EXECUTIVE FUNCTIONING: THE MIND-BODY CONNECTION

GT/LD Network
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INTRODUCTION: WHAT IS EF AND HOW DOES IT RELATE TO ADHD AND LD?

I. **Executive functioning defined (All roads lead to goal-directed behavior)**

A. Bruce Pennington: "The ability to maintain an appropriate problem solving set for attainment of a future g
Includes processes such as **planning, organizational skill, maintaining mental set, selective attentic
and inhibitory control** — for which the prefrontal regions of the brain are specialized.

B. Martha Denckla: Emphasizes **interference control, effortful and flexible organization, and strategic planning** - or **anticipatory, goal-directed preparedness to act**. The construct also includes **working memory**, as it includes maintaining internal representations to guide actions.

ISIS as the "infrastructure" of executive dysfunction (**Initiate, Sustain, Inhibit, Shift**).

C. Deborah Yurgelin-Todd: Describes frontal lobe functions as follows:

1) filtering sensory information
2) organizing information and behavior, putting in sequential order
3) sustaining and focusing attention
4) starting motor responses
5) coordinating motor programs into purposeful behavior

D. Goldberg: Describes the functions of the frontal lobe with the metaphor of the orchestra director

E. Several conditions that manifest, at least in part, with executive dysfunction

1. ADHD
2. Tourette's Syndrome
3. Obsessive-Compulsive Disorder
4. Traumatic Brain Injury
5. Depression
6. Learning Disabilities

I. **Executive functioning and ADHD**

A. Almost everyone agrees: ADD and ADHD reflect developmental impairment of multiple executive func

B. Martha Denckla: ADHD can be considered as a **disorder of inhibition, intention, and working memc**

C. Russell Barkley's theory of ADHD: ADHD comprises a **primary deficit in behavioral inhibition.**

1. Inhibition makes a crucial contribution to four other executive functions: (a) **Verbal working m**
(b) **nonverbal working memory,** (c) **self-regulation of affect, motivation and arousal, and reconstitution.**

2. These four occur in delays in responding and are protected by behavioral inhibition. They provide a sense of time, timing, and timeliness to behavior.

D. Thomas Brown's opposing view: Poor behavioral inhibition is not the primary executive deficit in ADHD, as **facilitating (activating) and inhibitory deficits** are both important. Brown's *Attention Activation Disorder* is characterized by deficits in (a) organizing and activating to work, (b) sustaining attention and concentration, (c) sustaining energy and effort, (d) managing affective interference, and (e) utilizing working memory and accessing recall.

III. Executive functioning and learning disabilities

A. Historical view: In 1970's, learning disabled students were described as "passive learners" who had weak metacognitive skills (similar to executive functions). Since the 1980's they have increasingly been described as "actively inefficient learners" (Torgesen).

B. Executive functions and reading disorders

1. Sustained attention and frustration tolerance are necessary for most readers to acquire a sufficient level of "automaticity" with the mechanics of reading to become fluent, comfortable readers.

2. Working memory is linked to comprehension in both poor and good readers.

3. Poor readers have trouble suppressing activation of irrelevant information.

4. Students with strong executive functioning skills are able to compensate effectively for language-based difficulties (Denckla).

C. Executive functions and written language

1. Verbal retrieval, sentence formulation, and written expression place strong demands on sequencing, organizational and self-monitoring skills, and on holding ideas in working memory

2. Paragraph and essay-length writing clearly stress planning, sequencing, prioritizing, and integrating information.

3. Children with executive functioning deficits commonly struggle with spelling and the automatic mastery of writing mechanics.

4. There is strong overlap between dysgraphia and ADHD (stimulants often improve handwriting significantly).

D. Executive functioning and math learning

1. Students with ADHD commonly have trouble automatizing math facts, even if they otherwise have a good mind for math. They also are prone to misreading operation signs and to having trouble with multiple-step and/or multiple-column procedures (see studies by David Geary and others).

2. Rebecca Bull and colleagues have found that the primary difficulties of poor math students are (a) trouble inhibiting preponent responses and learned strategies and (b) poor working memory.

3. Jack Nagliari has identified specific planning deficits in students with math disabilities.

E. Content area learning: Executive dysfunction is related to deficits in deliberate memorization and retrieval, as these processes are dependent upon the skilled use of mental strategy. Deficits in these areas complicate preparing for and taking tests and often first become problematic in middle school.

NEUROLOGICAL UNDERPINNINGS

I. Neurological foundations of executive functions and executive dysfunction

A. Complex brain systems are involved.

1. Although executive functions do not "reside" in the frontal lobes, frontal brain systems are extremely important in executive functioning.

