Contributions of Positive Executive Functions & Self-Regulation to Holistic Development & Mental Health Promotion

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Disclosure

Psychological Assessment Resources, Inc. - Test Author (royalties)

- Behavior Rating Inventory of Executive Function-2 (BRIEF2)
- Post-Concussion Executive Inventory (PCEI)
- Post-Concussion Symptom Inventory-2 (PCSI-2)

Many other tests & measures (no royalties)

- Acute Concussion Evaluation (ACE) – office, ED
- ACE Care Plan; Home/School Instructions
- Post-Concussion Symptom Inventory (PCSI) 5-7, 8-12, 13-18; Parent
- Children's Exertional Effects Rating Scale (ChEERS)
- Concussion Learning Assessment & School Survey-3 (CLASS-3) – Parent, Self-Report
- Progressive Activities of Controlled Exertion (PACE)-Self Efficacy (Child, Parent)
- Multimodal Assessment of Cognition & Symptoms (MACS)
- Concussion Recognition & Response (CRR) –Parent/Coach app
- Concussion Assessment & Response (CARE)- Medical app

Goal/ Objectives

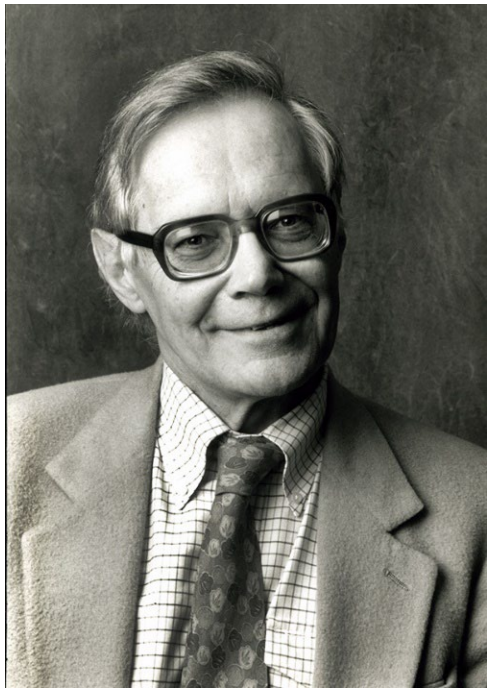
- Define the models/ definitions of the executive functions as traditionally viewed and applied (clinical deficit)
- Redefine the executive functions as a strength-based self-regulation system
- Describe the role of EF/SR in holistic terms – physical and mental health

A few more Goals

- Traditional (clinical) use of executive function
- Flip our views of executive function in a positive "function" direction from a clinical "negative" dysfunction view
- Propose the relationship of "positive" self-regulated function to positive health and development

Executive Function is
the orchestration of basic cognitive processes during goal-oriented problem solving

Ulrich Neisser
Cognitive Psychology, 1967



“Giants of Executive Function”

The unity and diversity of executive functions

Hans-Lukas Teuber, 1972

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Cognitive Psychology **41,** 49–100 (2000)
doi:10.1006/cogp.1999.0734, available online at http://www.idealibrary.com on IDEAL®

The Unity and Diversity of Executive Functions and Their Contributions to Complex "Frontal Lobe" Tasks: A Latent Variable Analysis

Akira Miyake, Naomi P. Friedman, Michael J. Emerson, Alexander H. Witzki, and Amy Howerter

University of Colorado at Boulder

and

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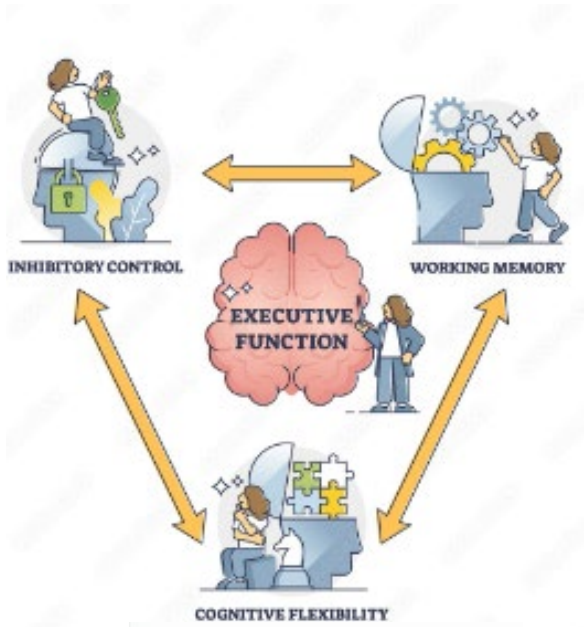
University of Michigan



Akira Miyake

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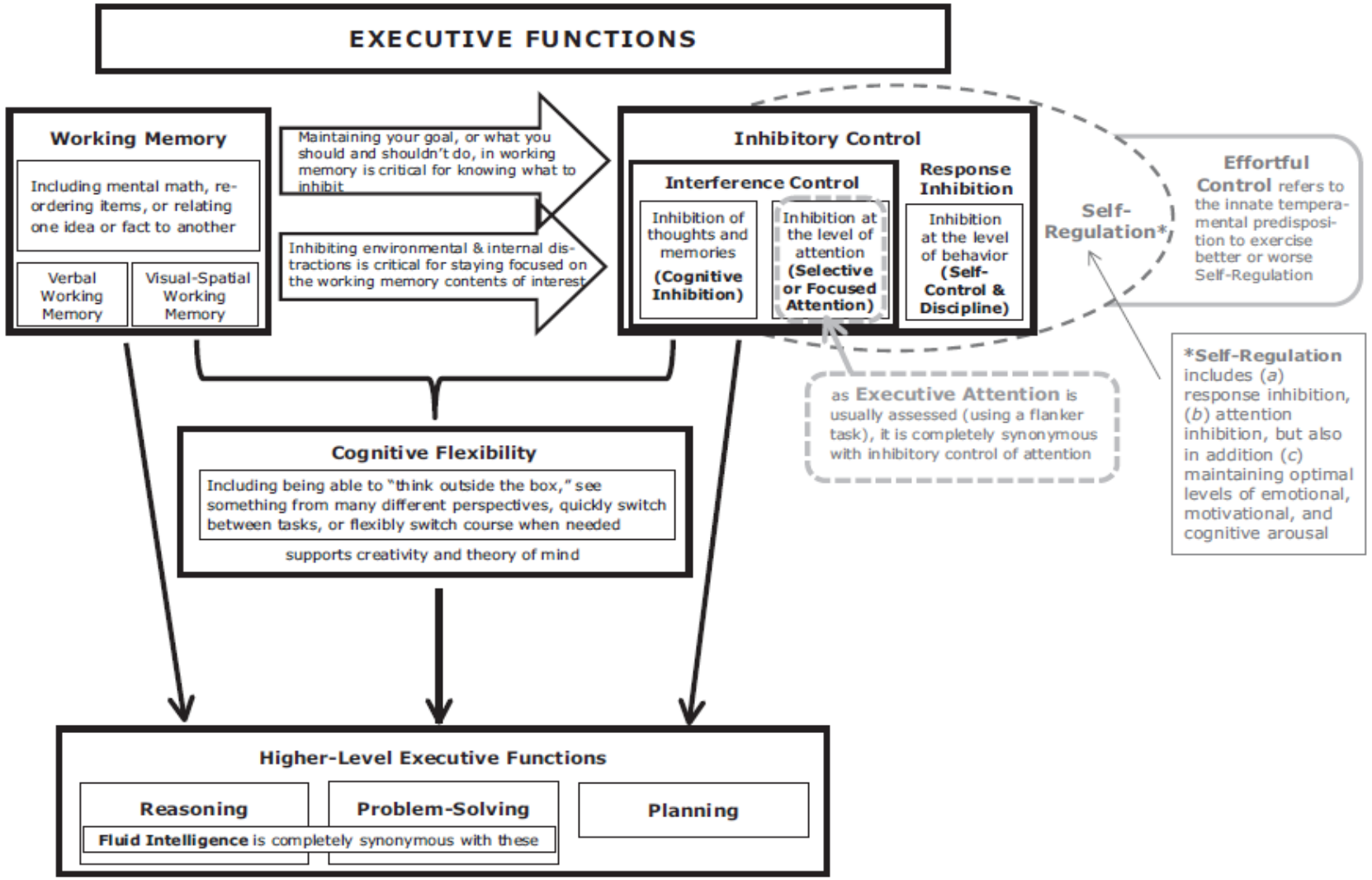
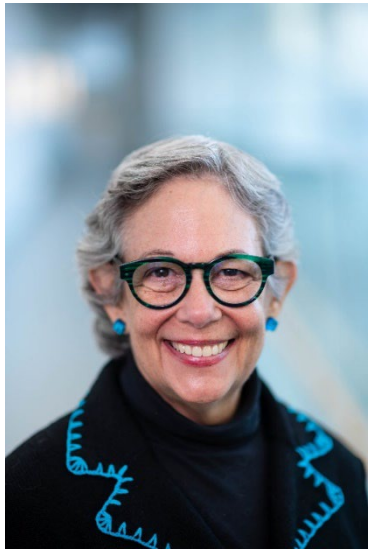


Figure 4

Executive functions and related terms.



