Adult Executive Function Skill Development

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Outline

• What are EFs, and why do they matter?
• When & how do EFs develop?
• Which factors influence EFs?

Self-Reported Executive Functioning

Items from the Dysexecutive Questionnaire (DEX):

• I have trouble making decisions, or deciding what I want to do
• I have difficulty thinking ahead and planning for the future
• I find it difficult to keep my mind on something, and am easily distracted
• I act without thinking, doing the first thing that comes to mind
• I lose my temper at the slightest thing
• I am unaware of/unconcerned about how others feel about my behavior
• I have difficulty realizing the extent of my problems

Our behavior lies along a continuum
Factors that influence behavior

- Financial instability
- Chronic stress

Behaviors & programs that combat life challenges, reduce stress levels, and build EF skills

Proactive, goal-directed behavior

Reactive, impulsive behavior

SELF-CONTROL

Controlling one’s:
- Thoughts
- Feelings
- Behavior

Examples:
- Not getting distracted from a goal
- Not making an impulse purchase
- Not getting angry

Adult EF skills

- Skills needed to get & keep a job, pay rent, care for children, etc.
- Informed by cognitive neuroscience research

PLANNING

SELF-CONTROL

MONITORING

Examples:
- How well am I doing?
- Is my behavior appropriate in this setting?
- What is she thinking?

Prefrontal cortex

MONITORING

Moment-by-moment awareness of:
- Thoughts, feelings, behavior
- Performance, progress
- Surroundings, context
- Others’ behavior

Meta-analysis conducted with Neurosynth
PLANNING

- Identifying long-term goals
- Identifying obstacles and possible solutions
- Specifying steps needed to achieve goals
- Setting appropriate deadlines & reminders

Examples:
- Drafting a household budget
- Identifying steps needed to prepare a job application
- Making arrangements for child-care

Meta-analysis conducted with Neurosynth

Self-Reported Executive Functioning (DEX)

- I have trouble making decisions, or deciding what I want to do
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Adult EF skills are inter-related

Long-term goal: Get healthier
Specific goal: Exercise after work

- Pack exercise clothes before leaving for work
- Turn down dinner invitation
- Make sure that behavior is consistent with the goal

Outline

- What are EFs, and why do they matter?
- When & how do EFs develop?
- Which factors influence EFs?
Psychosocial Maturity Index  Steinberg et al., 2007

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<table>
<thead>
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<tbody>
<tr>
<td><strong>Development of brain networks</strong></td>
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| Why do EFs develop so late? Because prefrontal cortex is still maturing until our mid-twenties | }

### Psychosocial Maturity Index

<table>
<thead>
<tr>
<th>Impulsivity</th>
<th>“I do things without thinking.”</th>
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<tr>
<td>Sensation Seeking</td>
<td>“I sometimes like to do things that are a little frightening.”</td>
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<tr>
<td>Risk Perception</td>
<td>“If you did this activity (e.g., had unprotected sex), how much are you at risk for something bad happening?”</td>
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<tr>
<td>Resistance to Peer Influence</td>
<td>“Some people think it’s better to be an individual even if people will be angry at you for going against the crowd. BUT Other people think it’s better to go along with the crowd than to make people angry at you.”</td>
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<tr>
<td>Future Orientation</td>
<td>“Some people take life one day at a time without worrying about the future BUT Other people are always thinking about what tomorrow will bring.”</td>
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### Development of EF-dependent behaviors

#### Laboratory tests

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<thead>
<tr>
<th>Psychosocial Maturity Index</th>
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<table>
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<th>% of individuals scoring at average adult level</th>
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<tr>
<td>5 10-11</td>
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<td>15 12-13</td>
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<td>25 14-15</td>
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<td>35 16-17</td>
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<td>45 18-21</td>
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<td>55 22-25</td>
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### Why do EFs develop so late? Because prefrontal cortex is still maturing until our mid-twenties

#### Development of brain networks

- increased efficiency of function within regions
- increased communication between regions

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Executive Function Webinar
EF skills require communication between prefrontal cortex and other brain regions.

