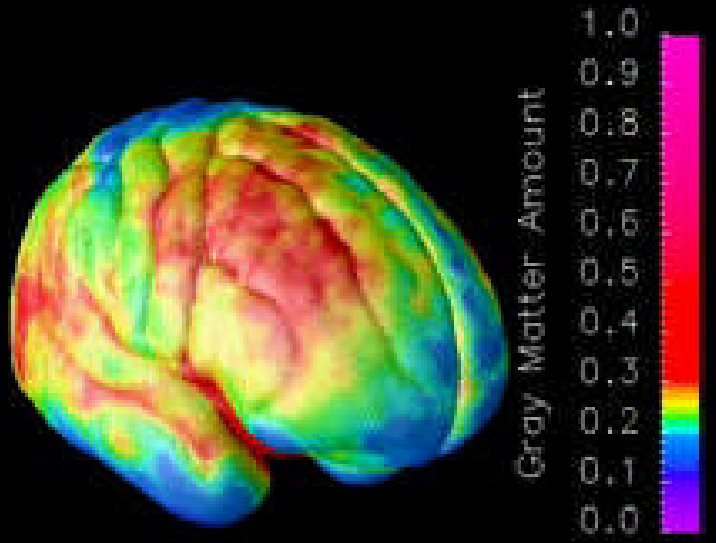
Executive Function: Concepts, Assessment & Intervention



Peter K. Isquith, Ph.D
Gerard A. Gioia, Ph.D.
Robert M. Roth, Ph.D.

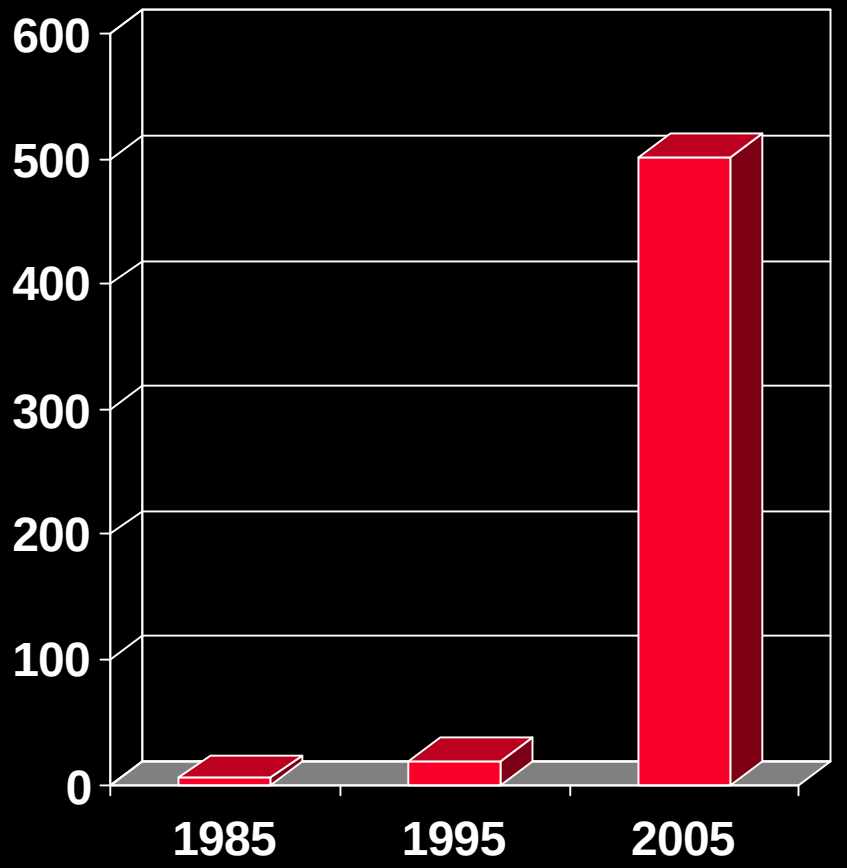
PAR Psychological Assessment Resources, Inc.

Interest in Executive Function in Children

- 5 articles in 1985
- 14 articles in 1995
- 501 articles by 2005

– *Bernstein & Waber*

Executive Function in Education, 2007



Plan

- What are Executive Functions?
- How do we identify them?
- What is the developmental course?
- What is the brain basis?
- How do they manifest in clinical disorders?

Executive Function Definitions

- Planning and sequencing of complex behaviors
- Ability to pay attention to several components at once
- Capacity for grasping the gist of a complex situation
- Resistance to distraction and interference
- Inhibition of inappropriate response tendencies
- Ability to sustain behavioral output for relatively prolonged periods

Stuss & Benson, 1984

Orchestration of basic cognitive processes during goal-oriented problem-solving

Neisser, 1967

Functions of the "Orchestra"

- Perception
- Attention
- Language processes
- Visual-spatial processes
- Memory
- Sensory inputs
- Motor outputs
- Knowledge & skills
  - social
  - non-social

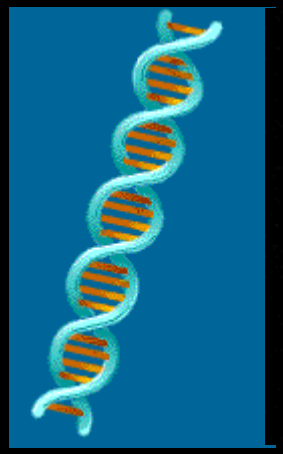
Functions of the "Conductor"

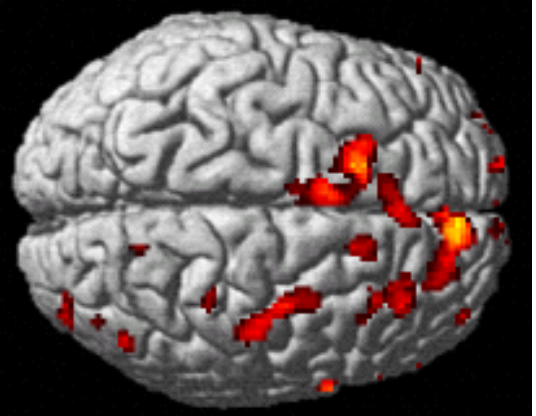
- Inhibit
- Shift Flexibly
- Modulate Emotions
- Initiate
- Working Memory
- Plan
- Organize
- Self-monitor & evaluate

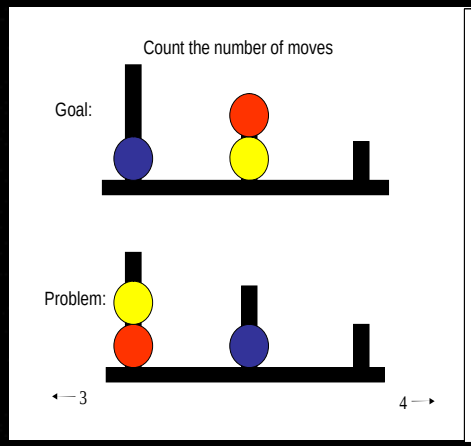
Methods of Assessing EF

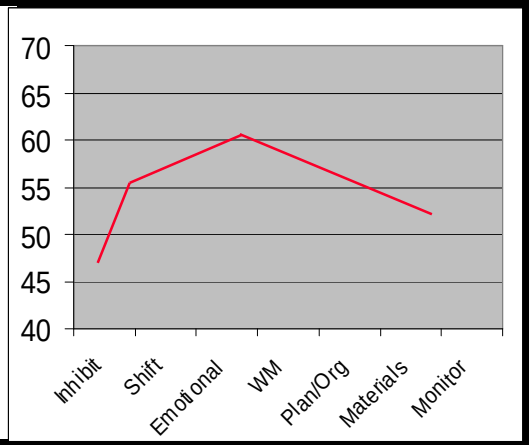
Micro **Molar** **Macro**

Genetics *Structural & Functional Imaging* *Performance Tests* *Observations*









Measurement of Executive Functions

- Executive Functions are dynamic, fluid
- All tests and tasks require content and EF
- Many tests are too structured to observe EF
- Examiner as “Executive”

Methods of Assessing EF Advantages

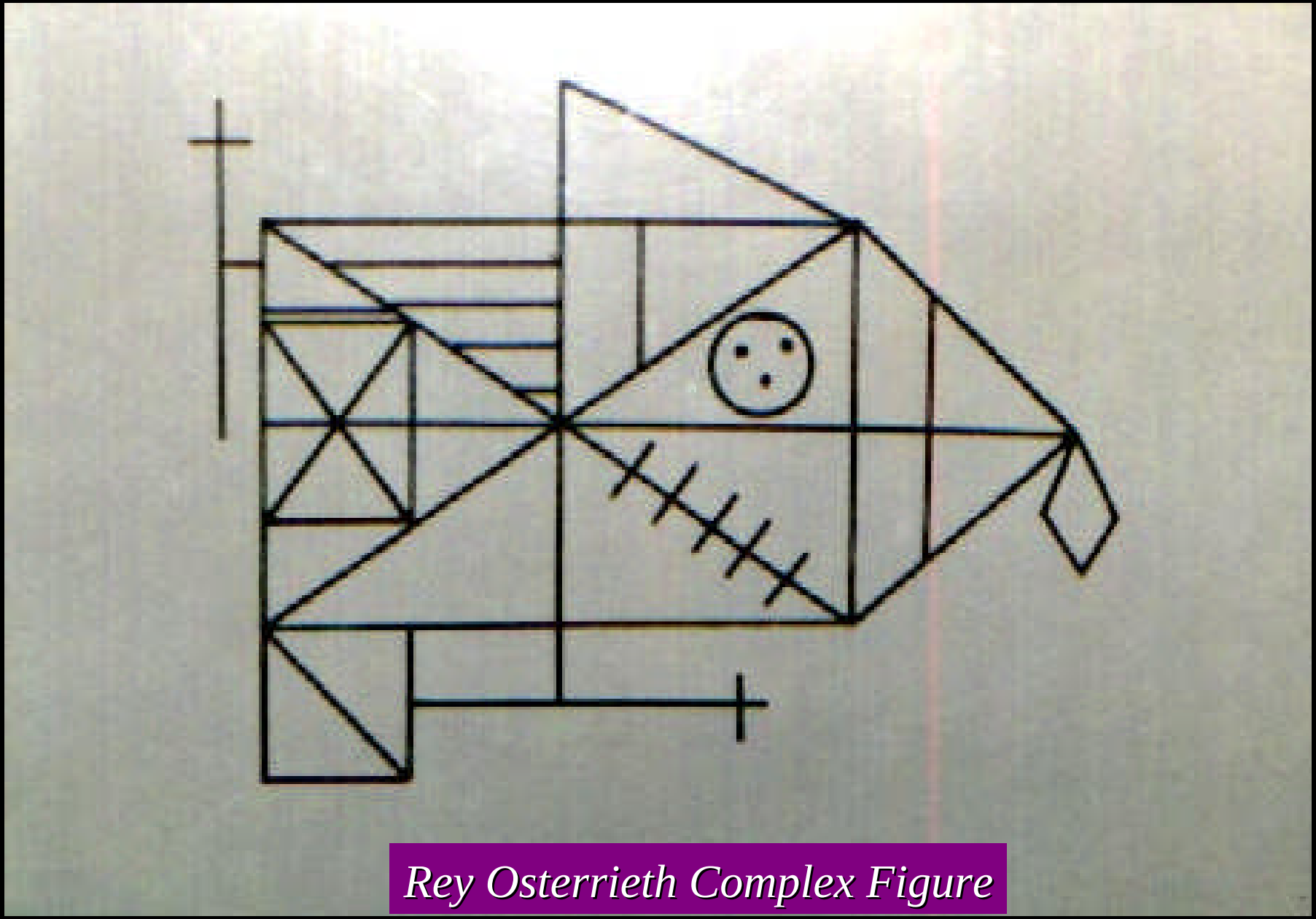
- Molar Level
  - Increased specificity of process
  - Increased task control and internal validity
- Macro Level
  - Opportunity for EF in dynamic action
  - Increased ecological validity

Methods of Assessing EF Disadvantages

- Molar Level
  - Fragmentation of EF out of context
  - Decreased ecological validity
  - Influence of “content” variance
- Macro Level
  - Decreased control of environmental contingencies
  - Respondent variance (rating scales)

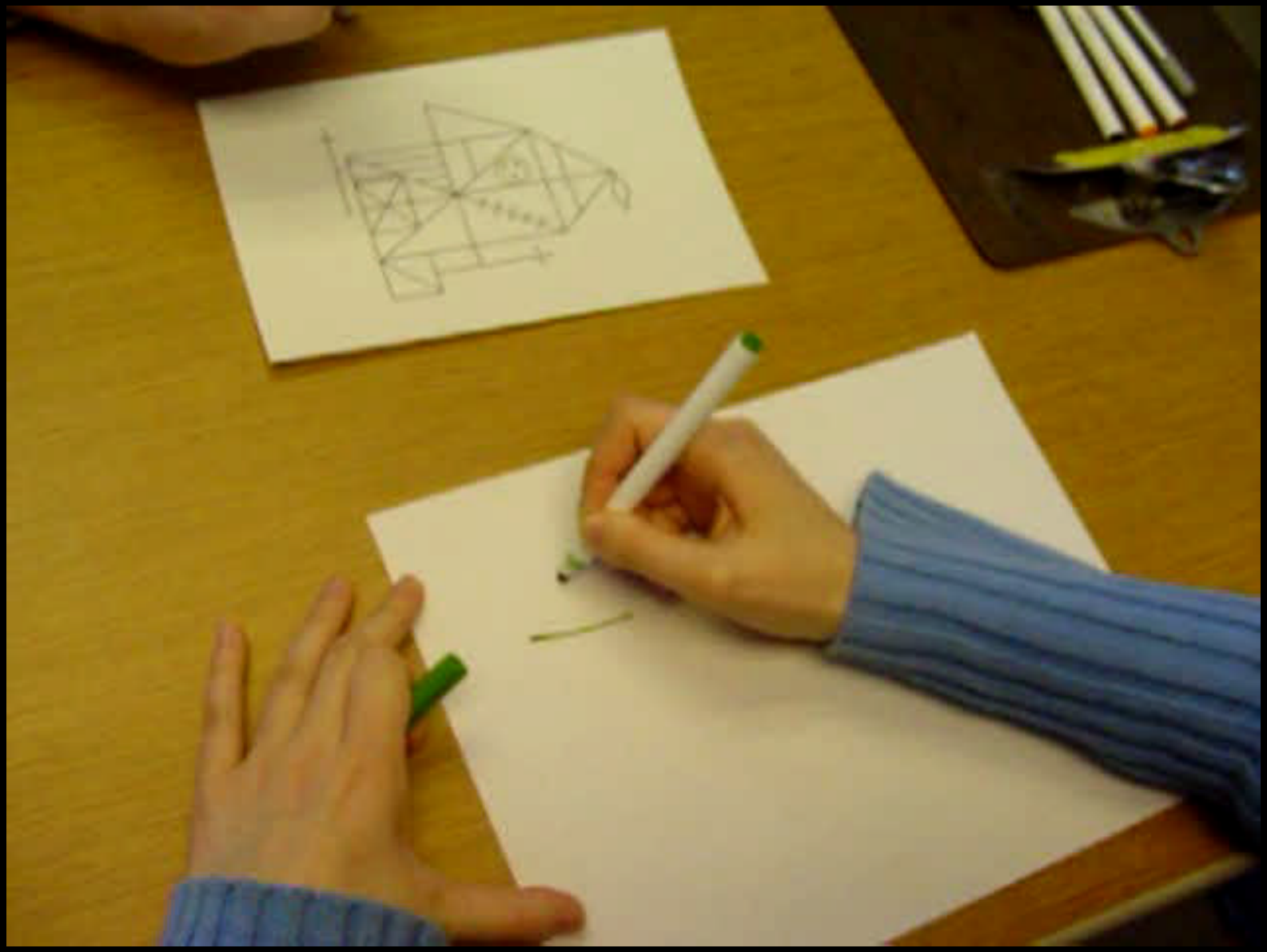
Performance Tests tapping Executive Functions

- Verbal Fluency / Figural Fluency
- Stroop Color-Word Interference Test
- Rey-Osterrieth Complex Figure
- Tower of Hanoi / Tower of London
- Wisconsin Card Sorting Test
- Mazes
- Trail Making
- Continuous Performance Tests

