THE MARSHMALLOW TEST: EXECUTIVE FUNCTIONING IN CHILDREN AND TEENS

With Educational Interventions

Presented by David T. Andersen, Ph.D.
Topics for Today: Part One

• Definition of Executive Functioning (EF).
• Looking at the neurological basis for EF.
• The Marshmallow test: emotional control and behavioral inhibition.
• The importance of neuroplasticity and mirror neurons in the development of EF skills, especially the skills of inhibition and emotional control.
Topics for Today: Part Two

• Attention and executive functioning.

• The influence of working memory and the capacity to self-monitor on reading comprehension.

• Teaching EF skills.
Executive Functioning: Definition

- Executive Functioning Skills are a set of eight inter-related cognitive operations, mediated by the frontal lobes, that are responsible for goal directed, problem solving behavior.
EF Defined

- These cognitive operations consist of the capacity to inhibit or resist an impulse (Inhibit), to shift freely from one activity or mental set to another (Shift), and to regulate emotional responses (Emotional Control). In addition, executive functioning includes the capacity to initiate or begin a task or activity (Initiate), to hold information in mind for the purpose of completing a task (Working Memory), to manage current and future oriented task demands (Plan/Organize), to keep track of one’s possessions (Organization of Materials), and to monitor one’s own performance or to pay attention to the effect of one’s behavior on others (Monitor).
An additional EF definition

• Steven Feifer, a prominent school neuropsychologist, suggests that executive functioning can also be thought of as a set of multiple cognitive processes that act in a coordinated way to direct cognition, emotion, and motor functions.
Why Focus on Executive Functioning?

• The emergence of executive functioning deficits in PPT conversations. EF skills have become a main focus for psychologists, neuroscientists, and educators. Cognitive neuropsychology in general is a hot topic and it seems to be the direction in which school psychology is headed.

• As LD classifications seem to diminish, there has been a greater emphasis on EF skill deficits.

• *Most importantly*, EF skills are essential to academic and social success.

• **The Marshmallow Test**: Behavioral inhibition and emotional control
Left Hemisphere: Cerebral Cortex, Cerebellum, and Brain Stem
Frontal Lobes

- Evolutionary Perspective: Frontal lobes are the most recent addition to the human brain.
- Frontal lobes comprise about 33% of the entire cerebral cortex for humans (about 15% for monkeys, 8% for dogs).
- Studies have shown that in mammals, the higher and more complex degree of social living, the more frontal lobe architecture there will be.
- The function of the frontal lobes is often compared to the function of an orchestra conductor.
Frontal Lobe and Limbic System
Right Hemisphere

- Dorsolateral
- Orbitofrontal
- Prefrontal Cortex
Frontal Lobe and Limbic System 2

- Hypothalamus
- Pituitary gland
- Amygdala
- Hippocampus
Frontal Lobes (Continued)

- Developmental Perspective: Last part of the brain to fully mature (between 18 to 20 years of age). This has legal implications in cases of capital crimes.

  However,

- in terms of neuroplasticity, the brain never ceases to develop.
Neuroplasticity

• Refers to the discovery by neuroscientists that the structure and functioning of the brain changes, in children and adults, due to experience.

• Experience for the nervous system involves the activation of neural firing in response to a stimulus. When neurons become active, their connections to each other grow and supportive cells proliferate. This is how experience shapes neural structure.
A Neuron Schematic

- Dendrite
- Soma (cell body)
- Nucleus
- Axon terminal button
- Axon
- Myelin sheath
Neuroplasticity

- Neuroplastic changes not only generate structural alterations, they also are accompanied by changes in brain function, mental experience (feelings and emotional balance), and physical responses to stress.
- An important axiom in neuroscience is: “Cells that fire together, wire together.”
- Indeed, **learning** can be defined as the associations between neurons that are developed through repeated neural firing.
Neuroplasticity

• Neuroplasticity was found through advances in neuro-imaging techniques, the discovery of mirror neurons, and the results from autopsies, hemisphere-ectimies, and strokes.
Neuroplasticity (Continued)

• This has significant implications for educators.
• Skills that you have not learned, you can learn through repetition, sustained attention and effort in mastering the skill, and having the skill modeled (and scaffolded) by more competent peers and adults (one of Vygotsky’s main ideas).
Neuroplasticity

• Mirror neurons are important to neuroplasticity in that they refer to processes within our social brain that perceive the intentional, goal directed actions of others and link this perception to the priming of the motor systems needed to engage in the same action. In other words, what we see, we become ready to do or to feel.
Neuroplasticity, inhibition, and emotional control

• Example from the attachment theory and emotional intelligence literature: Young children learn to regulate emotions through empathically based interactions with parents and other caregivers. These interactions set up the neural pathways from the frontal lobes to the amygdala, part of the emotional brain.
Emotional Control: The Marshmallow Test Revisited

