

Presenter Disclosure – Prior 12 Months

Speaker (Honoraria):

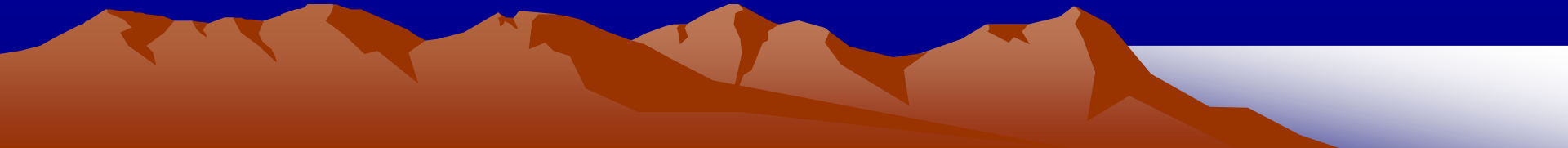
- Curry Ingram Academy, Brentwood, TN
- Learning at the Beach Pediatrics Conference, VCU Medical Center, Virginia Beach, VA
- Montgomery County Intermediate Unit, Norristown, PA
- Medical College of Wisconsin, Door County Institute, Egg Harbor, WI
- Australian Conference on Neurodevelopmental Disorders, Launceston, Tasmania
- Rawson Saunders School, Austin, TX
- Cruz Clinic, Livonia, MI
- J & K Seminars, Lancaster, PA
- NeuroDiff Clinic, Lyon, France
- Activa Foundation, Madrid, Spain
- ADANA Parents Association, Barcelona, Spain
- University of Alabama, Division of Continuing Education, 2020 Annual ADHD Conference
- Premier Educational Seminars, Inc., Eau Claire, WI (Pesi.com)
- University of Texas at San Antonio Health Sciences Center
- Leading Edge Seminars, Toronto, Canada
- Lines and Thoughts (ADHD Organization), Israel

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- Ironshore Pharmaceutical Co. (Speaker)
- Medici Pharmaceutical Company (Germany)
- Duke University Autism Center of Excellence, Durham, NC (Consultant)



Executive Functioning (EF), Self-Regulation, and ADHD: Is ADHD EFDD??

Russell A. Barkley, Ph.D.

Clinical Professor of Psychiatry
Virginia Treatment Center for Children
Virginia Commonwealth University Medical Center
Richmond, VA

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Sources:

Barkley, R. A. (2015). *Attention deficit hyperactivity disorder: A handbook for diagnosis and management* (4th 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.

Barkley, R. A. (2011). *The Barkley Deficits in Executive Functioning Scale*. New York: Guilford.

Email: drbarkley@russellbarkley.org

Websites: russellbarkley.org, adhdlectures.com

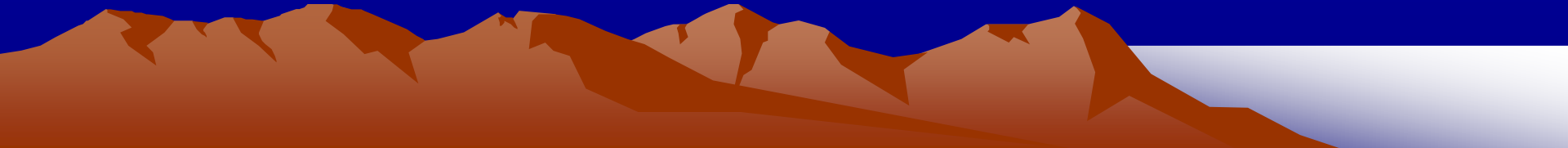


Understanding the Symptoms of ADHD

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



Serious Problems with the EF Construct

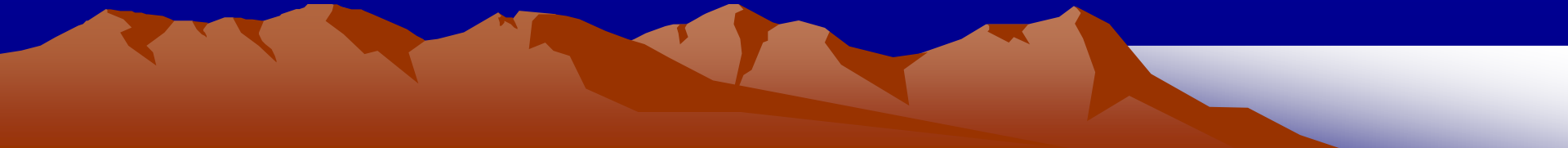
- Lacks a consensus theory— just vague descriptions, component lists, and thematic diagrams
- Lacks any consensus definition
 - More than 20 definitions exist
 - Most emphasize self-regulation, goal directed behavior, and planning and problem-solving
- Recent reviews consider EF to be a “meta”-construct 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 their component tests vary widely
- And there is great controversy over whether ADHD is a disorder of EF given the marked variability in results of studies using such tests
- So why not just abandon the term altogether? (Koziol, 2015)

Why the Controversy About the Role of EF in ADHD?

- 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 no significant correlations with EF ratings
 - 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)



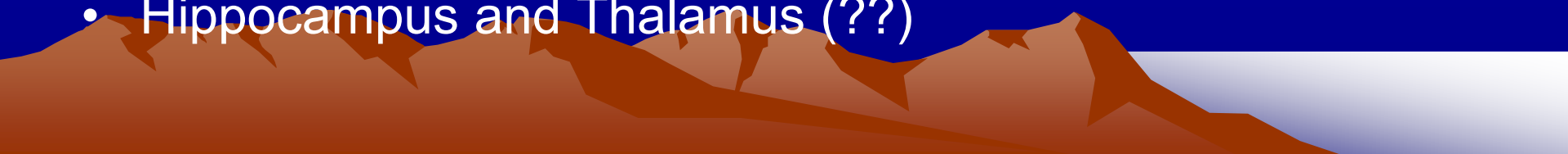
The Neuro-Anatomy and Neuropsychology of ADHD Virtually Guarantee It!



Neuro-Imaging Findings

All 7 major functional brain networks involve the cortical, basal ganglia, thalamic, and cerebellar regions. [There are likely 17 minor networks]

In ADHD we find smaller volumes (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
 - Anterior corpus callosum (splenium)
 - Amygdala ??
 - Hippocampus and Thalamus (??)
- 