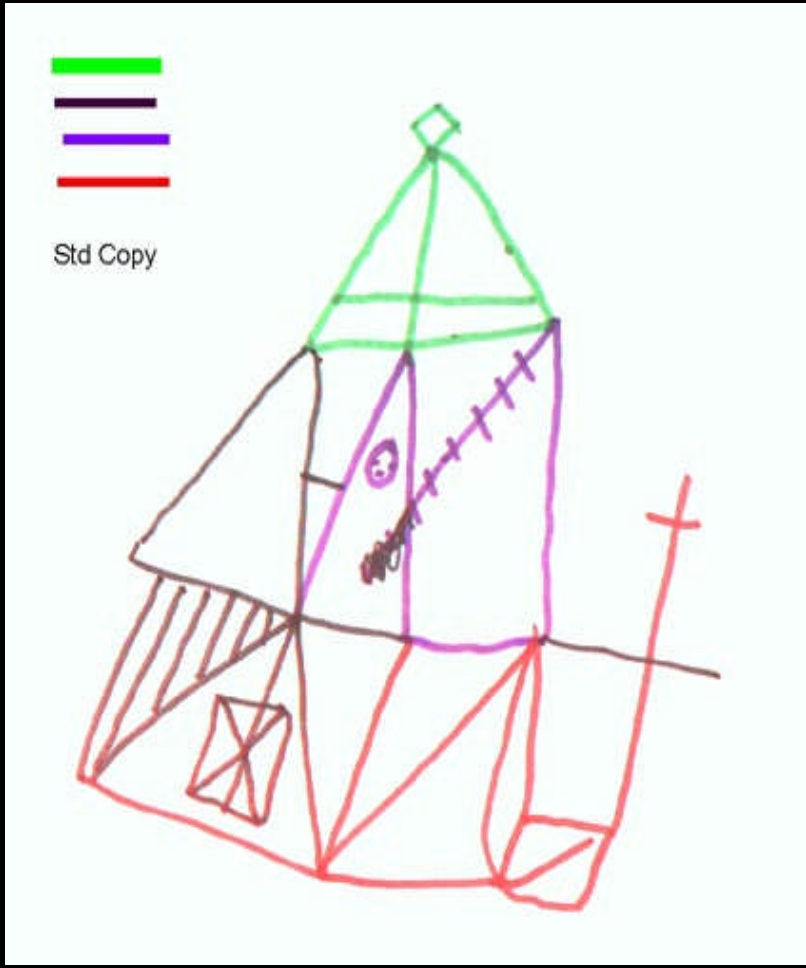


Rey Osterrieth Complex Figure

The Rey-Osterrieth Complex Figure



9-year-old with Reading Disorder



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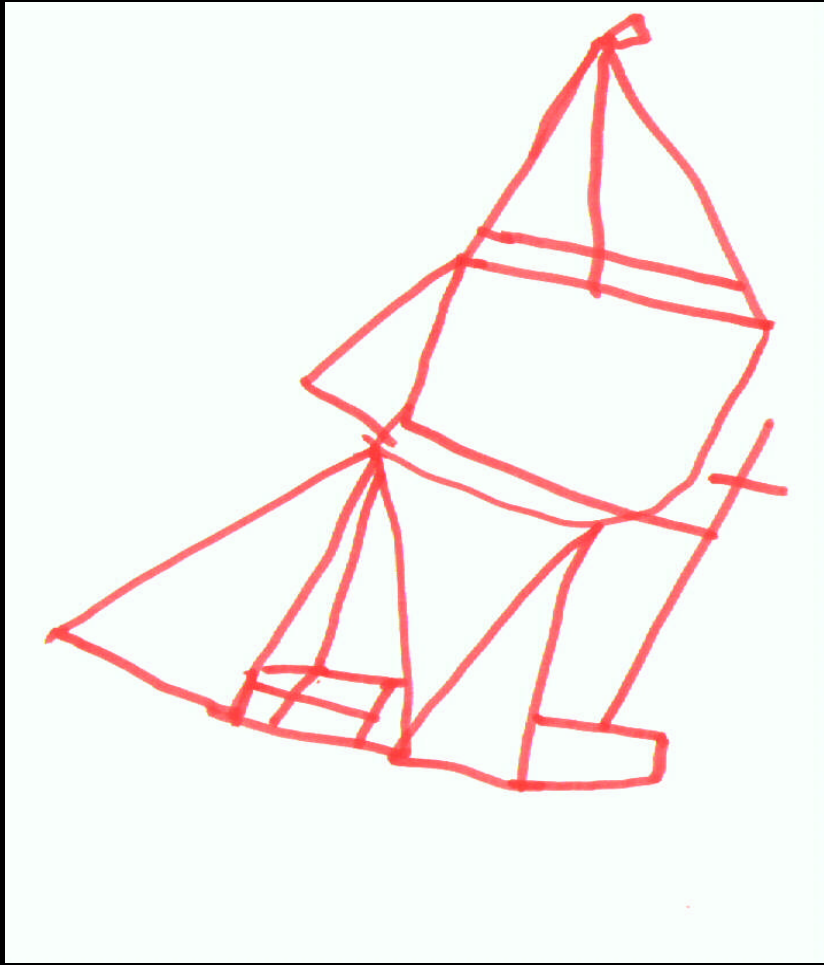
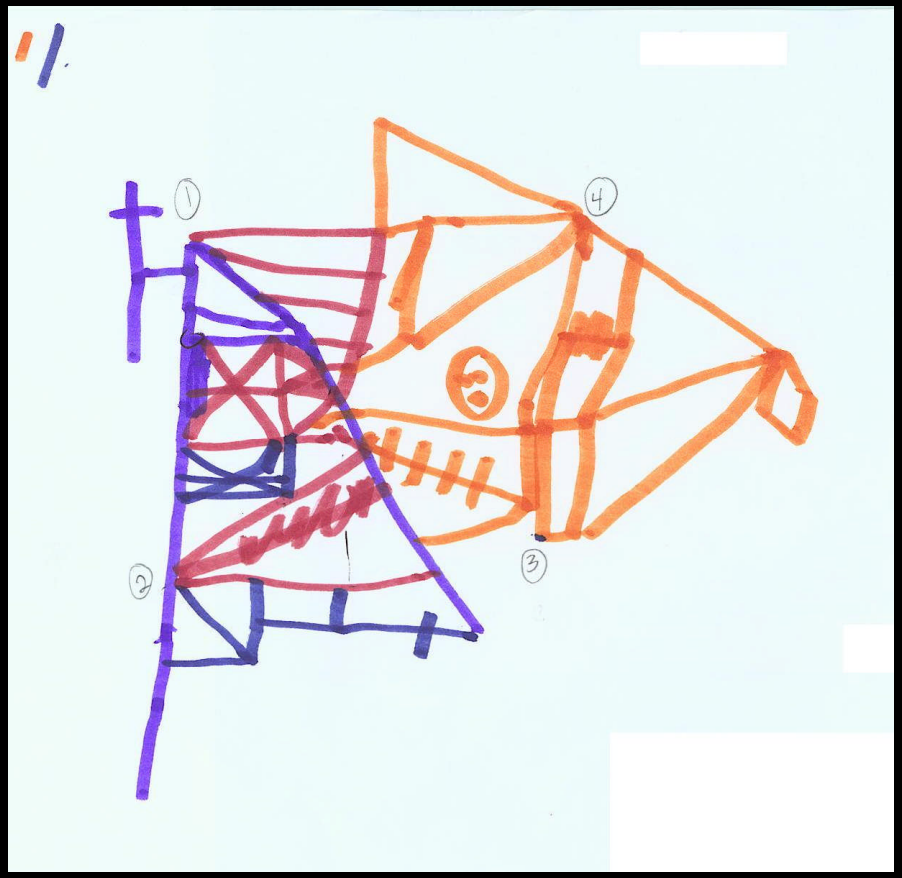


Recall

8 year-old boy with Asperger's



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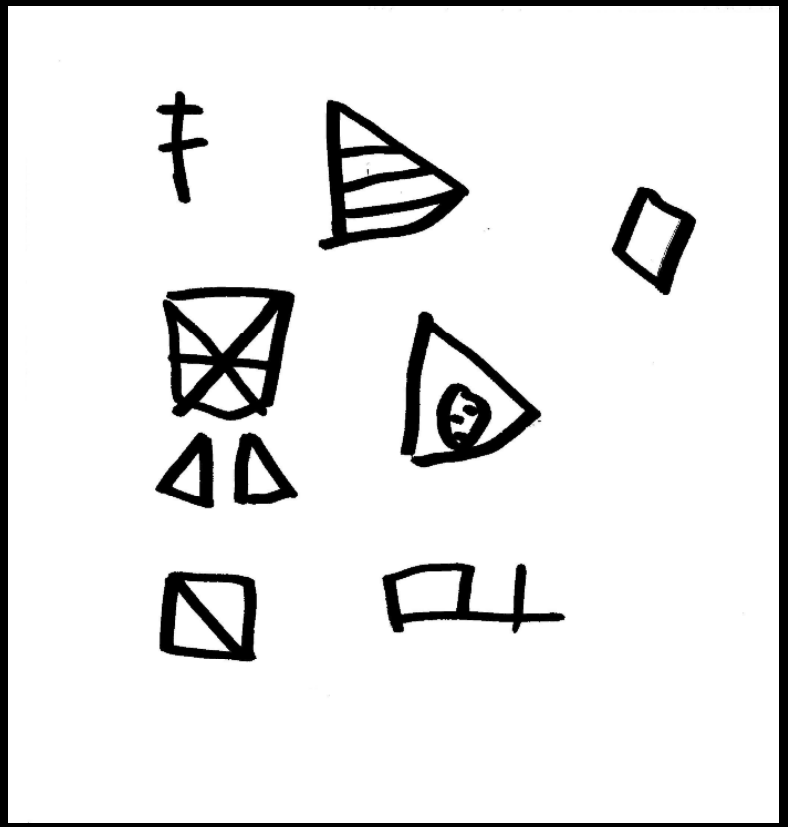
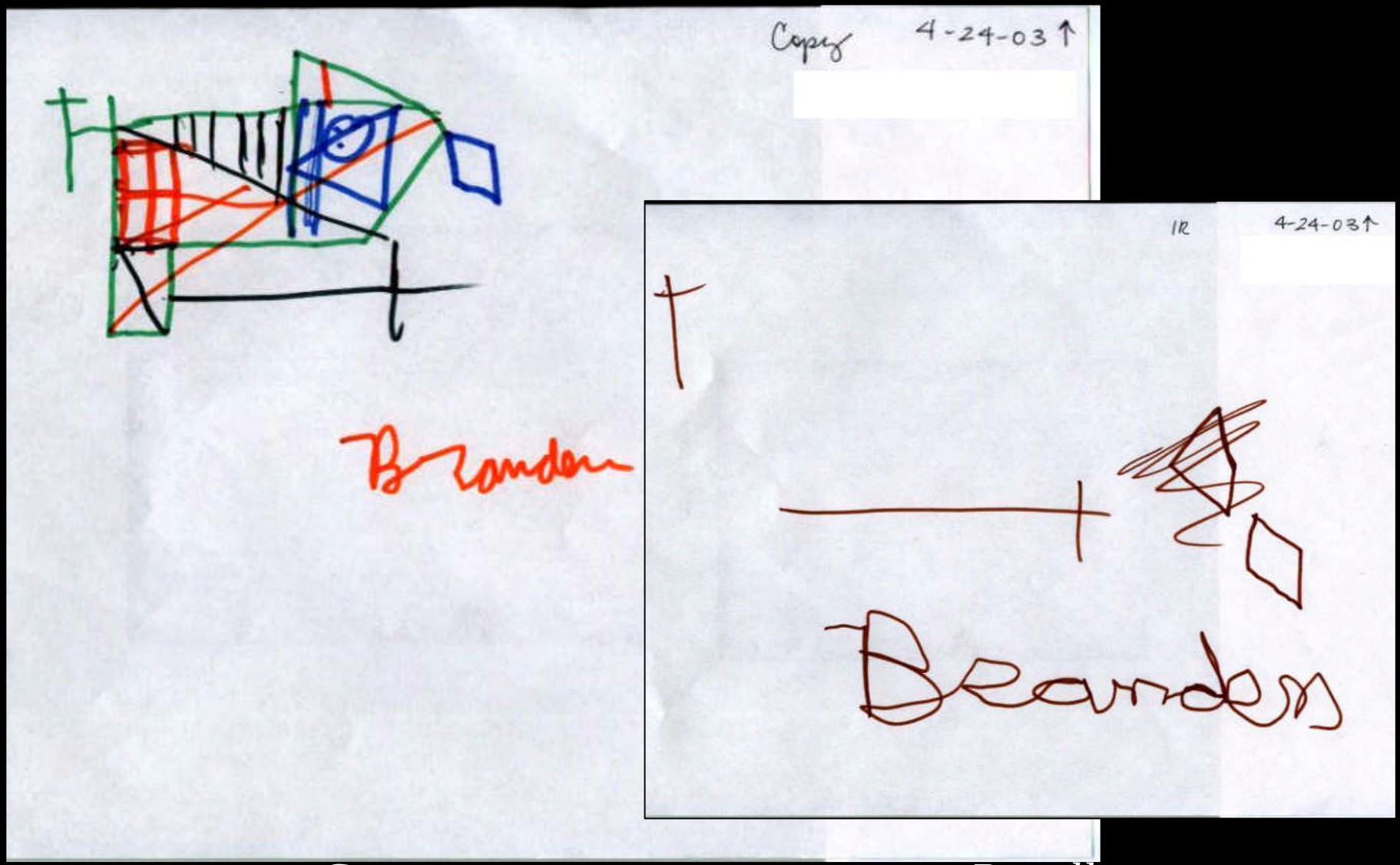


