When Executive Functions Go Wrong

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Definitions

Executive Functions (Luria)

Executive function is defined as the ability to maintain an appropriate problem-solving set for attainment of a future goal. This set can involve (a) an intention to inhibit a response or to defer it to a later, more appropriate time; (b) a strategic plan of action sequences and/or; (c) a mental representation of the task, including the relevant stimulus information encoded in memory and the desired future goal-state.

Luria, A.R. (1966). Human brain and psychological process. New York: Harper & Row.

Executive Functions (Welsh & Pennington)

Executive function is primarily the set maintenance required to achieve a future goal. This set would include the requisite skills of planning, organization, inhibition of maladaptive responses, self-monitoring, and flexibility of strategies contingent on feedback.

Goldman-Rakic (1990) would add to this definition the concept of working memory.

Welsh, M. C., Pennington, B. F., & Groisser, D. B. (1991). A normative developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology*, 7(2), 131-149.

Components of executive function

Executive function components

Executive Function (EF) is a multidimensional construct that refers to the higher-level cognitive processes needed for goal-directed control of thoughts, behaviors, and emotions (Friedman & Miyake, 2017).

The construct typically includes:

- Working Memory
- Inhibitory Control
- Cognitive Flexibility
- Set-Shifting
- Planning/Problem Solving
- Attention Regulation
- Emotional Regulation

There is a developmental unfolding of basic functions from infancy through adulthood:

- Inhibitory control at ages 3-4 years
- Set-shifting at ages 3-4 (simple response sets), with most growth occurring at ages 5-6 years
- Working memory at ages 4-14 years
- The development of these basic executive functions are not mutually exclusive and build on one another to facilitate increased demands.

Executive function components

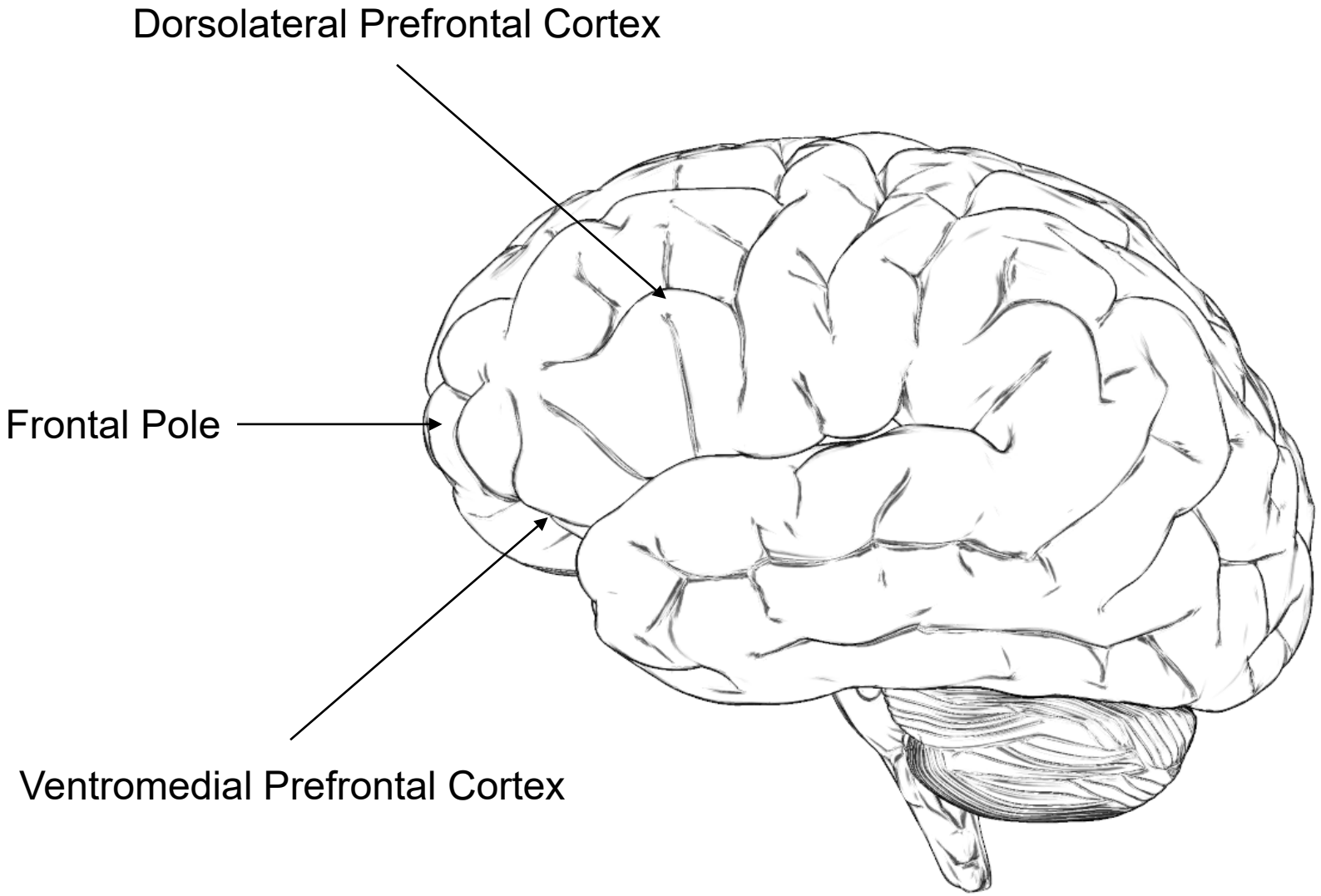
Control processes associated with EF have been described in conceptual and empirical models going back over 35 years.