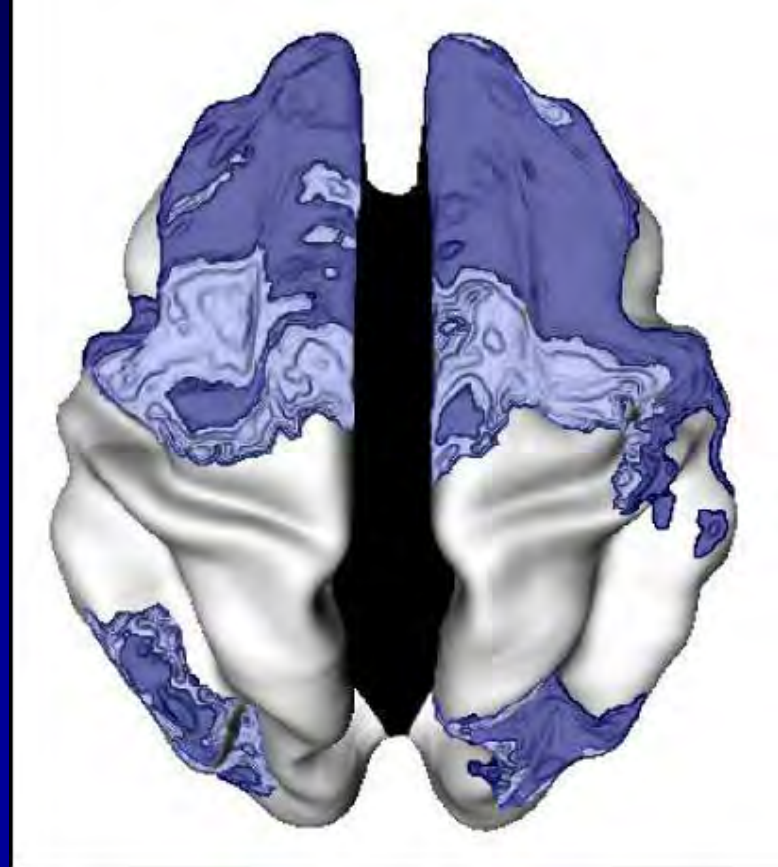
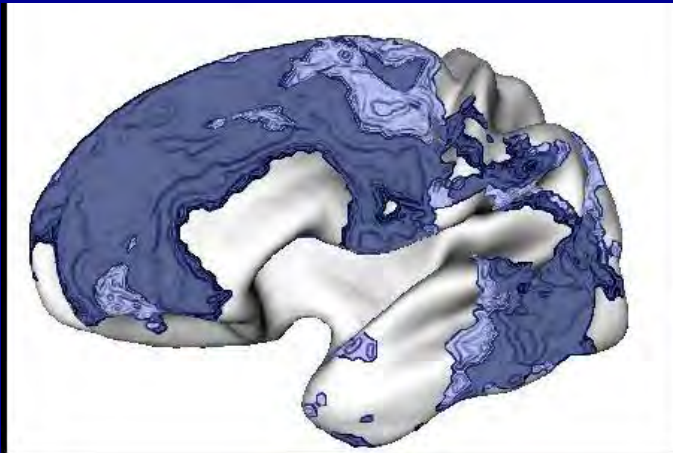
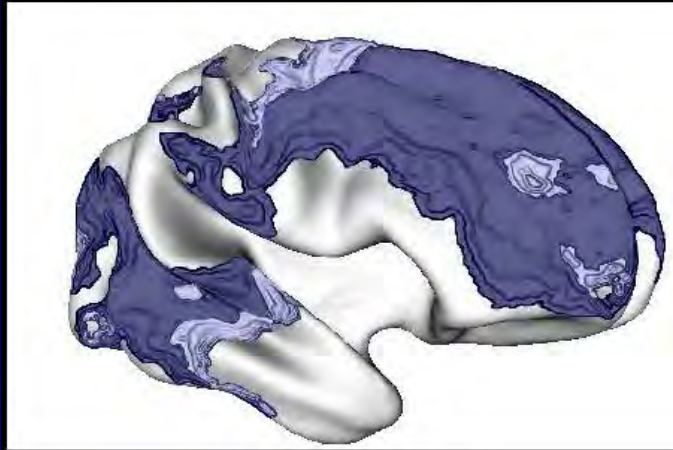
More Neuro-Imaging Results

- 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 involving connectivity within the EF networks 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.

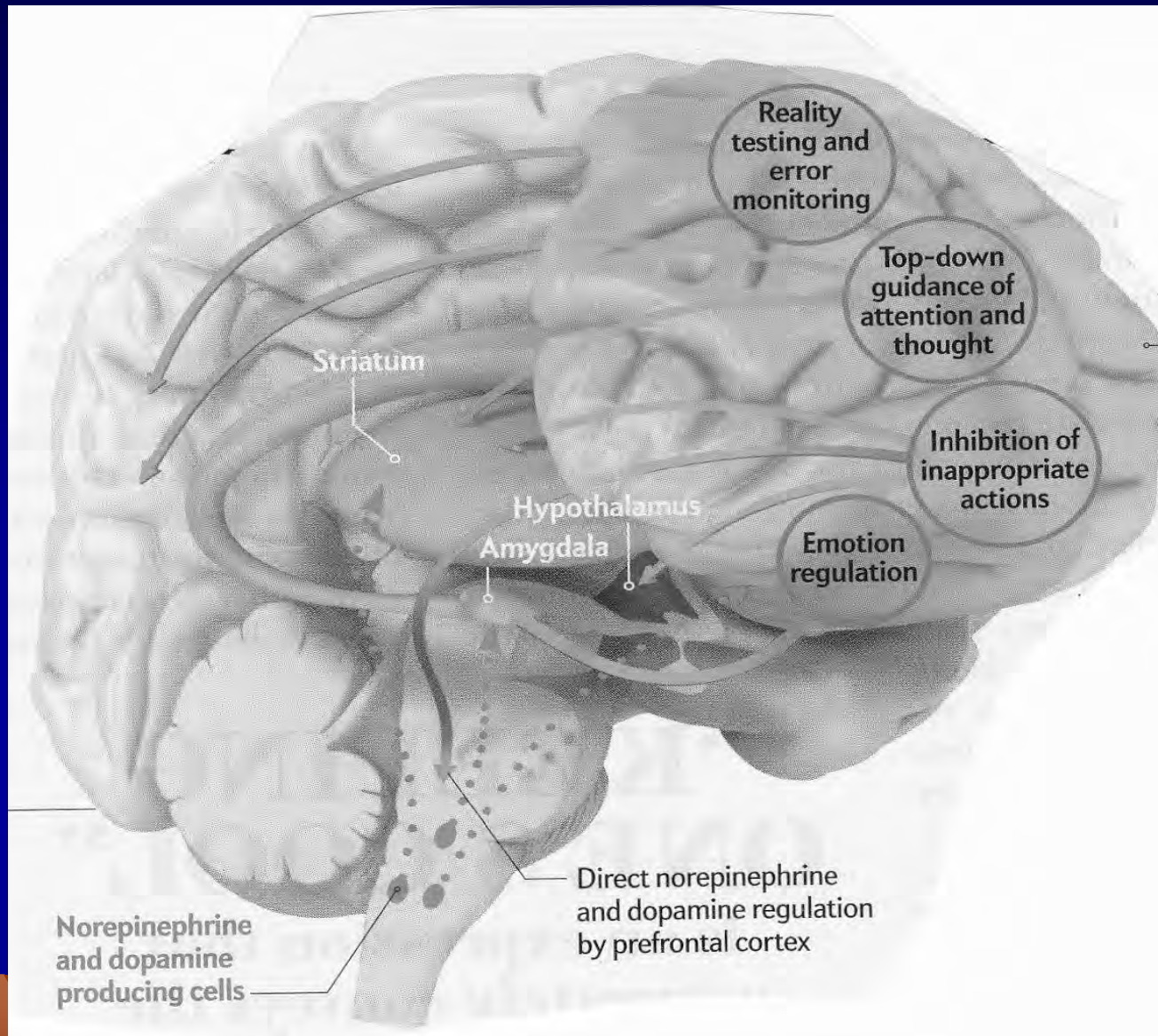
Proceedings of the National Academy of Sciences, 104, 19649-19654.




