### The New Science of Executive Functioning

Towards a Better Understanding of ADHD www.samgoldstein.com



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1

#### **Relevant Disclosure**

- Co-author of Comprehensive Executive Functioning Scales
- Co-Author of Cognitive Assessment System –Second Edition
- Co-Editor Handbook of Executive Functioning Co-Editor Handbook of Intelligence and Achievement
- Testing
  Co-author of Raising a Self-disciplined Child
- Editor in Chief of JAD
- Compensated Speaker

2

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#### What is ADHD?

ADHD is a bio-psychosocial condition characterized by core symptoms of inattention, hyperactivity and impulsivity leading to/interacting with cognitive deficits causing impairment in all walks of life.

4

#### What is ADHD?

- ADHD appears to primarily involve the basal ganglia, cerebellum and the frontal lobes.
- Co-morbidity of other developmental, emotional and behavioral conditions with ADHD probably confounds findings from different study groups. (Hendren et al, 2000)
- The symptoms of ADHD lead to a nearly infinite number of consequences

5

ADHD appears to be a condition stemming in part from inefficient self-regulation.

#### The Curious Story of Phineas Gage

- September 13, 1848 nearly 4:30 pm
- Phineas Gage ( aged 26 years) was the foreman of a railroad track construction crew blasting granite bedrock near Cavendish, Vermont
- · He is described as being good with his hands and good with his men
- In a few minutes, the course of his life will be changed dramatically

7

#### The Curious Story of Phineas Gage

- The job Phineas has is to use a "tamping iron" which is designed to set explosives
- A tamping iron is a rod about 3 ½ feet long weighing 13 ½ lbs pointed at one end flat on the other
- The flat end is for tamping packing down- black blasting powder, in holes in the granite
- the pointed end for poking a hole in the gunpowder to carefully press the ropelike fuse into the coarsegrained explosive material

8

#### The Curious Story of Phineas Gage

- Gunpowder is very tricky to work with so they follow a prescribed and practiced pattern • Pour the powder, set the fuse, pour the sand, tamp the
- sand plug, shout a warning, and run like mad! • But something went wrong - no one knows what
- The flat end of his tamping iron slipped into the hole, a spark flies, and BAM!
- The tamping iron flies straight up, though his head and lands with a loud clang about thirty feet away

#### The Curious Story of Phineas Gage

- It is hard to believe but, Phineas is alive and speaks even as blood is pouring down his face
- He is brought to town on an ox cart ambulance
- · Arriving in town he gets down from the cart without help, goes into the Cavendish hotel and talks calmly to those he meets
- He is treated by Dr. Harlow and recovers
- But there were signs that something was wrong

10

#### The Curious Story of Phineas Gage

- Dr. Harlow found that his behavior was odd One day the doctor found him roaming around town, his head still heavily bandaged, in the rain with no
- coat or shoes · He would not take direction from the doctor
- Phineas stated that he wanted to go home and intended to walk...the 20 miles to get there
- Ten weeks later Dr. Harlow declares Phineas is ready to go home even though he still seems odd

11

#### The Curious Story of Phineas Gage

- About 10 months later Phineas is physically healed and returns to Cavendish, carrying his tamping iron, looking to get his old job back
- Phineas is unreliable, insulting, uses vulgar language, changes his mind frequently, and can no longer direct activity at the mine
- Dr Harlow reports that Phineas "comes up with all sorts of new plans... but they are no sooner announced than he drops them.
- · He is like a small child who continually changes his mind

12

#### The Curious Story of Phineas Gage

- Before the accident 'he possessed a wellbalanced mind, was seen as a shrewd, smart business man, very energetic and persistent in executing all his plans of operation' (p 59)
- After the accident his mind was radically changed; so much so that his friends said he was no longer Phineas Gage
- Although most of his brain was not damaged, his frontal lobes were were

13

## Fleishman (2002, p 70)

- From Damaiso (1994) article in *Science*The rod passed through the left frontal lobe, between the two
- between the two hemispheres, then to left hemisphere
- The damage was to the front of the frontal cortex more than the back, and the underside more than the top



13



#### A Bit of EF Neuroanatomy

Prefrontal

• Rich cortical, sub-cortical and brain stem connections.



16

# More Specifically

• The dorsolateral prefrontal cortex (DLPFC) is involved with integrating different dimensions of cognition and behavior.



