Executive Attention
Its Impact on Reading

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NEUROLOGY—REVEALED BY AMRI AND FMRI—UNDERLYING ADHD

- Frontal (and all subdivision!)
- Striatal (emphasis on caudate)
- Cerebellar (most distinctive)
- Underactivated caudate and MPH response of caudate most consistent findings
“Attention-deficit/hyperactivity disorder is characterized by a delay in cortical maturation.”

- Cortical growth-to-max trajectories measured on aMRI
Impulsive cognitive style is attributable to an additive or interactive dysfunction in multiple (but probably related) cognitive systems and their closely related mediating neural networks” (Sergeant et al., 2003; Willcutt et al., 2005)
EF Popularized As Neuropsychology of ADHD

- Executive Function (EF) is domain of direct interest, implicates “Frontal” circuits
- Barkley’s book explains that all EFs flow (linearly, developmentally) from the primary one, INHIBITION
- Others view INHIBITION and RESPONSE PREPARATION as “two sides of the same coin”
- Add “Sustain,” “Initiate” and “Shift”
Emphasis Shift: Not Just Inhibition is Deficient with ADHD

- Speed of Motor Output
- Timing of Motor Output
- VARIABILITY of Motor Output
- These now “Motor Endophenotype”
● Does the “traditional triad” cover the syndrome?
● Is “hyperactivity” too superficial or redundant?
● Isn’t “inattention” misleading” (better choice “attention mis-allocation”)
Is EDF “diagnostic” of ADHD?

- No! Most with ADHD show EDF but reverse is not true!
- EDF is NOT a diagnosis but a “processing problem” (educators’ terminology)
- EF has “server loops” from other “posteriorly based” systems (also described as “ingredients”)

Learning Disability

EF Deficit

Academic Difficulty
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PROJECT III: THE EFFECTS OF ADHD (BEYOND DECODING ACCURACY) ON READING FLUENCY AND COMPREHENSION

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Specific Aims

Using ADHD as a model:

1. How does processing speed contribute to reading efficiency?
2. How does working memory contribute to reading comprehension?
3. How does repeated exposure and practice affect reading efficiency and textual fluency?
Participants

- $n = 100$, grades 4-8 (50 control/50 ADHD)
- Exclusion criteria (ADHD/controls)
  - Adequate word recognition/decoding skills
  - No Language Disorder ($< 1.5$ sd on CELF-4 receptive or expressive language composite OR $< 1.0$ sd on both)
- Neuropsychological assessment, ERP, fMRI, and DTI
Inclusions and Exclusions

- DSM-IV diagnosis
  - DICA-IV interview
  - Conners’ Rating Scales
  - ADHD Rating Scale IV

- Must meet on DICA-IV, 1/2 parent and 1/2 teacher rating scales

- Autism/PDD
- Conduct Disorder
- Anxiety Disorders
- Mood Disorders
- Psychosis
- Language Disorders
- Word Reading < 37th percentile
- IQ < 70 or > 130
- Long acting psychotropics
- Contraindications to MRI
Deconstructing Executive Control

Functions
- Response inhibition
- Working memory
  - Verbal
  - Spatial
- Response preparation
  - Initiation
  - Planning
  - Processing speed
  - Variability of responding

Methods
- Brain
  - aMRI
  - fMRI
  - DTI
  - Electrophysiology
- Cognitive
- Motor
- Oculomotor
Deconstructing Executive Control

Functions

- Response inhibition
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Methods

- Brain
  - aMRI
  - fMRI
  - DTI
  - Electrophysiology
- Cognitive
- Motor
- Oculomotor
As a group, children with ADHD are slow on nearly every timed task

- Motor (Cole et al., 2008, Neurology)
- Oculomotor (Mahone et al., 2009, JAACAP)
- Reaction times on computer tests (Wodka et al., 2007, JCEN)

Reaction times are also more variable

Implications for all academic work

Can we separate “processing” speed from responding speed?
Processing Speed and Fluency

- Poor fluency increases demands on other processes (e.g., working memory) can affect comprehension.