Adele Diamond, 2013

Miyake “core 3” and beyond

Executive Functions Beyond the “Holy Trinity”: A Scoping Review

Natália Martins Dias[1], Isabela Espezin Helsdingen[1], Eduarda Kammers Rita Momm de Lins[1], Camila Erlinda Etcheverria[1], Vanessa de Araújo Dechen[2], Luana Steffen[3], Caroline de Oliveira Cardoso[3], and Fernanda Machado Lopes[1]

Miyake et al 2000

- … although our choice of the three target functions in this study seemed a reasonable one, it is certainly not exhaustive
- there are other important relatively basic functions that need to be added to the current list.
- more complex concepts like “planning” needs to be examined

Dias et al 2023

- analysis of how the “noncore” components are conceptually and methodologically addressed
- Executive functions are not limited to the three commonly investigated core components

EXECUTIVE FUNCTIONS BEYOND THE "HOLY TRINITY" Dias et al., 2023

Scoping Review* showed good agreement that executive function:

- is a multidimensional construct
- comprised of a set of control processes
- that regulate behavior, emotion, and cognition
- in the service of goal-directed problem solving
- including inhibit, shift, working memory (e.g., Miyake et al., 2000)
- But also: initiate, plan, organize, monitor, emotional control

**n = 242 studies sampled from 3,473 articles*

Review > J Int Neuropsychol Soc. 2011 Sep;17(5):759-65. doi: 10.1017/S1355617711000695.
Epub 2011 May 24.

Functions of the frontal lobes: relation to executive functions

Donald T Stuss [1]

Affiliations + expand

PMID: 21729406 DOI: 10.1017/S1355617711000695

Don Stuss 1941-2019

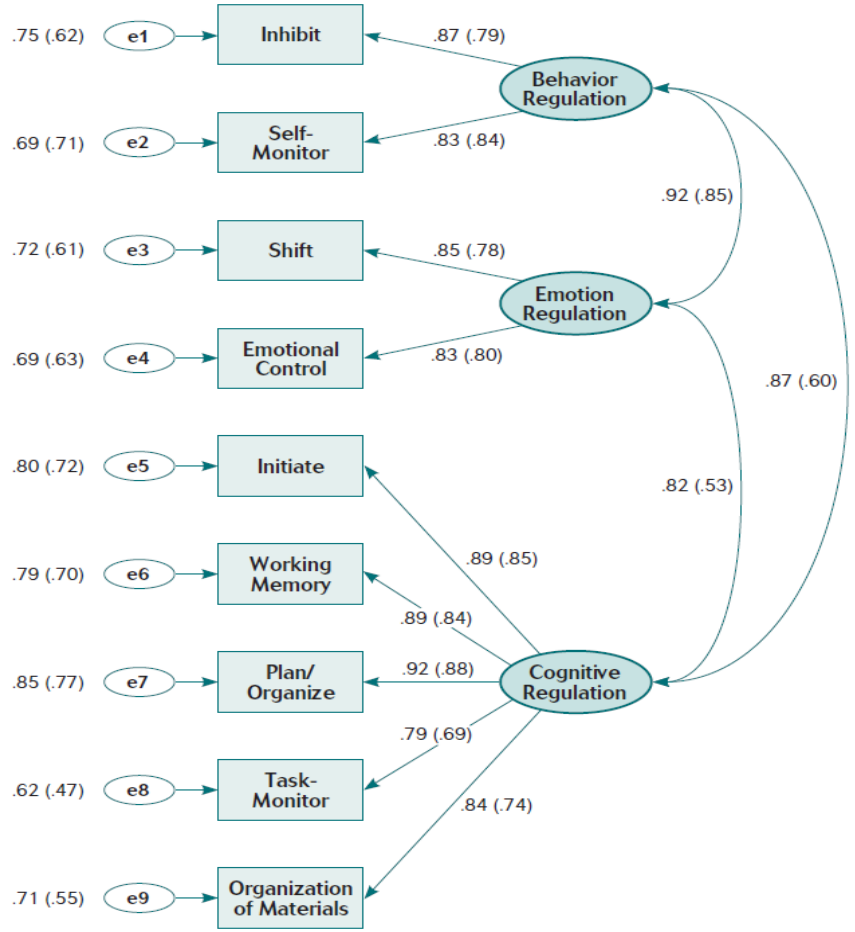
Abstract

Proceeding from the assumptions that specific frontal regions control discrete functions and that very basic cognitive processes can be systematically manipulated to reveal those functions, recent reports have demonstrated consistent anatomical/functional relationships: dorsomedial for energization, left dorsolateral for task setting, and right dorsolateral for monitoring. There is no central executive. There are, instead, numerous domain general processes discretely distributed across several frontal regions that act in concert to accomplish control. Beyond these functions, there are two additional "frontal" anatomical/functional relationships: ventral-medial/orbital for emotional and behavioral regulation, and frontopolar for integrative-even meta-cognitive-functions.

EVERYDAY BEHAVIOR MODEL: EF is a multidimensional construct

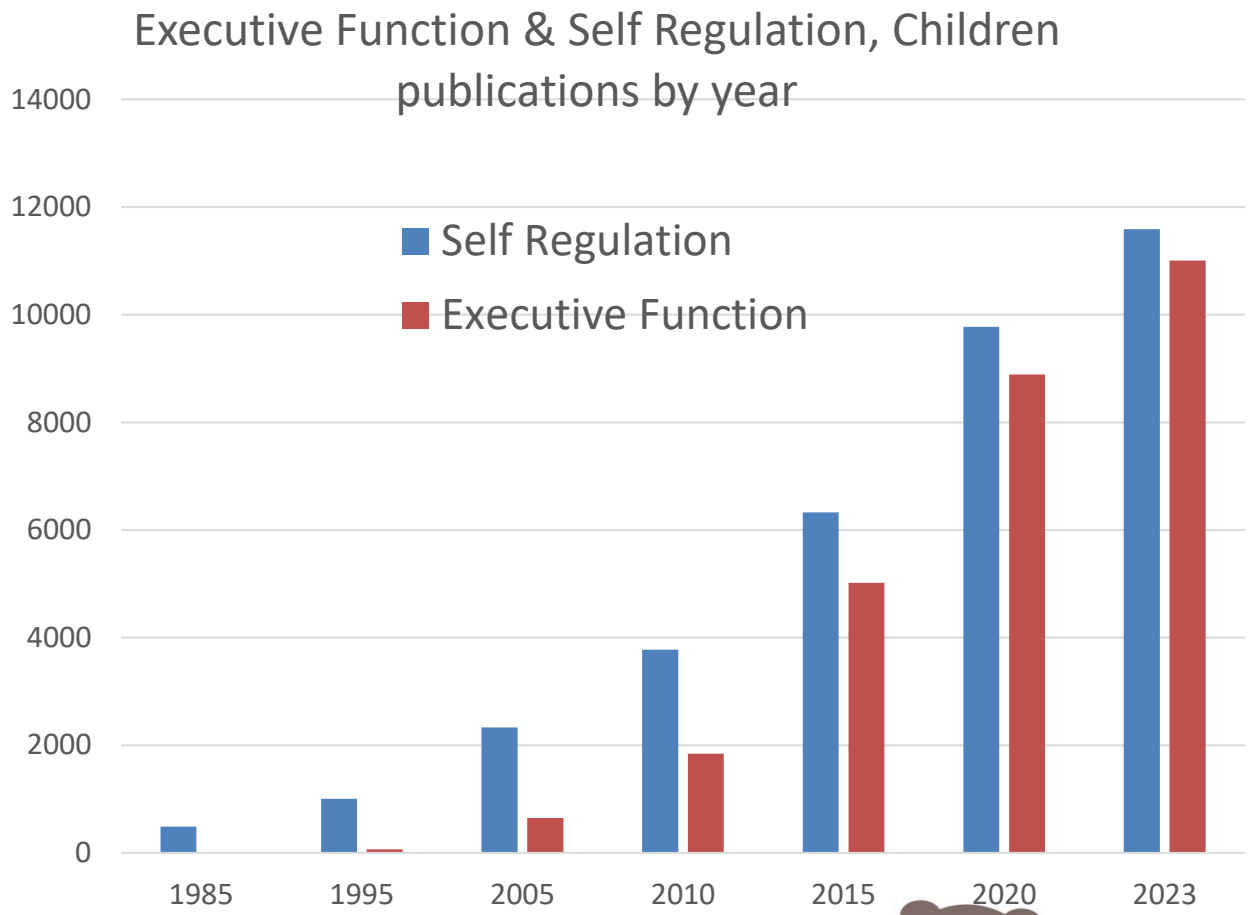
An umbrella term encompassing distinct, but interrelated, abilities that contribute to management of goal-directed behaviors including inhibiting, shifting, and regulating emotions; initiating; planning; organizing; and monitoring while holding goals in working memory.