Dorsolateral prefrontal

 This area is associated with verbal and design fluency, ability to maintain and shift set, planning, response inhibition, working memory, organizational skills, reasoning, problem solving and abstract thinking.

17

# More Specifically:

#### The anterior cingulate cortex (ACC) is involved in emotional drives, experience and integration, inhibition of inappropriate responses, decision making and motivation



18

 Lesions in this area can lead to low drive states such as apathy and may also result in low drive states for such basic needs as food or drink and possibly decreased interest in social or vocational activities and sex.



# Frontal Lobes and Executive Function(s)

What do we mean by the term Executive Function(s)?



#### Goldstein, Naglieri, Princiotta, & Otero (2013)

- We found more than 30 definitions of EF(s).
- Executive function(s) has come to be an umbrella term used for many different abilities, including planning, working memory, attention, inhibition, self-monitoring, self-regulation and initiation carried out by pre-frontal areas of the frontal lobes.

22

#### What is Executive Function(s)

- 1. Barkley (2011): "EF is thus a self-directed set of actions)" (p. 11).
- 2. Dawson & Guare (2010): "Executive skills allow us to organize our behavior over time" (p. 1).
- 3. Delis (2012): "Executive functions reflect the **ability to manage and** regulate one's behavior (p. 14).

23

#### What is Executive Function(s)

- Denckla (1996): "EF (is) a set of domain-general control processes..." (p. 263).
- Gioia, Isquith, Guy, & Kenworthy (2000): "a collection of processes that are responsible for guiding, directing, and managing cognitive, emotional, and behavioral functions" (p. 1).

24

#### What is Executive Function(s)

- 6. Pribram (1973): "executive programmes ...to maintain brain organization " (p. 301).
- Roberts & Pennington (1996): EF "a collection of related but somewhat distinct abilities such as planning, set maintenance, impulse control, working memory, and attentional control" (p. 105).

25

#### What is Executive Function(s)

- Stuss & Benson (1986): "a variety of different capacities that enable purposeful, goal-directed behavior, including behavioral regulation, working memory, planning and organizational skills, and self-monitoring" (p. 272).
- Welsh and Pennington (1988): "the ability to maintain an appropriate problem-solving set for attainment of a future goal" (p. 201).

26

#### What is Executive Function(s)

10. McCloskey (2006): "a diverse group of highly specific cognitive processes collected together to direct cognition, emotion, and motor activity, including ...the ability to engage in purposeful, organized, strategic, self-regulated, goal directed behavior" (p. 1)

"think of executive functions as a set of independent but coordinated processes rather than a single trait" (p. 2).

#### What is Executive Function(s)

- 10. Lezak (1995): "a collection of interrelated cognitive and behavioral skills that are responsible for purposeful, goal-directed activity," ...
- 11. "how and whether a person goes about doing something" (p. 42). 12. Luria (1966): "... ability to correctly evaluate their own behavior
- and the adequacy of their actions" (p. 227).

28



29

And Finally. . . . An NICHD panel in 1994 identified 33 EFs by consensus!

#### The Top Six Were:

- Self-regulation
- Sequencing of behavior
- Flexibility
- Response inhibition
- Planning
- Organization of behavior

31



32



- Those that involve planning or decision making.
- Those that involve error correction or troubleshooting.
- Situations when responses are not well-rehearsed or contain novel sequences of actions.
- Dangerous or technically difficult situations.
- Situations that require the overcoming of a strong habitual response or resisting temptation.

BRIEF Scales	ADHD Inatt	ADHD Hy-Imp	CBCL Inatt-P	CBCL Inatt-T	BASC Attn-T	BASC Hy-lm-
Inhibit	.42	.73	.58	.63	.54	.81
Shift	.39	.59	.59	.49	.50	.53
Emotion	.39	.56	.57	.49	.47	.66
Initiate	.55	.36	.50	.69	.55	.41
WM	.60	.44	.64	.74	.65	.55
Plan/Org	.63	.33	.56	.67	.60	.54
Organize Mat	.49	.15	.40	.60	.50	.53
Monitor	.54	.45	.65	.78	.57	.65
I - Beh. Reg	.44	.70	.65	.60	.54	.73
II – Metacog	.67	.38	.63	.80	.64	.56
Global EF	.63	.60	.72	.80	.62	.68







# EF and ADHD

EF deficits are not necessarily unique to ADHD. They are neither necessary nor sufficient to make a diagnosis of ADHD. When EF impairments are measured in children with ADHD they tend to reflect specific rather than global impairments.

