Woodcock, M.B. Johnson, *Woodcock-Johnson psycho-educational battery- revised* (Riverside, Chicago, 1989).]

**WMS** - Wechsler Memory Scale [D. Wechsler, *Wechsler memory scale- revised manual* (Psychological Corporation, San Antonio, 1987).]

**WISC-IV** - Wechsler Intelligence Scale for Children – IV [D. Wechsler, *Wechsler intelligence scale for children – fourth edition* (Psychological Corporation, San Antonio, 2003).]

S9. Tuckman & Hinkle (1986)

**Devereaux Elementary School Behavior Rating Scale** [M. Swift, *Devereaux elementary school behavior rating scale II manual* (Devereaux Foundation, Devon, 1982).]

**Piers-Harris Children's Self-Concept Scale** [E.V. Piers, D.B. Harris, *J. Educ. Psychol.* **55**, 91 (1964).]

S10. Davis et al. (2011)

**CAS** - Cognitive Assessment System [J.A. Naglieri, *The essentials of CAS assessment* (Wiley, New York, 1999).]

- 1) Planning scale - strategy generation & application, self-regulation, intentionality, utilization of knowledge

**Matching numbers:** find and underline the 2 matching numbers in each of the 8 rows of numbers; strategy use leads to better results

**Planned codes:** associate letters to test items, complete a page using codes (e.g. XX or OX) corresponding to letters (e.g. A, B, C) where the organization of codes varies so one must update; strategy use leads to better results

**Planned connections:** draw lines to connect numbers and letters in alternating sequence

- 2) Attention scale - focused, selective cognitive activity, resistance to distraction

**Modified Stroop test**

**Number detection:** identify single digit numbers only when they appear in a specific font)

**Receptive attention:** perform letter discrimination on the basis of physical identity (r,r) or conceptual (r, R)

**WJ-III** - Woodcock-Johnson Tests of Achievement III [R.W. Woodcock, K.S. McGrew, N. Mather, *Woodcock-Johnson III* (Riverside Publishing, Rolling Meadows, 2001).]

S11. Kamijo et al. (2011)

**Modified Sternberg task** - EEG (electroencephalogram) recording taken while performing task [S. Sternberg, *Science* **153**, 652 (1966).]

S12. Lakes & Hoyt (2004)

**Intervention:** LEAD - Leadership Education through Athletic Development

**Response to Challenge Scale** [K.D. Lakes, W.T. Hoyt, *The response to challenge scale (RCS)* (Orange County, 2003).]

**Physical self-regulation** - physical control and skillfulness from awkward to skillful

**Cognitive self-regulation** - ability to focus attention and efforts on task at hand from distractible to focused

**Affective self-regulation** - assess self-confidence, emotional control, persistence and will from quitting to persevering

**SDQT** - Strengths and Difficulties Questionnaire [R. Goodman, *J. Child Psychol. Psych.* **38**, 581 (1997).]

**WISC-III** - Wechsler Intelligence Scale for Children – III [D. Wechsler, *WISC-III: Wechsler intelligence scale for children* (Psychological Corporation, San Antonio, 1991).]

S13. Flook et al. (2010)

**Teacher & Parent BRIEF** - Behavior Rating Inventory of Executive Function

[G.A. Gioia, P.K. Isquith, S.C. Guy, L. Kenworthy, *Behavior rating inventory of executive function* (Psychological Assessment Resources, Lutz, 2000).]

S14. Manjunath & Telles (2001)

**Tower of London** – Yoga group showed decreased planning time, decreased execution time & decreased number of moves.

S15. Lillard & Else-Quest (2006)

**Dosage & Duration:** Duration information difficult to specify as subjects in the study were 5- and 12-year-old students already enrolled in the Montessori curriculum.

**WJ-III** - Woodcock-Johnson - III [R.W. Woodcock, K.S. McGrew, N. Mather, *Woodcock-Johnson III* (Riverside Publishing, Rolling Meadows, 2001).]

S16. Riggs et al. (2006)

**CBCL** - Child Behavioral Checklist [T.M. Achenbach, *Manual for the child behavior checklist and 1991 profile* (Department of Psychiatry, Univ. of Vermont, Burlington, 1991).]

S17. Raver et al. (2008, 2011)

**PSRA** - Preschool Self-Regulation Assessment [R. Smith-Donald, C.C. Raver, T. Hayes, B. Richardson, *Early Childhood Quar.* **22**, 20 (2007).]

**PPVT** - Peabody Picture Vocabulary Test [L.M. Dunn, L.M. Dunn, *Peabody picture vocabulary test- third edition* (American Guidance Service, Circles Pines, 1997).]