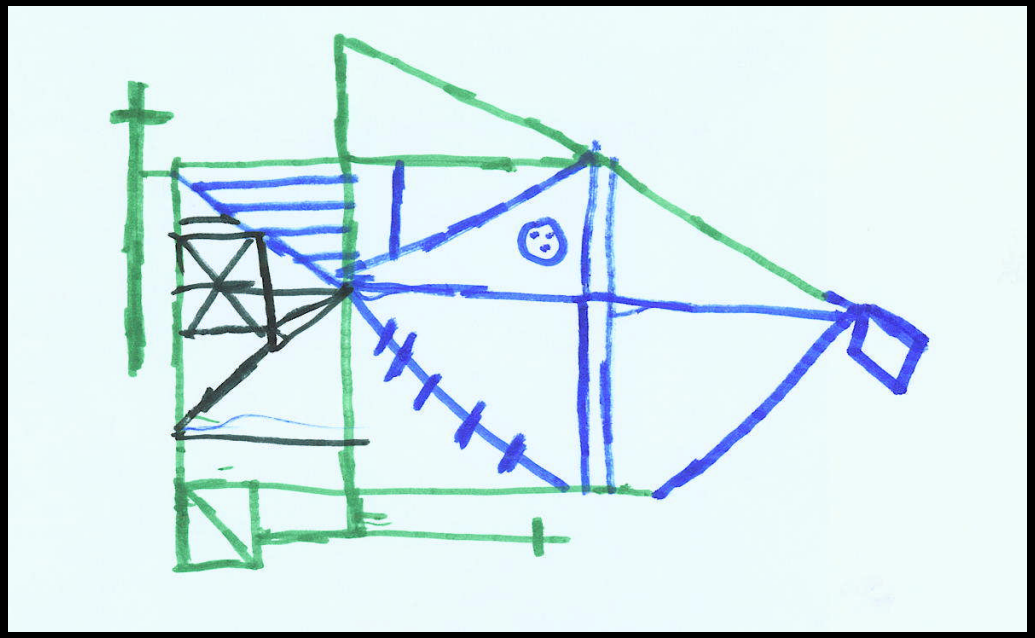
Recall

10 year-old boy with ADHD-C



Copy *Recall*

10 year old with ADHD-I



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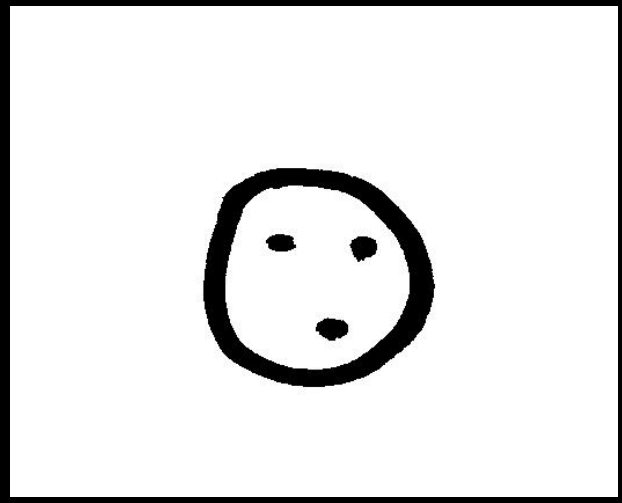
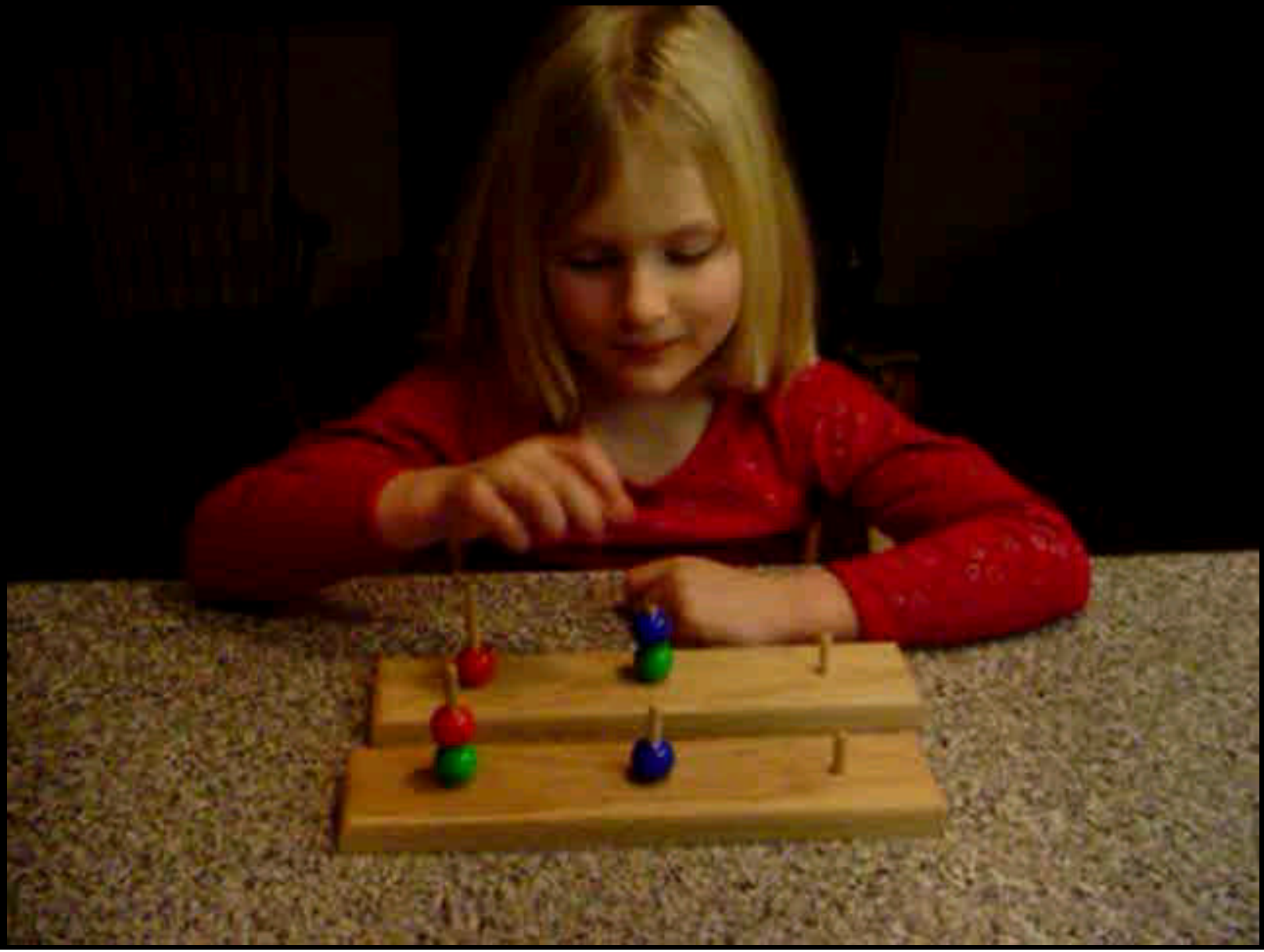


Recall


The Handbook of
Rey-Osterrieth
Complex Figure Usage:
Clinical and Research Applications
Edited by
Jeffrey A. Knight, PhD
Psychological Assessment Resources, Inc.

The Tower of London

Tower of London 6 Move



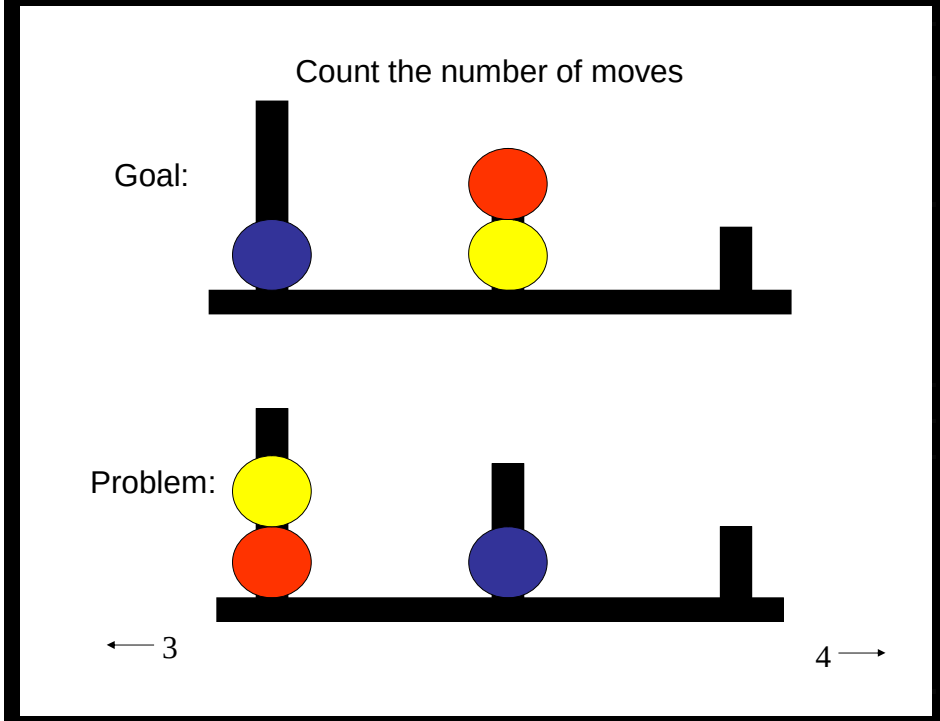
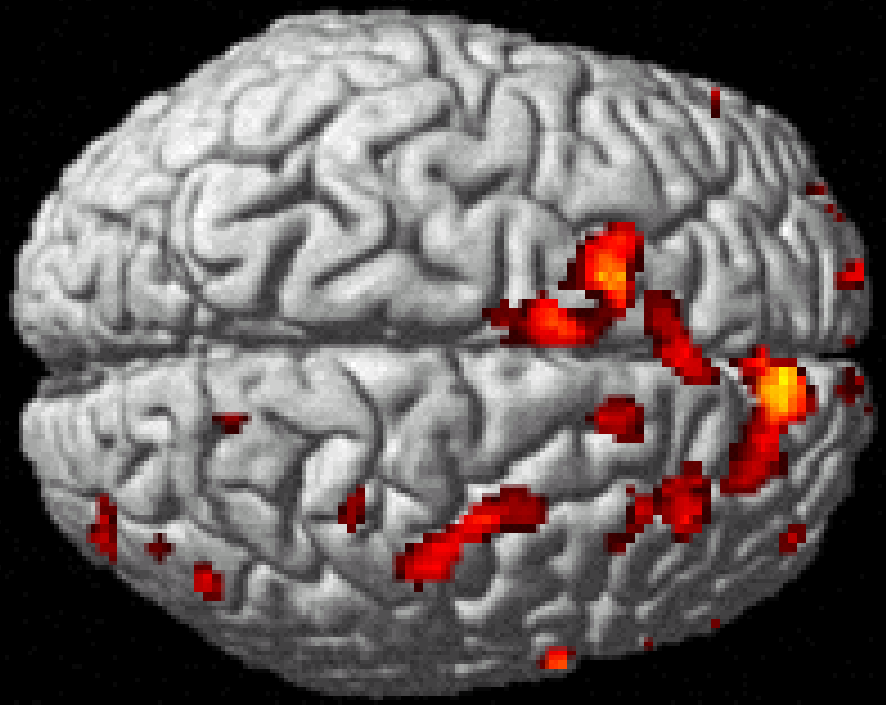


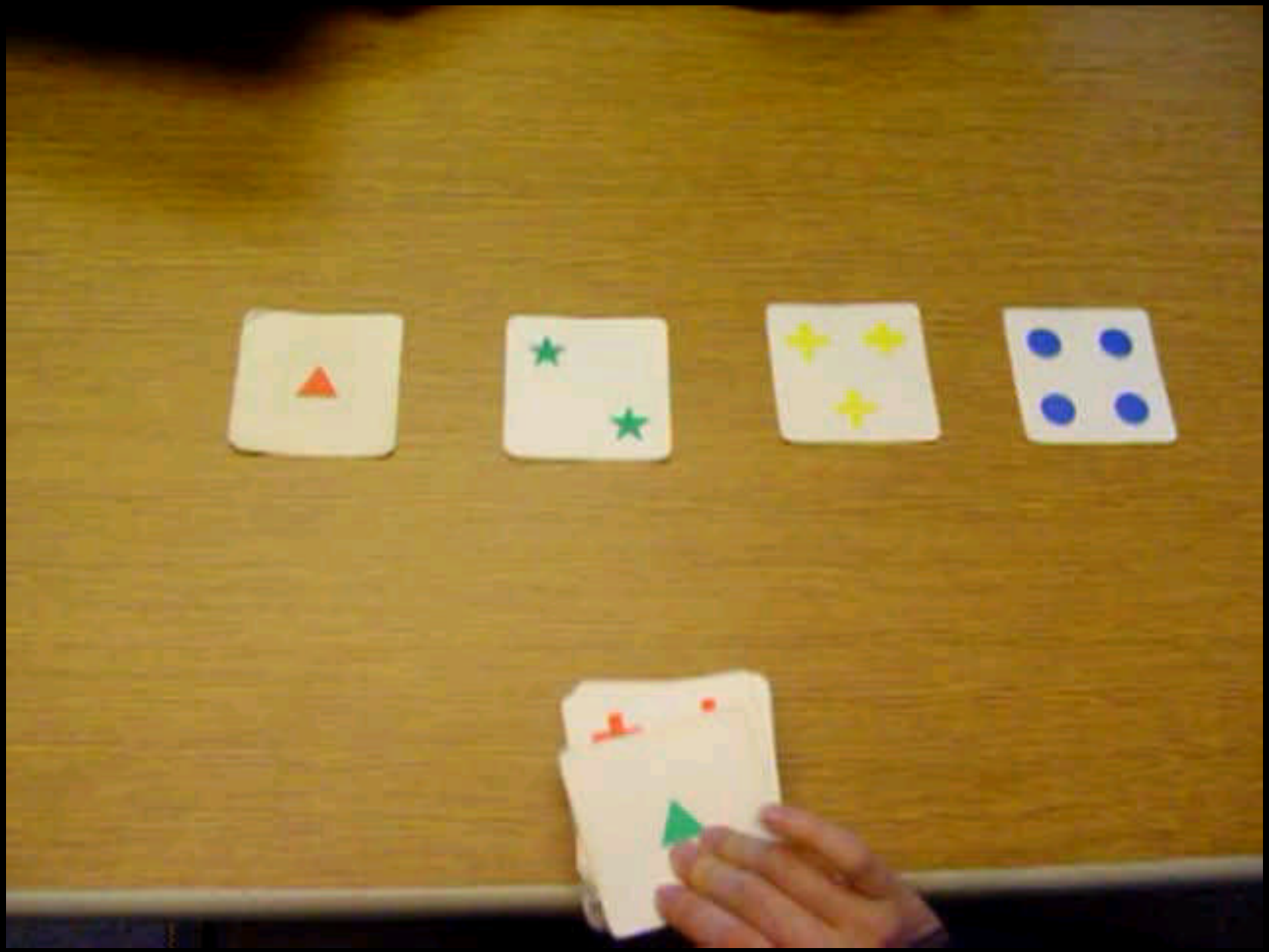
Illustration of a Tower of London task adapted for fMRI



fMRI during the hard condition relative to the easy task condition (difficulty being based on number of moves required to solve problem) in a healthy adult, showing prominent frontal lobe activation

From the Brain Imaging Laboratory at Dartmouth Medical School; Roth et al. (2006)

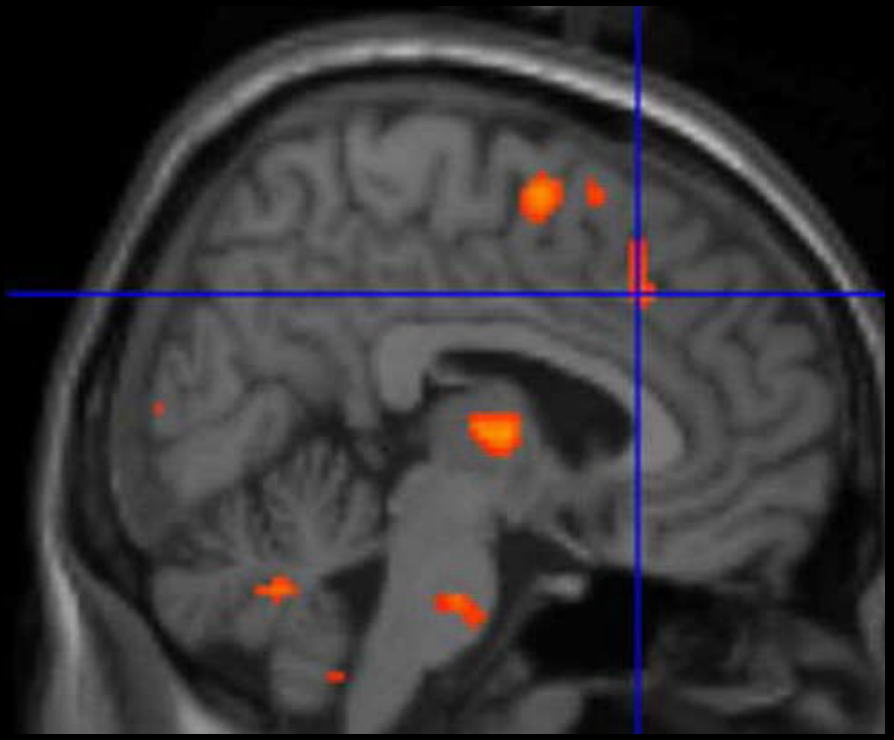
Wisconsin Card Sorting Task



Stroop Task: Inhibit

Illustration of a Counting Stroop task adapted for fMRI

Neutral Condition	Congruent Condition	Incongruent Condition
XXXX	TWO	TWO
XXXX	TWO	TWO
XXXX		TWO
XXXX		



fMRI during the incongruent condition relative to the congruent condition in a group of 13 healthy adults, showing prominent activation of the dorsal anterior cingulate gyrus

From *the Brain Imaging Laboratory at Dartmouth Medical School (Roth et al., 2006)*

Limitations to Performance Tests:

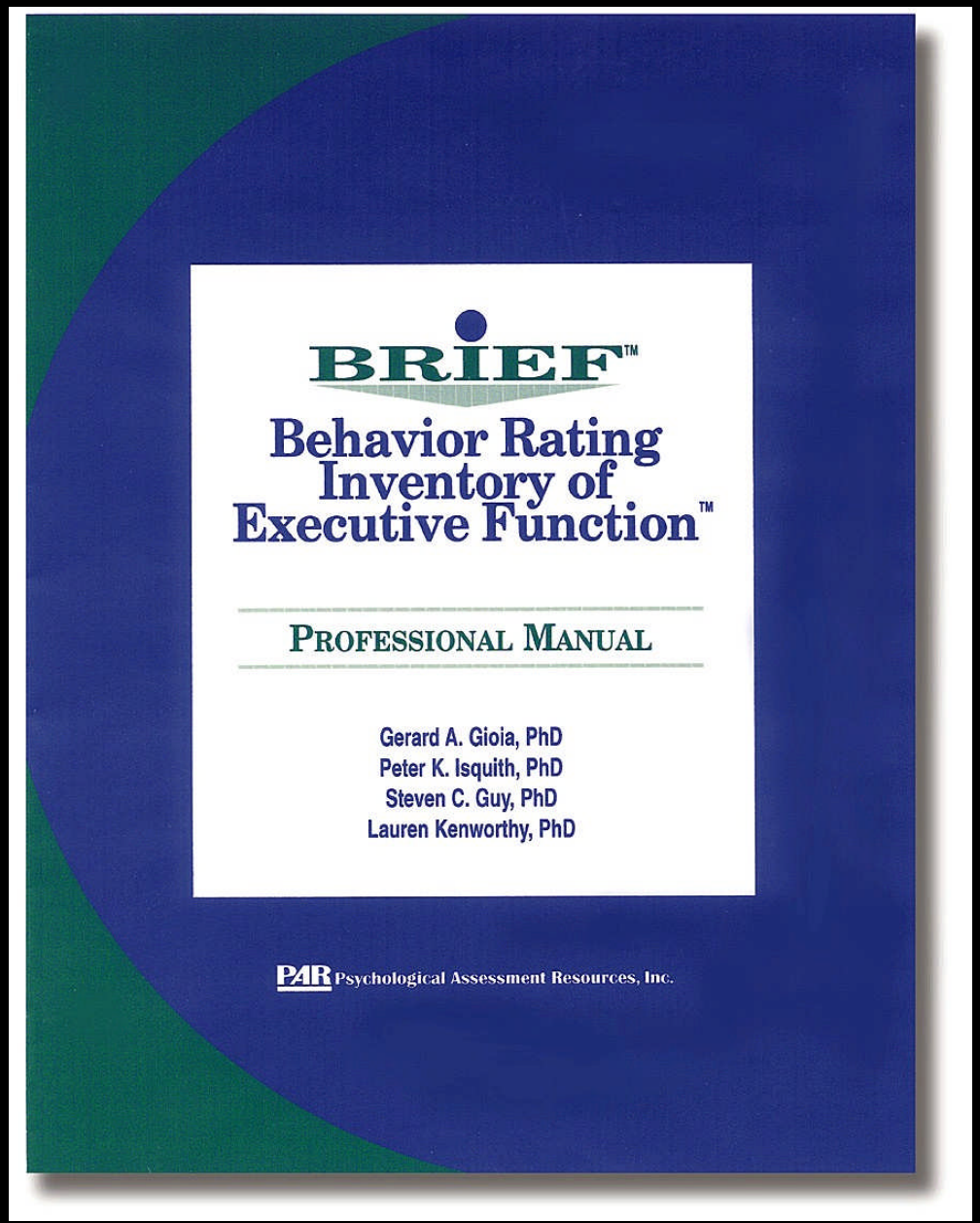
- EF tests are molar, tapping several EF and non-EF functions that can be disrupted in many ways
- Differences in cognitive ‘style’ or ability can affect EF performance regardless of EF
- Sensitivity/Specificity limited- Pts who should have EF deficits do well on EF tests; EF performance not sensitive to frontal vs extra-frontal lesions
- Discriminant Validity- If EF tasks are impaired in several disorders, then EF’s are not helpful in distinguishing between disorders

Pennington & Ozonoff, 1996

“Macro Level”

Impetus:

- Clinical need for external validation, ecological validity, real-world anchor
- Common parent descriptions
- Performance tests versus rating scales


BRIEF™
Behavior Rating Inventory of Executive Function™
PROFESSIONAL MANUAL
Gerard A. Gioia, PhD
Peter K. Isquith, PhD
Steven C. Guy, PhD
Lauren Kenworthy, PhD
PAR Psychological Assessment Resources, Inc.

BRIEF Conspirators

Gerard A. Gioia, Ph.D. Lauren Kenworthy, Ph.D.
Children's National Medical Center

Peter K. Isquith, Ph.D. Robert M. Roth, Ph.D.
Dartmouth Medical School

Steven C. Guy, Ph.D.
Independent Practice

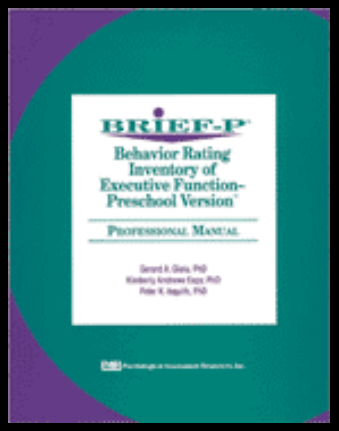
Kimberly Andrews Espy, Ph.D.
Vice Provost, University of Nebraska, Lincoln

Rating scales of everyday executive behaviors

- Adult:
  - Frontal Systems Behavior Scale (FrSBe)
  - Dysexecutive Questionnaire (DEX)
  - Behavior Rating Inventory of Executive Function (BRIEF-Adult Version)
- Child
  - Behavior Rating Inventory of Executive Function (BRIEF)
  - Dysexecutive Questionnaire-Children's (DEX-C)

A BRIEF Geneology

2000



2003

2004

2005

?

200?

BRIEF Basics

	BRIEF	*BRIEF-P*	*BRIEF-SR*	*BRIEF-A*
Items / Scales	86 / 8	63 / 5	80 / 8	80 / 9
α	.80 - .90's	.80 - .90's	.80 - .90's	.80 - .90's
Retest	.80 - .90's	.80 - .90's	.80 - .90's	.80 - .90's
Inter-rater	P - T r = .30	P - T r = .17 - .28	S - P = .50 S - T = .25	Self-Informant = .67
Covary	BASC, CBCL, ADHD-IV	CBCL, ADHD-IV	CBCL, BASC, ADHD-IV, CHQ	Beck, Dex FrSBe, CAD, STAI
Clinical Groups	ADHD, LD, TS, ASD, Frontal lesion, PKU, Trauma	ASD, ADHD, Language, LBW	ADHD, ASD, Anx/Dep, T1DM	ADHD, MCI, MS, TBI, Epilepsy

BRIEF Clinical Studies

- **ADHD -** Jarratt et al, 2005; Loftis, 2005; Viechnicki, 2005; Lawrence et al., 2004; Blake-Greenberg, 2003; Palencia, 2003; Kenealy, 2002; Mahone et al., 2002
- **Reading Disorders** - Gioia et al., 2002; Pratt, 2000.
- **Autism Spectrum Disorders** - Gilotty et al., 2002; Gioia et al., 2002
- **Bipolar Disorder vs ADHD** - Shear et al., 2002
- **Tourette's Syndrome** - Mahone et al., 2002; Cummings et al., 2002
- **Traumatic Brain Injury -** Landry et al., 2004; Brookshire et al., 2004; Gioia et al., 2004; Mangeot et al., 2002; Vriezen et al., 2002; Jacobs, 2002;
- **Spina Bifida and Hydrocephalus -** Burmeister et al., 2005.; Brown, 2005; Mahone et al., 2002.
- **Obstructive Sleep Apnea -** Beebe, 2004, 2002
- **Galactosemia -** Antshel et al., 2004
- **Childhood onset MS -** McCann, et al., 2004
- **Sickle Cell** - Kral et al., 2004
- **22q11 Deletion -** Kiley-Brabeck, 2004
- **PKU -** Antshel et al., 2003
- **Frontal lesions, PKU & Hydrocephalus -** Anderson et al., 2002

BRIEF: Inhibit

- Is impulsive
- Has trouble stopping when silly
- Has to be closely supervised
- Does not think before doing

BRIEF: Shift

- Is stubborn
- Cannot get a disappointment off their mind
- Resists accepting a different way to solve a problem
- Becomes upset with new situations

BRIEF: Emotional Control

- Overreacts to small problems
- Explosive, angry outbursts
- Tearful easily
- Mood changes frequently

BRIEF: Initiate

- Does not take initiative
- Is not a self-starter
- Needs to be told to begin a task even when willing
- Has trouble coming up with ideas for what to do in play or free time
- Lies around the house a lot (couch potato)

BRIEF: Working Memory

- Is absent-minded
- When given three things to do, remembers only the first or last
- Trouble with multistep chores

BRIEF: Plan/Organize

- Good ideas but can't get the job done
- Written work poorly organized
- Starts project without the right materials
- Trouble planning for future play activities
- Underestimates time needed to complete tasks

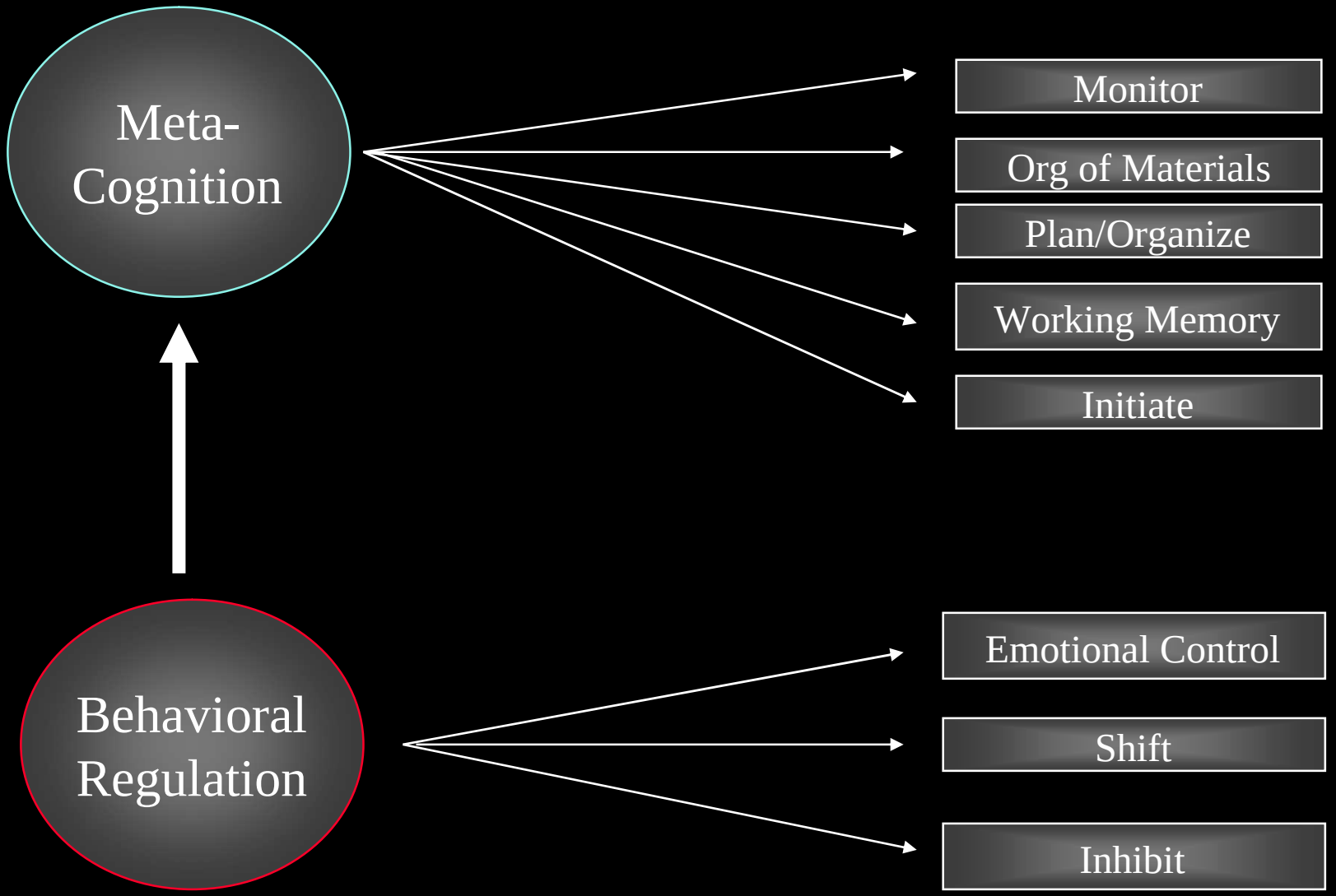
BRIEF: Monitor

- Doesn't ask for help when needed
- Doesn't check work for mistakes
- Makes careless errors
- Unaware of how behavior affects others
- Leaves work incomplete

BRIEF: Organization of Materials

- Leaves playroom a mess
- Loses lunch box, lunch money, permission slips, homework
- Cannot find clothes, glasses, shoes, toys, etc
- Backpack is disorganized

BRIEF Structure



PFA of Parent BRIEF With BASC Parent Rating Scale (n=80)

Scales	Factor			
	1	2	3	4
Working memory	.904			
Plan/organize	.878			
Monitor	.799			
Initiate	.791			
BASC attention problems	.698			
Organization of Materials	.516			
BASC hyperactivity		.720		
BASC conduct problems		.607		

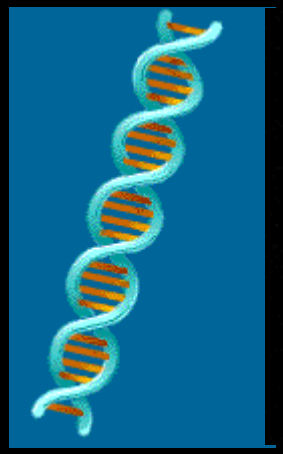
PFA of Parent BRIEF With BASC Parent Rating Scale *(Cont....)*

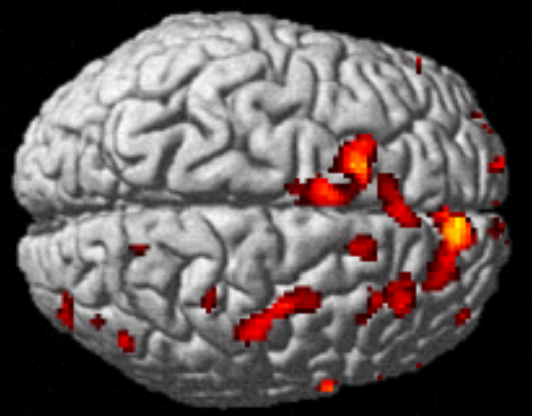
Scales	Factor			
	1	2	3	4
BASC anxiety			.764	
BASC depression			.696	
BASC somatization			.661	
BASC atypicality		.467	.531	
BASC withdrawal			.521	
Inhibit				-.769
Emotional control				-.686
BASC aggression				-.565
Shift				-.392