2. The frontal lobes are densely connected with other cortical and subcortical brain regions.

3. A very recent study in JAMA (Castellanos, et al). found 3-4 percent smaller total brain volume in ADHD children, including unmedicated children. Brain size correlated negatively with symptom severity. Largest difference was in cerebellum; the caudate nucleus (part of the basal ganglia) was smaller in younger children but normal by age 15. Unmedicated children showed significantly smaller volume of white matter (myelinated axons or connective fibers), reflecting immaturity and raising the possibility that stimulant medication may actually enhance brain maturation.

B. Relationship between what Martha Denckla calls motor control and mental control

1. ADHD research: The three parts of brain that are most heavily involved in ADHD are motor regions: prefrontal cortex, medial frontal area of basal ganglia, and cerebellum (J. Giedd).

2. The cerebellum coordinates movement but is also important for mental processing. It keeps developing well into adolescence and is not as genetically programmed as many other structures (e.g., is less similar in twins). It thus seems to be influenced strongly by experience (J. Giedd).

C. Working memory. There are cells in the frontal lobe that only fire between the stimulus and the subsequent response. These seem to be working memory or "intentional" neurons that allow the brain to "bring to mind" events in the absence of direct stimulation and to provide the temporal and spatial continuity between past experience and present (or future) actions.

D. EEG studies: ADD children have 9/1 theta/beta ratio (average = 4/1), reflects mental idling.

E. Imaging studies - SPECT scans.

1. Lou's (1984) SPECT study: Found hypoperfusion of frontal lobes but increased blood flow on Ritalin.

2. Daniel Amen's SPECT scans: "The harder they try, the worse it gets." Helps to explain Brown's idea of trouble with activation.

F. Extremely high heritability of ADHD.

II. Brain development and executive functions

A. Early development of the frontal lobe: Between 3 and 6 years, the most rapid brain growth is in the frontal lobe areas involved in planning, organization, and maintaining attention and vigilance (corresponds with the "5-7 shift" and readiness for formal schooling.).

B. Frontal development and developmental stages: There is a close correlation between maturational spurts in frontal lobes and transitions into neo-Piagetian stages.

C. Adolescence and beyond: Protracted development of the frontal lobe in adolescence and adulthood (myleination not complete until fourth or fifth decade of life).

1. Dramatic spurt in frontal lobe maturation between 17-20 (corresponds to Priscilla Vail's 16-19 shift). Helps explain late bloomers.

2. Deborah Yurgelun-Todd (Mclean Hospital): Teens have more trouble than adults identifying expressions of fear. On MRI, adults activated in limbic region and prefrontal cortex, in teens, mainly limbic activation. Teens activated amygdala bilaterally, adults left amygdala. On a verbal fluency task, children activated left temporal, teens increasingly activated left frontal.

3. Kurt Fischer has identified cognitive changes through age 25 with corresponding changes in EEG through early 20's.

4. There is also evidence for a significant spurt in the myelination of fibers connecting the frontal lobes and limbic regions between 40 and 50, allows for a "second chance" at the development of reflective thinking.

5. Many middle age women report ADHD symptoms for the first time – or a worsening of existing symptoms. May be related to estrogen depletion, as estrogen facilitates the release of dopamine.

III. Factors that affect executive functioning

A. Stress:

1. Stress disorganizes the brain (try to organize and set priorities when your stressed!)

2. Anxiety can mimic ADHD/EF. High amygdala activation produces high volume of dopamine. Too much dopamine flooding the brain can be just as bad as not enough, as it can "disconnect" frontal lobe's central executive from other brain functions (Denckla).

3. Stress (particularly the adrenal steroid **cortisol**) significantly interferes with the functioning of the brain's major memory center (**hippocampus**). Over time, cortisol can kill hippocampus cells and retard growth of new cells. Prolonged stress can lead to significant hippocampal shrinkage and increased risk for Alzheimer's Disease.

B. Resting the nervous system: The importance of sleep

1. Sleep is highly associated with mental and physical health in children, adolescents, and adults. Sleep is also extremely important for learning and memory consolidation throughout the life span.

2. A recent study by Dr. Eve Van Cauter found that one week of sleep deprivation (4 hours per night) in adults slowed glucose metabolism in the brain by 30-40 percent (similar to the functioning of the elderly). Also, cortisol levels were higher during sleep in sleep-deprived group (linked to development of memory impairments and age-related insulin resistance).

3. A single night of partial sleep deprivation (5 hours) affects executive functions in children.

4. Almost all teenagers as they reach puberty become "walking zombies" (James Maas).

5. Core symptoms of ADHD and sleep disruption/deprivation are strikingly similar, as are neuropsychological profiles. Children with ADHD have high incidence of sleep disturbance, particularly variability in sleep latency. Treatment studies using (a) chronotherapy for insomnia and (b) dopamine stimulating drugs to treat movements in sleep lead to significant improvement in sleep, attention, and behavior.