Gioia, Isquith, Guy & Kenworthy, 2000



Interest in "Self Regulation & Executive Function in Children" (PsychInfo search)

- 484 articles in 1985
- 1,005 articles in 1995
- 2,331 articles by 2005
- 3,774 articles by 2010
- 6,327 articles by 2015
- 9,777 articles by 2020
- 11,591 articles as of 2023



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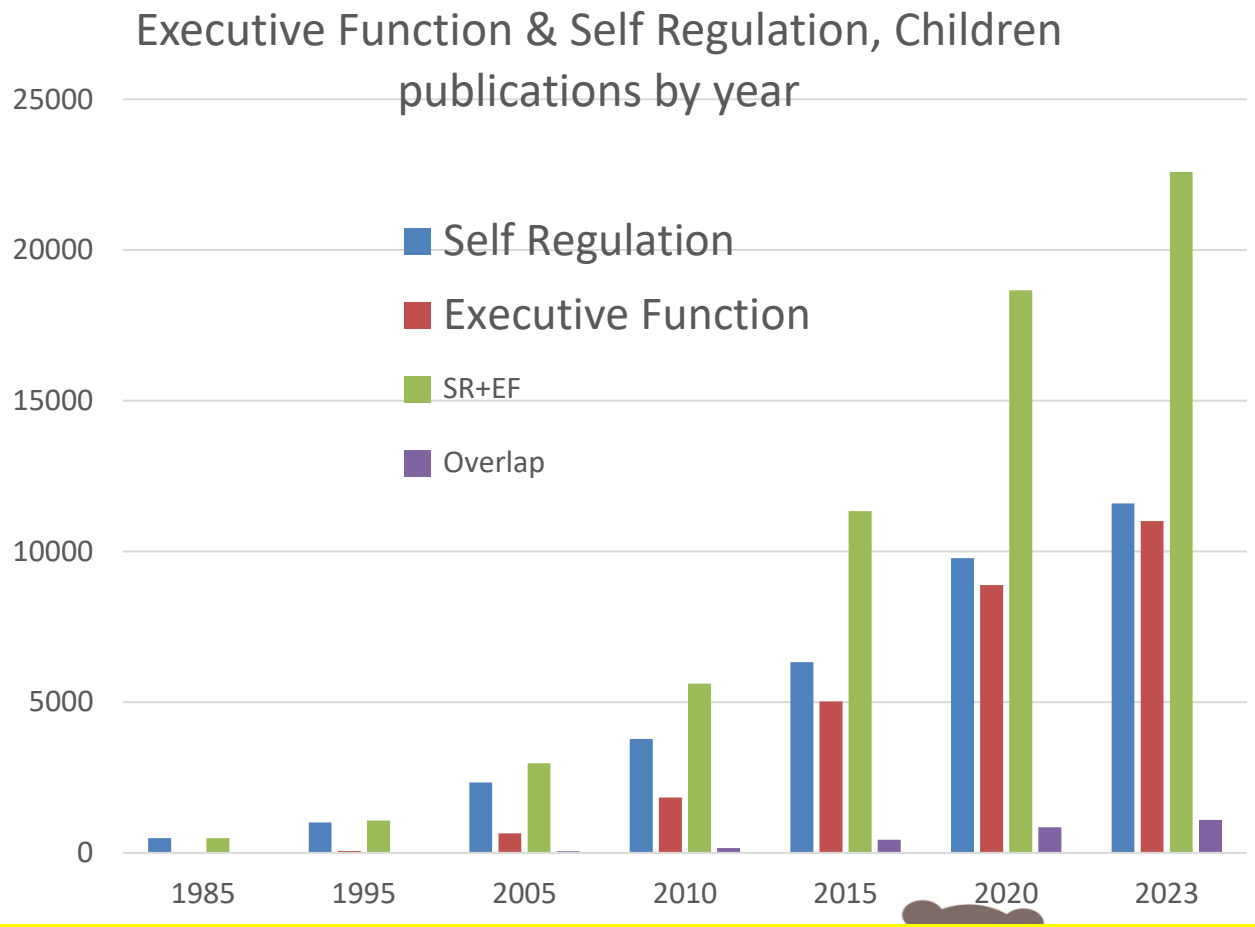
Overlap of "Self Regulation & EF in Children articles" (PsychInfo search)

- 484 articles in 1985 (0)
- 1,005 articles in 1995 (4)
- 2,331 articles by 2005 (51)
- 3,774 articles by 2010 (158)
- 6,327 articles by 2015 (430)
- 9,777 articles by 2020 (847)
- 11,591 articles as of 2023 (1,089)