37

#### **Executive Function or Functions**

- EF has been described as having three components: inhibitory control, set shifting (flexibility), and working memory (Davidson, Amso, Anderson, & Diamond, 2006; Miyake et al., 2000;Zelazo & Müller, 2002). These abilities are described as
- relatively independent (Wiebe, Espy, & Charak, 2008).
- Thus, Executive Functions is the view -- a multidimensional model (Friedman et al., 2006; Miyake et al., 2000).
- EF has been described as a unitary construct (e.g., Duncan & Miller, 2002; Duncan & Willer, 2002; Miller & Cohen, 2001).
   There is some evidence that a multidimensional structure of executive function is OK in older children and adults, but unidimensional in early childhood.
   Both views are supported • Both views are supported by some research (Miyake et al., 2000), which indicates that EF represents a unitary construct with partially different components.

38



#### Executive Function(s)

- One way to examine this issue is to research the factor structure of behaviors related to EF(s)
- To do so, we examined the factor structure of the Comprehensive Executive Function Inventory (CEFI)
- · We conducted a series of research studies to answer the following question:
  - What is the underlying structure of the behaviors assessed on the CEFI? Is there is just one underlying factor called executive function), or do the behaviors group together into different constructs suggesting a multidimensional structure?

40

#### **EXPLORATORY FACTOR ANALYSES**

- For the *first half* of the normative sample using item scores: EFA of the 90 items was conducted
- The scree plot test and the very simple solution criterion both indicated that only one factor should be retained.
- The ratio of the first and second eigenvalues was greater than four for all three forms, which is a common rule to support a one factor solution.

41

#### **EXPLORATORY FACTOR ANALYSES**

- Using the second half of the normative sample EFA was conducted using raw scores for the Attention, Emotion Regulation, Flexibility, Inhibitory Control, Initiation, Organization, Planning, Self-Monitoring, and Working Memory scales
- Both the Kaiser rule (eigenvalues > 1) and the Eigenvalue Ratio criterion (> 4) unequivocally indicated one factor.

#### **EXPLORATORY FACTOR ANALYSES**

Conclusions

• When using parent (N = 1,400), teacher (N = 1,400), or self-ratings (N = 700) based on behaviors observed and reported for a nationally representative sample (N = 3,500) aged 5 to 18 years Executive Function *not* functions is the best term to use.

43











CEFI: WISC-IV, CAS, and WJ III

- $\mbox{ \bullet}$  Data from the Neurology, Learning and Behavior Center in Salt Lake City, UT
- Children given the CEFI, WISC-IV (N = 43), CAS (N = 62), and the WJIII achievement (N = 58) as part of a typical test battery.





















#### **EF** Interventions

Can strategic, instructional interventions provide remedial and compensatory support for children with EF deficits?

### Cognitive Strategy = EF Instruction

- A strategy is a procedure that the learner uses to perform academic tasks
- Using a strategy means the child thinks about 'how you do what you do'
- Successful learners use many strategies.
- Some of these strategies include visualization, verbalization, making associations, chunking, questioning, scanning, using mnemonics, sounding out words, and self-checking and monitoring.

55

My Granddaughter Hones Her EF Skills













































# Follow the order.

#### 73

#### Benefits of Strategy Instruction

- Students feel a sense of power
- Students become more responsible
- Work completion and accuracy improve
- Students develop and use a personal study process
- They know how to "try"
- On-task time increases: students are more "engaged"

74

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#### Conclusions

- The concepts of ADHD and EF are evolving.
  Behavioral problems associated with ADHD have been associated with EF deficits.
- Data from the CEFI Standardization indicate that when measured using observable behaviors the term Executive Function is supported.
   EF weakness represents poor efficiency.
- · EF ability is not the same as behaviors associated with EF.
- Children with ADHD often demonstrate a gap between what they know and what they do.
- All children with low EF ability and low EF behaviors do not have ADHD but all children with ADHD
  demonstrate deficits in behaviors associated with good EF.
- Demonstrate demonstrate demonstrates in terrators associated with good Er. The CEFI provides a well normed measure of EF that has demonstrated reliability & validity.
  There is emerging evidence that children can be taught to be more strategic an important indication of efficient EF. This should and does help children with ADHD reduce impairment, increase self regulation and find success.

76