- 2 (Carlson et al., 2004), 3 (Hughes, 2002), 4 (Espy, 2004), & 6 factors (Daigneault et al., 1992).

For preschool children, there has been some debate over the number of EF components that exist.

- Some investigators suggest a one factor model (Allan & Lonigan, 2011) and other groups suggest multiple (2 or 3) dimensions (Garon et al., 2008).

Executive processes are critical to the integrity of many learning and social-behavioral functions (Martin et al., 2016).



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Executive dysfunction

Executive dysfunction

Executive functions are critical for nearly every aspect of human functioning; thus, with dysfunction or impairment in any of these functions, difficulties arise.

Various terms:

- Executive Dysfunction
- Executive Functioning Disorder
- Dysexecutive Syndrome
- Front Lobe Injury/Dysfunction

Problems of dysregulation

- Cognitive dysregulation
- Learning problems
- Behavioral dysregulation
- Emotional dysregulation

Executive dysfunction

Developmental factors are also present in executive dysfunction

- There is a sequential unfolding of various EF over the course of development.
- An insult incurred at any of these developmental time points can impact specific functions, and perhaps the future development of these functions.
  - Principle of developmental ascendency
- Problems/injuries lying silent.
- Slowed/delayed development.
- EF have a have differential effects on learning and behavior over time with both neurological and environmental factors (e.g., poverty) contributing to the developmental integrity of EF.

Executive functions in elementary school children with and without problems in written expression.

Hooper SR, Swartz CW, Wakely MB, de Kruif RE, Montgomery JW

Journal of Learning Disabilities (2002)

Abstract

This study examined the executive functioning of 55 elementary school children with and without problems in written expression. Two groups reflecting children with and without significant writing problems were defined by an average primary trait rating across two separate narratives. The groups did not differ in terms of chronological age, ethnicity, gender, socioeconomic status, special education status, or presence of attention problems or receptive vocabulary capabilities; however, they did differ in reading decoding ability, and this variable was controlled for in all analyses. Dependent measures included tasks tapping an array of executive functions grouped conceptually in accordance with a model of executive functioning reflecting the following domains: initiate, sustain, set shifting, and inhibition/stopping. Analysis of covariance (ANCOVA) procedures revealed statistically significant group differences on the initiation and set shift domains, with the sustaining domain approaching significance. Children with writing problems performed more poorly in each of these domains, although the effect sizes were small. A multiple regression that employed these four factors and the reading decoding variable to predict the primary trait score from the written narratives revealed a statistically significant regression function; however, reading decoding contributed most of the unique variance to the writing outcome. These findings point out the importance of executive functions in the written language process for elementary school students, but highlight the need to examine other variables when studying elementary school-age children with written expression problems.

Differences Between Good and Poor Writers on Executive Function Domains

Domains	Good Writers		Poor Writers		F-Value
	Mean	SD	Mean	SD	
Initiation	93.98	24.69	79.73	17.38	4.81**
Set-Shifting	96.55	9.97	84.81	7.39	3.93**
Sustain	101.45	10.74	97.82	9.22	2.46+
Inhibition/Stopping	101.40	12.74	97.94	7.93	1.19

