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- Cove School, Northbrook, IL
- Learning Disability Association Annual Conference, Lebanon and Kuwait
- ADHD Workshop, Brooklyn College, NY
- Vera French Mental Health Center, Davenport, Iowa
- Georgetown Pediatrics Annual Conference, Pawleys Island, SC
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An Update on ADHD, Self-Regulation, and Executive Functioning

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Sources:

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Current Status of EF

- A term used extensively in education, psychology (especially neuropsychology), psychiatry, neuroscience, and other disciplines
- Typically regarded as “those cognitive abilities needed for goal-directed action”
- Considered to be an umbrella term (meta-construct) that comprises a set of interacting mental abilities
- Serves as the basis for self-regulation
- Argued as being humanity’s highest faculty
- Largely mediated by the brain’s prefrontal cortex
Serious Problems with the EF Construct

- Lacks any consensus definition
  - More than 20 definitions exist
  - Most emphasize self-regulation, goal directed behavior, and problem-solving

- Considered to be a meta-construct serving as an “umbrella” term for a set of more specific components
  - But up to 33 components have been attributed by experts to EF

- Assessment of EF nearly always employs psychometric tests. But:
  - Many tests exist that assess EF but without any clear definition of the term how can we be sure that they evaluate EF?
  - Many tests of EF started out as measuring other mental abilities
  - Many are unreliable and often poorly normed
Does ADHD = EFDD???

(Executive Function Deficit Disorder)
The Neuro-Anatomy and Neuropsychology of ADHD Virtually Guarantee It!
The Prefontal Cortical Networks Involved in EF Are Also the Networks Implicated in Self-Regulation and in ADHD

- **The frontal-striatal circuit**: Associated with deficits in response suppression, freedom from distraction, working memory, organization, and planning, known as the “cool” or “what” EF network.

- **The frontal-cerebellar circuit**: Associated with motor coordination deficits, and problems with the timing and timeliness of behavior, known as the “when” EF network.

- **The frontal-limbic circuit**: Associated with symptoms of emotional dyscontrol, motivation deficits, hyperactivity-impulsivity, and proneness to aggression, known as the “hot” or “why” EF network.


Executive Brain Networks

Striatum

Hypothalamus

Amygdala

Reality testing and error monitoring

Top-down guidance of attention and thought

Inhibition of inappropriate actions

Emotion regulation

Norepinephrine and dopamine producing cells

Direct norepinephrine and dopamine regulation by prefrontal cortex
Current Paradox

- ADHD is a disorder of brain networks that contribute to EF – so it has to be an EF disorder.
- But only 35-50% or fewer ADHD cases are impaired on EF psychometric tests (≥93rd %).
- Yet 86-98% of clinical-referred adults with ADHD are impaired on rating scales of EF in daily life as are 65-75% of ADHD children followed to adulthood with persistent ADHD.
- EF tests have low or no significant correlations with EF ratings in daily life:
  - 0-10% of shared variance between tests & ratings
  - less than 20% for best combination of EF tests.
- EF tests and EF ratings are NOT measuring the same construct.
How to Resolve the Problems?

- Most common construct assigned to EF by expert neuropsychologists is self-regulation
- So make self-regulation the core of EF
  - A self-directed action
  - Intended to alter subsequent behavior
  - So as to change the probability of a future (delayed) event or consequence (improve longer term welfare)
- Understand that humans use at least 7 different self-directed actions for self-regulation to achieve delayed goals
Resolving the Paradox

• Each type of self-directed action can be considered an executive function (or a specific EF component)
• These EFs develop in a step-wise sequence
• They exist to address the problems and opportunities involved in social (group) living
• View EF as a hierarchy of levels (in biology - an extended phenotype) similar to Michon’s model of driving
Building a Theory of EF: Linking Inhibition, Self-Control, and the Executive Functions
What is EF?

• An executive function can be defined as a major type of action-to-the-self (a type of self-regulation)

• There are 7 major types of EFs:
  – Self-Awareness (meta-cognition)
  – Inhibition and interference control
  – Nonverbal working memory
  – Verbal working memory
  – Emotional
  – Self-Motivation
  – Planning and problem-solving

• Each likely develops by behavior being turned on the self and then internalized (privatized, inhibited)

• They likely develop in a step-wise hierarchy - Each needs the earlier ones to function well
Self-Awareness (Self-Directed Attention)
Inhibition (Self-Restraint)
Emotion Regulation (Self-Directed Emotions)
Verbal Working Memory (Self-Speech)
Nonverbal Working Memory (Self-Directed Sensing)
Inhibition (Self-Restraint)
Self-Awareness (Self-Directed Attention)

Planning & Problem-Solving (Self-Directed Play)
Motivation Regulation (Self-Directed Motivation)

Sequential Development of the EFs

Age – Neurological Maturation
The EFs Create Four Developmental Transitions in What is Controlling Behavior

• External — Mental (private or internal)

• Others — Self

• Temporal now — Anticipated future

• Immediate — Delayed gratification
  (Decreased Temporal Discounting of Delayed Consequences)
Michon’s Model of Driving

**Level IV: Strategic Abilities**
i.e., Purpose or goals for using the car, best routes through traffic to attain the goals, time likely needed to attain each goal, knowledge needed to enact the plan effectively (weather, traffic, construction, known accidents, etc.)