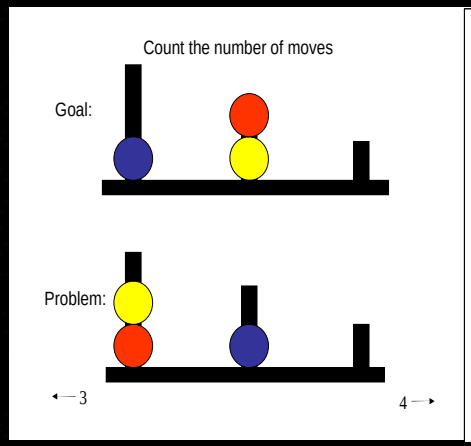
Methods of Assessing EF

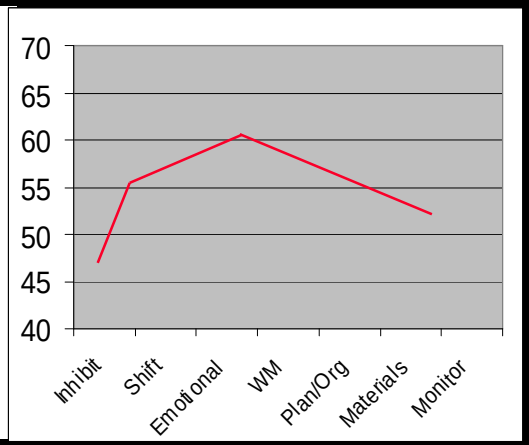
Micro **Macro**

Genetics *Structural & Functional Imaging* *Performance Tests* *Observations*









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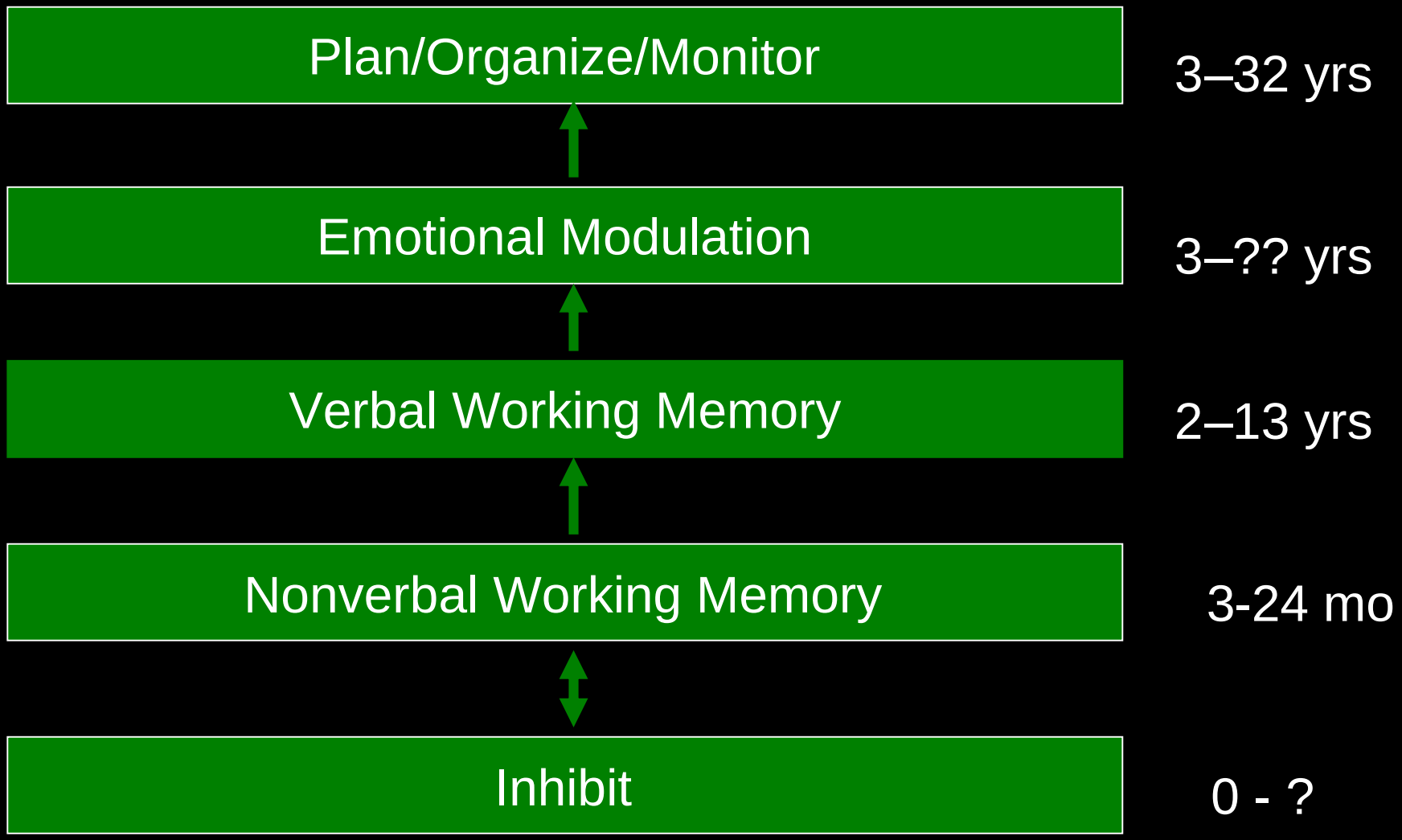
Development of Executive Functions:



Change in effect Size Across Childhood on Performance Tests of Executive Function

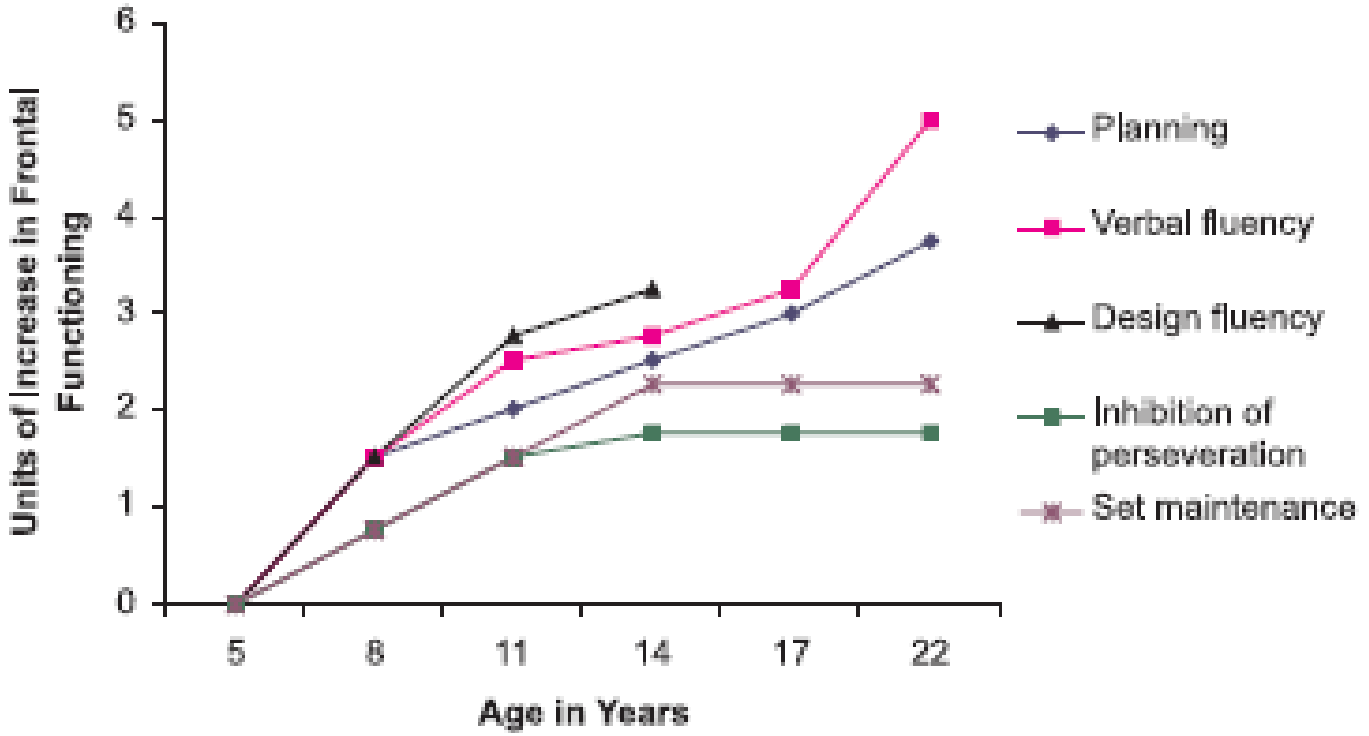


Figure 1. Developmental course of frontal functions based on average effect sizes of age-related change in performance on measures of frontal lobe functioning.

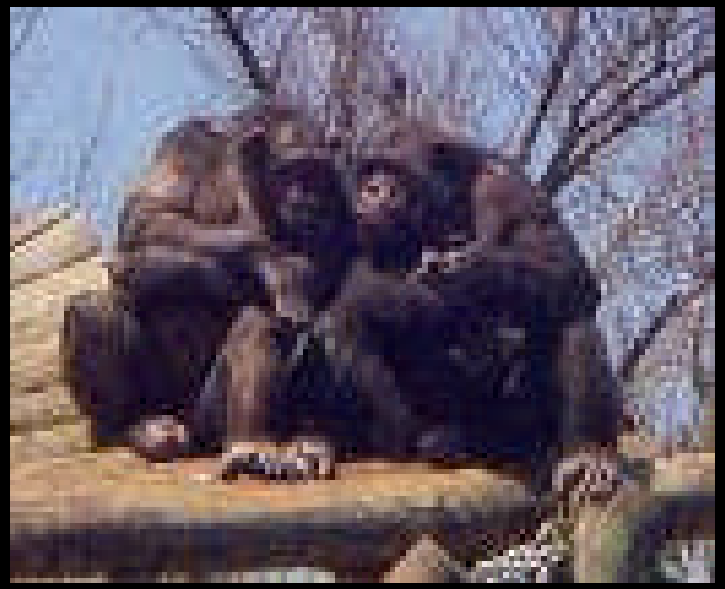
Romine & Reynolds, 2005; Applied Neuropsychology

Adolescence

"Youth today love luxury. They have bad manners, contempt for authority, no respect for older people, and talk nonsense when they should work. Young people do not stand up any longer when adults enter the room. They contradict their parents, talk too much in company, guzzle their food, lay their legs on the table and tyrannize their elders“

Socrates c 400 BC

Adolescence: Not just for humans anymore



- Many species show an adolescent period
- Acquisition of skills permit survival away from parents
  - Increased affiliation with peers
  - Increased risk taking behaviors
- May reflect evolutionary need to avoid inbreeding

Risk Taking Behavior

- Adolescents are highest sensation seeking & risk taking group
- As much as 80% show risk behaviors in a month
- >50% engage in drinking & driving, unprotected sex, illegal drug use, minor criminal activity (Arnett, 1992)

Is Risk Taking Normal

Supreme Court of the United States

---------- ♦ ----------

DONALD P. ROPER, SUPERINTENDENT,
POTOSI CORRECTIONAL CENTER,
Petitioner

v.

CHRISTOPHER SIMMONS

---------- ♦ ----------

**On Writ Of Certiorari To The
Supreme Court Of Missouri**

---------- ♦ ----------

BRIEF FOR THE AMERICAN PSYCHOLOGICAL ASSOCIATION, AND THE MISSOURI PSYCHOLOGICAL ASSOCIATION AS *AMICI CURIAE SUPPORTING RESPONDENT*

www.apa.org/psyclaw/roper-v-simmons.pdf

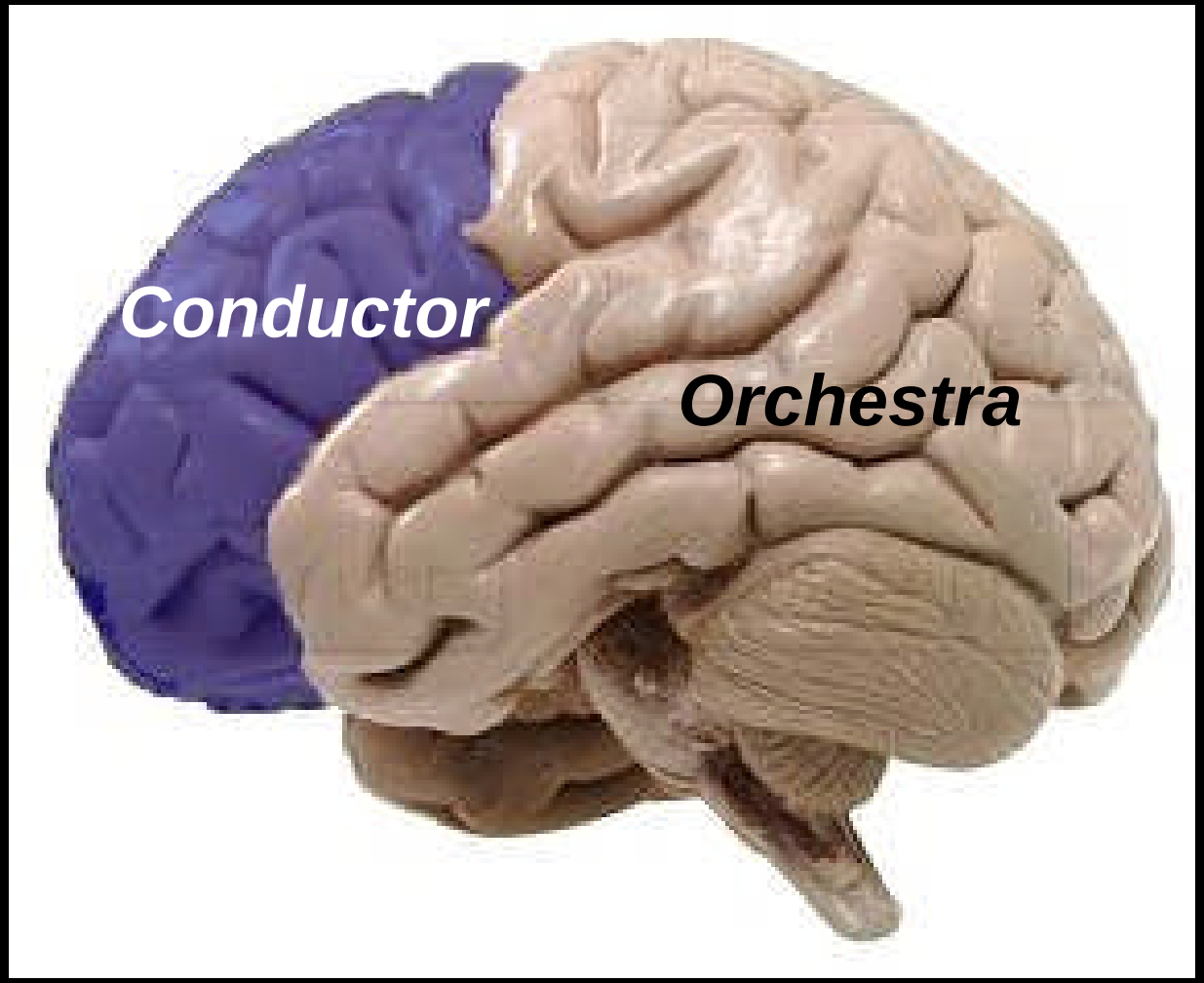
SUMMARY OF ARGUMENT

At ages 16 and 17, adolescents, as a group, are not yet mature in ways that affect their decision-making. Behavioral studies show that late adolescents are less likely to consider alternative courses of action, understand the perspective of others, and restrain impulses. Delinquent, even criminal, behavior is characteristic of many adolescents, often peaking around age 18. Heightened risk-taking is also common. During the same period, the brain has not reached adult maturity, particularly in the frontal lobes, which control executive functions of the brain related to decision-making. Adolescent risk-taking often represents a tentative expression of adolescent identity and not an enduring mark of behavior arising from a fully formed personality. Most delinquent adolescents do not engage in violent illegal conduct through adulthood.

Plan

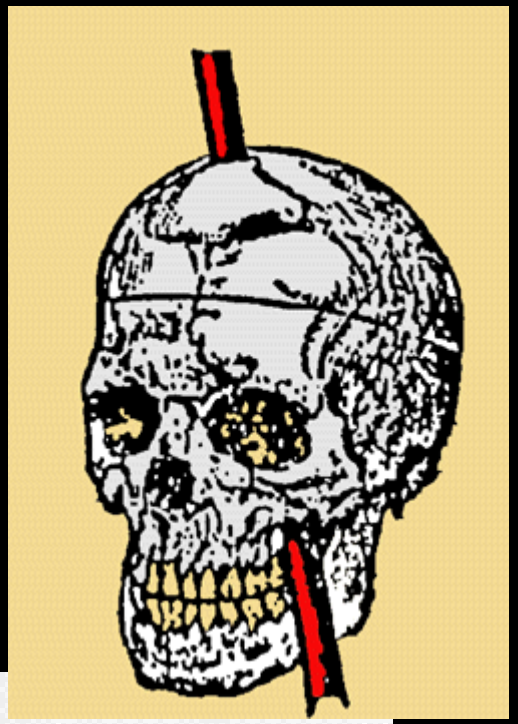
- What are Executive Functions?
- How do we identify them?
- What is the developmental course?
- What is the brain basis?
- How do they manifest in clinical disorders?

