

# Executive Functioning, Self-Regulation, and ADHD: Impact on Understanding and Treatment

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Sources:

- Barkley, R. A. (2015). *Attention deficit hyperactivity disorder: A handbook for diagnosis and management (4<sup>th</sup> ed.)*. New York: Guilford Press
- Barkley, R. A. (2012). *Executive Functions: What They Are, How They Work, and Why They Evolved*. New York: Guilford Press.
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## What is ADHD? DSM-5 Criteria

- Developmentally Inappropriate Symptoms
  - Two lists of inter-related symptoms (Inattention, Hyperactive-impulsive)
  - To be a symptom it must occur “Often” or more frequently
  - Need to have 6 (or 5 for adults) symptoms from either symptom list
  - Parenthetical clarifications added for teens and adults (untested)
- Childhood Onset (Symptoms - Impairment)
  - Age 12 (treat as being flexible – 16 is better)
  - Unless acquired secondary to neurological injury
- Cross-setting Occurrence of Symptoms
- Significant Impairment
- Corroboration of self-reports through others
- Exclusion of Other Disorders
- No Subtypes – Just “presentations” emphasizing current symptoms: Inattentive, Hyperactive, or Combined Types

## Understanding the Symptoms of ADHD

The two dimensions of neuropsychological deficits are in:

### 1. **Hyperactivity-Impulsivity** (Executive Inhibition)

- Deficient motor inhibition (restless, hyperactive)
- Impaired verbal inhibition (excessing talking, interrupting)
- Impulsive cognition (difficulty suppressing task irrelevant thoughts, rapid decision making;
- Impulsive motivation (prefer immediate gratification, greater discounting of delayed consequences)
- Emotion dysregulation (impulsive affect; poor “top down” emotional self-regulation)
- Restlessness decreases with age, becoming more internal, subjective by adulthood

## More on ADHD

**Inattention:** But 6 types of attention exist – not all are impaired in ADHD. What is?

### Executive Attention (& Functioning)

- Poor persistence toward goals, tasks, and the future (can't sustain attention/action over time)
- Distractible (impaired resistance to responding to goal-irrelevant external and internal events)
- Deficient task re-engagement following disruptions (skips across uncompleted tasks)
- Impaired working memory (forgetful in daily activities, cannot remember what is to be done)
- Diminished self-monitoring

# Executive Functioning:

## Nature and Problems

From R. A. Barkley (2012). *The Executive Functions: What They Are, How They Work, and Why They Evolved*. New York: Guilford Press

## 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*” but little agreement exists beyond this
- Considered to be an umbrella term (meta-construct) that comprises a set of interacting mental abilities but no consensus exists on why they qualify as EF or on how many. Some consensus that EF serves as the basis for self-regulation but little effort has been made to explain the link
- Argued as being humanity’s highest faculty, but why?
- Largely mediated by the brain’s prefrontal cortex but not exclusively so

## Serious Problems with the EF Construct

- Lacks a consensus theory– just vague descriptions, component lists, and thematic diagrams
- Lacks any consensus definition
  - More than 20 definitions exist
  - Most emphasize self-regulation, goal directed behavior, and planning and problem-solving
- So why not just abandon the term altogether? (Koziol, 2015)
- Recent reviews consider EF to be a “meta”-construct or “umbrella” term for a set of numerous specific components
  - Up to 33 components have been attributed by experts to meta-construct of EF
  - Yet there is no definitional or operational basis for making such a determination – how does an EF and non-EF mental ability differ?
  - And factor analytic studies of EF batteries often reveal a single, large construct with smaller (weaker) dimensions often reflecting method variance (the tests given)
- As a result, assessment batteries and component tests vary widely

Does ADHD = EFDD????

(Executive Function Deficit Disorder)

## The Neuro-Anatomy and Neuropsychology of ADHD Virtually Guarantee It!

### Neuro-Imaging Findings

All 7 functional networks involve the cortical, basal ganglia, thalamic, and cerebellar regions.