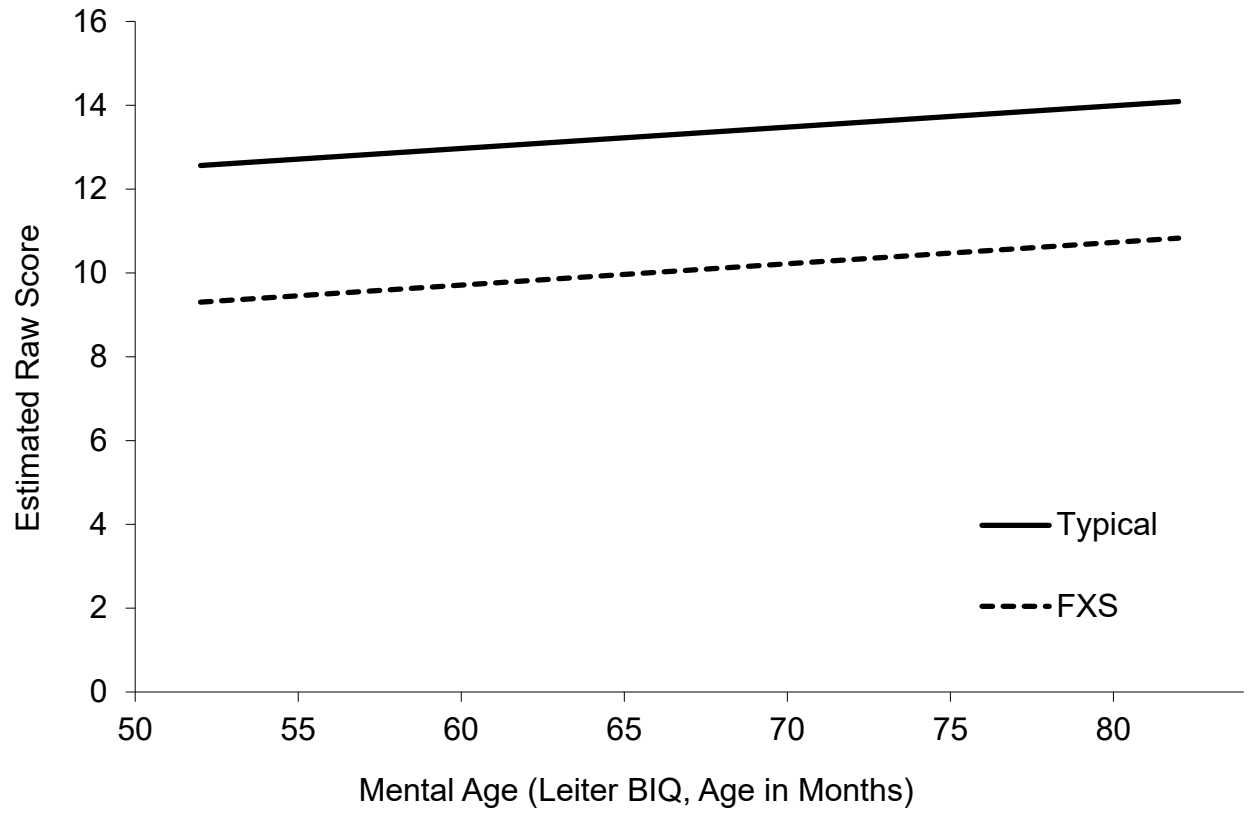
Developmental trajectories of executive functions in young males with fragile X syndrome

Hooper SR, Hatton D, Sideris J, Sullivan K, Ornstein PA, Bailey DB.
Research in Developmental Disabilities (2018).