Greater than 2 years' delay
0 to 2 years delay

Ns: ADHD=223; Controls = 223

Executive Networks



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

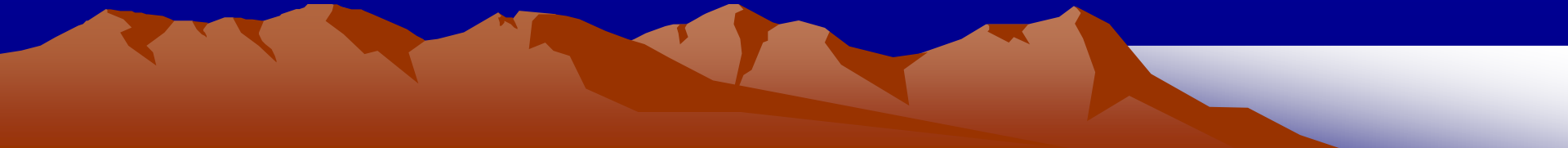
- The frontal-striatal-thalamic circuit: Associated with deficits in response suppression, freedom from distraction, mental representations that guide behavior (working memory), manipulation of mentally held information (organization, planning, and problem-solving), and responding to novelty. Typically 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.
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Building a Theory of EF: Linking Inhibition, Self-Control, and the Executive Functions



What is EF?

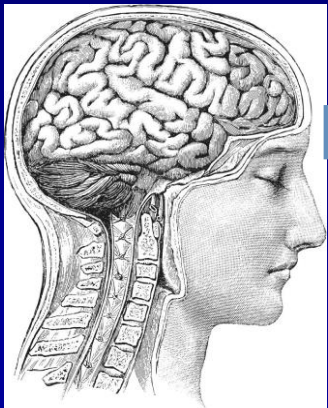
- EF is self-regulation. Self-regulation (SR) is
 - A self-directed action
 - Intended to change subsequent behavior
 - So as to alter the probability of a delayed consequence
- Thus, SR is self-improvement in support of one's longer term welfare
- An executive function can be defined as step 1 above – an action-to-the-self
- There appear to be 7 types of self-directed actions and so 7 forms of self-regulation
- Each likely develops the same way -- by behavior being turned on the self and then internalized (privatized, inhibited)



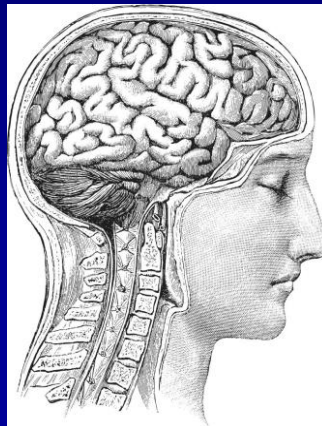
3 Important Processes in the Development of EF

- The **Self-Direction** of Actions
 - Behavior toward the world and others gets redirected to the self, occurring in the absence of external events and others that initially would prompt such behavior.
 - The stimulus for such behavior is initially a mental visual image but later can be self-speech
- The **Privatization** of Those Self-Directed Actions
 - With development, self-directed actions become less visible
 - This is likely the result of the inhibition of the brain-related activity associated with these actions from entering the spinal cord (switch is the basal ganglia and right frontal lobe?)
- The **Regulation** of the Behavior by These Self-Actions
 - The self directed actions come to govern the self and ongoing behavior, resting control of behavior from the environment

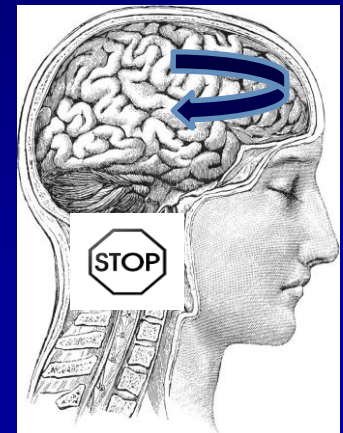
The Development of an Executive Function



Externally Directed
Action



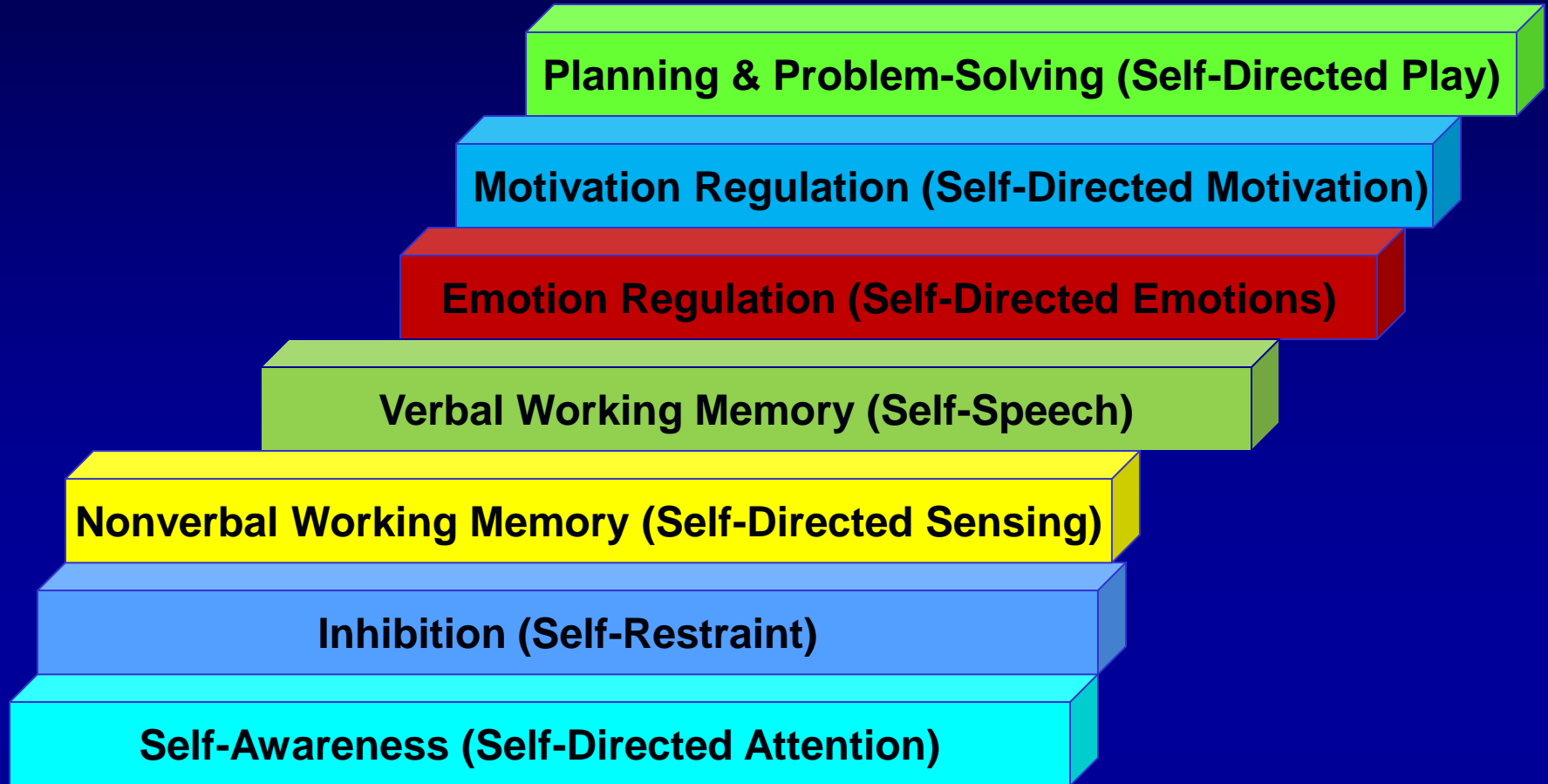
Self-Directed Action



Privately Directed Action
(Cognitive-Mental)