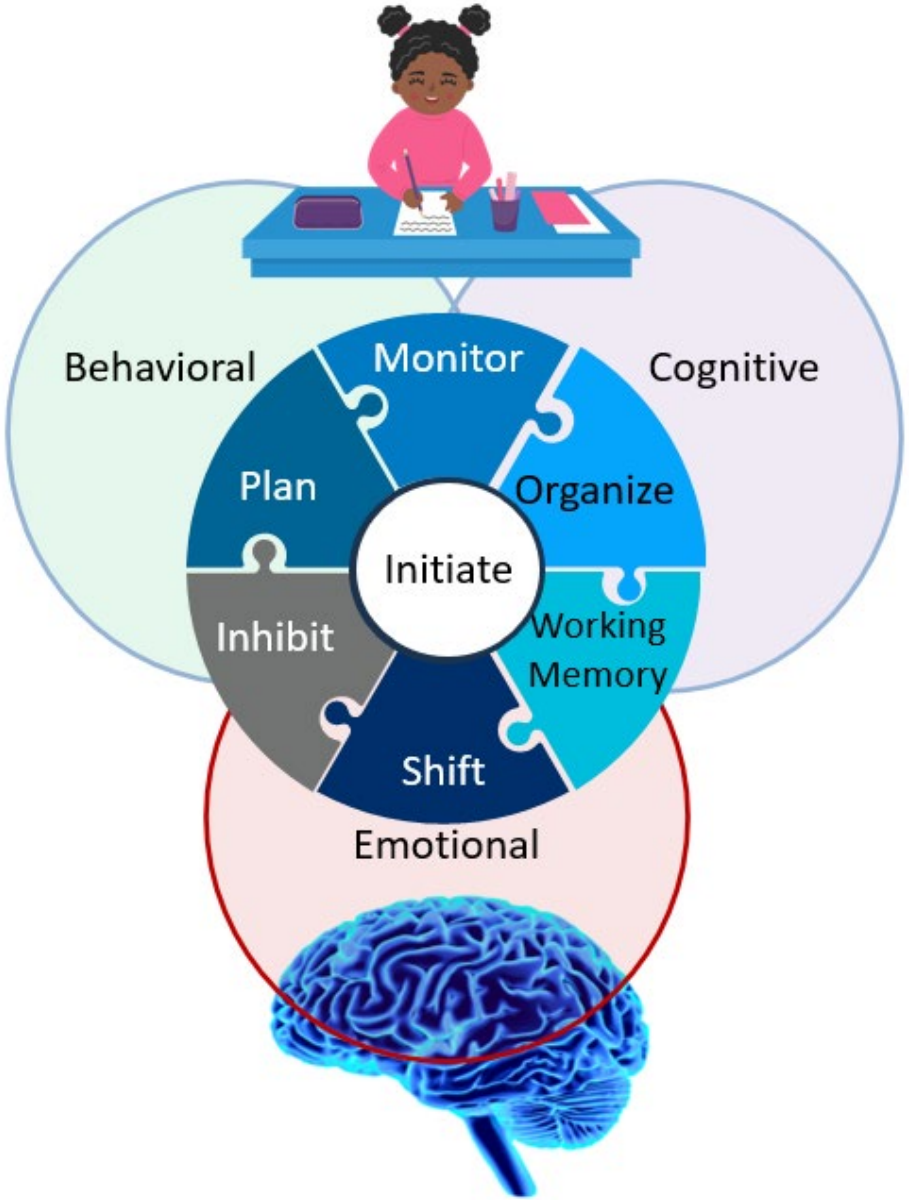


Percent Overlap	0%	0.4	1.7	2.8	3.8	4.5	4.8

Self Regulation

Executive Function

"Frontal"

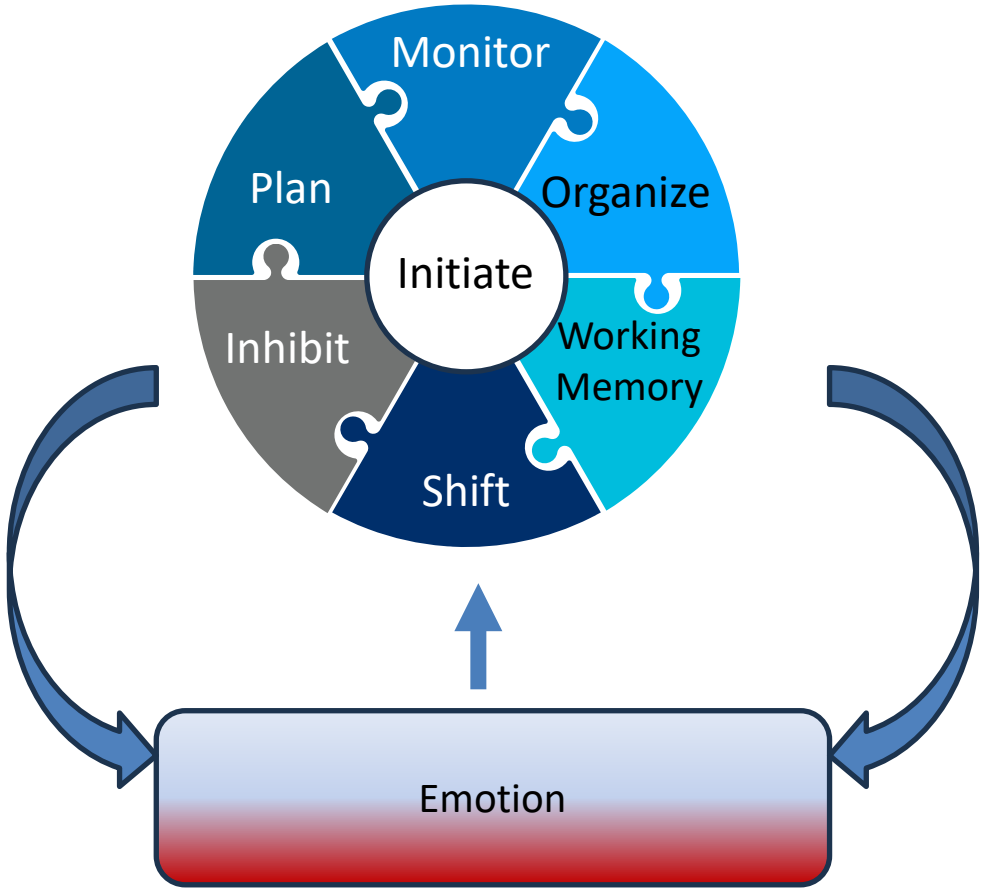


The executive system has multiple subsystems with anatomical & behavioral separation.

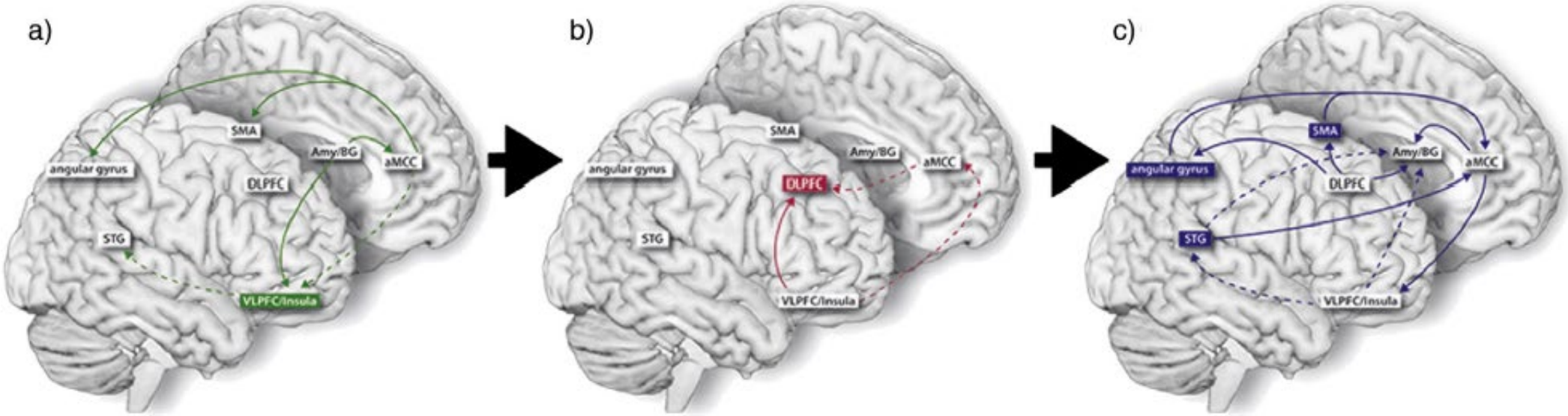
They regulate emotional, behavioral, and cognitive functioning in the service of goal-oriented problem solving.

The Special Case of Emotion Regulation

- Emotions provide arousal to enable initiation
- Emotions can overwhelm other functions, including executive functions
- Executive functions must modulate emotions to keep them at an appropriate level



The Special Case of Emotion Regulation



a) Emotion is relayed via amygdala and basal ganglia to the PreFrontal Cortex (PFC)

b) The DLPFC initiates the regulation and signals the system to bring control

c) The amydala and basal ganglia help down-regulate the emotional state

Kohn et al., 2014

EXECUTIVE FUNCTION: THE CONDUCTOR OF THE ORCHESTRA

Functions of the "Orchestra"

- Perception
- Attention
- Language processes
- Visual–spatial processes
- Memory
- Sensory inputs
- Motor outputs
- Knowledge and skills
  - Social
  - Nonsocial

Functions of the "Conductor"

- Inhibit → Pump the brakes
- Shift Flexibly → Plan A or Plan B
- Apply & Modulate Emotions → Motivate
- Initiate Action → The Ignition
- Working Memory → Hold it in Mind
- Plan → Sketch it out
- Organize → Put it in order
- Self-monitor/evaluate → Check on it

Gioia, Isquith, & Guy., 2001
Goldberg & Bougakov, 2000
Holmes Bernstein & Waber, 1991