In ADHD we find smaller (3-10%), less activity (10-25%+), and delayed development (2-3 yrs.) in these brain regions:

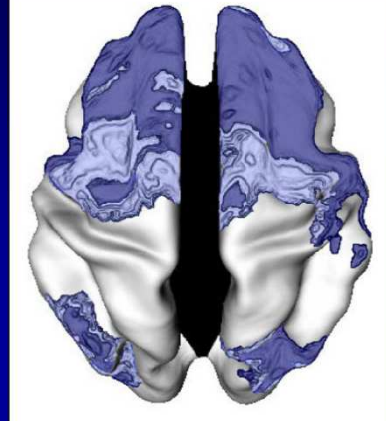
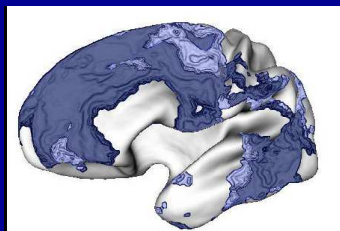
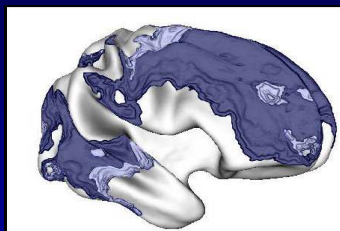
- Orbital-Prefrontal Cortex (primarily right side)
- Basal Ganglia (mainly striatum & globus pallidus)
- Cerebellum (central vermis area, more on right side)
- Anterior cingulate cortex
- Amygala
- Hippocampus and Thalamus (??)

## More Neuro-Imaging Results

- Size of these regions is correlated with degree of ADHD symptoms, particularly inhibition
- No substantial gender differences
- Structural differences in volume persist to late adolescence then some normalization
- Functional differences may persist into adulthood in most cases, especially in frontal-parietal regions
- Results are not due to taking stimulant medication
- Indeed, longer term use of stimulants has been associated with improved growth in these regions (neuroprotection)

## Delayed brain growth in ADHD (3 yrs.)

From Shaw, P. et al. (2007). ADHD is characterized by a delay in cortical maturation. *Proceedings of the National Academy of Sciences*, 104, 19649-19654.



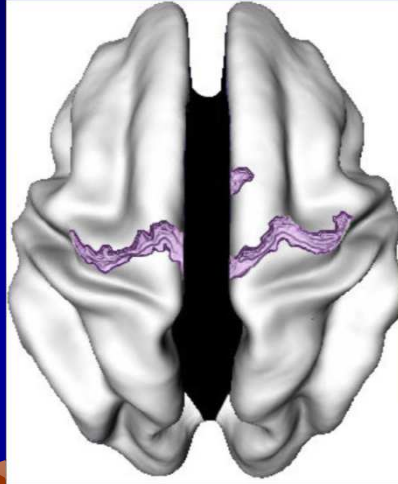
Greater than 2 years' delay  
0 to 2 years delay

Ns: ADHD=223; Controls = 223

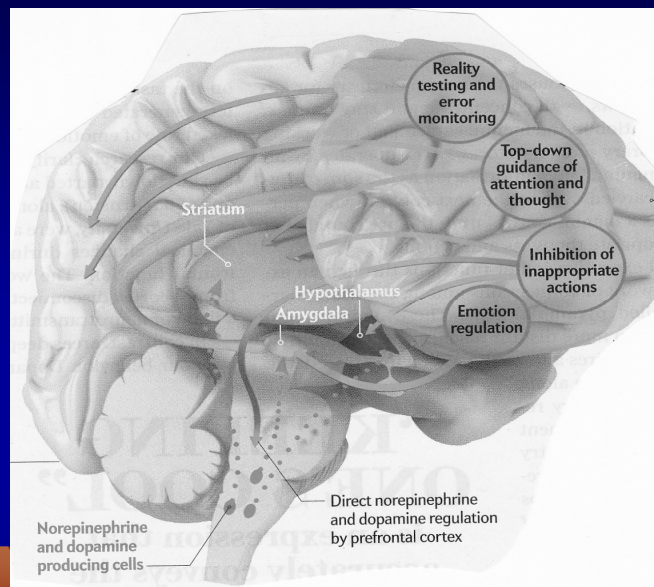
## Early cortical maturation in ADHD children

From Shaw, P. et al. (2007). ADHD is characterized by a delay in cortical maturation. *Proceedings of the National Academy of Sciences*, 104, 19649-19654.

**Fig. 4.** Regions where the ADHD group had early cortical maturation, as indicated by a younger age of attaining peak cortical thickness.