Sequential Development of the 7 EFs

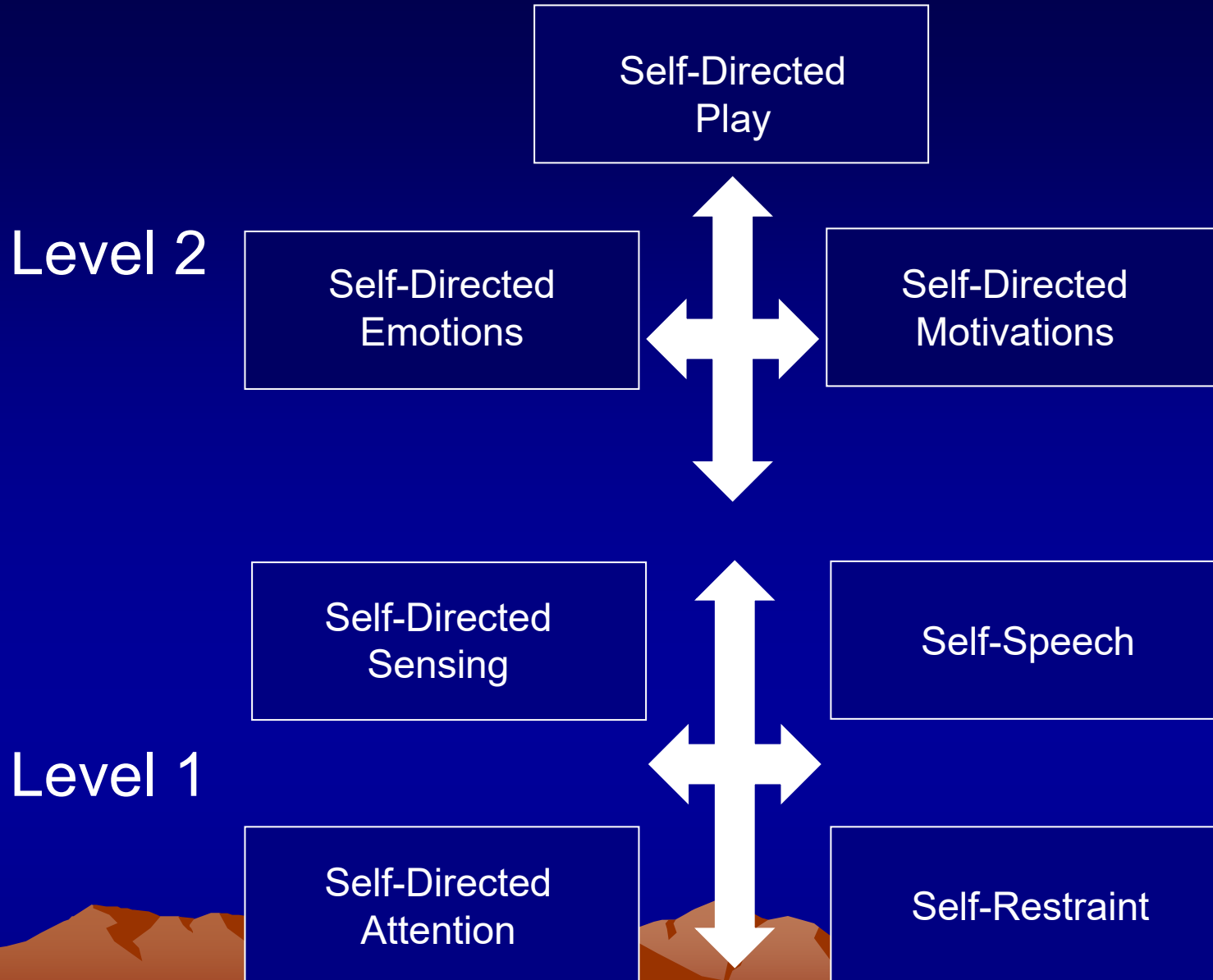
The EFs likely develop in a step-wise sequence and in a hierarchy - Each needs the earlier ones to function well



Age – Neurological Maturation



7 Major Self-Directed Actions (EFs)



The 5 EFs Used in Daily Life

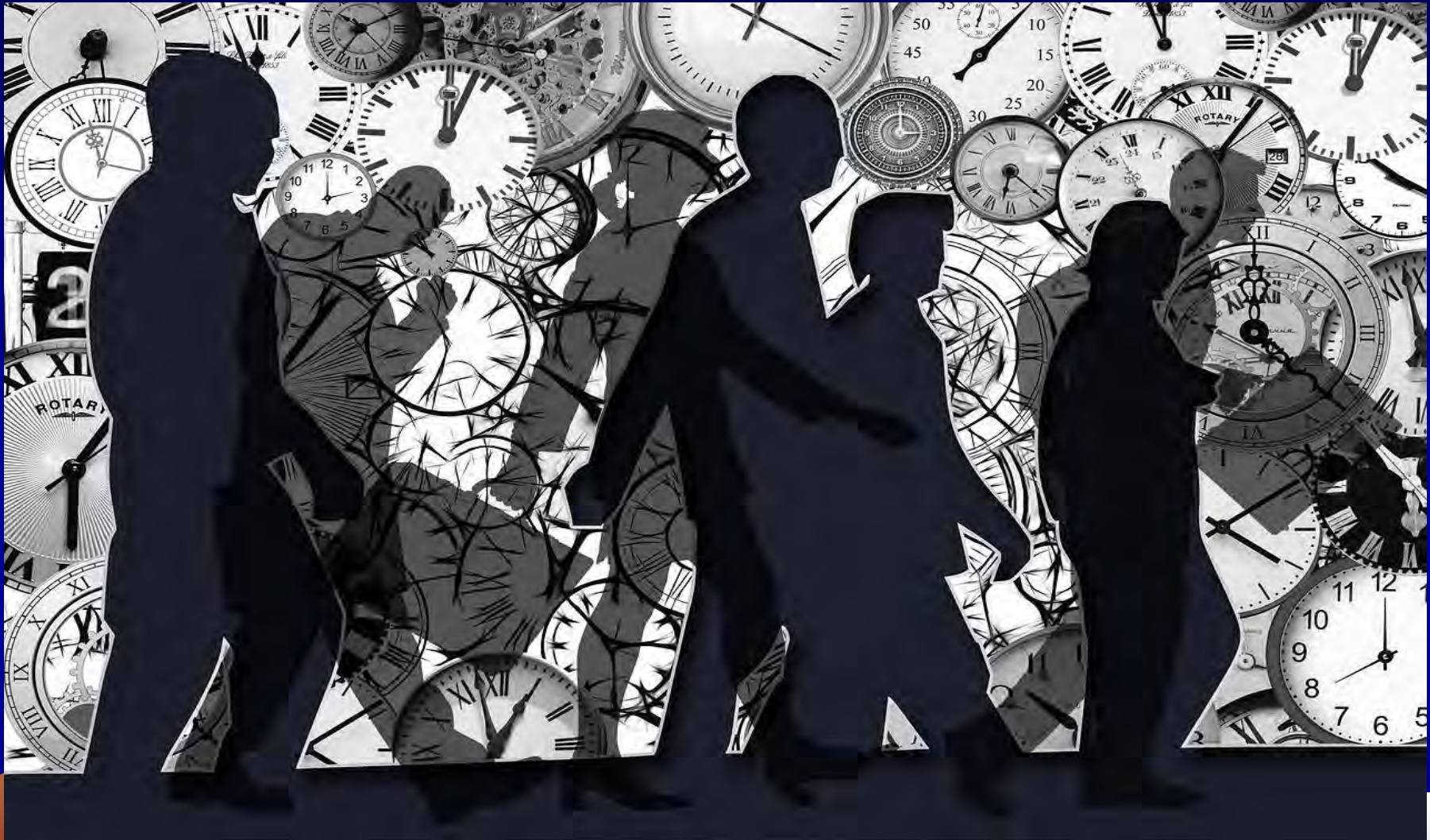
- The 7 EFs are largely cognitive/mental in nature
- They are used interactively to allow self-regulation over time to attain goals and improve one's longer term welfare during daily life activities
- The 7 cognitive EFs result in at least 5 EFs in daily life activities:
 - Self-Restraint (subordinating immediate desires for longer term goals and welfare)
 - Time Management (self-management to time)
 - Self-Organization and Problem Solving
 - Self-Motivation (and activation)
 - 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
(A Decrease in the Temporal Discounting of Delayed Consequences)