- Higher level processes compete with decoding for time limited resources and create a bottleneck.
Children with ADHD show deficits in rapid color naming (Wodka et al., 2008; Tannock et al., 2000)

Treatment with stimulants improves naming speed (Bedard et al., 2002)

Elements of naming appear separable

- Articulation time, pause time, variability (Neuhaus et al., 2001)

Visual-Verbal Connection (“see-it/say-it”) involving arcuate and/or inferior longitudinal fasciculus
Variability Predicts Reading Comprehension

Naming variability is a stronger predictor of comprehension than pause time

Li, Cutting, Ryan, Zilioli, Denckla, & Mahone (2009). JCEP
Why Slower?

- We measure response times
- Response times are composed of a chain of processes (Pashler & Johnson, 1989)
  - Perceptual analysis
  - Decision / response preparation
  - Response execution
Useful for studying dual-task interference (i.e., the bottleneck problem)

Two targets (T1 & T2) are presented—each in choice reaction time format

When *stimulus onset asynchrony* (SOA) between T1 and T2 is short, the response time for T2 (RT2) increases sharply

- Bottleneck at *response selection/preparation* stage
- Selection of T2 response postponed till after the T1 response has been selected
Long SOA, Control

Long SOA, ADHD  *ADHD hypothesized to have longer Response Selection time but same Perception and Execution*
Short SOA, Control

Short SOA, ADHD
The PRP Effect in ADHD

N = 17 (8 ADHD)
SOA: \( p = .000; \quad \eta^2 = .92 \)
SOA x Group: \( p = .08, \eta^2 = .30 \)
Do White Matter Anomalies Contribute to “slowing” in ADHD?

- Fiber track disturbances addressed with diffusion tensor imaging (DTI)
- *Fractional anisotropy* (FA) reflects directionality of water diffusion through tissue
  - FA higher in more organized white matter fibers
  - Myelinated tracts restrict diffusion
- Higher FA is associated with greater fiber integrity
- Several regions of increased FA in ADHD

- No regions of decreased FA

- Increased FA correlates with decreased reading fluency

Statistical parametric maps are at a threshold of $p<0.001$, with a cluster extent of 80mm$^3$

*Peterson, Ryan, Richardson, Rimbodt, Cutting, & Mahone (2009). International Neuropsychological Society*
Recent studies reported pathological increases of FA (e.g., Williams syndrome (Hoeft et al. 2007))

Given reports of decreased white matter volume in ADHD (Mostofsky, 2002; Castellanos, 2002; Hill, 2003) the finding of increased FA in ADHD suggests that:
- Decreased branching of white matter tracts;
- Reduced number of crossing association or commissural fibers;
  - May result in increased directionality of water diffusion within the white matter
Working Memory

- Temporary retention of information that was just experienced but no longer exists
  - Can be stored for short periods of time
  - Manipulation or rehearsal
  - Central to *dual-tasking*
  - May be necessary to guide controlled behavior
  - Increased working memory load may negatively affect performance (*Rubia, 2001*)
Working memory is thought to be dependent on dorsolateral prefrontal brain circuit.

Hypothesize that children with ADHD have less efficient brain activation on WM tasks.

This inefficiency affects WM and will ultimately impede reading comprehension.
**Working Memory and Reading Comprehension**

Delayed Response Task  
*(D’Esposito et al., 1999)*

½ “maintenance” trials  
(“Forward”)

½ “manipulation” trials  
(“Alphabetize”)

**4 Runs**  
16 trials in each run:  
8 maintenance  
8 manipulation (WM)  
pseudorandom order

Each trial separated by 3-9 s,  
with central crosshair on the screen
alphabetize
H - 1
Performance on the **DAB-2** was associated with activation in the right prefrontal cortex in a region comprising both dorsolateral prefrontal cortex (DLPFC) and dorsomedial prefrontal cortex (DMPFC). Performance on the **GORT-IV** was not associated with any activation in the prefrontal cortex.
Regions important for working memory (DLPFC) and self-monitoring necessary for complex-knowledge based decision-making (DMPFC) showed a strong association with DAB-2, but not GORT-IV

- Unsupported listening format of the DAB-2 may place demands on working memory more than the GORT-IV
- Format of hearing the passage and comprehension questions (in addition to reading them) on the GORT-IV may minimize working memory demands, c/w DAB-2