**Level III: Tactical Abilities**
i.e., abilities required to operate the vehicle on roadways in the presence of and interactions/conflicts with other drivers and their vehicles, such as driving laws, knowledge of safe driving tactics, etc.

**Level II: Operational Abilities**
i.e., familiarity with and sound management of the vehicle and its components such as steering, braking, acceleration, signaling, mirrors, seat belts, other safety equipment [ex. Driving a car in an empty parking lot]

**Level I: Basic Cognitive Abilities Required to Drive**
i.e., normal reaction time; visual field perception; motor speed, agility, coordination, and range of motion; visuo-spatial reasoning; hearing; language and reading abilities, etc.
Barkley’s Model of EF

**Level I: Instrumental – Self-Directed Abilities**
i.e., self-awareness, executive inhibition and interference control, nonverbal and verbal working memory, planning, problem-solving, self-motivation, emotion regulation

**Level II: Methodical – Self-Reliant Abilities**
Essential for daily adaptive functioning, self-care, and social self-defense
i.e., Self-Organization and Problem-Solving, Self-Management to Time, Self-Restraint, Self-Motivation, Self-Regulation of Emotions

**Level III: Tactical – Reciprocal Abilities**
i.e., Underlies human social exchange, turn taking, reciprocity, promise keeping. Basis of economic behavior (trading); Underlies ethics, social skills and etiquette; Basis for legal contracts

**Level IV: Strategic – Cooperative Abilities**
i.e., Underlies human coordinated group activities in which goals can be attained that are not possible for any individual. Underlies cooperative ventures, division of labor, formation of communities and governments
EF is the use of self-directed actions (self-regulation) to choose goals, and to select, enact, and sustain actions across time toward those goals, usually in the context of others and often relying on social and cultural means. This is done for the maximization of one’s longer-term welfare as the person defines that to be.

(Barkley, 2012)
Self-Regulatory Strength is a Limited Resource Pool

S-R Fuel Tank (Willpower)

The pool increases in capacity with maturation.

Use of EF/SR reduces the pool temporarily.

- Inhibition & Self-Restraint
- Self-Management to Time (NV-WM)
- Self-Organization & Problem-Solving (V-WM)
- Emotional Self-Regulation
- Self-Motivation

So Does:
Stress, Alcohol, Drug Use, & Illness
How Does ADHD Fit Into EF?

EF Comprises a Single Domain that Can Be Usefully Subdivided into two Broad Dimensions

**Inhibition:**
- Motor
- Verbal
- Cognitive & Emotional

**Meta-Cognition:**
- Nonverbal WM
- Verbal WM
- Planning/Problem-solving
- Emotional self-regulation

Hyperactivity-Impulsivity

Where does ADHD fit into them?

Inattention
The Brain as a Knowledge vs. Performance Device

ADHD

Performance  Knowledge
Understanding ADHD

- ADHD disrupts the 7 forms of EF/SR and most upper levels of its extended phenotype but especially the tactical and higher levels thereby creating a disorder of self-regulation across time.

- ADHD can be considered as “Time Blindness” or a “Temporal Neglect Syndrome” (Myopia to the Future).

- It adversely affects the capacity to hierarchically organize behavior across time to anticipate the future and to pursue one’s long-term goals and self-interests (welfare and happiness).

- It’s not an Attention Deficit but an Intention Deficit (Inattention to mental events & the future).
Understanding ADHD

It’s a Disorder of:

• Performance, not skill
• Doing what you know, not knowing what to do
• The when and where, not the how or what
• Using your past at the “point of performance”

The point of performance is the place and time in your natural settings where you should use what you know (but may not)
The Value of the Concept of Delayed Executive Age in ADHD

• ADHD appears to delay EF development by 25-40%, or an average of 30%
• Use this estimate to understand a child’s executive age or EA (chronological age minus 30%)
• Adjust expectations to match this EA
• Determine new responsibilities and freedoms based on their EA not their CA
• Provide accommodations or scaffolding to support the child at this EA
Implications for Treatment