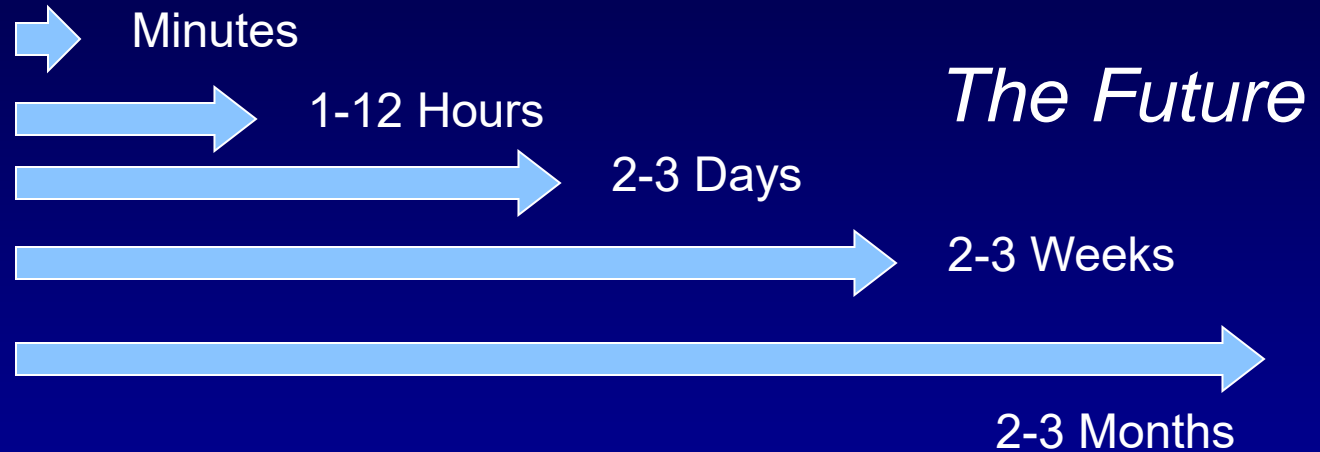
Time is Ubiquitous in Adult Human Affairs



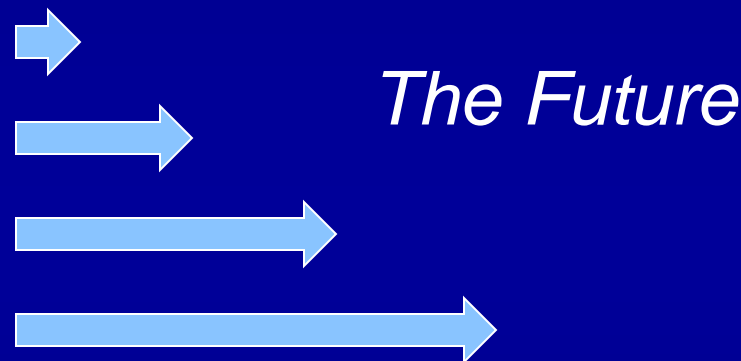
The Development of Foresight: An Emerging Window on Time