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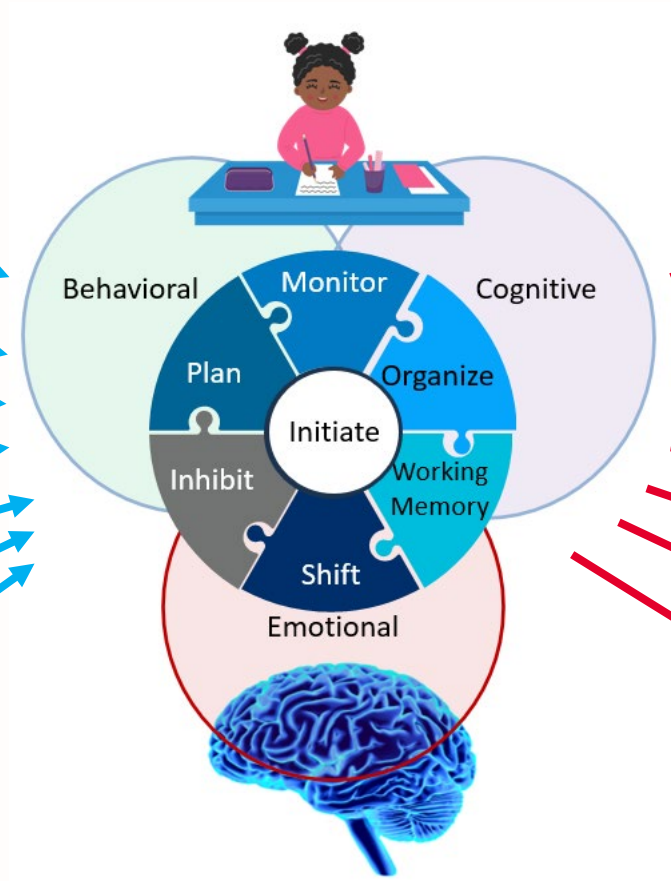
Influences

- Genetic
- Health
- Economic
- Environmental
- Social-Emotional
- Opportunity
- Physical Activity



Outcomes

- Health
- Behavioral Health
- Academic
- Social
- Emotional
- Vocational
- Athletic

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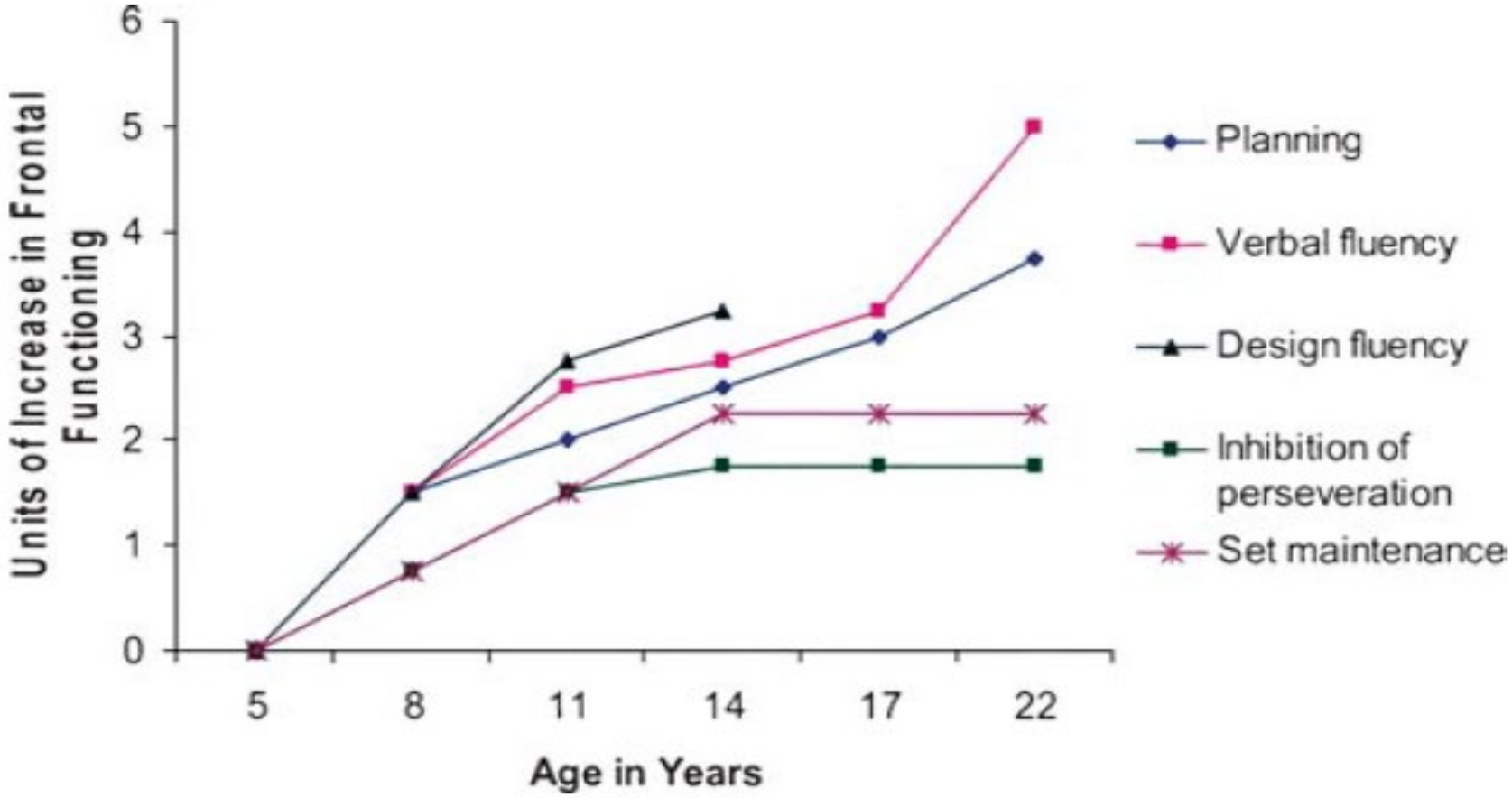
DEVELOPMENT OF EXECUTIVE FUNCTIONS
Meta-Analysis of Effect Sizes by Age



Romine & Reynolds, 2005

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How do we identify (assess) the executive functions?

- Performance Tests (micro)
  - Wisconsin Card Sorting Test
  - Verbal/ Figural Fluency
  - Flanker Task
- Everyday Behavior (macro – multiple domains)
  - Behavior Rating Inventory of Executive Function (BRIEF), published in 2000

Ecological Validity: relation of test to the everyday world – "execute" as the root concept

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Advantages of EF Performance Tests:

- Increased specificity of processes
- Increased control and internal validity
- Decades of research on test behavior

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Advantages of the Everyday Ratings of Self-Regulation

- Captures EF in everyday, real-world settings
- Increases ecological validity & generalizability
- Captures multiple perspectives & settings
- Time- and cost-efficient
- Explains substantially more variance in student functioning than performance tests

Behavior Rating Inventory of Executive Function, 2nd Edition (BRIEF-2) – since 2000

- Ages 2-90 years
- >1600 peer-reviewed empirical publications
- >100 clinical trials
- >180 languages on 6 continents
- Screening forms included
- Parent, teacher, self-report forms

Delis EF scale, Barkley EF scale, Naglieri & Goldstein (CEFI), Brown EF scale

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Think Complementary Methods: Not “or” but “and”