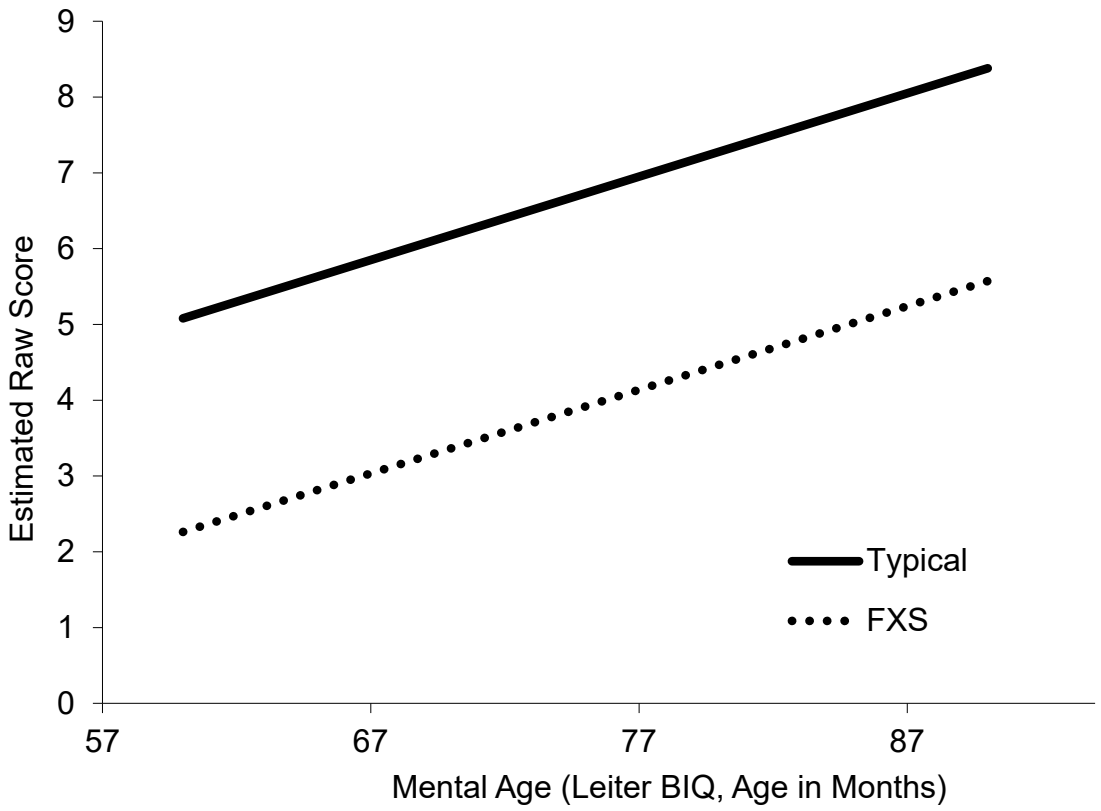
Abstract

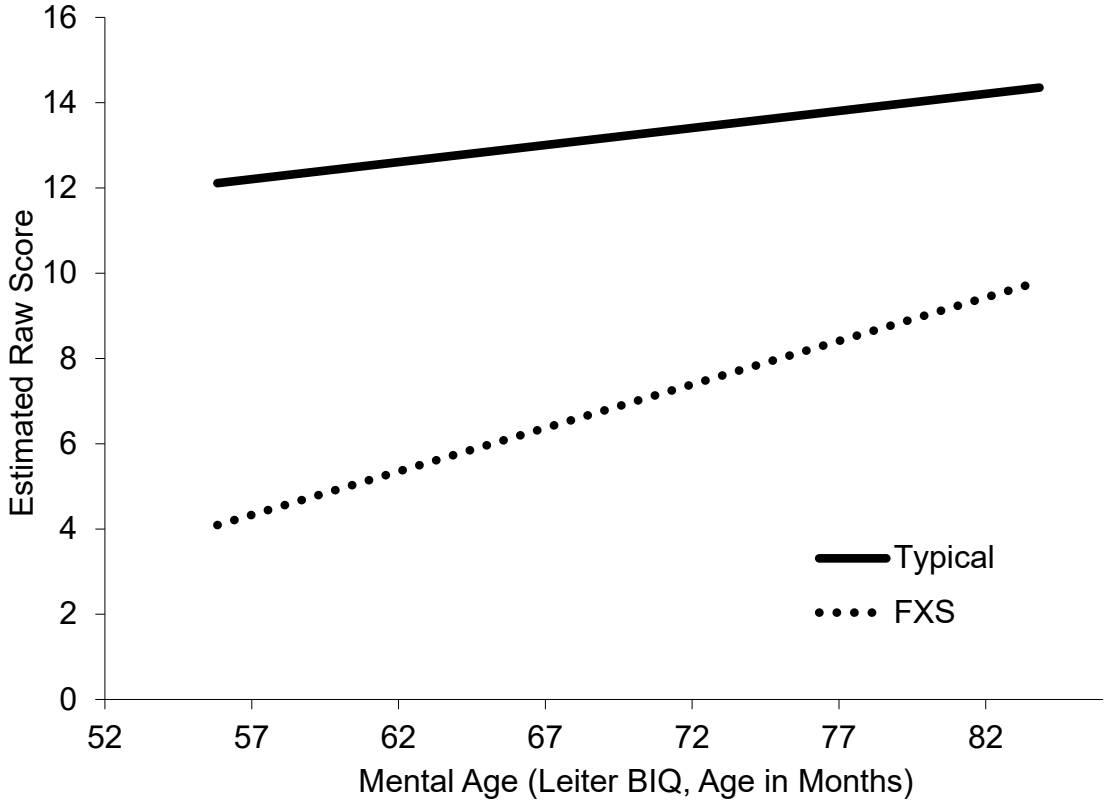
The primary aim of this longitudinal study was to examine the development of EF in males with FXS compared to Mental Age (MA)-matched controls. The sample comprised 56 boys with FXS (ages 7-13 years), and matched typical boys (ages 4-8 years). EF tasks included measures of inhibitory control, memory, cognitive flexibility/set-shifting, problem solving/planning, and processing speed. Tasks were administered at three time points over five years. The MA-Matched Typical boys significantly outperformed the FXS boys on all EF tasks, with the FXS Group showing a pattern of slow, but positive growth on most of the tasks. For working memory tasks, significant interactions were noted between MA and autism symptoms severity, and MA and medication status. The probability of task completion increased with MA. These findings contribute to our understanding of the development of EF in this population. They also lay the foundation for use of EF tasks in treatment, particularly with respect to documenting improvements and practice effects, and in understanding associations with targeted developmental outcomes.