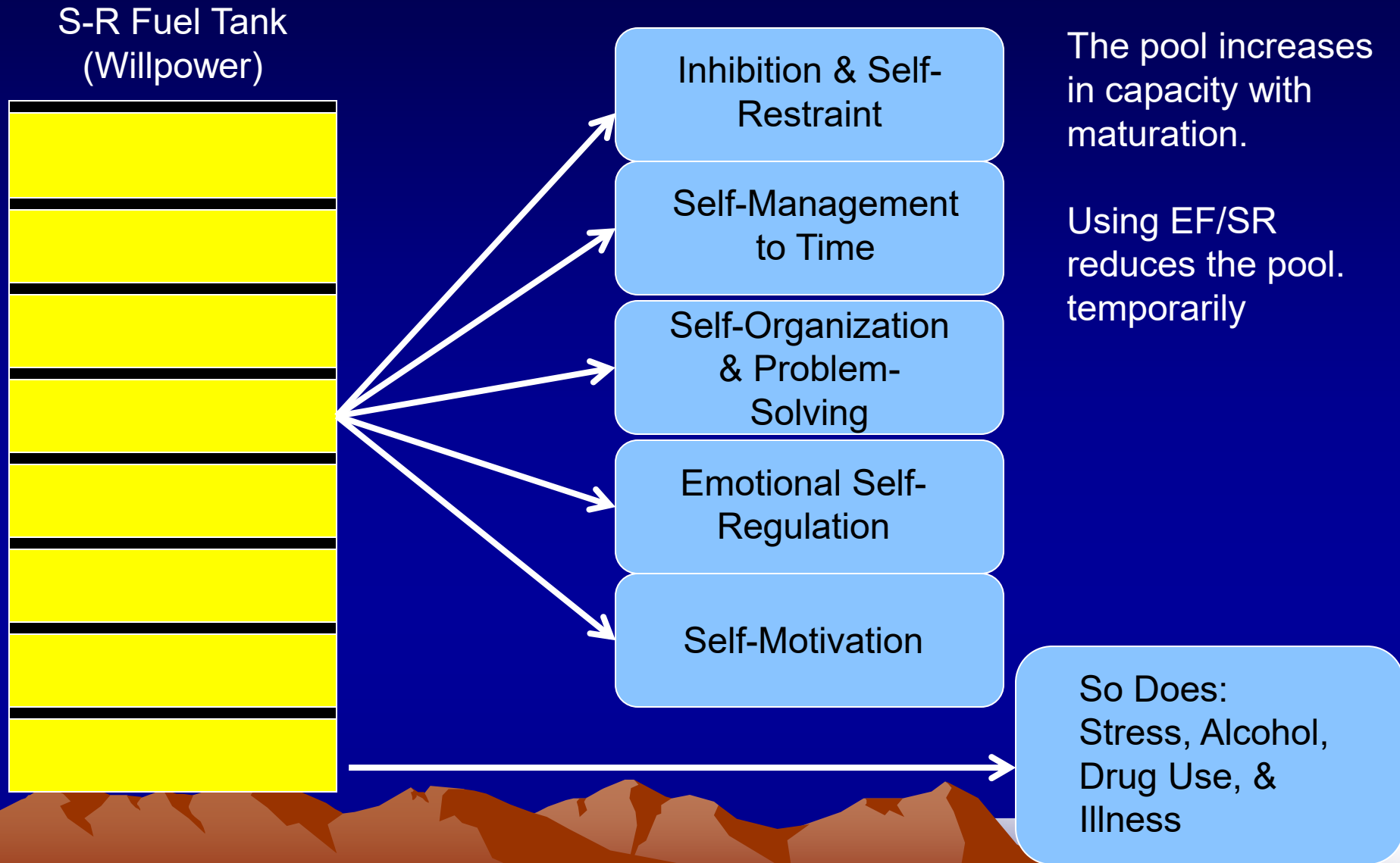
Typical Person



ADHD



Self-Regulatory Strength May Be a Limited Resource Pool or Capacity



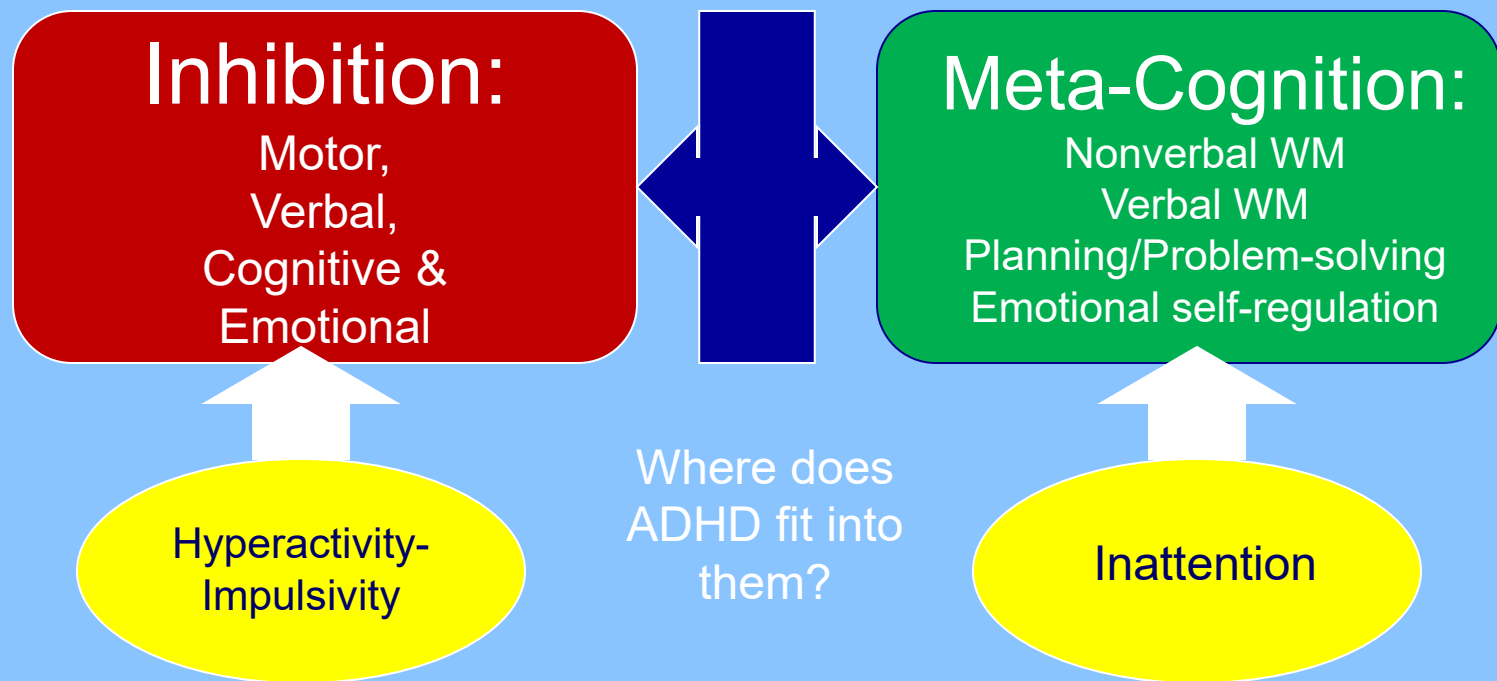
Extending EF-SR Theory to ADHD



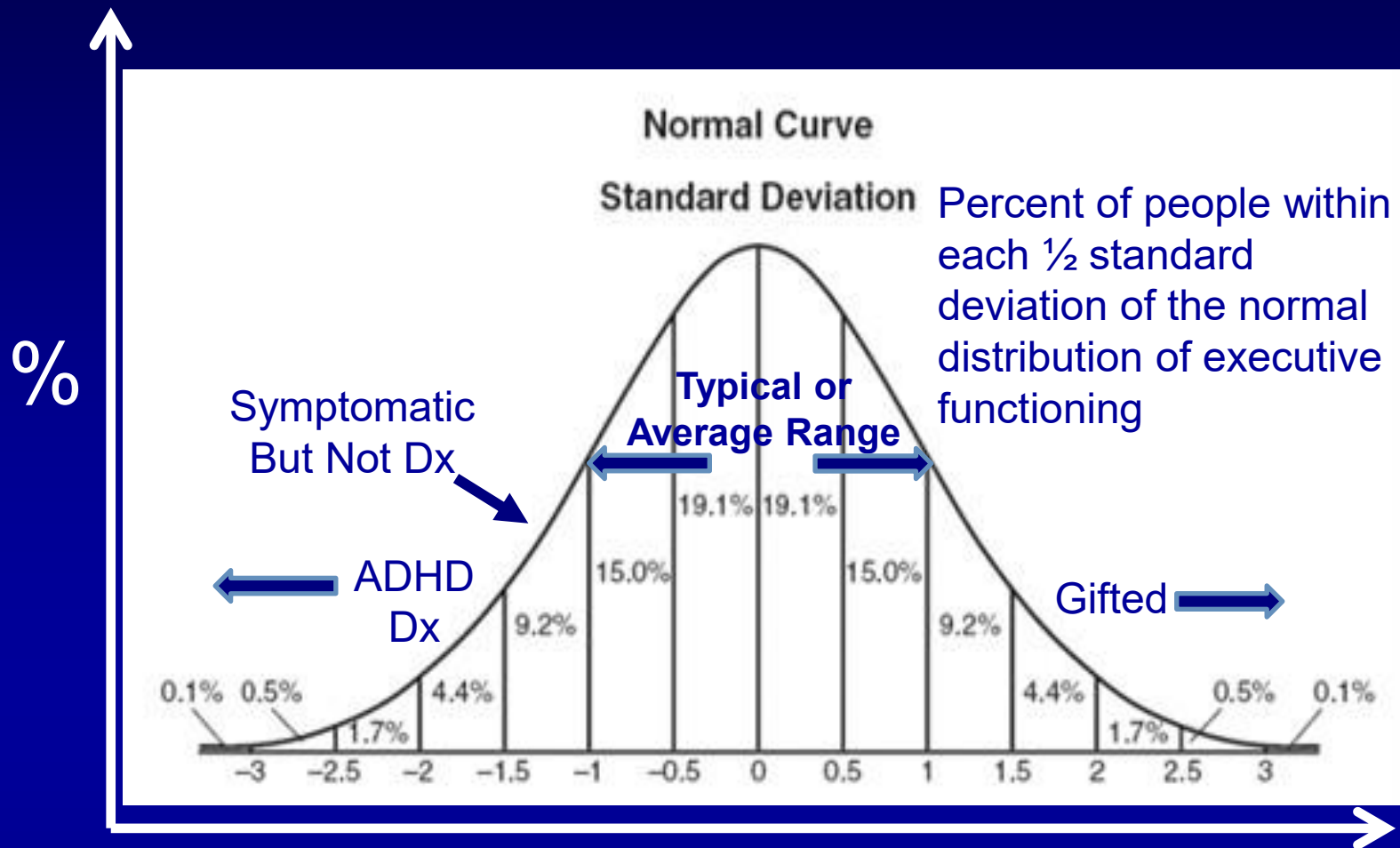
How Does ADHD Fit Into EF?