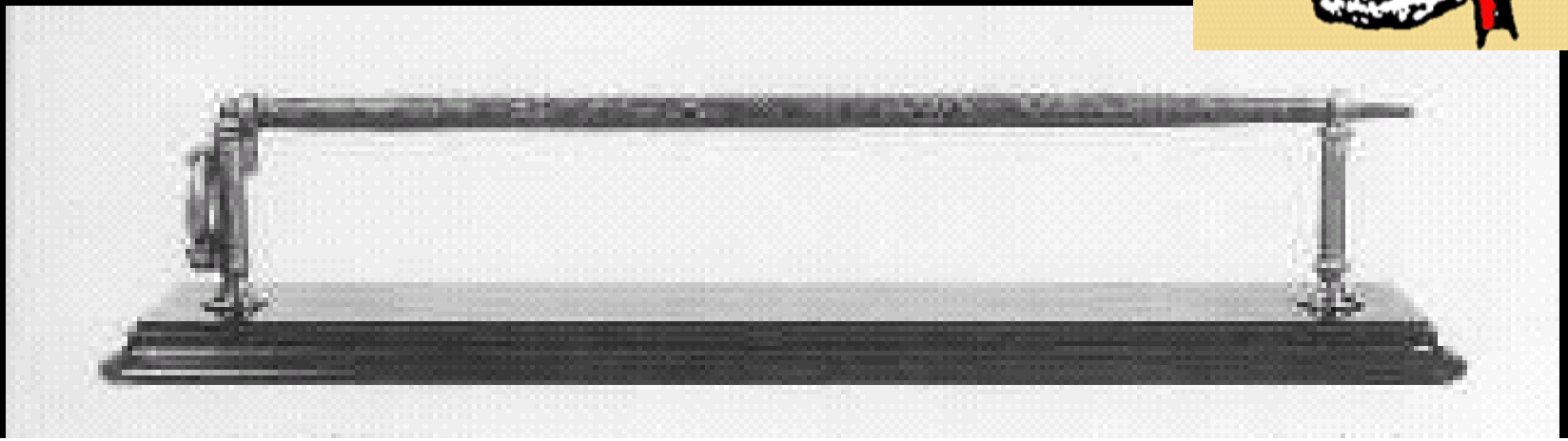
The "Conductor Metaphor" meets the "Frontal Metaphor"



Phineas Gage: 9/13, 1848 in Ludlow, VT

- 3’ tamping iron shot through left cheek and exited left frontally
- Destroyed much of left frontal lobe



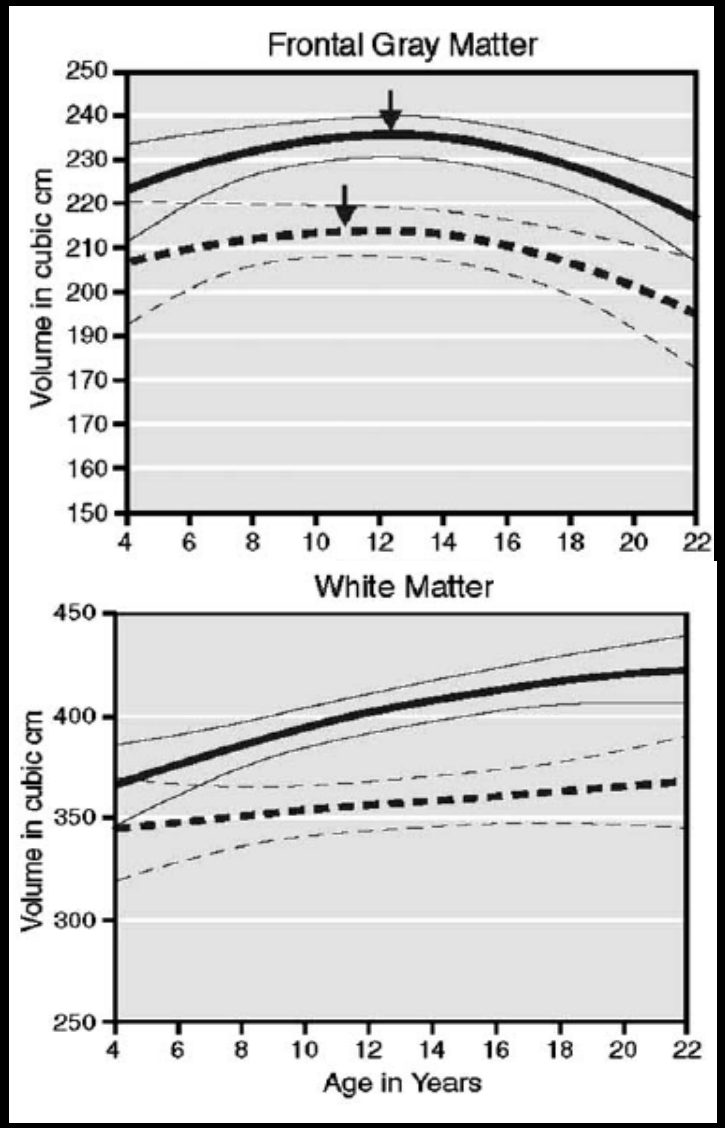


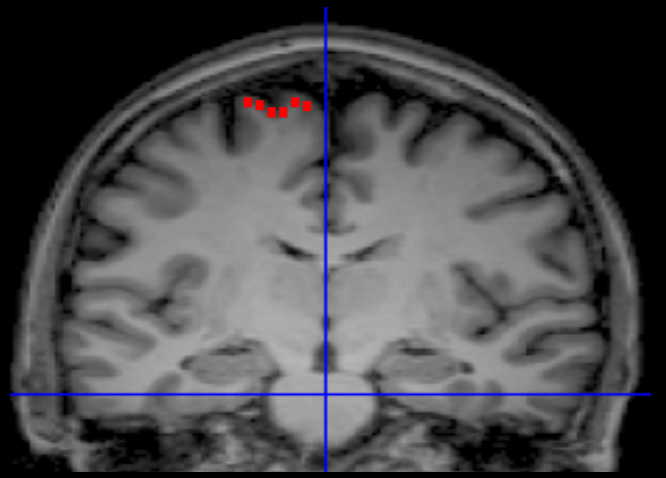
Phineas Gage: A changed man

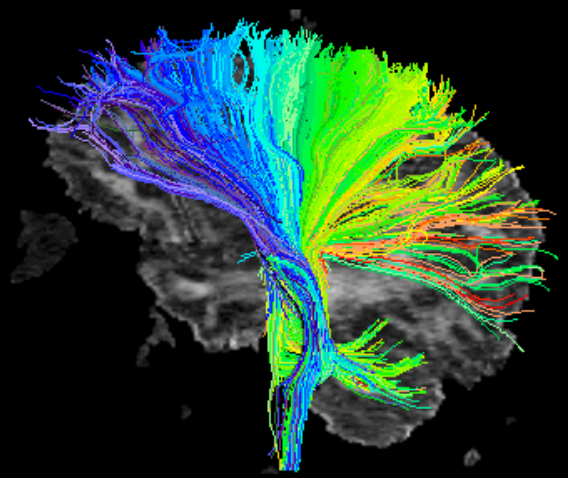
“He is fitful, irreverent, indulging at times in the grossest profanity, impatient of restraint or advice when it conflicts with his desires; at times pertinaciuously obstinate yet capricious and vascillating. His friends and acquaintances said he was no longer Gage”

Harlow, 1868

STRUCTURAL BRAIN CHANGES







Lenroot et al. (in press; Neuroscience and Biobehavioral reviews)

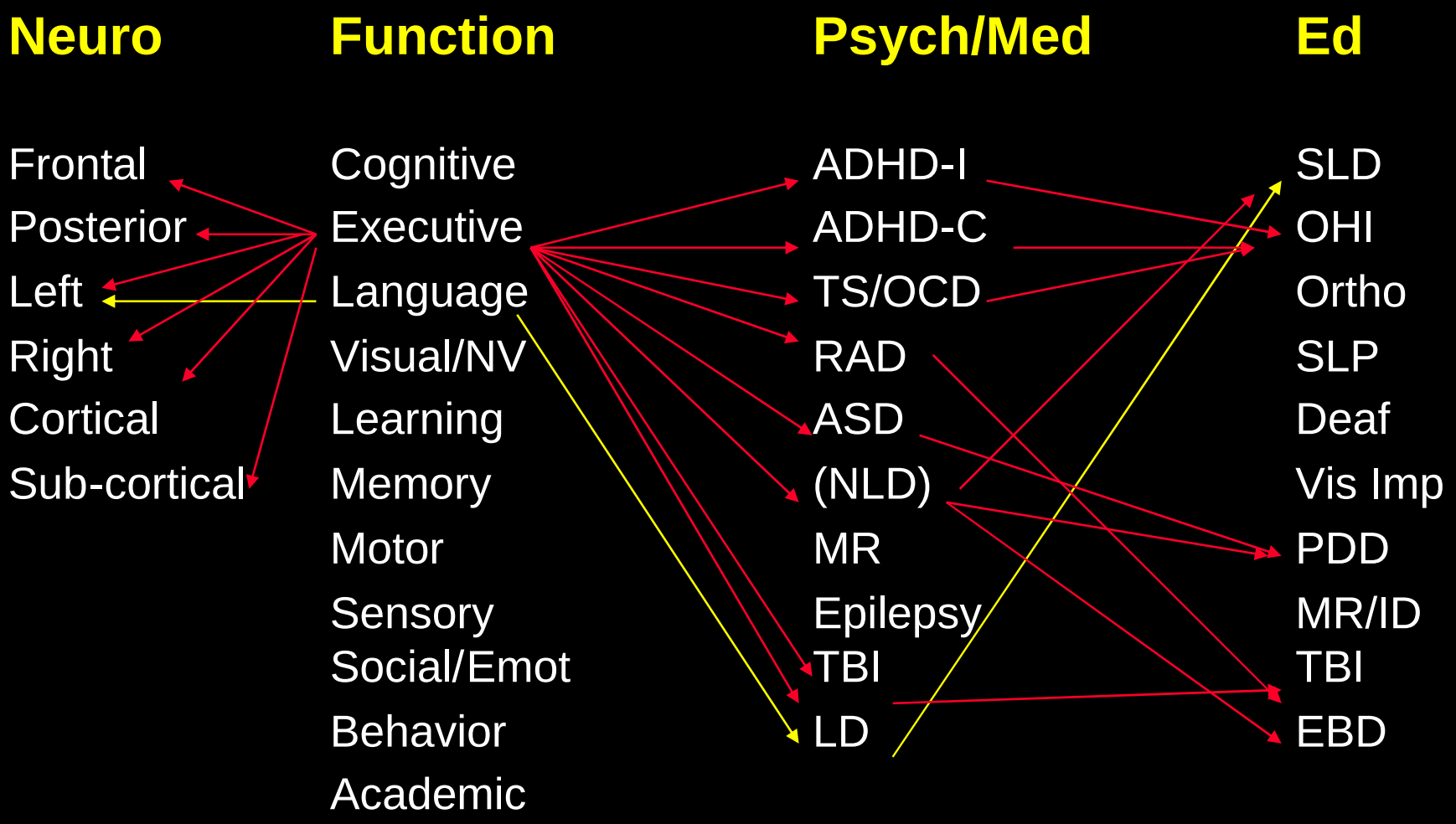
Plan

- What are Executive Functions?
- How do we identify them?
- What is the brain basis and developmental course of executive functions?
- How do they manifest in clinical disorders?

Disorders of Executive Function

- No singular, core disorder
- Symptom onset delayed due to prolonged development & environmental demand
- Performance on standardized tests often appropriate
- Discrepancy between ability and performance
- Fluid social domain often most challenging

Diagnostic Frameworks:



CLINICAL APPLICATIONS:
*Pediatric A*DHD

Recent Conceptualizations

With a better understanding of brain-behavior relationships, particularly the frontal lobes:

- ADHD is undergoing further redefinition in terms of a disorder of the executive functions (EF) (Barkley, 1997, 2000; Brown, 1999; Denckla, 1996; Pennington & Ozonoff, 1996)
- primacy of “attention” is being questioned.

DSM-IV Diagnostic Criteria: ADHD Predominantly Inattentive Type

6 or more maladaptive and developmentally inappropriate Symptoms for > 6 months

Working Memory	Often fails to give close attention to details or makes careless mistakes in schoolwork, work or other activities
Working Memory	Often has difficulty sustaining attention in tasks or play activities
Working Memory	Often does not seem to listen when spoken to directly
Working Memory	Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace

DSM-IV Diagnostic Criteria: ADHD Predominantly Inattentive Type

Plan/Organize	◆ Often has difficulty organizing tasks
Working Memory	◆ Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort
Organization	◆ Often loses things necessary for tasks or activities
Inhibitory Control	◆ Is often easily distracted by extraneous stimuli
Working Memory	◆ Is often forgetful in daily activities

DSM-IV Diagnostic Criteria, ADHD Predominantly Hyperactive, Impulsive Type

6 or more maladaptive and developmentally inappropriate Hyperactivity Symptoms for > 6 months

Inhibit? Arousal?	Often fidgets with hands or feet or squirms in seat
Inhibitory control	Often leaves seat in classroom or in other situations in which remaining seated is expected
Inhibitory control	Often runs about or climbs excessively in situations in which it is inappropriate (adolescents may be subjective)
Inhibitory control	Often has difficulty playing or engaging in leisure activities quietly
Inhibitory control	Is often “on the go” or acts as if “driven by a motor”
Inhibitory control	often talks excessively

Pennington & Ozonoff, 1996

ADHD Studies:	Consistency	Effect
WCST Persev	4/10	.45
Trails B Time	4/6	.75
Stroop Time	4/5	.69
Mazes	3/4	.43
Letter Fluency	1/4	.27
Category Fluency	0/3	-
Tower	3/3	1.08
Motor Inhibition	6/6	.85

Pennington & Ozonoff, 1996

- 15 of 18 studies found ADHD worse than Controls on 40 of 60 putative EF tasks
- 10/13 found NO differences on non-EF tasks
- Same analysis in CD and TS revealed EF task deficits ONLY with comorbid ADHD
- EF tasks do better at excluding normals than at including ADHD
- EF alone is not sufficient to explain ADHD?

Reading Disability and ADHD: Is there a Common Deficit in Executive Function?

- 151 Controls, 104 ADHD, 109 RD, 64 ADHD+RD
- 5 Factor Battery of EF and Reading tasks:

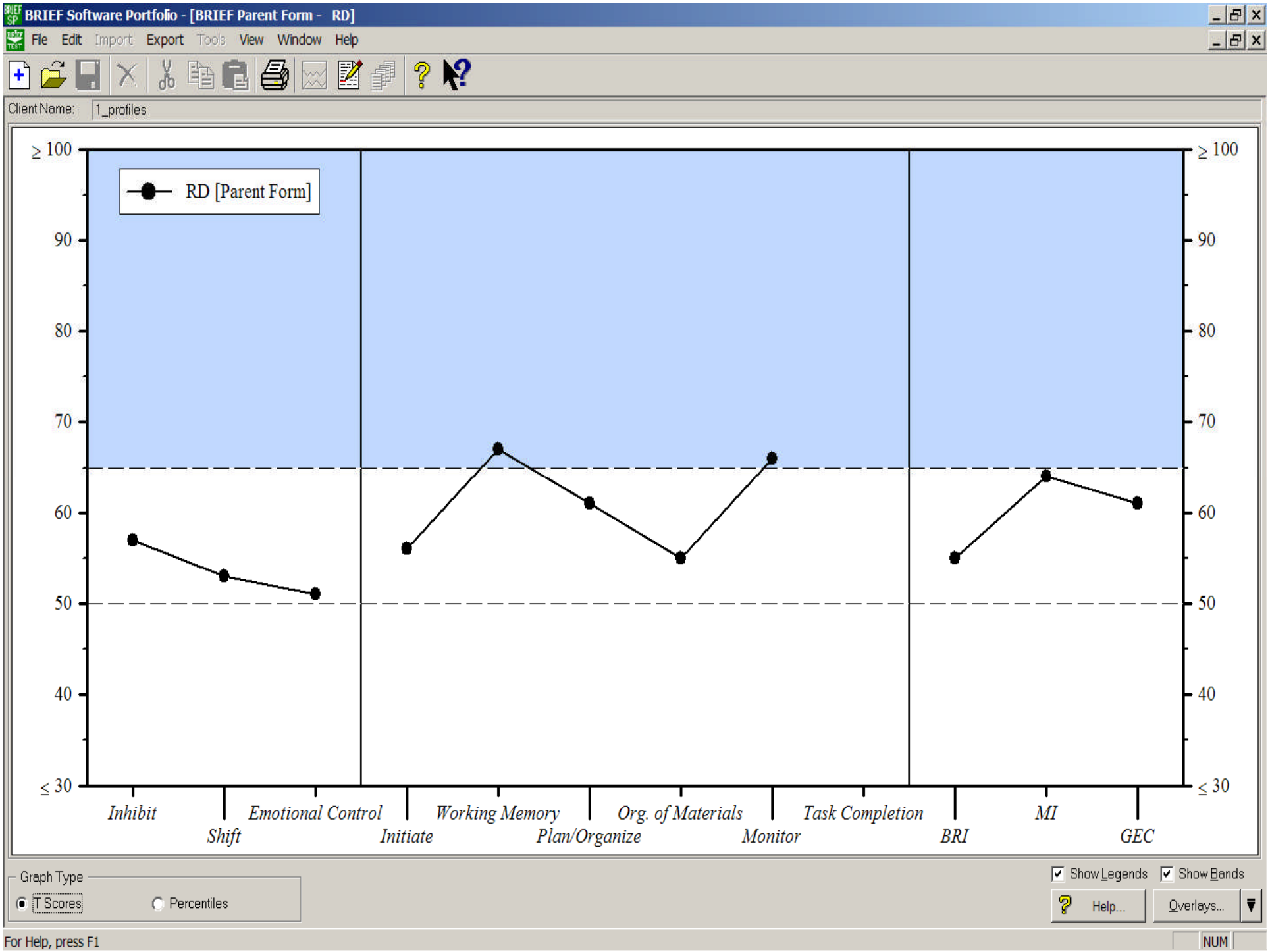
Language	Proc Speed	WM	Shift	Inhibit
Lindamood	Stroop Word	Count span	Trails B	CPT Com
Ortho Coding	Stroop Color	Sent span	WCST	CPT Om
Nonwords	Stroop CW	Arithmetic		Stop Sig
Pig Latin	Coding	Digits F		-RT
	Symbol Srch	Digits B		-RT Var