## Executive Brain Networks



## The Frontal Parietal Cortical Network Can Be Usefully Fractionated into Four EF Reciprocal Sub-networks: All are Implicated in Self-Regulation and in ADHD

- The frontal-striatal-thalamic circuit: Associated with deficits in response suppression, freedom from distraction, mental representations that guide behavior (working memory), manipulation of mentally held information (organization, planning, and problem-solving), and responding to novelty. Typically known as the “cool” or “**what**” EF network
- The frontal-cerebellar circuit: Associated with motor coordination deficits, but also with problems with the automaticity of actions, the anticipation of rewards, and the rate, rhythm, force, and especially timing and timeliness of behavior and thought. I call it the “**when**” EF network.
- The frontal-limbic circuit: Associated with symptoms of emotional self-regulation, motivation deficits, hyperactivity-impulsivity, and proneness to reactive aggression, known as the appraisal, “**hot**” or “**why**” EF network
- The frontal-cingulate-parietal network: Associated with deficits in self-awareness, performance monitoring, and error detection.

## Why the Controversy in ADHD Research about EF?

- ADHD is a disorder of brain networks that contribute to EF/SR
  - So logically ADHD must be a disorder of EF/SR
- But only 35-50% or fewer of ADHD cases are impaired on EF psychometric tests ( $\geq 93^{\text{rd}}$  %)
  - So ADHD cannot be a disorder of EF in half or more cases
- 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.
  - So ADHD must be primarily a disorder of EF in daily life
- Which Measurement Approach is Right??



## More on the Controversy

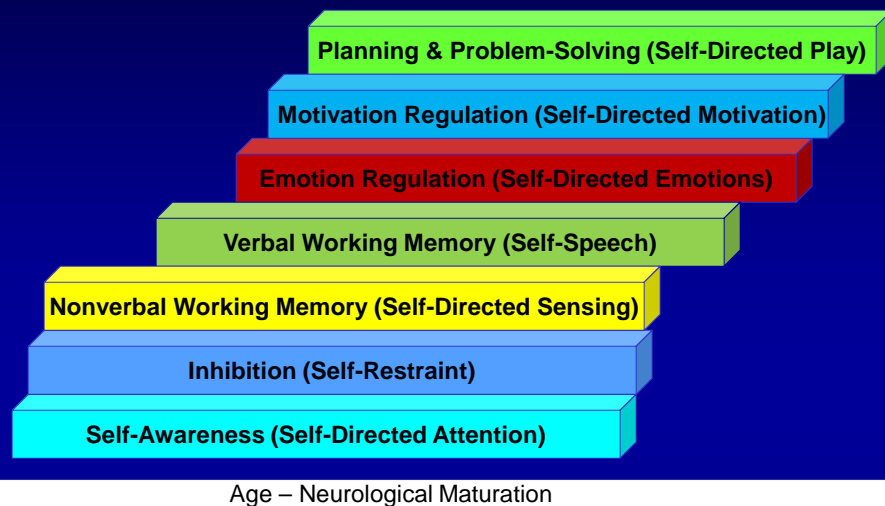
- EF tests have little or no significant correlations with EF or ADHD ratings in daily life;
  - so they are not measuring the same construct (only share 0-10% of their variance – trivial!)
- EF tests poorly predict impairments in major life domains
  - So why are they still viewed as the “gold” standard for assessing EF?
- EF ratings are stronger predictors of such impairments
- Yet EF tests are used in the vast majority of research to build theories of EF and to make claims about the development of EF, differentiation among disorders in their impact on EF, and whether early EF deficits predict outcomes later in life
  - EF ratings would likely have shown entirely different results
- And EF ratings and ADHD symptom ratings share 50-70% of their variance reflecting near co-linearity (a single dimension)

## Building a Theory of EF: Linking Inhibition, Self-Control, and the Executive Functions

## What is EF?

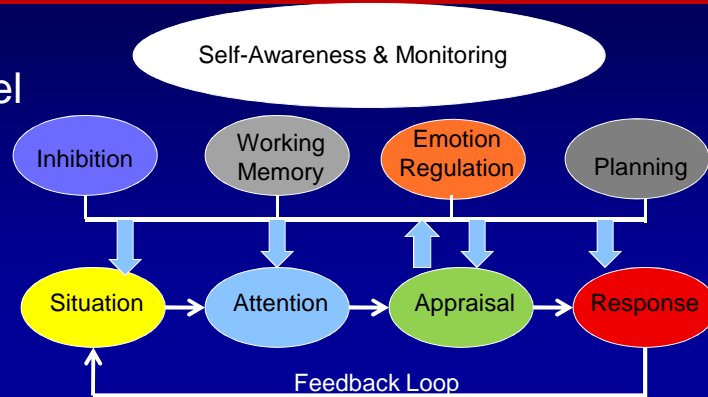
- EF is self-regulation. Self-regulation is
  - A self-directed action
  - Intended to change impending behavior
  - So as to alter the probability of a delayed consequence
- An executive function can be defined as a major type of action-to-the-self (a type of self-regulation)
- Each likely develops 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