EF Comprises a Single Domain – Probably Self-Regulation.
It Can Be Usefully Subdivided into two Broad Dimensions

How Do Stimulants Improve Behavior and Work?

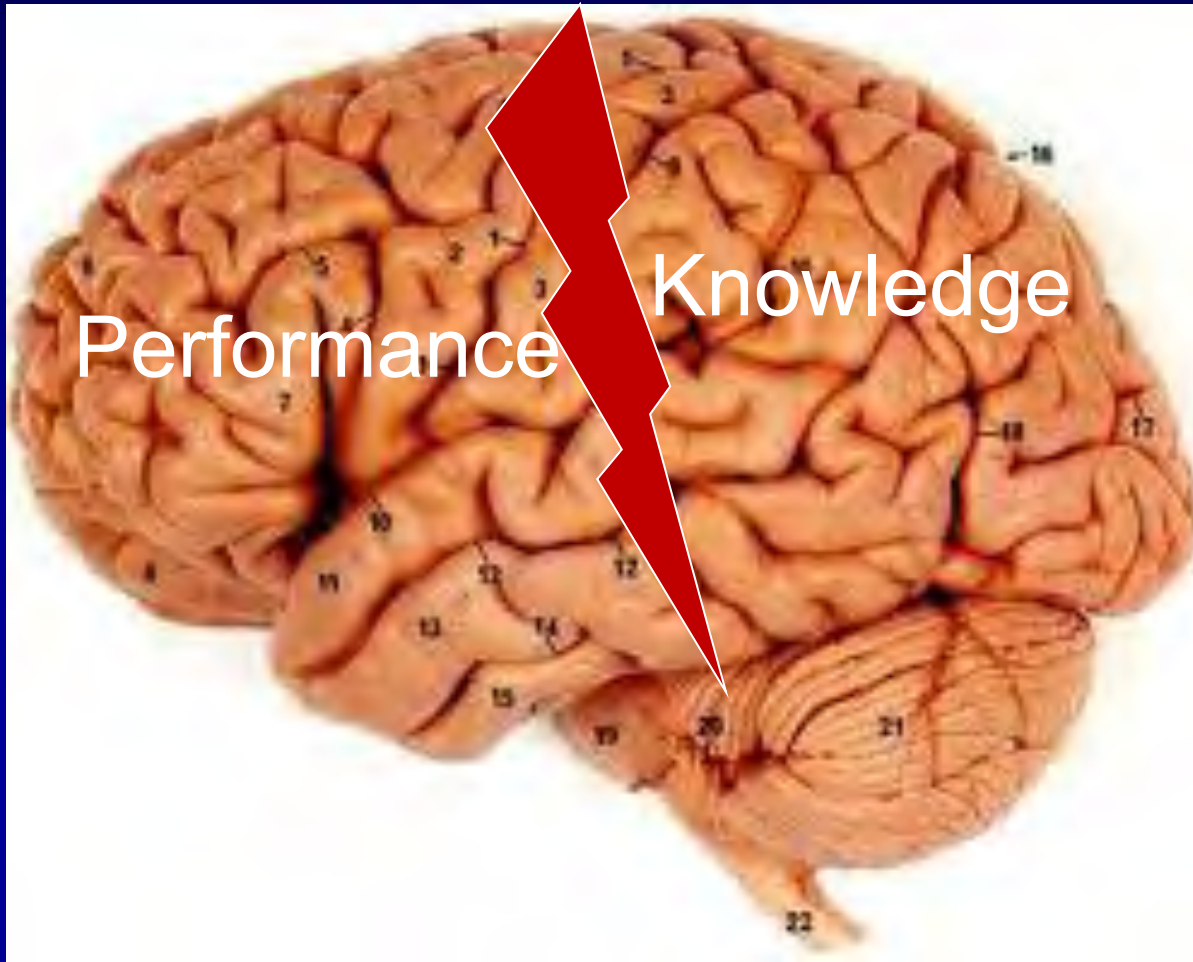


The Bell Curve of EF and ADHD



The Brain as a Knowledge vs. Performance Device

ADHD



Understanding ADHD

- ADHD disrupts the 7 forms of EF/SR thereby creating a disorder of self-regulation across time
- It therefore diminishes the 5 EFs in daily life
- ADHD can be considered as “Time Blindness” or a “Temporal Neglect Syndrome” (myopia or near-sightedness 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)
- Thus, it’s not an Attention Deficit but an Intention Deficit (Inattention to the probable future)

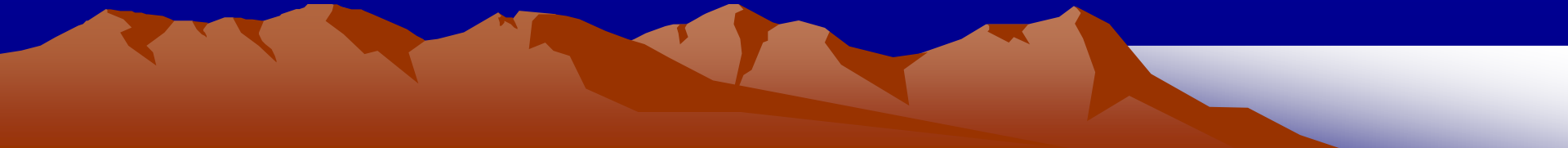
Understanding ADHD

It's a Disorder of:

- The guidance of actions by mental representations
- Performance, not skills or knowledge
- 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 his or her 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