- The ability to regulate emotions derives in part from early attachment experiences with caregivers where emotions were consistently (not perfectly) recognized, validated, empathized with, and seen as opportunities for intimacy, social relationships, and goal attainment.
Emotional Control

• Relational experiences throughout life promote the development of self regulation in the brain, specifically, the pre-frontal regions. This insight – that neural pathways develop in response to interpersonal relationships – has generated the research in the new field of interpersonal neurobiology.
Emotional Control: The Marshmallow Test Revisited

- Researchers have found that over time, the *interpersonal regulation* of affect becomes internalized into self-soothing and the capacity to regulate inner states.
- Studies have shown that children born into a family where parents do not respond to the child’s affective experience have deficits in brain functioning as early in life as one year.
- The EF skill of emotion regulation in children and teens involves the ability to be aware of, tolerate, put into words, and use emotions adaptively to regulate distress.
Summary: The Importance of Appropriate Emotional Regulation

• The awareness and integration of affect that is characteristic of behavioral inhibition and emotional control has been shown to increase creativity and cognitive flexibility while improving decision making and problem solving skills. In other words, appropriate emotional control enhances cognitive performance. It also has been shown to be associated with several important mental health benefits.
Part Two: Executive Functioning Skills and Attention

- Executive Functioning Skills refer to a set of interrelated cognitive operations that are responsible for purposeful, goal directed and problem solving behavior. These operations are all mediated by the frontal lobe.

- Sustained Attention is a core or foundational skill that is important to several domains of EF. Sustained Attention refers to the ability to direct and maintain a focused attention on a specific stimulus.

- Selective Attention refers to the ability to attend selectively to stimuli in the environment.
Executive Functioning Skills and Attention

- Sustained Attention and Selective Attention are requirements for basic information processing and they are skills mediated by the right dorso-lateral cortex of the frontal lobe. The function of attention has been compared to the combined effects of a spotlight and a vacuum cleaner and it is the primary way neural structures develop. That is, the brain learns mainly from what the mind attends to.
Executive Functioning, Attention, and ADHD

• William James, a well known philosopher and one of the founders of the field of psychology, famously said in the late 1800’s.

• “The education of attention would be an education par excellence.”

• ADHD is seen as a frontal lobe dysfunction where the neurons responsible for attention and the inhibition of behavior are “asleep.” Stimulant medications work because they target and stimulate these neurons.
EF Skills (Continued)

- There are two strands of EF: Behavioral Regulation (BR) and Metacognition (MC).
  - BR: Inhibit, Shift, Emotional Control.
Working Memory, Monitoring and Reading

• Of children identified as having specific learning disabilities, the great majority (over 80%) have a disability in the area of reading.

• On the WISC-IV, the two test indices that best predict successful readers are the Verbal Comprehension and Working Memory Indices. Verbal Comprehension looks at concept formation (vocabulary), social judgment, and abstract thinking; working memory in reading refers to the capacity to remember the information that comes at the beginning of a sentence or paragraph so that the information that comes later makes sense. Good readers have good working memory.
Monitoring

• Good readers also have the metacognitive ability to monitor their performance. This means that a successful reader pays attention to comprehension and quickly becomes aware if the material has not been understood.

• In contrast, poor readers will decode large sections of the text before they become aware of comprehension deficits.
Teaching EF Skills

• In general, children who have executive functioning issues require structure in their daily lives, clear and simple directions on how to accomplish tasks, clear expectations, and lots of praise when they display even the smallest EF skills.

• Remember to create an environment that functions as a surrogate frontal lobe. Examples would include graphic organizers, sticky notes, and nonverbal signals from teacher to student to help the student refocus or to inhibit behavior.
Teaching EF Skills

• Stated another way, when teaching executive functioning skills, it is important to create an environment that functions as an executive function. Through repetition, modeling, and engagement with the specific intervention, neural pathways develop in the student that are then used for both behavioral regulation and meta-cognitive skills.
Teaching EF Skills

• Overlearned tasks are less likely to overwhelm a student’s existing capacity for EF skills. For example, learning to drive a stick shift at first takes all of your attention. When shifting becomes automatic, one can simultaneously drive and think about other tasks.

• Explicitly demonstrate problem solving strategies that the student will need in class. This helps with the EF skills of initiating and monitoring.
Teaching EF Skills

• Reading: requires attention, impulse control, cognitive flexibility, working memory, and self monitoring.

Math: requires attention, self monitoring, planning and organizing, working memory, and impulse control.

Writing: requires working memory, self monitoring skills, and the capacity to initiate a task or activity, and the integration of information from several brain centers.
Educational Interventions

• Educational Interventions need to function as a surrogate frontal lobe (See handout). Repetition is essential.