Arnsten, Berridge, & McCracken, 2009

“bottom-up” processing: reacting to external cues

“top-down” processing: focusing on goal-relevant information & responses

Windows of vulnerability & opportunity for the developing brain

- The brain is most sensitive to environmental factors (for better or for worse) while it is still developing
- Each brain network has its own developmental timecourse
- Therefore, the window of greatest opportunity & vulnerability depends on the brain network

Windows of vulnerability & opportunity for specific brain networks

- Basic emotional circuitry matures early
- Neglect/abuse in first few years of life can have long-lasting effects on social and emotional functioning (Nelson & Fox)

- EF circuitry matures late
- Early environmental influences are less likely to permanently affect it (Fox & Nelson)
- Strengthening EF skills could help to cope with deficits in other areas

Outline

- What are EFs, and why do they matter?
- When & how do EFs develop?
- Which factors influence EFs?
Factors that influence EFs on a daily basis

The importance of getting good sleep

Prof. Matthew Walker, UC Berkeley
https://www.youtube.com/watch?v=51e2NEmuI7I

Prof. Allison Harvey, UC Berkeley
https://www.youtube.com/watch?v=EMdaQMIXF-Q

The importance of exercise

Factors that influence EFs over the longer term

Short-term benefits (same-day)

- Increased blood flow to the brain, bringing vital nutrients to cells
- Effects on mood, stress, and EFs that last for several hours

Long-term benefits (after several months)

- Leads to formation of new neurons & connections in the brain
- Improves resilience to stress, lowering hormonal response to stressors

Factors that influence brain development have long-lasting effects

Prefrontal cortex is particularly sensitive to the environment

For review see Mackey, Raizada, & Bunge (2012), http://bungelab.berkeley.edu
Influences on prefrontal cortex development

**Negative influences**
- Malnutrition
- Exposure to drugs, toxins
- Neglect, abuse
- Brain injury
- Chronic stress

**Positive influences**
- Higher socioeconomic status (many factors)
- Exercise?
- Cognitive training?
- Mindfulness?

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Prefrontal cortex is sensitive to experience even in adulthood: Effects of 3 months of reasoning training

**Structural changes**
Changes in prefrontal white matter tracts

**Functional changes**
Increased communication between prefrontal cortex and other regions

**Ways in which the environment shapes the brain**

- # connections between neurons
- Speed of communication
- # support cells
- Blood vessels


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Promising approaches to EF skill development in adults?

Mackey, Whitaker, & Bunge, *Frontiers in Human Neuroanatomy*, 2012
Mackey, Miller Singley, & Bunge, *Journal of Neuroscience*, 2013
http://bungelab.berkeley.edu
2 types of programs that target adult EF skills

**Field-based interventions**
- Not necessarily called EF interventions, but may tap into one or more EF skills
- Designed with needs of constituents in mind, targeting the real-world challenges they face
- Often involve face-to-face interactions
- Effectiveness may or may not have been evaluated rigorously

http://www.tedxbeaconstreet.com/beth-babcock-science-reshaping-poverty/

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2 types of programs targeting adult EF skills

**Laboratory-based cognitive training**
- Derived based on years of research
- Well-controlled studies
- Precise data collection
- Focus on strengthening specific EF skills
- Often computerized
- Training is not directly linked to real-life challenges, but rather focuses on general EF skills that – in theory – should transfer to improved functioning in daily life

Training-related improvements in cognitive performance persist over time but depend on age; an online study including > 140,000 participants

Karey Ballard¹, Daniel A. Starnberg², Joseph L. Hardy³, and Michael Scanlon⁴; Lumos Labs, Inc., San Francisco, CA

![Image](lumosity.png)

- Benefits are greatest when training every other day or so (distributed practice)
Laboratory-based cognitive training

- Powerful approach for developing & rigorously assessing science-based interventions
- Important limitations:
  - Repetition of the same task many times ("drill and kill") doesn’t account for the pivotal role of motivation in learning
  - A focus on isolated cognitive skills ignores research showing limited transfer of skills from one setting/context to another
  - To solve real-world problems, we need to work backwards from what we want to achieve

Promising approach to EF skill development

Combine the strengths of field-based and laboratory-based interventions

- Form partnerships between scientists, practitioners, and industry to identify, develop, & test interventions that build on existing science to address real-world problems

Example:

- Science shows that EF skills are essential ingredients for life, and that they can be strengthened with practice
- Two-generational approaches to EF skill development in parents & their children may produce sustainable change

Analogy to nutrition science

Isolation of essential nutrients

Thiamine (Vitamin B1)
- First identified in 1926
- Functions in brain & body are now well-understood
- Can diagnose & treat B1 deficiency, preventing illness & death

Vitamin craze

'Whole food' movement – but now we can treat people with specific nutritional deficiencies