Impact of Diagnostic Group for the Day/Night Task (inhibitory control)



Impact of Diagnostic Group on MA for Leiter-R Reverse Memory (visual working memory) and WJ-III Memory for Words (verbal working memory)





The relationship of teacher ratings of executive functions to emergent literacy in head start

Hooper SR, Costa L-JC, Green, MB, Catlett SR, Barker A, Fernandez E, Faldowski, RA

Journal of Reading and Writing (in press).

Abstract

The purpose of this study was to investigate the concurrent relationships between selected teacher-rated EF and a comprehensive array of emergent literacy skills in preschool children (N = 114 3-year-olds) after adjusting for targeted covariates including at-risk status. The teacher-completed Behavior Rating Inventory of Executive Function-Preschool (Inhibitory Self-Control, Flexibility, Emergent Metacognition). Emergent literacy measures: oral language, pre-reading, pre-writing, vocabulary, print knowledge, phonological awareness. After controlling for selected covariates (age, gender, classroom) and at-risk status, when the three EF indices were included in the model the amount of variance significantly increased for all of the emergent literacy outcomes, with the total variance accounted for ranging from 32% (Phonological Awareness) to 59% (pre-Writing). The amount of new variance added by the teacher ratings of EF ranged from 6% (Vocabulary) to 18% (Language). Emergent Metacognition was a significant predictor for most outcomes except Phonological Awareness and Reading Conventions; Flexibility and Inhibitory Self-Control were significant predictors of Language.

Intervention overview

Intervention overview

EF can improve.

General principles for improvement include:

- Teach them, train them, and practice them
  - Automaticity is a key ingredient to improvement
- Reduce external factors that negatively affect executive processes (e.g., stress, lack of sleep)
- Reduce demands on EF (e.g., learning strategies to reduce working memory load; scaffolding a problem-solving task)

Aptitude-Treatment Interactions Revisited: Effect of Metacognitive Intervention on Subtypes of Written Expression in Elementary School Students

Hooper SR, Wakely MB, de Kruif REL, Swartz CW

Developmental Neuropsychology (2006)

Abstract

We examined the effectiveness of a metacognitive intervention for written language performance, based on the Hayes model of written expression, for 73 fourth-grade (n =38) and fifth-grade (n =35) students. The intervention consisted of twenty 45-min writing lessons designed to improve their awareness of writing as a problem-solving process. Each of the lessons addressed some aspect of planning, translating, and reflecting on written products; their self-regulation of these processes; and actual writing practice. All instruction was conducted in intact classrooms. Prior to the intervention, all students received a battery of neurocognitive tests.

Intervention overview

Diamond & Ling (2015) reviewed 84 cognitive and physical activity studies of EF intervention. They concluded:

- Wide transfer does not occur, but generally appears to be narrow in scope.
- The amount of time spent practicing is critical; i.e., more practice leads to better performance.
- Executive functions require continue challenges to show continued growth.
- Once practice ceases, gains drop off.
- Those with the lowest executive functions seem to benefit the most from any targeted intervention.
- Aerobic exercise, without a cognitive component, does little to improve executive functions.
- Addressing the moderators of executive function (e.g., stress) also can improve functioning.

Conclusions

Conclusions

- Executive functions are multidimensional, particularly at older ages, and identifying the specific subcomponents that may be affected when things go wrong will be critical.
- There is a strong neurodevelopmental basis to EF, but other factors can influence their development as well (e.g., poverty).
- A breakdown at any age can have a negative impact on learning, behavioral, emotional, or cognitive capabilities.
  - A breakdown at an earlier age can lead to slower growth of many different functions
- Be aware of “injuries lying silent” (until later developmental demands surface).
- All EF are regulatory and thus disruption will cause dysregulation.
- EF can improve, and will require teaching and practice to create routines and automaticity.
- A variety of intervention vehicles are available, but few have strong outcomes with robust generalizability and sustainability.

THANK YOU!

Questions?