Willcutt, Pennington, Olson, Chhabildas & Huslander, 2005

- Factors support multiple, related EF domains
- ADHD: inhibit, speed, WM
- RD: Language, speed, WM, inhibit
- ADHD + RD: Additive Deficits
- ADHD/RD show similar EF performance
- Slow & Variable processing speed may be a common deficit
- No plan, organize, monitor tasks included

Willcutt, Pennington, Olson, Chhabildas & Huslander, 2005

Rating Scale Profiles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RD [Parent Form]
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Working Memory
Plan/Organize
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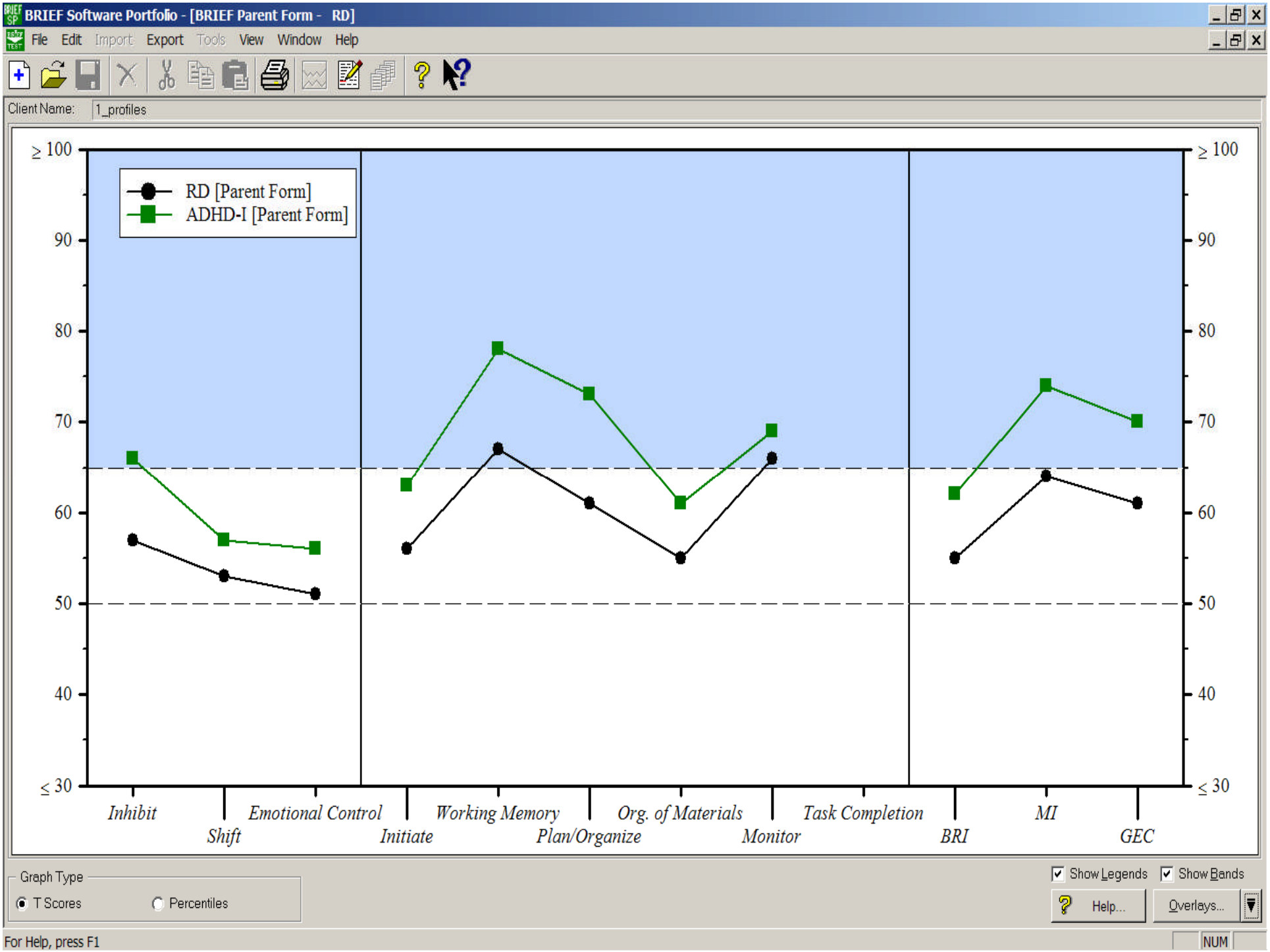
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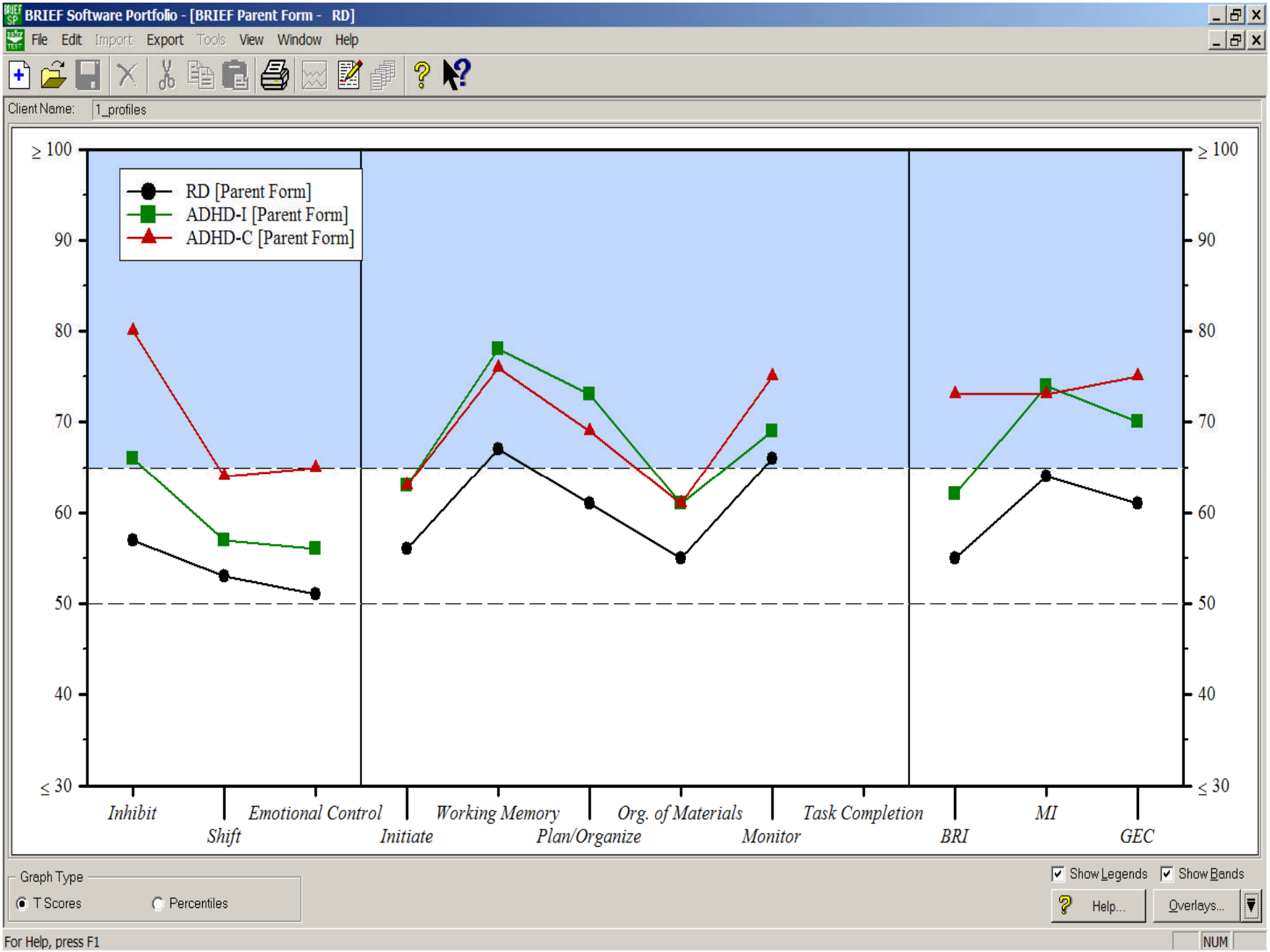
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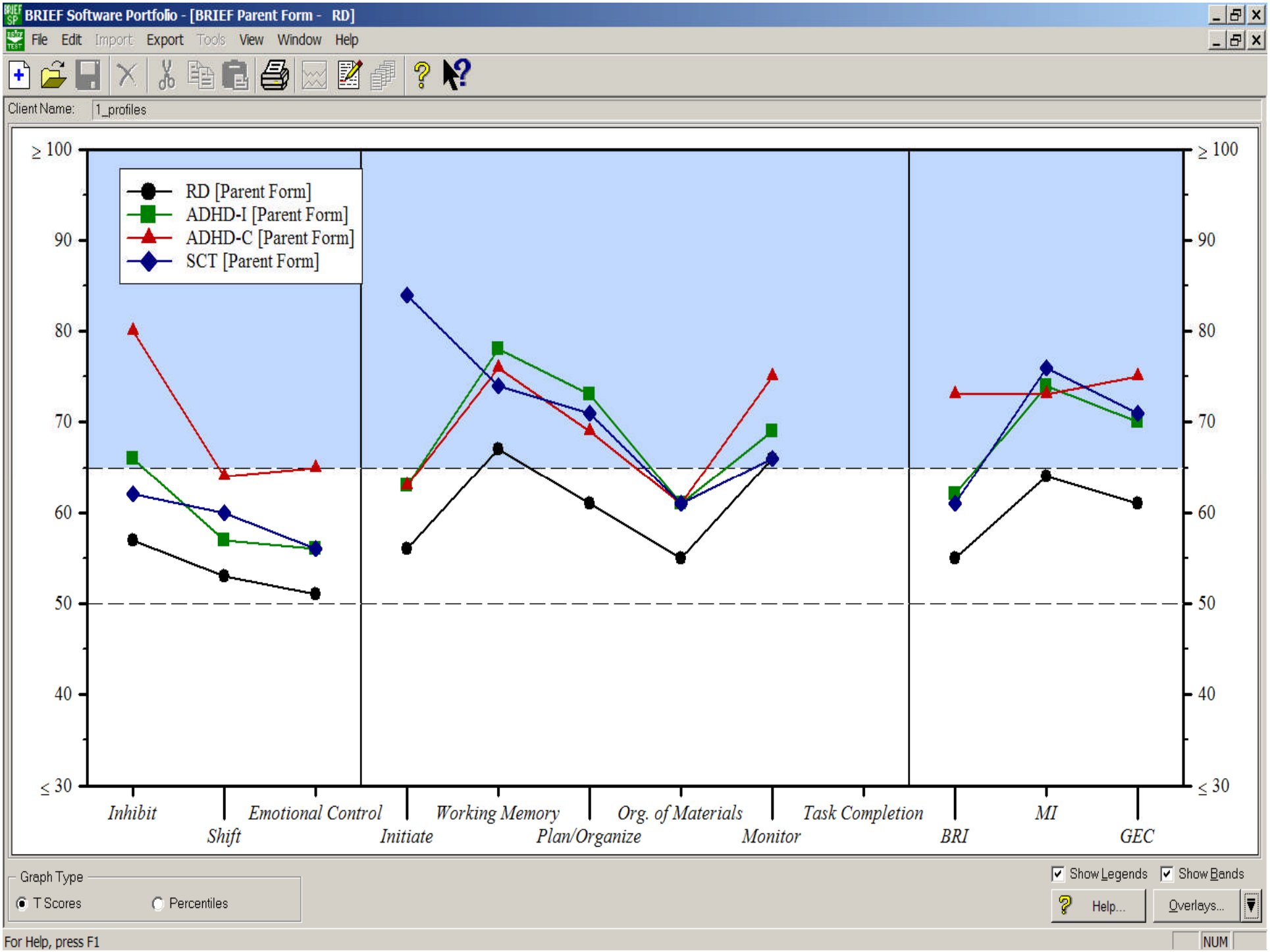
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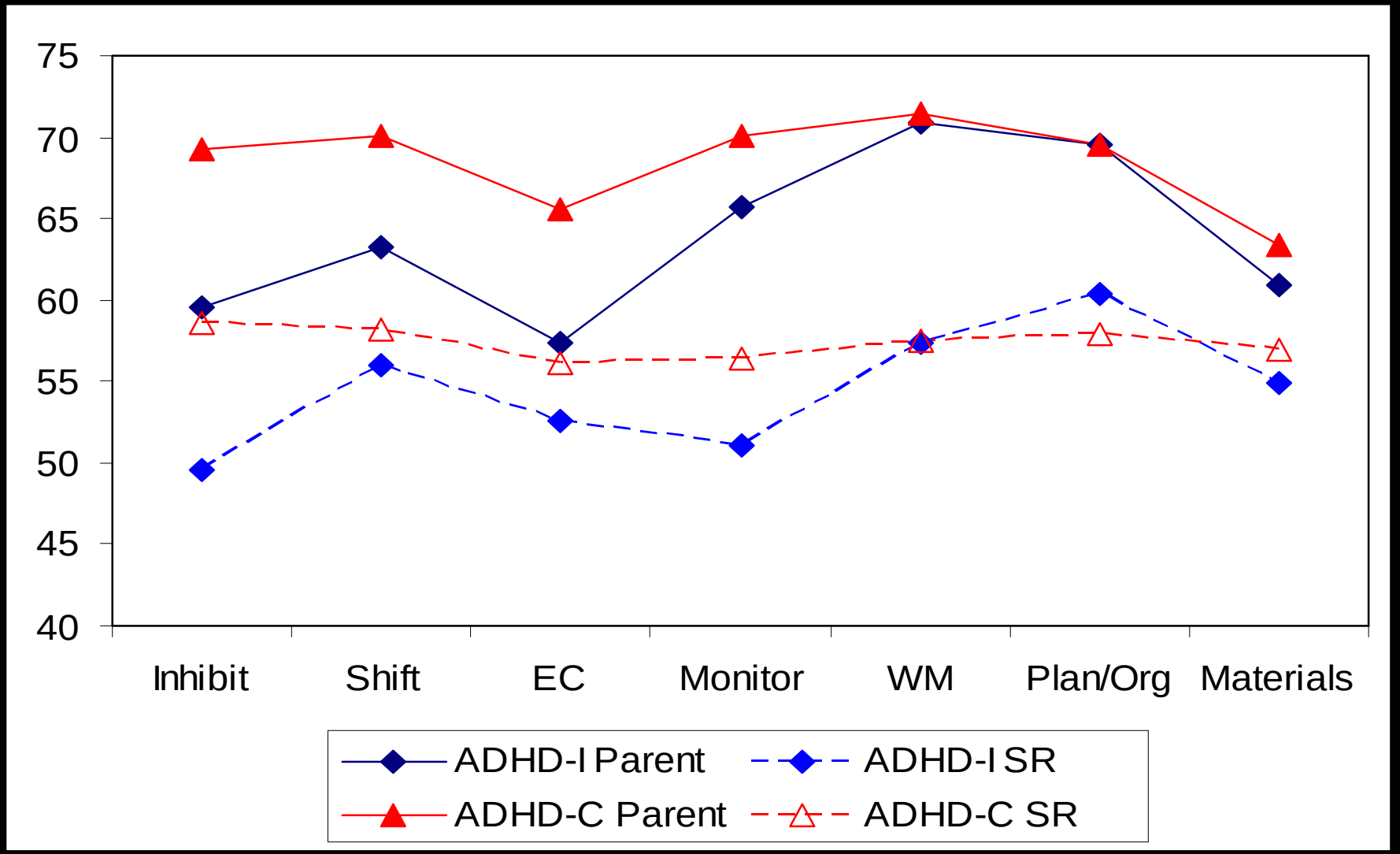
Parent vs Adolescent Reports in ADHD



