Executive Function:
Concepts, Assessment & Intervention

Peter K. Isquith, Ph.D
Gerard A. Gioia, Ph.D.
Robert M. Roth, Ph.D.
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
<table>
<thead>
<tr>
<th>Functions of the “Orchestra”</th>
<th>Functions of the “Conductor”</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Perception</td>
<td>• Inhibit</td>
</tr>
<tr>
<td>• Attention</td>
<td>• Shift Flexibly</td>
</tr>
<tr>
<td>• Language processes</td>
<td>• Modulate Emotions</td>
</tr>
<tr>
<td>• Visual-spatial processes</td>
<td>• Initiate</td>
</tr>
<tr>
<td>• Memory</td>
<td>• Working Memory</td>
</tr>
<tr>
<td>• Sensory inputs</td>
<td>• Plan</td>
</tr>
<tr>
<td>• Motor outputs</td>
<td>• Organize</td>
</tr>
<tr>
<td>• Knowledge &amp; skills</td>
<td>• Self-monitor &amp; evaluate</td>
</tr>
<tr>
<td>• social</td>
<td></td>
</tr>
<tr>
<td>• non-social</td>
<td></td>
</tr>
</tbody>
</table>
Methods of Assessing EF

Micro
Genetics

Structural & Functional Imaging

Molar
Performance Tests

Macro
Observations

Goal:
Problem:

Count the number of moves

40 45 50 55 60 65 70

40 45 50 55 60 65 70

Inhibit Shif Emotional WM Plan/Org Materials Monitor
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
9-year-old with Reading Disorder

Copy

Recall
8 year-old boy with Asperger’s

Copy

Recall
10 year-old boy with ADHD-C
10 year old with ADHD-I
The Tower of London
Tower of London 6 Move
Goal:

Problem:

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

<table>
<thead>
<tr>
<th>Neutral Condition</th>
<th>Congruent Condition</th>
<th>Incongruent Condition</th>
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</thead>
<tbody>
<tr>
<td>XXXX</td>
<td>TWO</td>
<td>TWO</td>
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<td>XXXX</td>
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<tr>
<td>XXXX</td>
<td>TWO</td>
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<tr>
<td>XXXX</td>
<td>TWO</td>
<td>TWO</td>
</tr>
</tbody>
</table>

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 Genealogy

2000

2003

2004

2005

200?
### BRIEF Basics

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

Meta-Cognition

Behavioral Regulation

- Monitor
- Org of Materials
- Plan/Organize
- Working Memory
- Initiate

- Emotional Control
- Shift
- Inhibit
### PFA of Parent BRIEF With BASC Parent Rating Scale (n=80)

<table>
<thead>
<tr>
<th>Scales</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working memory</td>
<td>0.904</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan/organize</td>
<td>0.878</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitor</td>
<td>0.799</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiate</td>
<td>0.791</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC attention problems</td>
<td>0.698</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organization of Materials</td>
<td>0.516</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC hyperactivity</td>
<td></td>
<td></td>
<td></td>
<td>0.720</td>
</tr>
<tr>
<td>BASC conduct problems</td>
<td></td>
<td></td>
<td></td>
<td>0.607</td>
</tr>
</tbody>
</table>
## PFA of Parent BRIEF With BASC

### Parent Rating Scale (Cont.)

<table>
<thead>
<tr>
<th>Scales</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASC anxiety</td>
<td>.764</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC depression</td>
<td>.696</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC somatization</td>
<td>.661</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC atypicality</td>
<td>.467</td>
<td>.531</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BASC withdrawal</td>
<td>.521</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inhibit</td>
<td></td>
<td></td>
<td></td>
<td>-.769</td>
</tr>
<tr>
<td>Emotional control</td>
<td></td>
<td></td>
<td></td>
<td>-.686</td>
</tr>
<tr>
<td>BASC aggression</td>
<td></td>
<td></td>
<td></td>
<td>-.565</td>
</tr>
<tr>
<td>Shift</td>
<td></td>
<td></td>
<td></td>
<td>-.392</td>
</tr>
</tbody>
</table>

#### Factor Loadings

- Factor 1
- Factor 2
- Factor 3
- Factor 4
Methods of Assessing EF

Micro
- Genetics
- Structural & Functional Imaging

Macro
- Performance Tests
- Observations

Goal:

Problem:

Count the number of moves

Graph showing data for different conditions.
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?
Development of Executive Functions:

- **Plan/Organize/Monitor**: 3–32 yrs
- **Emotional Modulation**: 3–?? yrs
- **Verbal Working Memory**: 2–13 yrs
- **Nonverbal Working Memory**: 3–24 mo
- **Inhibit**: 0 - ?