• Teaching skills is inadequate
• The key is to design prosthetic environments around the individual to compensate for their EF deficits
• Therefore, effective treatments are always those at the “point-of-performance”
• The EF deficits are neuro-genetic in origin
• Therefore, medications may be essential for most (but not all) cases – meds are neuro-genetic therapies
  – They are also associated with neuro-protective effects (normalizing effects) on brain structure and functioning as well as on EF tasks
• But some evidence suggests some EFs may also be partly responsive to direct training, albeit temporary
• While ADHD creates a diminished capacity: Does this excuse accountability?
  – (No! The problem is with time and timing, not with consequences)
More Treatment Implications

• Behavioral treatment is essential for restructuring natural settings to assist the EFs
  – They provide artificial prosthetic cues to substitute for the working memory deficits (signs, lists, cards, charts, posters)
  – They provide artificial prosthetic consequences in the large time gaps between consequences (accountability) (i.e., tokens, points, etc.)
  – But their effects do not generalize or endure after removal because they primarily address the motivational deficits in ADHD

• The compassion and willingness of others to make accommodations are vital to success

• A chronic disability perspective is most useful
How can we compensate for EF deficits? By reverse engineering the EF system

- Externalize important information at key points of performance
- Externalize time and time periods related to tasks and important deadlines
- Break up lengthy tasks or ones spanning long periods of time into many small steps
- Externalize sources of motivation
- Externalize mental problem-solving
- Replenish the SR Resource Pool (Willpower)
Replenishing the EF/SR Resource Pool

S-R Fuel Tank (Willpower)

- Greater Rewards and Positive Emotions
- Statements of Self-Efficacy and Encouragement
- 10 minute breaks between EF/SR tasks
- 3+ minutes of relaxation or meditation
- Visualizing and talking about future rewards before and during SR demanding tasks
- Routine physical exercise; Also Glucose ingestion

Regular limited practice using EF/SR and the Willpower Pool can increase later pool capacity. However, the capacity may eventually diminish once practice is terminated.

How Does ADHD Differ from the Autistic Spectrum (ASD)

• Neuroanatomically:
  – ADHD has reduced gray and white matter and less functional interconnectivity (and more disrupted) between the prefrontal regions, basal ganglia, and cerebellum, among others.
  – ASD involves excess brain matter with increased local connectivity within regions but greatly reduced long-range connectivity to other brain regions, particularly evident in regions related to language, imitation, and social functioning, (incl. theory of mind). There is also likely increased neurons and heightened functioning in sensory-motor nerves both centrally and peripherally.

• Executive functioning:
  – ADHD disrupts the development of all EF components but especially inhibition, self-awareness, and working memory (with nonverbal WM more deficit than verbal WM)
  – ASD principally disrupts verbal WM, not inhibition, along with brain modules related to universal grammar generation, language, and social functioning (social beings as unique stimuli) that can produce downstream disruption in other EF components such as self-motivation, planning, problem-solving, etc.
ADHD vs. ASD (cont.)

• Developmental outcomes:
  – ADHD: 15-35% recover from disorder by age 30. While 40% require special education, nearly all now complete high school. Vast majority are employed by adulthood with 70-90% living independently of family or origin by young adulthood.
  – ASD: <10% no longer qualify for diagnosis but most of these re-diagnosed as ADHD, OCD, and anxiety disorders; 60-90% in special education, 10% living independently, 10% have a close friend, 40% may be employable (mostly in entry level work).

• Treatments:
  – ADHD has multiple effective medications available for its management, 55% may be normalized while taking it, may show neuro-enhancement from prolonged medication use, and responds well to teacher and parent administered behavioral interventions. But all must be sustained through adolescence to impact adult adjustment
  – ASD has no medications for its specific management but may be improved in developmental course by intensive ABA therapy, especially if provided during the 2-6 year age period. Early intensive treatment impacts adaptive self-help and educational placement and attainment by adolescence with far less impact on socialization.
Conclusions

• The EF/SR system is multi-leveled and arranged in a hierarchy over maturation

• ADHD disrupts behavioral inhibition and the internalization of the instrumental self-directed EFs producing a cascading of deficits into higher levels of EF

• By disrupting EF/SR, ADHD affects:
  – Self-restrain or inhibit behavior, thoughts, words, emotions
  – Self-manage to time; anticipate and prepare for the future
  – Self-organize and problem solve across time
  – Self-motivate across time
  – Self-regulate emotions across time
Conclusions

• Behavior in people with ADHD cannot be hierarchically organized and sustained in support of longer term goals and welfare

• This results in a serious and pervasive disorder of self-regulation across time and settings and impaired social functioning (reciprocity, cooperation, and mutualism)

• Preventing them from dealing effectively with the probable future and pursuing one’s long-term goals and welfare

• Thereby requiring the design of prosthetic environments that compensate for EF/SR deficits while using neuro-genetic medicines to temporarily improve or normalize the instrumental self-directed EFs