Means and Standard Deviations for BRIEF Composite and Clinical Scales

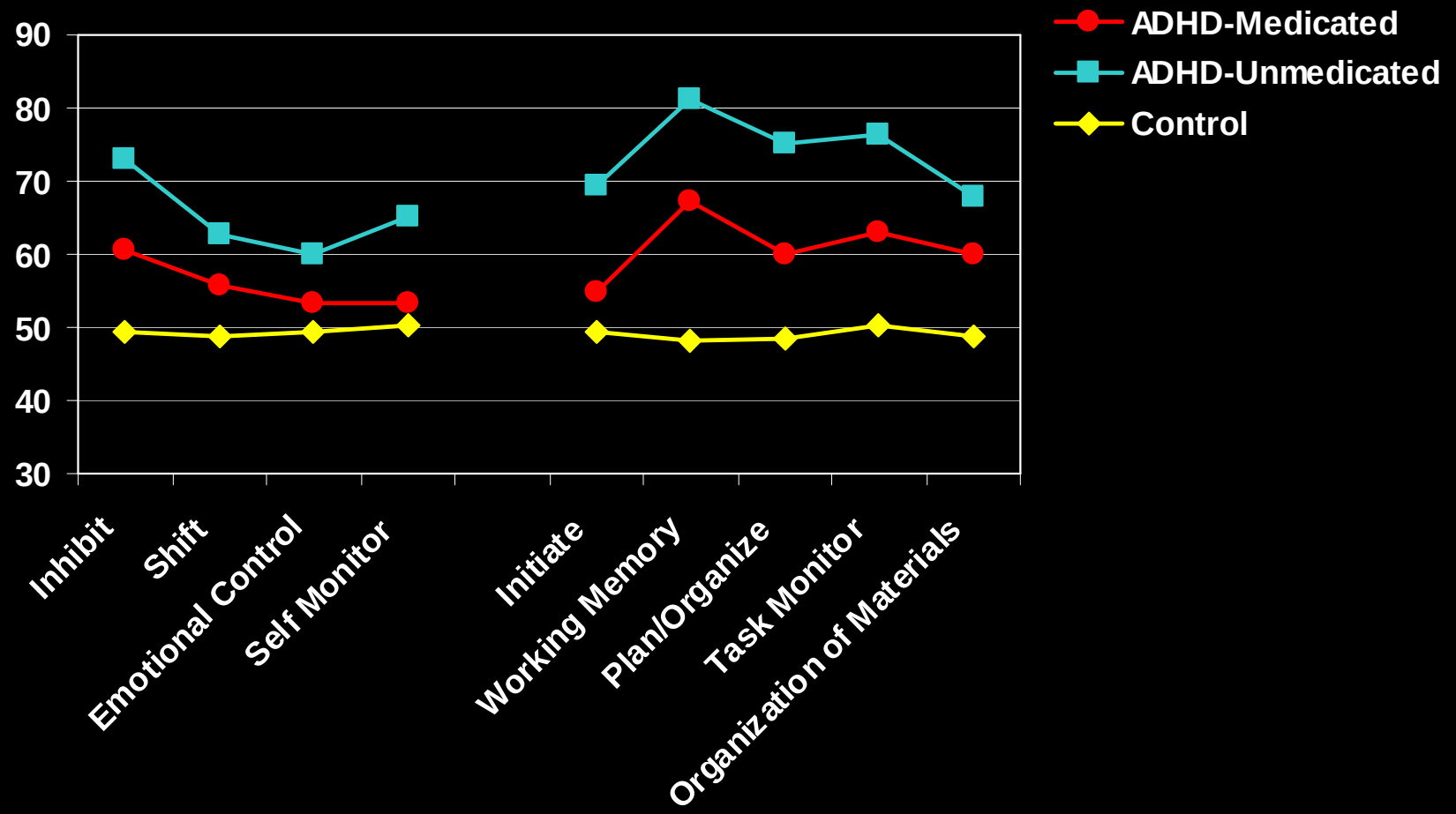
BRIEF Scale/ Index	Placebo	Methylphenidate	t	P
GEC	67.94 (8.36)	59.53 (11.79)	3.13	.006
Behav. Reg. Index	67.18 (10.47)	59.41 (12.07)	2.49	.024
Metacog. Index	65.71 (7.99)	57.94 (11.92)	3.41	.004
Inhibit	67.88 (10.65)	59.06 (13.09)	2.94	.01
Shift	61.35 (12.58)	57.12 (12.83)	1.19	.25
Emotional Control	62.35 (8.12)	56.47 (10.09)	2.11	.051
Initiate	64.47 (8.5)	56.63 (11.53)	2.93	.01
Working Memory	69.53 (7.58)	60.47 (12.68)	3.34	.004
Plan/ Organize	63.24 (9.79)	56.35 (13.35)	2.72	.015
Organ of Materials	59.29 (10.76)	53.41 (9.73)	2.31	.034
Monitor	65.71 (7.99)	58.41 (11.02)	2.52	.02

Note: Mean T scores are reported.
Double blind placebo-controlled crossover design. n=17

Kunin-Batson, A. (2001) Effects of methylphenidate on neuropsychological functioning in children with attention deficit hyperactivity disorder. Unpublished dissertation, Finch University of Health Sciences/ The Chicago Medical School.

Executive Functions in Adult ADHD

Self Report Executive Function in Unmedicated (n=27) and Medicated (n=16) Adults with ADHD, and Healthy Controls (n=42)



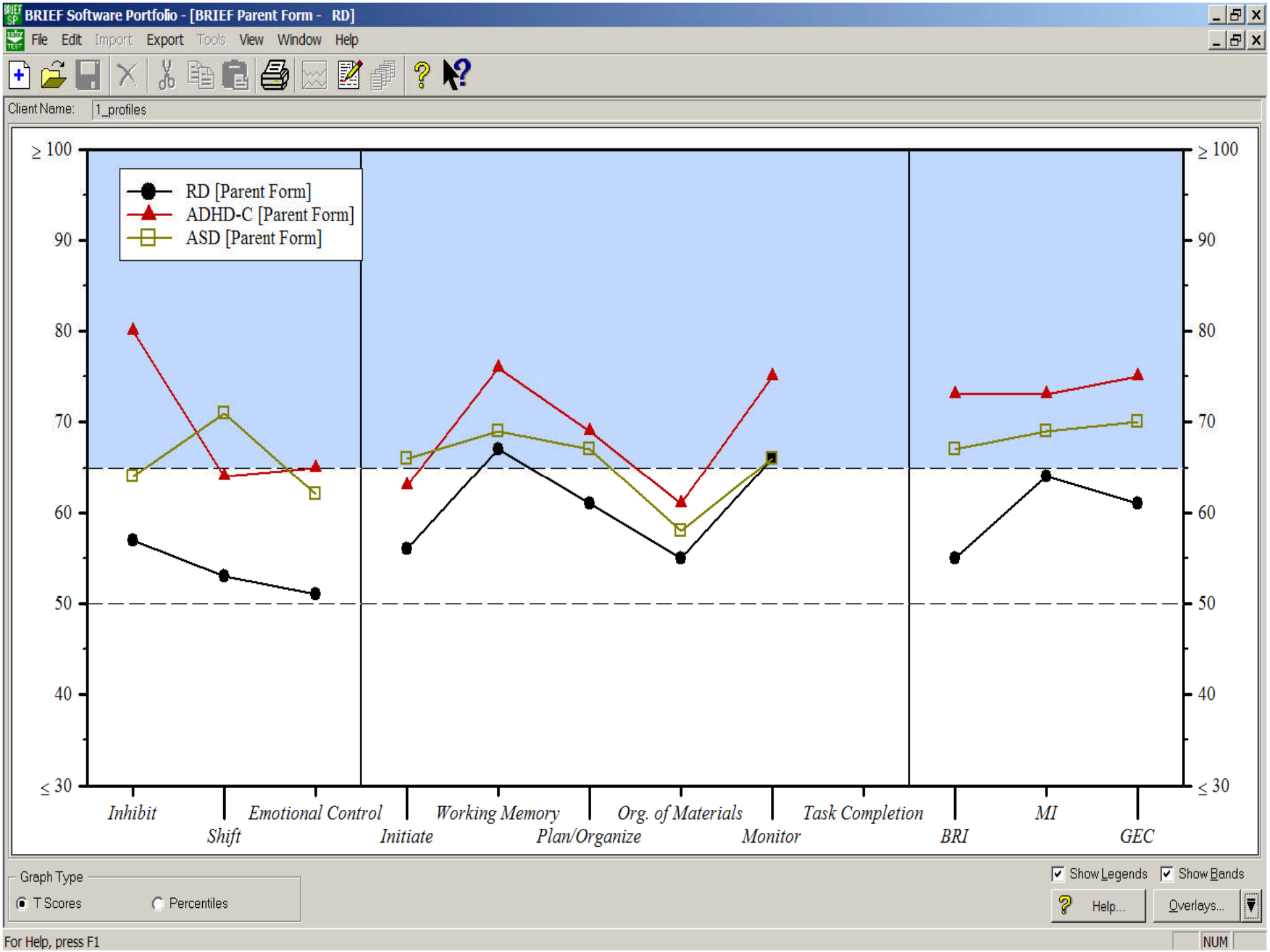
Biederman, Fried, et al., unpublished data

Pennington & Ozonoff, 1996

ASD Studies:	Consistency	Effect
WCST Persev	6/8	.90
WCST Cats	2/2	1.65
Trails B Time	1/2	.62
Tower	4/4	2.07

-Inhibitory deficits prominent in ADHD

-Shift deficits prominent in ASD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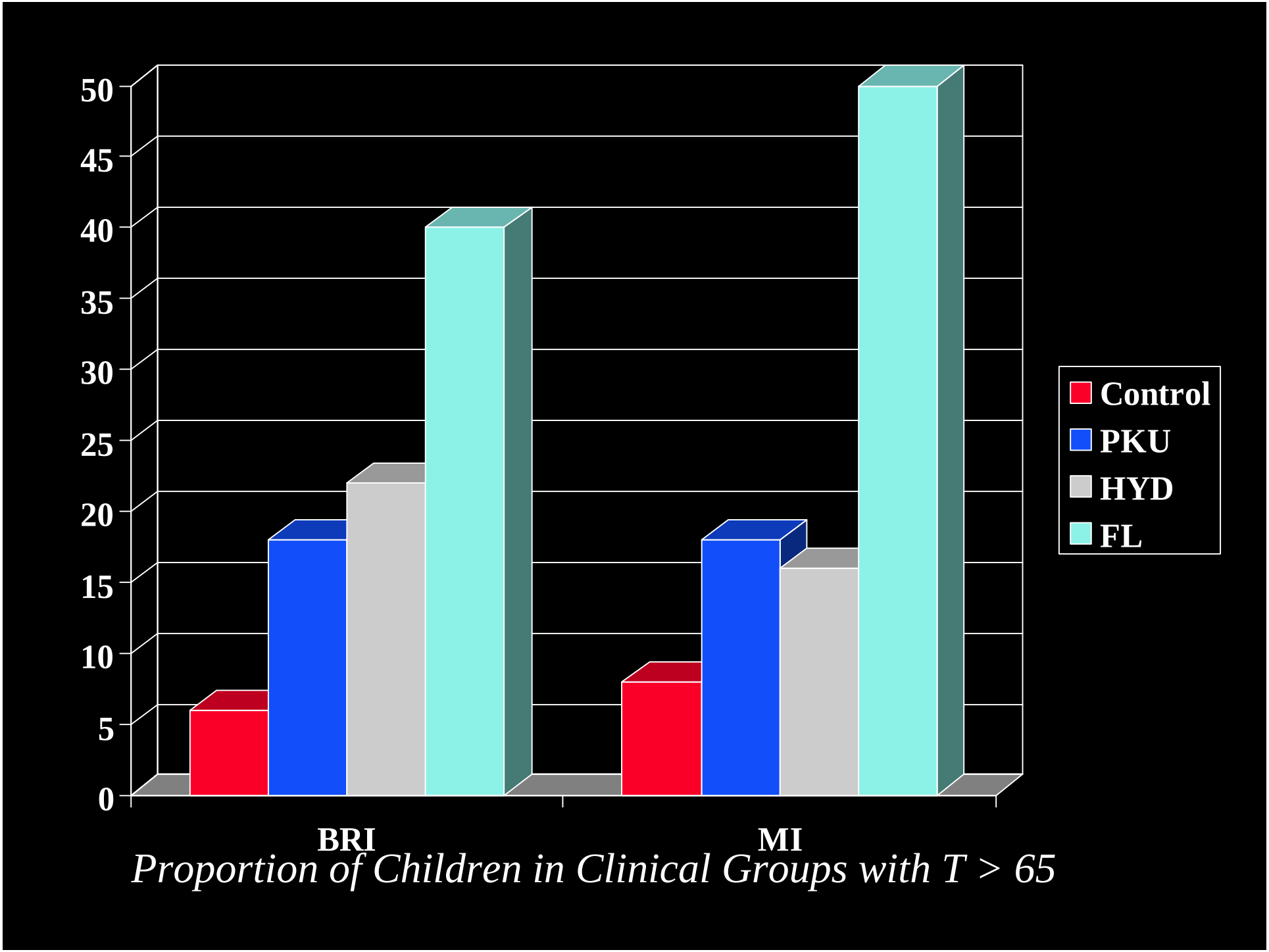
In Sum:

- Performance tests and rating scales show profile differences between ADHD, RD and ASD groups BUT also common deficits
- These profiles cut across age and gender
- Tests and scales are complementary: micro/molar to macro
- Neither tests nor scales of EF are necessary or sufficient to diagnose conditions
- EF is not a *diagnosis*; EF is a *function*

BRIEF & Brain Disease:

Anderson, Anderson, Northam, Jacobs & Mikiewicz, 2002

- 44 PKU
- 45 Hydrocephalus
- 20 Frontal Lesion (8 prenatal, 12 acquired)
- Neuropsychological testing, including performance EF tests, showed no differences between groups



Proportion of Children in Clinical Groups with T > 65

Correlations between Measures and High-Stakes Test scores

Measure	MCAS English	MCAS Mathematics
Coding	.47***	.32**
Symbol Search	.42***	.39***
Letter–Number	.44***	.37***
NEPSY Tower	.07	.15
D-KEFS Inhibition	.39***	.24*
D-KEFS Inhibition–Switch	.38***	.20
BRIEF BRI	–.46***	–.47***
BRIEF MI	–.61***	–.61***
BASC Internalizing	–.44***	–.43***
BASC Externalizing	–.42***	–.41***
BASC School Problems	–.55***	–.56***

Waber, Gerber, Turcios, Wagner & Forbes, 2006

Plan

- What are the Executive Functions?
- How do we identify them?
- What is the brain basis and developmental course?
- How do they manifest in clinical disorders?
- How do we intervene?

Model of Executive Function Intervention

- Knowledge Base
- Settings
- Tool Kit
- Delivery System

Knowledge Base

- Operational Definitions
- Clinical Manifestations
- Ways to Recognize/ Assess

Task: Build EF expertise

Settings

- Home
- School
- Community (Job, peers)

Task: Define the structure

Tool Kit

- Targeted Functional Domains
- Strategies
- Scripts/ Routines

Task: Develop broad flexible tools

Delivery System

- “Key: Personnel: Mentor/ coach/ co-conductor
- “With” not “for”
- External to internal

Task: Promote independence

EF Intervention
General Principles

- Good Assessment: Define relevant EF deficit, associated domain specific abilities or deficits, and task/situational demands

- Determine the developmental level of child and what are age appropriate expectations for EF.

EF Intervention
General Principles

- Teach goal-directed problem-solving process,
- within everyday meaningful routines,
- having real-world relevance and application,
- using key people (parents/ teachers/ peers) as models, “coaches” (Co-conductor).

EF Intervention
General Principles

External to internal process

- External models of multi-step problem-solving routines
- External guidance to develop & implement everyday routines
- Practice application/ use of routines
- Fade external support to cueing internal generation & use of routines

EF Intervention
General Principles

External to internal process

- Internal control to generate & use specific problem-solving routine
- Generalization to new situation, requiring some external guidance
- Accumulate experience, examine conditions for selective use of various routines
- Feedback throughout (i.e., reward)

Interventions: General Principles

- must fit with child, environment, teacher, parents
- make rationale work for the teacher/parent
- involve teacher/parent in planning possible solutions
- measure success / failure

Structuring an EF intervention program

- Use of everyday routines (e.g., Goal-Plan-Do-Review)
- Support working memory via “hard copy” of routine
- Allowing child to become increasingly more active in formulating plans and reviewing their performance

Goal-Plan-Do-Review

GOAL

What do I want to accomplish?

PLAN

How am I going to accomplish my goal?

MATERIALS/ EQUIPMENT	STEPS/ASSIGNMENTS
1.	1.
2.	2.

PREDICTION: HOW WELL WILL I DO?

Self rating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Other Rating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

How much will I get done?

DO

PROBLEMS	SOLUTIONS
1.	1.
2.	2.
3.	3.

REVIEW: HOW DID I DO?

Self rating	1	2	3	4	5	6	7	8	9	10
Other rating	1	2	3	4	5	6	7	8	9	10

WHAT WORKED?	WHAT DIDN'T WORK
1.	1.
2.	2.

WHAT WILL I TRY NEXT TIME?

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