**Nonverbal Working Memory**

**Verbal Working Memory**

**Plan/Organize/Monitor**

**Emotional Modulation**

**Inhibit**

**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
"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
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)
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

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
“He is fitful, irreverent, indulging at times in the grossest profanity, impatient of restraint or advice when it conflicts with his desires; at times pertinaciously 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:

<table>
<thead>
<tr>
<th>Neuro</th>
<th>Function</th>
<th>Psych/Med</th>
<th>Ed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal</td>
<td>Cognitive</td>
<td>ADHD-I</td>
<td>SLD</td>
</tr>
<tr>
<td>Posterior</td>
<td>Executive</td>
<td>ADHD-C</td>
<td>OHI</td>
</tr>
<tr>
<td>Left</td>
<td>Language</td>
<td>TS/OCD</td>
<td>Ortho</td>
</tr>
<tr>
<td>Right</td>
<td>Visual/NV</td>
<td>RAD</td>
<td>SLP</td>
</tr>
<tr>
<td>Cortical</td>
<td>Learning</td>
<td>ASD</td>
<td>Deaf</td>
</tr>
<tr>
<td>Sub-cortical</td>
<td>Memory</td>
<td>(NLD)</td>
<td>Vis Imp</td>
</tr>
<tr>
<td></td>
<td>Motor</td>
<td>MR</td>
<td>PDD</td>
</tr>
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<td></td>
<td>Sensory</td>
<td>Epilepsy</td>
<td>MR/ID</td>
</tr>
<tr>
<td></td>
<td>Social/Emot</td>
<td>TBI</td>
<td>TBI</td>
</tr>
<tr>
<td></td>
<td>Behavior</td>
<td>LD</td>
<td>EBD</td>
</tr>
<tr>
<td></td>
<td>Academic</td>
<td></td>
<td></td>
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</tbody>
</table>
CLINICAL APPLICATIONS: Pediatric ADHD
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**

<table>
<thead>
<tr>
<th>Function</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan/Organize</td>
<td>Often has difficulty organizing tasks</td>
</tr>
<tr>
<td>Working Memory</td>
<td>Often avoids, dislikes, or is reluctant to engage in tasks that require sustained mental effort</td>
</tr>
<tr>
<td>Organization</td>
<td>Often loses things necessary for tasks or activities</td>
</tr>
<tr>
<td>Inhibitory Control</td>
<td>Is often easily distracted by extraneous stimuli</td>
</tr>
<tr>
<td>Working Memory</td>
<td>Is often forgetful in daily activities</td>
</tr>
</tbody>
</table>
### DSM-IV Diagnostic Criteria, ADHD Predominantly Hyperactive, Impulsive Type

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

<table>
<thead>
<tr>
<th>Inhibit?</th>
<th>Arousal?</th>
<th>Inhibitory control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Often fidgets with hands or feet or squirms in seat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Often leaves seat in classroom or in other situations in which remaining seated is expected</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Often runs about or climbs excessively in situations in which it is inappropriate (adolescents may be subjective)</td>
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<tr>
<td></td>
<td></td>
<td>Often has difficulty playing or engaging in leisure activities quietly</td>
</tr>
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<td></td>
<td></td>
<td>Is often “on the go” or acts as if “driven by a motor”</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Often talks excessively</td>
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</tbody>
</table>
Pennington & Ozonoff, 1996

<table>
<thead>
<tr>
<th>ADHD Studies</th>
<th>Consistency</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>WCST Persev</td>
<td>4/10</td>
<td>.45</td>
</tr>
<tr>
<td>Trails B Time</td>
<td>4/6</td>
<td>.75</td>
</tr>
<tr>
<td>Stroop Time</td>
<td>4/5</td>
<td>.69</td>
</tr>
<tr>
<td>Mazes</td>
<td>3/4</td>
<td>.43</td>
</tr>
<tr>
<td>Letter Fluency</td>
<td>1/4</td>
<td>.27</td>
</tr>
<tr>
<td>Category Fluency</td>
<td>0/3</td>
<td>-</td>
</tr>
<tr>
<td>Tower</td>
<td>3/3</td>
<td>1.08</td>
</tr>
<tr>
<td>Motor Inhibition</td>
<td>6/6</td>
<td>.85</td>
</tr>
</tbody>
</table>
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*  
- Lindamood  
- Ortho Coding  
- Nonwords  
- Pig Latin