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<th>Problem Behaviors</th>
<th>Thinking Systems</th>
<th>Instructional Strategies</th>
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| Difficulty Getting Started - slow/unable to begin a new task, activity, or assignment | Executive Function: Initiate | • provide written and oral directions;  
• check that directions are clear;  
• begin work with mentor;  
• segment the work into small initial steps;  
• fold student's paper in halves, quarters, accordion patterns and ask them to work on just the first space |
<p>|                         | Disorganized - poor time management skills; inability to plan ahead; difficulty with sequencing; messy desk/locker; failure to turn-in work although it is complete; misplaces books/materials; written work appears messy and lacks coherence. | Executive Function: Organization | • external organizers (calendars, watch with alarm); • instructional chart with sequence of steps articulated; • instruction chart posted on desk top on index cards or stickies; • daily schedule, routines, rituals; • study buddy; • assistive listening devices; • keyboarding instruction and computer; |</p>
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<th>Distractible - not responding when called upon; poor task completion; difficulty distinguishing important information/ main idea from less important; skipping from one activity to the next.</th>
<th>Executive Function: Sustained Attention</th>
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| • preferential seating;  
• instruction on appropriate academic level;  
• assignments that are highly engaging;  
• hands-on learning, based on interests and strength;  
• reducing the number of items per assignment;  
• alternating response modes;  
• permitting students to work problems in an unusual order (bottom to top);  
• using external non-verbal cues to prompt student to return to task;  
• increasing the amount of immediate feedback (e.g., circulate during independent work and correct some of each student's work to provide immediate feedback);  
• using cooperative learning after the strategies have been taught to whole class; |
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<th>Hyperactive - difficulty staying in chair; high level of gross-motor activity (younger children); restlessness (adolescents); seeks sensory stimulation (chewing, tapping, leg swinging);</th>
<th>Executive Function: Sustained Attention</th>
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| • providing acceptable opportunities for movement rather than attempting to restrict activity;  
• providing a specific number of walking passes (e.g., sharpening pencil, drinks of water, access to books, wall charts);  
• providing small manipulables to channel activity from gross to fine motor (e.g., clay, stress balls);  
• establishing work centers as opportunity to move to choice activity;  
• standing random-drills;  
• restating rules before the opportunity for rule infraction;  
• increasing proprioceptive feedback (consult with OT or PT);  
• instructional strategies that use tactile materials |
<p>| Impulsive - shouts out answers without being called upon; exhibits risk taking behaviors; does not think about consequences of behavior; difficulty following rules; difficulty taking turns; | Executive Function: Inhibition | • teaching self-monitoring skills; • teaching self-regulating skills; • teaching the behavior you want to see; • giving positive feedback 5 to 8 times more frequently than negative ones; • teaching student verbal or motor response to use while waiting (e.g., holding up a &quot;HELP&quot; card, writing note to self so he will remember) |</p>
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<th>Memory - inconsistent and/or poor recall of previously learned information; reduced reading comprehension with long and/or complex sentences; forgetting assignments, social commitments.</th>
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<td>Executive Function: Working Memory; Attention</td>
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<td>• segment study time into smaller units; structured breaks; alternating subject matter</td>
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<td>• mute-sensory instruction;</td>
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<td>• establish lesson context and links to prior knowledge;</td>
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<tr>
<td>• highlight most important features (color coding, shapes, size emphasis);</td>
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<tr>
<td>• provide opportunity for novel repetitions until student achieves automaticity of basic skills/facts</td>
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<td>Self-Monitoring and Evaluation - lacks &quot;internal voice,&quot; the internal dialogue to self-coach and/or guide thinking and behavior; unaware that his/her behavior is inappropriate, annoying to others; difficulty checking work once completed;</td>
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<td>Transition - difficulty transitioning between activities, subjects, classes; repeats same idea, question after receiving a response; repeats same error even when told it is incorrect</td>
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References


References


Appendix I: Empirically supported functions of the middle prefrontal cortex

1. Body regulation in terms of monitoring the sympathetic and parasympathetic nervous system.
2. Attuned communication with others.
4. Response flexibility: the capacity to pause before responding.
5. Empathy.
6. Insight.
7. Fear modulation.
8. Morality.
Appendix II: Improving Adult EF

- **Mindfulness meditation:** There are over 1000 peer reviewed journal articles in psychology on the mental health benefits of mindfulness meditation. Mindfulness has been shown to improve cortical functioning in the right dorsal lateral prefrontal cortex and it has been shown to prevent the adverse effects of aging on the capacity for attention. Mindfulness has also been shown to increase left prefrontal lobe and immune system functioning.

- **Exercise:** Increases cognitive abilities and the EF skill of memory. Exercise is associated with neurogenesis in the hippocampus - part of the limbic system that is important to memory. Exercise has also been shown to have several mental health benefits.