## Sequential Development of the 7 EFs



## The Two-Level View of Self-Regulation

EF Level



4 Stages at the Automatic Level of Human Action

## What Engages the EF System?

- Brain functioning can be over-simplified as being of two types: automatic (fast) vs. effortful (slow, executive, cognitively controlled)
- If 90-95% of adult daily behavior is being executed at the automatic level of brain functioning, what triggers the use of the EF system?
  - Novelty (includes people and their actions, not just settings, events, or cultural objects)
  - Time
  - Obstacles to goal pursuit (including social ones)
  - Errors (including social ones)
  - Violation of an anticipated outcome (frustrative non-reward)
  - Overtures to reciprocate, trade, or cooperate from or made to others

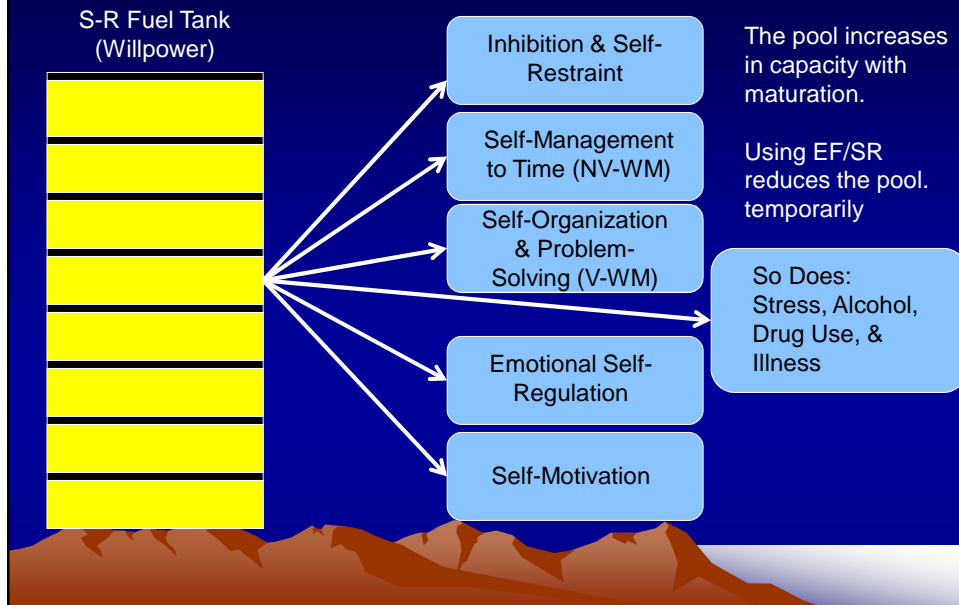
## The 5 EFs Used in Daily Life

- The 7 EFs are largely cognitive in nature
- They are used interactively to allow self-regulation over time to attain goals and improve one's longer term welfare during daily life activities
- The 7 cognitive EFs result in 5 EF behaviors as evident in daily life activities:
  - Self-Restraint (subordinating immediate desires for longer term goals and welfare)
  - Time Management (self-management to time)
  - Self-Organization and Problem Solving
  - Self-Motivation
  - Emotional Self-Regulation

## 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)

## Self-Regulatory Strength May Be a Limited Resource Pool



## Why Do We Have EF?

- Imitation and Vicarious Learning
  - Later, using Culture (products, knowledge) in the service of our goals
- Social Self-Defense – Protection from manipulation by others for their own ends
- Reciprocity – sharing, turn-taking, trading
  - Immediate and delayed (as in promise keeping)
- Cooperation – joining in a group venture that no one can accomplish alone and in which all share in the rewards
- Communalism – voluntarily living among, and sharing, reciprocating, and cooperating with select others in a larger community

## Executive Functioning - Defined

*EF is the use of self-directed actions (forms of 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)

## 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

Hyperactivity-  
Impulsivity

### Meta-Cognition:

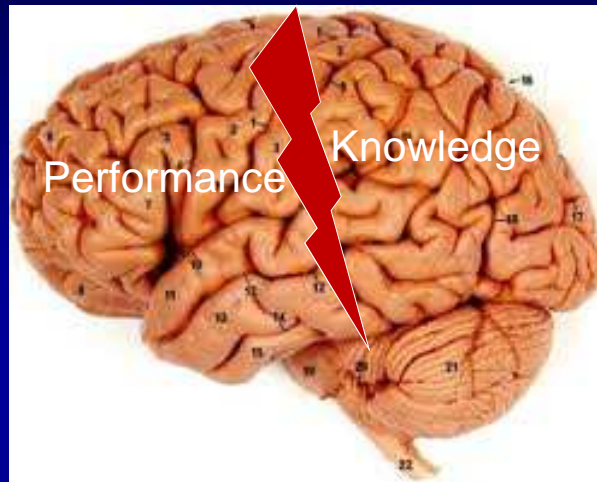
Nonverbal WM  
Verbal WM  
Planning/Problem-solving  
Emotional self-regulation

Inattention

Where does  
ADHD fit into  
them?