*Proc Speed*  
- Stroop Word  
- Stroop Color  
- Stroop CW  
- Coding  
- Symbol Srch

*WM*  
- Count span  
- Sent span  
- Arithmetic  
- Digits F  
- Digits B

*Shift*  
- Trails B  
- WCST

*Inhibit*  
- CPT Com  
- CPT Om  
- Stop Sig  
- -RT  
- -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
Rating Scale Profiles
Parent vs Adolescent Reports in ADHD
### Means and Standard Deviations for BRIEF Composite and Clinical Scales

<table>
<thead>
<tr>
<th>BRIEF Scale/ Index</th>
<th>Placebo</th>
<th>Methylphenidate</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEC</td>
<td>67.94 (8.36)</td>
<td>59.53 (11.79)</td>
<td>3.13</td>
<td>.006</td>
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<tr>
<td>Behav. Reg. Index</td>
<td>67.18 (10.47)</td>
<td>59.41 (12.07)</td>
<td>2.49</td>
<td>.024</td>
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<tr>
<td>Metacog. Index</td>
<td>65.71 (7.99)</td>
<td>57.94 (11.92)</td>
<td>3.41</td>
<td>.004</td>
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<tr>
<td>Inhibit</td>
<td>67.88 (10.65)</td>
<td>59.06 (13.09)</td>
<td>2.94</td>
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<td>Shift</td>
<td>61.35 (12.58)</td>
<td>57.12 (12.83)</td>
<td>1.19</td>
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<tr>
<td>Emotional Control</td>
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<tr>
<td>Initiate</td>
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<td>60.47 (12.68)</td>
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<td>Plan/ Organize</td>
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<td>56.35 (13.35)</td>
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<td>Organ of Materials</td>
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Note: Mean T scores are reported.
Double blind placebo-controlled crossover design. n=17

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**

<table>
<thead>
<tr>
<th>ASD Studies</th>
<th>Consistency</th>
<th>Effect</th>
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<tbody>
<tr>
<td>WCST Persev</td>
<td>6/8</td>
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<td>WCST Cats</td>
<td>2/2</td>
<td>1.65</td>
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<td>Trails B Time</td>
<td>1/2</td>
<td>.62</td>
</tr>
<tr>
<td>Tower</td>
<td>4/4</td>
<td>2.07</td>
</tr>
</tbody>
</table>

- Inhibitory deficits prominent in ADHD
- Shift deficits prominent in ASD
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*
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

<table>
<thead>
<tr>
<th>Measure</th>
<th>MCAS English</th>
<th>MCAS Mathematics</th>
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<tbody>
<tr>
<td>Coding</td>
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<td>.32**</td>
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<td>Symbol Search</td>
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<td>Letter–Number</td>
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<td>NEPSY Tower</td>
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<tr>
<td>D-KEFS Inhibition</td>
<td>.39***</td>
<td>.24*</td>
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<tr>
<td>D-KEFS Inhibition–Switch</td>
<td>.38***</td>
<td>.20</td>
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<tr>
<td>BRIEF BRI</td>
<td>−.46***</td>
<td>−.47***</td>
</tr>
<tr>
<td>BRIEF MI</td>
<td>−.61***</td>
<td>−.61***</td>
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<tr>
<td>BASC Internalizing</td>
<td>−.44***</td>
<td>−.43***</td>
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<tr>
<td>BASC Externalizing</td>
<td>−.42***</td>
<td>−.41***</td>
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<tr>
<td>BASC School Problems</td>
<td>−.55***</td>
<td>−.56***</td>
</tr>
</tbody>
</table>

*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
1. 
2. 

STEPS/ASSIGNMENTS
1. 
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
1. 
2. 
3. 

SOLUTIONS
1. 
2. 
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. 
2. 
1. 
2. 

WHAT WILL I TRY NEXT TIME?
References