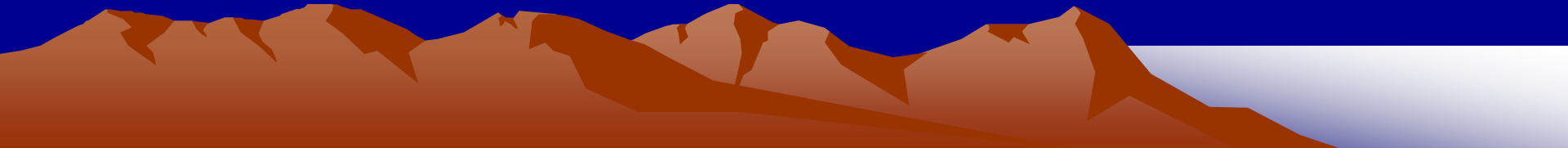
- Teaching skills is inadequate
- The key is to design prosthetic environments around the individual to compensate for their EF deficits
- Treatments must be at the “point-of-performance”
- The EF deficits are neuro-genetic in origin
- Therefore, medications may be essential for most (but not all) cases – 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 (e.g., CogMed, ACTIVATE, etc.) (no far transfer to functioning in natural settings for CogMed and no effects found for ACTIVATE)
 - 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 what the prefrontal lobes ordinarily do)
 - 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 or 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 behavioral rehearsal (moving from novelty and the EF “slow” system to automaticity/routinization in the non-EF “fast” brain)
 - Repeated 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 treatment now)
- The compassion and willingness of others to make accommodations at points of performance are vital to success
- A chronic disability perspective is most useful
- ADHD creates a diminished capacity: But this does not excuse accountability (The problem is with time, not with consequences)



How can we compensate for EF deficits?

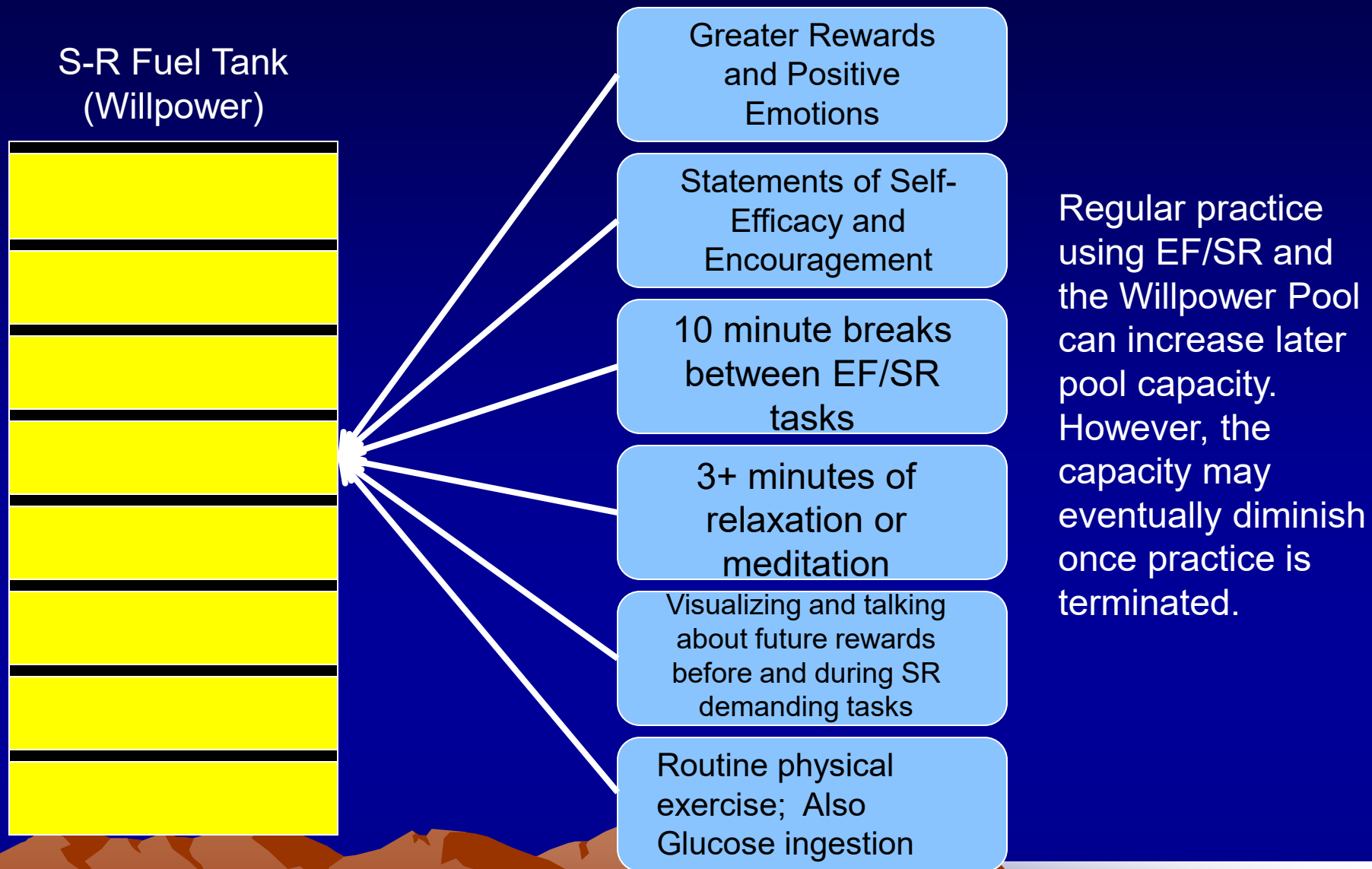
- Mental representations do not guide behavior very effectively – so off-load [externalize] them outside of the mind and into the environment
 - Externalize important information at key points of performance (off-load it to external storage devices)
 - Externalize time and time periods related to tasks and important deadlines (make time physical)
 - Break up lengthy long-term tasks into many smaller steps to be done more frequently
- 

More Compensatory Rules

- Externalize task organization, both spatially and temporally [as in task analysis and time-motion studies]
 - think about not just location, but frequency and sequencing of use of materials
 - Whatever is needed must be at “the point of performance”
- Externalize motivation – make consequences more external, frequent, & compelling
- Externalize and manualize mental problem-solving – put the pieces in their hands
- But what to do about emotional self-regulation???? (training alone doesn't work)
- And what can be done about that resource pool?

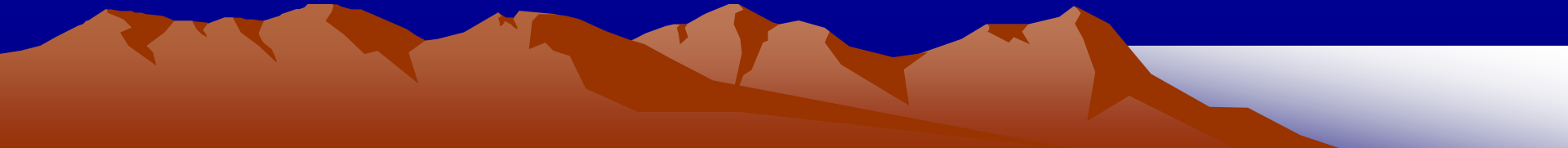


Replenishing the EF/SR Resource Pool



Conclusions

- ADHD delays and disrupts behavioral inhibition and the internalization of self-directed EFs producing deficits in all 7 EFs – mental events can't guide actions toward goals and the future
- 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-restraint, time management, self-organization, self-motivation, and self-regulated emotions



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 (social self-defense, reciprocity, cooperation, and mutualism) affecting nearly all major domains of life activities
- 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 self-directed EFs