## The Brain as a Knowledge vs. Performance Device

### ADHD



## Understanding ADHD

- ADHD disrupts the Z forms of EF/SR 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 are not. Hence, the problems posed by ADHD and other EF disorders

## 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 (EA ) not chronological age (CA)
- Adjust expectations to match this EA not the CA
- Determine new responsibilities and freedoms based on their EA not their CA
- Provide accommodations or scaffolding to support the child at this level of EA



## Implications for Treatment

- Teaching skills is inadequate
- The key is to design prosthetic environments around the individual to compensate for their EF deficits
- Effective treatments must be 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
- Is EF responsive to direct training?
  - Preschool play-based EF training (maybe – 2 promising pilot studies focusing on “at risk” children)
  - EEG Neurofeedback (questionable effectiveness; placebo controlled, blinded studies find no effects)
  - Cognitive training technology (doubtful – no far transfer to functioning in natural settings)
  - fMRI Neurofeedback training (1 promising pilot study by Katya Rubia)

## More Treatment Implications

- Behavioral treatment (BT) is essential for restructuring natural settings to assist the EFs – think of it as the external scaffolding needed to support the EF/SR system (externalizing the prefrontal lobes)
  - BT provides artificial prosthetic informational cues to substitute for the working memory deficits (signs, lists, cards, charts, posters)
  - BT provides artificial prosthetic consequences placed in the large time gaps between natural or social consequences thus increasing accountability and motivation (i.e., tokens, points, etc.)
- But BT serves two different purposes depending upon the nature of the problem/disorder being treated
  - Informational - knowledge and skill building
  - Motivational - knowledge and skill performance
- The effects of BT do not generalize or endure after removal because they primarily address the motivational deficits in ADHD and so must be sustained if gains are to be maintained

## More Treatment Implications

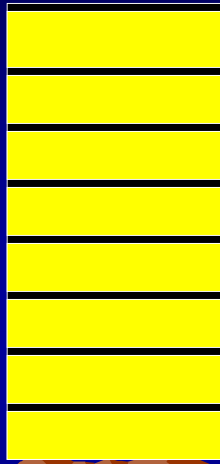
- Treatments that might be promising but remain largely untested in EF/SR disorders like ADHD
  - Over-learning and repeated rehearsal (moving from novelty and the EF “slow” system to automaticity/routinization in the non-EF “fast” brain)
  - Mental simulation of “if-then” situations to facilitate acquisition and practice of EF even in the absence of that situation
  - Observational learning – like mental simulation, video modeling or video self-modeling may be useful in promoting acquisition and practice of self-regulation and EF even in the absence of such direct learning events (being used in ASD research now)
- The compassion and willingness of others to make accommodations are vital to success
- A chronic disability perspective is most useful
- While ADHD creates a diminished capacity: Does this excuse accountability?
  - (No! The problem is with time and timing, not with consequences)

## How can we compensate for EF deficits? By reverse engineering the EF system

- Externalize important information at key points of performance (off-load working memory demands onto external storage devices)
- Externalize time and time periods related to tasks and important deadlines
- Break up lengthy long-term tasks spanning long periods of time into many smaller steps
- Externalize sources of motivation
- Externalize and manualize 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.

Adapted from Bauer, I. M. & Baumeister, R. F. (2011). Self-regulatory strength. In K. Vohs & R. Baumeister (Eds.), *Handbook of Self-Regulation* (2<sup>nd</sup> ed.) (pp. 64-82). New York: Guilford Press

## Conclusions

- ADHD delays and disrupts behavioral inhibition and the internalization of the instrumental level of self-directed EFs producing a cascading of deficits into all 7 components of EF
- In essence, ADHD produces a time or future blindness causing the individual to live more in “the now” and so be a less future-directed individual
- By disrupting EF/SR, ADHD affects the 5 major EFs seen in daily life activities:
  - 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