The Development of Executive Functions in Early Childhood

Cognitive Development in Context

How do experiences in home and school promote the emergence and refinement of children’s cognitive skills?
Executive Function skills are:
1. Rooted in biology
2. Develop across infancy, childhood, and adolescence
3. Shaped by context

What are Executive Functions?
- Neuroscience
  - Cognitive Control
    (and separable component skills)
- Education
  - Work-Related Skills
- Psychology
  - Executive Attention
  - Effortful Control
  - Self-Regulation
  - Executive Control
Defining EF

Cognitive skills, utilized for purposeful, future-oriented behavior, that underlie flexible adaptation to changing task demands, including regulation of attention, inhibition of inappropriate responses, coordination of information in working memory.

Working Memory
Attention Control/Shifting
Response Inhibition
**EF and Self-Regulation**

EF stems from focus on **Cognition**

Self-regulation has involved casts a wider net to include research on:

**Cognitive Development in Context**

- Contextual Experiences
- Children’s Cognitive Skills
- Brain Activity
- Genes
The Development of Executive Functions

Executive Function Skills Build Throughout Childhood and Adolescence

A range of tests measuring different forms of executive function skills indicates that they begin to develop shortly after birth, with ages 3 to 5 providing a window of opportunity for dramatic growth in these skills. Growth continues throughout adolescence and early adulthood; proficiency begins to decline in later life.


Changing Environments

Infancy | Pre-K | Elementary | Middle

0-2 years | 2-5 years | 5-10 years | 10-14 years
Changing Brains

0-2 years  2-5 years  5-10 years  10-14 years
Infancy  Pre-K  Elementary  Middle

Neuroscience and the Development of EF

EF “in the brain”:
• Prefrontal cortex
• Parietal cortex
• Subcortical structures
  • Hippocampus
  • Cerebellum
  • Amygdala

Volume 13, Issue 6, pages 876-885, 3 JAN 2010 DOI: 10.1111/j.1467-7687.2009.00938.x
EF and the Prefrontal Cortex

- EF develops into adolescence
- Some assume that slow development in the PFC is a limiting factor for the development of EF

Why are we concerned about EF skills?
- School readiness
- Academic achievement
EF starts in infancy

Early Adversity Plays a Role in Individual Differences

Adversity in early childhood

**Being Poor Affects Kids' Brains, Study Says**

“Children raised in poor households have clear differences in the physical structures of their brains compared to wealthier children, a new study finds.

Brain scans of 1,099 children and teenagers in nine major cities show the poorer kids have less surface area of the brain. This is important because having more brain surface area is linked with intelligence.”

[http://www.nbcnews.com](http://www.nbcnews.com)

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**EF as one or many?**

What is the structure of EF?

**Unitary skill** – common neural signature

**Differentiated system** – supported by neuroscience literature
**EF Components and Measurement**

Measuring EF across Multiple Levels of Analyses

<table>
<thead>
<tr>
<th>Teacher or Parent Report</th>
<th>Working Memory</th>
<th>Attention/Shifting</th>
<th>Response Inhibition</th>
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<tbody>
<tr>
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Working Memory

- Involves both:
  - **Storage** – how much can you hold in your memory
  - **Processing capacity** – “juggling” of information

In contrast to Memory Span

- **Memory Span**
  - aka, Short term memory
  - Increases reliably with age, reflecting increasing memory capacity
  - Sensitive to other factors
    - Expertise and knowledge – the more of an expert you are, the more you will remember*
Working Memory

- Viseospatial – CANTAB
- Verbal – Digit or Word Span

Teacher or Parent Report
- Can your child remember multistep directions

Classroom Tasks
- Jumping Game

Behavioral
- Span tasks, etc.

Neuro tasks
- N-back
Working Memory and Academic Outcomes

- Children with poorer working memory skills often struggle in math and literacy

- **Visuospatial WM** related to **math skills** in children with and without learning disabilities

- In contrast, greatest associations are seen between **WM on verbal tasks** and **reading skills**

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Attention Control/Set Shifting

**Attention/Shifting**

- Teacher or Parent Report
- Classroom
- Behavioral
- Brain

**Includes:**

- The ability to sustain and shift attention.

- Selective attention – ability to focus in the face of distraction
Attention Control/Set Shifting

Teacher or Parent Report:
• Does the child show strong concentration when drawing or coloring in a book? (when texting)

Classroom
• Distractor Task

Behavioral
• DCCS

Brain
• Flanker

Attention/Shifting and Academic Outcomes

• Parent ratings of attention uniquely predicts academic success
  • Age 4 links with college completion

• Interacts with aspects of emotion regulation

• Less strong direct links to academic achievement
  • But is important for other aspects of academic and social functioning*
Response Inhibition

**Involves:**
- Inhibiting a prepotent response

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**Teacher or Parent Report**
- Can sit still if asked?

**Classroom**
- Freeze Game

**Behavioral**
- Pair Cancellation, HTKS

**Brain**
- Go/No-go
Response Inhibition and Academic Outcomes

• Concurrently related to children’s math and literacy outcomes in early elementary school

• Links with reading might be “indirect”

• Lower inhibition is related to lower math scores in adolescence

• Developmental story – links are greater early in schooling rather than later, suggesting a shift from specific to more general effects of inhibition on children’s skills
What shapes EF Development?
Going to school!

Kindergarten

First Grade

The School Cutoff Design

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<th>Youngest 1st Graders</th>
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December 1

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Schooling Impacts on Executive Functioning

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Weiland & Yoshikawa, 2013; Brod, Bunge, Shing, 2017; Grammer et al., in prep
Weiland & Yoshikawa, 2013
Morrison, Kim, Connor, & Grammer, under review

What about classroom and school experiences matter?
Developing EF

- Expectations for appropriate behavior are derived from the environment
- **Context matters at both home and at school**
- **Development is protracted**

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Multitasking

Super attenders! (?)

Multitasking = dividing attention
Comes with a cost to working memory and attentional fatigue
**vs. Intervening on EF**

1. EF training can transfer, but transfer is NARROW
2. Time spent practicing matters, and once practice is over benefits can disappear
3. How we train also matters
4. EFs need to be challenged to improve
5. Children with the most room for improvement improve the most

Diamond & Ling (2016), DCN

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**Classroom Factors that Impact EF**

*School impacts the EF, but how?*

At the level of the classroom:
Classroom Factors that Impact EF

At the level of the classroom:
– Teacher language during instruction (Grammer, Coffman, & Ornstein, 2013)
– Individualized instruction and time in transition (Connor, Ponitz, Phillips, Travis, Glasney, & Morrison, 2010)

Talk about thinking and encourage children to do the same!
• Wh Questions
• Discuss strategies and thinking

Be clear about goals and plans:
• Advanced Organizers

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- Classroom structure and routine
  (e.g., Raver, Jones, Li-Grimm, Zhai, Bub, & Pressler, 2011)

At the level of the **child:**
- BROAD Practice with EF
  (e.g., Neville et al., 2013)
- Learning to be Mindful
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Thank you!