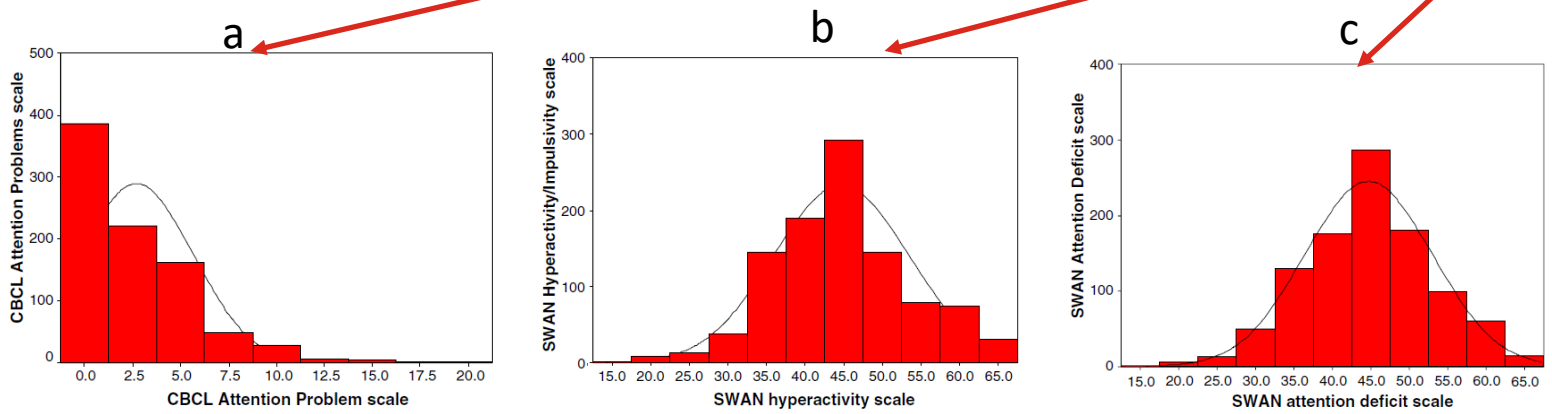
- Tests and BRIEF provide distinctive information
- Performance tests assess “cool” cognitive EF
- BRIEF assesses both “cool” and “hot” real world EF
- They are not interchangeable or equivalent
- They are complementary: macro + micro
- Need to integrate both together

Positive Executive Function – promoting achievement

- Positive neuropsychology has emerged to identify the individual's strengths in addition to their weaknesses in defining their full behavioral, cognitive and emotional repertoire (Randolph, 2018)
- Seligman (1998), Ruff (2003), Bandura (2005) have argued for a "health not just disease" model
- Identifying strengths in EF provides a full understanding of the individual's profile that can relate to everyday productive performance areas such as the creative arts, performing arts, manual skills, sports, and academics

Psychometrics of Measuring the Positive

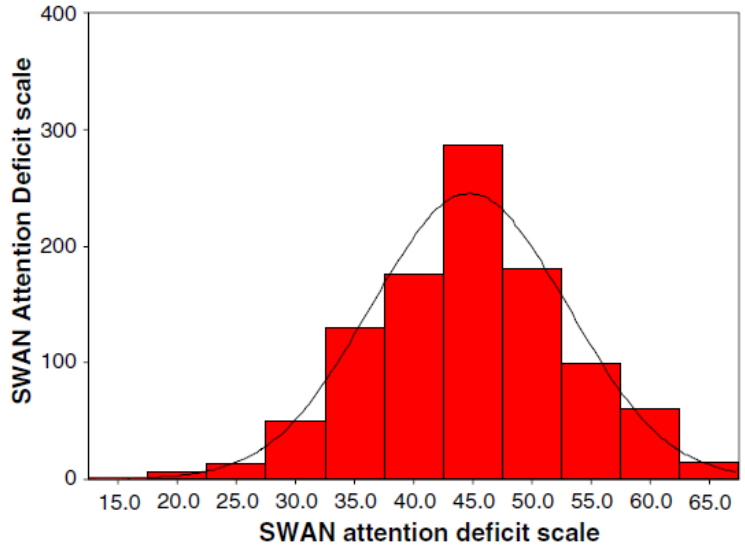
- "Positive" approach adopted in development of Strengths and Weaknesses of ADHD Symptoms and Normal Behavior (SWAN) Rating Scale
- Problem-oriented scales produce skewed "distribution" of scores
  - children without clinical problems are represented in a very restricted range of scores
- SWAN measures broader range of variability in attention, inhibitory control and emotion regulation at both ends of the spectrum – positive and negative.
- Framing the questions in a positive manner produces a more normal distribution displays a full range of variability in both problem (a) AND positive strength (b,c) behaviors.



Measuring the positive, the strengths

Children differ in their abilities to focus attention, control activity, and inhibit impulses. For each item listed below, how does this child compare to other children of the same age? Please select the best rating based on your observations over the past month. Compared to other children, how does this child do the following:

	far below	below	slightly below	average	slightly above	above	far above
1. Give close attention to detail and avoid careless mistakes							
2. Sustain attention on tasks or play activities							
3. Listen when spoken to directly							
4. Follow through on instructions & finish school work/chores							
5. Organize tasks and activities							
6. Engage in tasks that require sustained mental effort							
7. Keep track of things necessary for activities							
8. Ignore extraneous stimuli							
9. Remember daily activities							
10. Sit still (control movement of hands/ feet or control squirming)							
11. Stay seated (when required by class rules/social conventions)							



Executive functions &“performance” activities

- Strategic learning and performance framework involves the executive functions
- Academic world has embraced the executive function construct over past two decades
- Parallel literature has grown around role of “self-regulated learning” in performance success.
- **Hansen, Climie & Oxoby** (2020) discuss the executive functions in “performance-generation systems” such as art, music, and theater
  - "performers need to continuously shift attention”
  - “required to inhibit automated responses”
  - “they strive toward addressing multitasking challenges with fluidity and flexibility.”
- Similar arguments made with problem-solving in vocational areas, e.g., mechanical and engineering skill **(Taylor & Zaghi, 2021**)
- Large literature on executive function contributions to performance in sports (**Vestberg, Reinebo, Maurex, Ingvar, & Petrovic, 2017)**.
  - Particular interest in open skills sports that have dynamic, changing demands posed by an opponent **(Koch & Arenn, 2021**) requiring inhibitory control, working memory, planning, and flexible problem-solving with emotional control

Measuring positive EF strengths

Behavior Rating Inventory of Executive Function-Strong (v1.2a)
Self-Report Form

Name/ID:_____ **Today's date:**_____

Birthdate:_____ **Age:**_____ **Gender:**_____

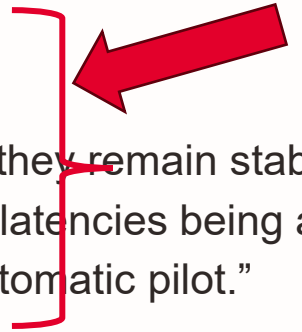
School/ Grade:_____

Instructions: On the following pages are statement that describe young people. We would like to know how you see yourself on these behaviors over the past 6 months compared to peers your age. Please answer all the items that best that you can. DO NOT SKIP ANY ITEMS. Think about yourself as you read each statement and circle:

0 = Below Peers 1 = Slightly Below Peers 2 = Average 3 = Slightly Above Peers 4 = Above Peers

Neurological basis to controlled motor and self-regulated activity
prefrontal – basal ganglia - neocerebellum

- Motor control and cognitive function engage overlapping brain regions – prefrontal cortex, basal ganglia and cerebellum (Diamond, 2000)
- Neocerebellum is important for the very same cognitive functions for which dorsolateral prefrontal cortex is critical. Most cognitive tasks that require dorsolateral prefrontal cortex also require the neocerebellum.
- Functional neuroimaging studies show consistently that when a cognitive task increases activation in dorsolateral prefrontal cortex it also increases activation in the contralateral cerebellum
- Co-activation of dorsolateral prefrontal cortex and the contralateral neocerebellum has been found with EF tasks (working memory, flexibility)
- The cerebellum and prefrontal cortex participate as critical parts of a neural circuit that is important when
  - (1) a cognitive task is difficult as opposed to easy,
  - (2) a cognitive task is new as opposed to familiar and practiced,
  - (3) conditions of the cognitive task change, as opposed to when they remain stable and predictable,
  - (4) a quick response is required, as opposed to longer response latencies being acceptable, and
  - (5) one must concentrate instead of being able to operate on “automatic pilot.”