C. Depression (talk about an executive buster!): Depression and disordered stress response

ASSESSMENT AND INTERVENTION

I. Assessment of executive functions

A. Measures of verbal and nonverbal fluency (e.g., *Controlled Oral Word Association Test; D-KEFS Design Fluency Test*)

B. Measures of word list learning (e.g., *Selective Reminding Test: California Verbal Learning Test for Children*)

C. Measures of motor sequencing/motor control (e.g., *Grooved Pegboard; Go/ No*)

D. Tasks involving planning (e.g., *Tower of London; Rey Osterrieth Complex Figure*; *CAS Planning subtests*)

E. Tasks requiring interference control (e.g., *Stroop;* tasks from the *CAS)*

F. Tests of working memory (e.g., digit span; following directions; *Paced Auditory Serial Attention Test)*

G. Tests of vigilance and impulse control (e.g., *TOVA; IVA; CAS Atttention subtests*)

H. Tests of mental flexibility (e.g., *Wisconsin Card Sorting Test*)

I. Tests of problem-solving, hypothesis testing (*D-KEFS 20 Questions Test*)

J. New battery: *Delis-Kaplan Executive Function System (D-KEFS)*

II. Common educational interventions

A. Arranging environments (e.g., preferential seating, study carrels, small group instruction).

B. Behavioral management . Interventions to improve on-task behavior have included:

1. Classroom-based contingency systems
2. Response cost programs (e, g, start out with 100 points, lose points for infractions)
3. Home–school contingencies
4. Peer–mediated contingencies

C. Technical supports

1. Fm systems using headphones and a microphone (auditory trainers)
2. Beepers (e.g., pageminders.com)
3. Timers

D. Study skills/ learning to learn strategies

1. Planning/goal setting/time management
2. Segmenting and sequencing tasks
3. Monitoring and tracking assignments
4. Learning-to-learn strategies for organizing time and materials, organizing and remembering information, sequencing ideas (in writing).

E. Executive coaching

III. Promoting self-regulation and optimal functioning: What's good for the heart is good for the brain

A. Promoting sleep: the importance of resting the nervous system

1. Make sleep a high priority.

2. Follow good sleep hygiene (see books by Mark Durand and/or William Dement). For teenagers, minimize bright lights after 9:00 pm and expose to bright lights first thing in the morning.

3. Consult with a physician regarding possible sleep disorder and effects of medication on sleep.

B. Practice stress management: Deep rest heals the nervous system of stress, in part by lowering cortisol level.

1. *Transcendental Meditation* (www.tm.org) is best documented, with over 600 published studies. Lowers cortisol levels. Increases coherence between left and right hemispheres, front and back of brain. Increases cerebral blood flow. Improves emotional regulation and sleep. Reduces blood pressure as effectively as medication in adolescents and adults (with only positive side effects). Increases ability to focus attention.

2. "Do Turtle" (students "go into their shell); use techniques from Brain Gym.

3. The Relaxation Manual by June Groden and Joseph Cautela: Combines progressive muscle relaxation and visual imagery; is used extensively even with autistic and low functioning students.

C. Facilitate relaxed alertness in the classroom: This is the optimal mode for learning (high challenge, low threat).

1. Reduce threat to minimize "downshifting", explore with children what interferes with their feeling safe in school.

2. Minimize fear-based motivation. Teach students to set goals, stay in touch with the emotions that motivate the goals. Teach adaptive motivation (preference for difficulty and increased effort with difficulty).

3. Practice empathy (see Robert Brooks' The Self-esteem Teacher).

D. Encourage physical activity (due to the overlap between motor and mental control)

1. Encourage aerobic exercise, strengthening, and stretching. Movement stimulates the executive brain, primes the "executive pump".
2. Patterned programmed movements may be particularly beneficial, e.g., martial arts, yoga, dance, swimming, drumming).

3. Use strategies from *Brain Gym* (e.g., "cross crawl"); use techniques for kinesthetic learners (who need movement to get and keep their brains activated).

E. Diet: Food affects the nervous system (as is obvious in children's limited emotional regulation when hungry).

1. In Healing ADD, Dr. Daniel Amen recommends a relatively high protein, low carbohydrate diet (e.g., Barry Sears' *Zone Diet*) for all types of ADD except the overfocused/inattentive type.
2. See Jean Carter's Your Miracle Brain for broad nutritional suggestions.
3. Drink water: Brain is more vulnerable to stress (more cortisol production) when dehydrated.

