



EPICREHAB

CLINICAL RESEARCH CONSORTIUM

Executive Function and Capacity Approximation



March 2, 2011

DEFINITIONS

- Executive function is the ability to integrate various component cognitive abilities to produce meaningful task performance.
- Executive dysfunction is the relative inability to devise novel responses, suppress habitual responses, identify and correct errors, and plan, organize, and initiate new solutions to challenging tasks.

EXECUTIVE FUNCTION IMPORTANCE

- Is it possible to have a mind without the ability to process language?
 - Yes, obviously people with aphasia are able to reason, experience emotions, and maintain established personality traits.
- Is it possible to have a mind without executive functions?

EF: NATURAL DEVELOPMENT

- Executive function develops throughout childhood and adolescence in healthy response to challenges that signal inadequacy.
 - Begins at 3-4 months
 - Peaks at 15-16 years
 - Mediated by attentional capacity.
 - Affected by educational experiences.
 - Plastic into older adulthood, but growth must be stimulated.

EF: NATURAL DEVELOPMENT

- Executive function parallels development of white matter, indicating links among gray matter structures and sub-cortical structures.
- At about age 6 months, the ability to direct gaze is established
 - The first indicator of a large set of executive functions having to do with attention.

EF: NATURAL DEVELOPMENT

- Rather than being stimulus-bound, the child can focus attention and resist external stimulation.
- The infant is able to choose what to look at.
- Considered in this way, the executive functions promote self-determination and the development of the mind.

EF: NATURAL DEVELOPMENT

- Executive functions develop with different trajectories.
- Inhibition is a good example, the one most easily identified as linked to maturation up into early adulthood.
 - Follows gradual myelination of the brain that continues until the early 20s.

EF: NATURAL DEVELOPMENT

- Social and cultural structures accommodate for the development of executive functions, e.g. classrooms and the military.
- Classrooms have more structure in early years, with self-regulation in the later years.
- Students in late adolescence who are unable to handle the absence of structure can benefit from a delay of two or three years as their myelination progresses.

EF: NATURAL DEVELOPMENT

- Military recruits at age 18 are not fully myleninated but have strict behavioral controls and an emphasis on *interpersonal* responsibility and "chain of command" structure.
- Leadership, with its lower level of structure, is offered to 18-year-olds in a limited manner.
- 23-year-old lieutenants are at the lower margin of adequate executive function if they are males, although females are more inherently capable at this age.

EF: NATURAL DEVELOPMENT

- Thus, in the early years, age is an important index of likely inherent executive function development.
- The most accessible index of EF development that can be measured in terms of *capacity* is working memory.

COGNITIVE WORK CAPACITY

- George Miller

- Magical number 7, plus or minus 2.
- Miller, G. A. (1956). "The magical number seven, plus or minus two: Some limits on our capacity for processing information". *Psychological Review* 63 (2): 343–355. <http://psychclassics.yorku.ca/Miller/>.

- Nelson Cowan

- 4 discrete chunks, if not able to use rehearsal.
- Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, 24, 87-185.

WORKING MEMORY CAPACITY

- The original estimate of “seven, plus or minus two” is an indication of verbal working memory span and is too large for working memory in general.
 - Based on forward digit span.
 - More realistic to base it on backward digit span (four or five digits) or the visuospatial span (three or four chunks).

WORKING MEMORY

- Defined by Baddeley:
 - A system for the temporary holding and manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning, and reasoning" (1986).
- Defined by Dehn:
 - The management, manipulation, and transformation of information drawn from short-term and long-term memory (2008).

WORKING MEMORY COMPONENTS

- Baddeley (2006) - Central executive and three components
 - Phonological loop
 - Visuospatial sketchpad
 - Episodic buffer

CENTRAL EXECUTIVE

- Responsible for controlling the other three components and focusing attention.
- Responsible for multitasking.
- Coordinates information from various sources and manages separate tasks that are simultaneous.
- Simultaneous work appears to occur in the episodic buffer.

LOOPS & SKETCHPADS

- The phonological loop is designed for sequential processing, while the visuospatial sketchpad is best for holistic processing.
- Most people verbally recode much of their visuospatial input.
- The phonological loop appears to be a function of duration rather than chunks of information.

WM: BASIC EDUCATIONAL CAPACITY

- Regulates phonological, auditory, linguistic, and visuospatial processing.
- Strongly affects and limits *reasoning*.
- High correlation between fluid intelligence and working memory.
- Some studies argue that fluid intelligence is entirely due to working memory.
- Fluid intelligence diminishes beyond middle adulthood, paralleling diminution of working memory capacity.

WM AND ADHD

- ADHD strongly affects the development of working memory capacity.
- Inability to inhibit distraction by deactivating information not relevant to the task limits working memory.
- If inhibition is not fully functional, irrelevant information interferes with processing information that should be the focus of attention, which leads to deficits in working memory performance.

CASE EXAMPLE: MICKEY

- I have a 19-year-old client who experienced a brain injury that brought about substantial limitations and executive function at other component cognitive functions at age 14.

CASE EXAMPLE: MICKEY

- An excellent rehabilitation program has led him to the threshold of accommodated employment in a retail setting.
- Instead of the natural development of executive functions, his therapists have worked to develop artificial structures that we call "rules".
- As he has developed ability to follow rules, he has been integrated into mainstream academic and work environments.

CASE EXAMPLE: MICKEY

- His executive functions will not need to be fully developed in order to be successful.
- Contrast that with a 19-year-old male who has not learned basic societal rules.
- In competition for an entry-level job, my brain-damaged client will probably do better in meeting the employer's needs than the non-rule following 19-year-old.
- The difference will be reversed somewhere in the mid 20s as the non-rule following 19-year-old develops his own internal regulation processes through the school of hard knocks.

NEXT MONTH ...

- Interdisciplinary Rehabilitation of Executive Dysfunction
 - The Importance of Depression in Magnification of Executive Dysfunction
 - Depression is an interdisciplinary challenge.
- Remediating Executive Function Deficits
 - Defining the *just-right challenge* for adults with work disability.