Classic requirements for the executive functions

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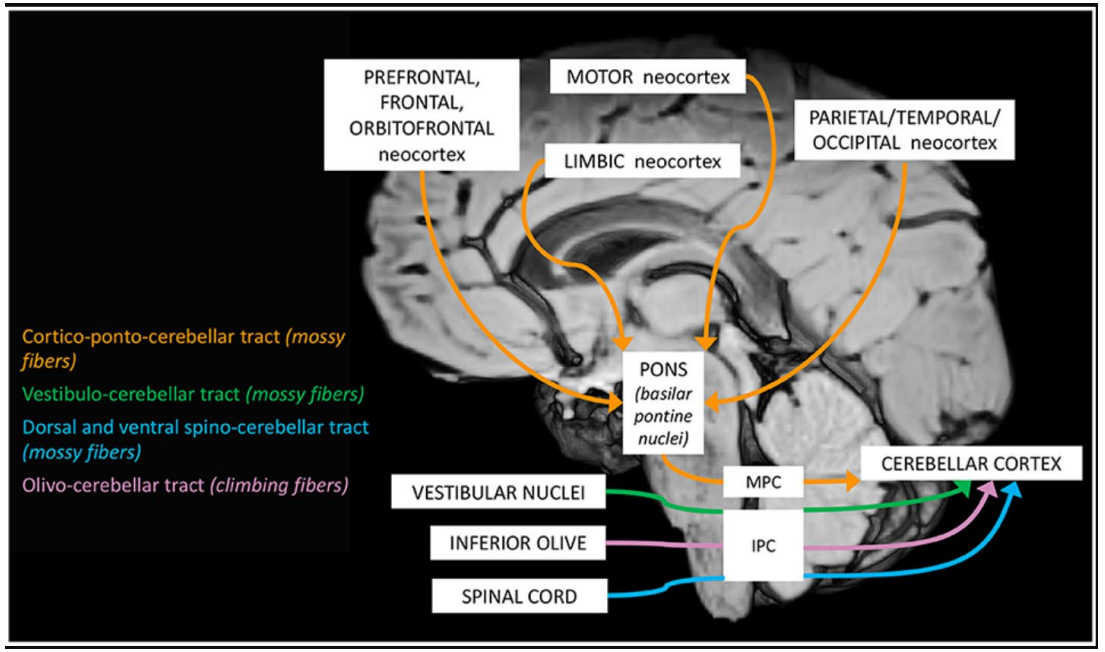
Coordinated, Strategic Movement & Executive Function neurological neighbors

EF: DLFC: attn/ wm, inhibition,flexibility, organized response

Emotion: dopamine regulates behavior, motivation, reward behavior

Motor: basal ganglia (caudate nucleus-dopamine) Coordinated movements

Motor: (neocerebellum, basal ganglia (caudate nucleus-dopamine) Coordinated movements



Physical activity causes changes in neuronal signaling in the dopaminergic system, possibly representing a reinforcing behavioral mechanism

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Cognitive benefits of exercise, sports, & performing arts

Skill acquisition during sport & performance arts may increase cognitive function

Increases may be more enduring

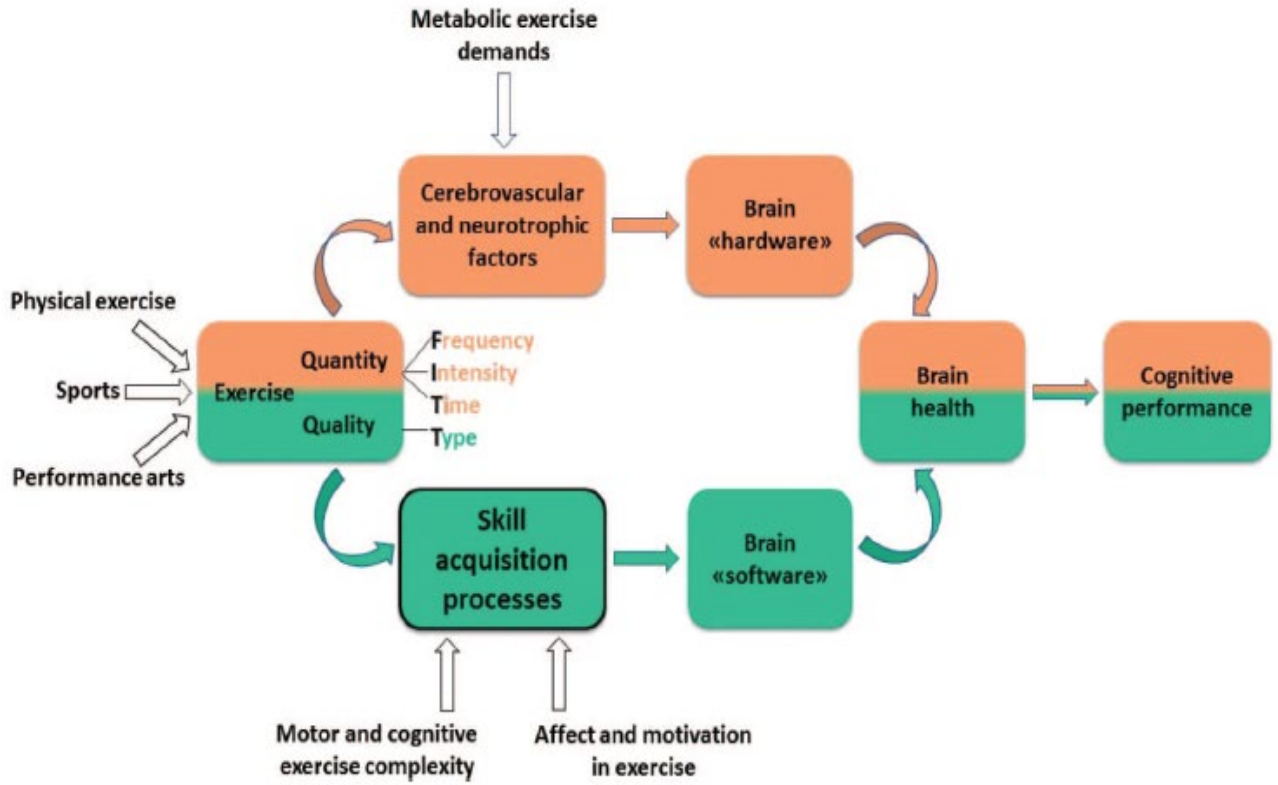

Figure 2. Hypothesized mediating roles of exercise demands and the process of skill acquisition on brain health and cognitive performance. See the online article for the color version of this figure.

Tomporowski & Pesce 2019 ***"Exercise, Sports, and Performance Arts Benefit Cognition Via a Common Process"***

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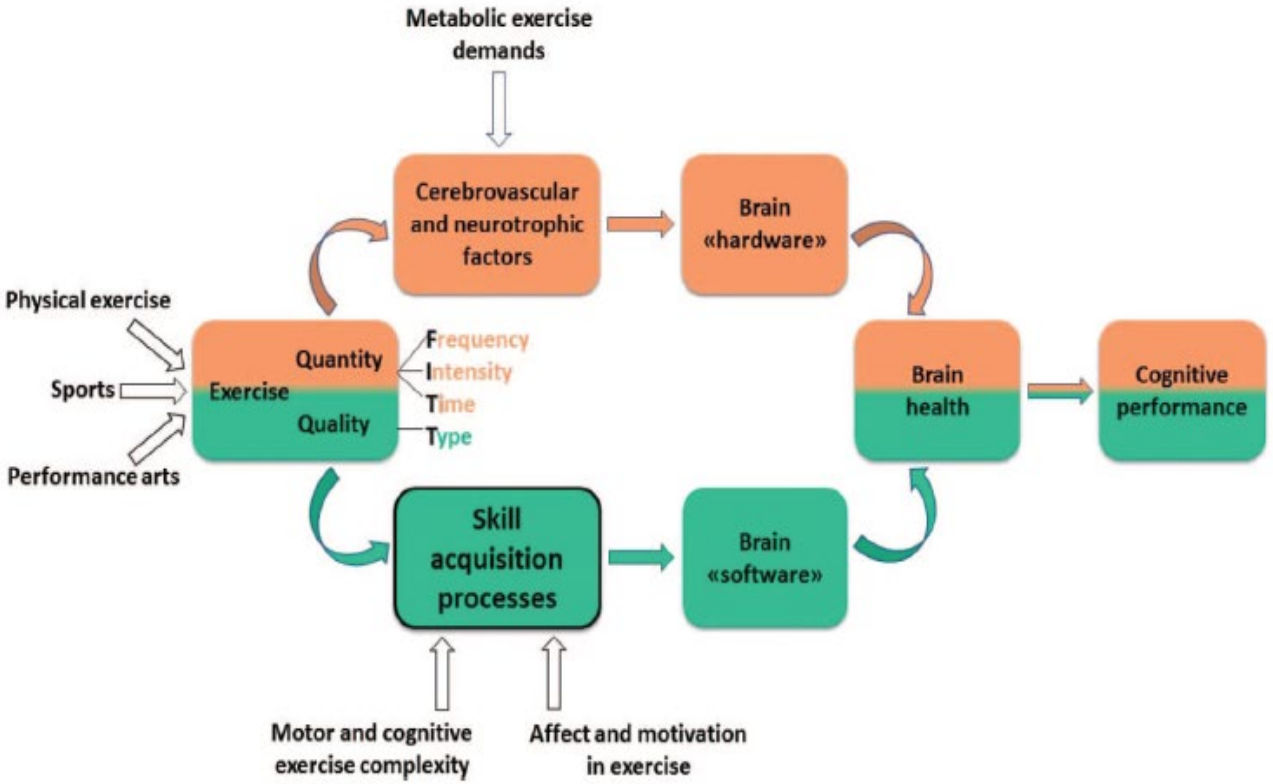
Cognitive benefits of exercise, sports, & performing arts

Public Significance Statement

"Physical activities that are mentally engaging and include an element of skill learning may enhance peoples' cognitive functions beyond gains achieved from exercise programs designed to promote physical and brain health. Regardless of exercise mode, **instructional methods that properly challenge learners' thoughts and actions enrich and maintain cognition.** These findings apply across the life span."