IV. **Provide increased structure of time and space** (Be frontal lobes for students who lack them).

A. Organize space (duct tape as metaphor)

B. Organize time:

1. Practice estimating, predicting expected time (people with ADHD are poor estimators of time).

2. Use schedules, clocks, timers

3. Find ways of building in down time, including time with eyes closed.

V. **Teach strategies for self-regulation, self-monitoring, self-reinforcement.**

A. Behavioral regulation

1. Philip Kendall's Stop and Think
2. Bonnie Camp's Think Aloud
3. ALERT program ("How Does Your Engine Run"): Developed and implemented by occupational therapists. Very useful in the classroom.
4. Strategies for emotional control (e.g., from *Rational Emotive Therapy*)
5. Myrna Shure's preschool program

B. Cognitive-behavioral strategies for academic learning

1. Steve Graham and Karen Harris' Self-Regulated Strategy Development
2. University of Kansas strategies
3. Mnemonic techniques

C. Use modeling, attributions, and teaching of others

1. Model self-talk re: planning strategizing, organizing, problem-solving
2. Model self-talk for 20 Questions, verbal fluency, memory strategies
3. Attributions help to shape executive system (point out "I've noticed that you can really organize when you put your mind to it").
4. Encourage children and adults to teacher others.

Play games that demand executive skills

A. Emphasize games that require classification (integrating global and local), planning ahead, waiting until the right time, organizing materials, prioritizing, use of strategy, anticipating another's moves, working within a time frame.

B. These could include the following: *Blurt, Outburst, Taboo, Tribond, Scattegories, Set, Scrabble, Hangman, Risk, Chess, Monopoly, Battleship, Checkers, Chess, Clue, The Logical Journey of the Zambinis.*

I. **Intervention in specific executive areas**

A. Initiate

1. Facilitate neurological readiness to act. Include "rag doll", *Brain Gym* strategies such as "brain buttons" and "cross crawl", and "anchoring" strategy from NLD (see Thom Hartmann's book, Healing ADD). Could also include push ups, trampoline, headstands.

2. Teach children to "size up" new tasks, determine the relevant component parts. Teach left hemisphere strategies using self-talk ("What am I being asked to do?"). Teach right hemisphere strategies using visualization ("See yourself doing it").

3. Teach prioritizing and sequencing of steps in time. Use predict and compare strategy (which can greatly reduce procrastination) and various means of marking the passage of time. Always map time left to right.

4. Use external prompts such as beepers to provide reminders, e.g., "Get your butt in gear." (www. PageMindersInc.com)

5. Teach strategies to combat procrastination (e.g., break tasks into small chunks, work in short periods, set time limits to avoid hyper-focusing).

6. Model the breathing, posture, and self-talk of students who know how to get started (see the *Neuro-Linguistic Programming* [*NLP*] strategies in Thom Hartman's book, including strategies for planning the future).

7. Encourage students to set their own goals, track their own progress (e.g., ReadNaturally.com).

8. Use humor: Jokes can help kids get started.

B. Sustain

1. Use external means to monitor time, give feedback.
2. Use of mirrors, videotape, beepers.
3. Have child use ear plugs or head phones during work time to reduce distraction.

C. Inhibit: Behavioral regulation drives metacognition (Barkley).

1. Medication: Stimulants improve inhibitory control and other executive skills (including working memory)
2. Self-talk ("stop and think"; "go slow")
3. Relaxation work
4. Practice *Stroop* task (see web site)

D. Shift

1. Minimize transitions; move from unstructured to structured to formal
2. Use a transition clock (from The Difficult Child)
3. Practice transitions (visualize and/or role play)
4. Use of paradox (e.g., have child pretend to freak out, fall apart when role playing a transition.
5. Play *Set*

E. Working Memory

1. Use computer programs such as *Earobics* to develop verbal working memory
2. Use guided imagery to develop nonverbal working memory

VIII. **Direct training of attention and related processes** (the process-specific intervention of Mateer; Kearns; Selmud-Clikeman).

A. Assumptions: Attentional abilities can be improved by providing structured opportunities for exercising particular aspects of attention. Hypothesis: Repeated activation and stimulation of attentional systems leads to changes in cognitive capacity that presumably reflect changes in neuronal activity.

B. Attention Process Training (Sohlberg and Mateer). Training focuses on a group of hierarchically organized remediation tasks that tap five dimensions of attention: focused, sustained, selective, alternating, and divided.

IX. **Other promising interventions**

A. Neurofeedback training (using feedback to regulate brain waves)

B. Interactive metronome (www.interactivemetronome.com)

SUGGESTED READING

Brain Development

Byrnes, J. (2001) Minds, Brains, and Learning: Understanding the Psychological and Educational Relevance of Neuroscientific Research. New York: Guliford Press

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