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Tomporowski & Pesce 2019 ***"Exercise, Sports, and Performance Arts Benefit Cognition Via a Common Process"***

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Tasks, situations requiring (demanding) the executive functions

- Requiring multiple steps
- Not immediate but due in the future
- Cannot be completed all in one's head
- Is novel (hasn't been done regularly, not a regular routine, or mastered previously)
- …

The cerebellum and prefrontal cortex participate as critical parts of a neural circuit that is important when

(1) a cognitive task is difficult as opposed to easy,
(2) a cognitive task is new as opposed to familiar and practiced,
(3) conditions of the cognitive task change, as opposed to when they remain stable and predictable,
(4) a quick response is required, as opposed to longer response latencies being acceptable, and
(5) one must concentrate instead of being able to operate on "automatic pilot."

Tasks, situations requiring (demanding) the executive functions

- Open skill sports (dynamic, changing demands)
- Cognitively demanding sports
- Requiring strategic, momentary, flexible problem-solving
- Co-Activation: Act to Learn, Learn to Act
- Skilled motor performance require:
  - holding game knowledge & strategy in mind (working memory)
  - analyze situation, strategize, organize, mobilize a plan
  - resist distraction/ stay on task
  - resist temptation to respond/ act too early
  - control emotional activation

Th
wh

and predictable,
response latencies being acceptable, and
instead of being able to operate on “automatic pilot.”

Role of the “Control Functions”

EF is one of the best predictors of school readiness and has been implicated in academic, social, psychological, behavioral and physical/athletic functioning

Blair & Razza, 2007; Zhou, Chen, & Main, 2012

Why focus on positive executive functions?

Critical for:

- School readiness (Blair & Razza, 2007)
- School success from Pre-K through college (Alloway & Alloway, 2010)
- High school completion (Friedman, Miyake, Robinson & Hewitt, 2011)
- Career success (Bailey, 2007)
- Social success (Hughes & Dunn, 1998)
- Health/ Survival (Hall, Crossley & D'Arcy, 2010)
- Athletic performance (Vestburg, 2017,2021)
- Etc…

Promotion of Holistic Health & Development
- Cognitive
- Physical
- Emotional

Review

- There is no unitary EF; distinct processes related to the frontal lobes and their command relationship with other brain regions
- They serve to regulate cognition, behavior, emotion
- EF development and action is sensitive to positive and negative influences – risks and resilience factors
- Physical activity plays a role in EF development – neuroanatomical, function relationships
- Executive functions are predictive of near and long-term academic, social, emotional, behavioral outcomes
- Measure EF with different approaches; everyday profile, examine more specific processes (tests)

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Review

- Flipping our viewpoint from deficit/problem to ability/ strength
- Positive neuropsychology moves from the clinical/ problem-oriented focus to strengths-based performance focus
- Applications to many contexts: academics, sports, mental health, resilience, performing arts, mechanics/engineering, etc.
- A focus on “strengthening strengths” will serve toward maximizing everyday problem solving with benefits for child and adult social and emotional health, academic and vocational productivity and success, and physical health.

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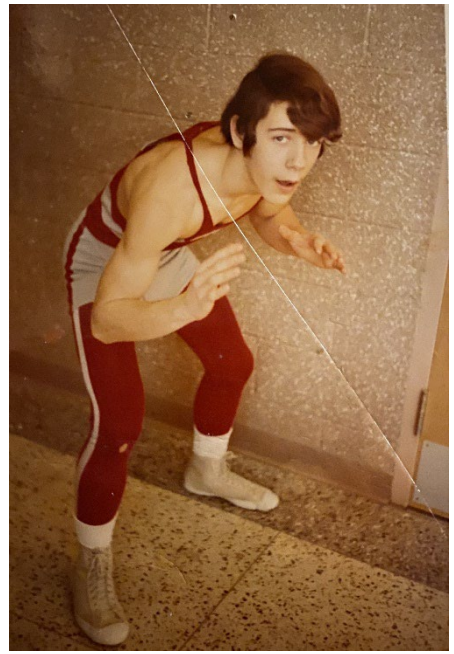
Thank you! Grazie!!



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Other necessary requirements for optimal development of the executive functions

- Language (inner speech)
- Environmental supportive, structure (not chaos)
- Positive role models
- Reasonable Goals to achieve (Vygotsky zone of proximal development)

Relationship between Physical Activity, Sports & Executive Function

Self-Regulation/ Executive Function ← Sports*

* What is the relationship?

- Increased heart rate (endorphins, BDNF, cardiovascular)?
- Increased dedication, motivation, persistence?

- Do sports help to develop better EFs? (e.g., working memory, inhibitory control, strategic behavior, planning/ organization, monitoring, emotional control)

Children's National

Effects of exercise on brain, cognition, academics Erickson et al., 2019

TABLE 1. Committee-assigned grades for the effects of PA on various ages and clinical outcomes.

Population or Measure	Grade
Children <6 yr	Not assignable
Children 6–13 yr	Moderate
Children 14–18 yr	Limited
Young and middle-age adults 18–50 yr	Not assignable
Older adults >50 yr	Moderate
Adults with dementia	Moderate
Risk of dementia and cognitive impairment	Strong
Other clinical disorders (i.e., ADHD, schizophrenia, MS, Parkinson's, stroke)	Moderate
Biomarkers of brain health	Moderate
Acute bouts	Strong
Overall	Moderate

There is moderate-to-strong support that PA benefits cognitive functioning during early and late periods of the lifespan and in certain populations characterized by cognitive deficits.

"but promising"

Exercise will commence at the end of this session…

Physical Activity/ exercise & Cognition/EF
Breaking it down

- Physical exercise with low cognitive demand, such as resistance training or aerobic exercise, yields little or no improvement in cognitive abilities,
- Whereas cognitively demanding physical activity shows the strongest effects (Diamond & Ling, 2016, 2019; Gu, Zou, Loprinzi, Quan, & Huang, 2019).
- Prolonged participation in cognitively demanding physical exercise had a positive impact on cognitive functions and cognitive vitality across the lifespan (Best, 2010; Diamond & Ling, 2016; Etnier & Chang, 2009; Marchetti et al., 2015).

Children's National

EF and Sports – Complexity of demands

- Elite athletes in **Open Skill Sports** demonstrated significantly higher performance in working memory, cognitive flexibility compared to elite **Closed Skill Sport** athletes, but not inhibition (unlike other studies). (Koch & Krenn, 2021)
- Training hours/ experience in **OSS** significantly had positive effect on inhibition, working memory & cognitive flexibility (Huijgen et al. 2015; Ishihara et al., 2017; Yongtawee & Woo, 2017)
- **OSS** superior to **CSS** in EF (inhibition, cog flexibility) in15 studies (Zhu et al., 2020)

Children's National

Self-Regulation/ Executive Function → Sports*

* What is the relationship?

Vestburg found Executive Functions (Design Fluency) predicted success in:

- elite adult soccer players (goals, assists) (2017)
- young elite soccer players (2021)

- Monitoring (evaluating what worked, what didn't)

Teaching "Goal-Plan-Do-Review" model of athletic problem-solving?