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Consistently Inconsistent: Executive Dysfunction in Pediatric Traumatic Brain Injury

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Overview

- Between 2006 and 2014, the number of TBI related ER visits, hospitalizations, and deaths increased by 53%
- The most recent CDC Statistics (2014) indicated that TBI (of all severity levels) accounted for 2.87 million hospital visits, hospitalizations, and deaths with over 837,000 of these involving children.
- 2,529 child deaths attributed to TBI during this time
- Almost half of these injuries for individuals 0-17 years attributed to falls (49%)

Centers for Disease Control and Prevention, 2019

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Definition and Course

- The Centers for Disease Control (CDC) defines a Traumatic Brain Injury (TBI) as a disruption of brain functioning which results from an external injury to the head.
 - Classified as mild, moderate, or severe depending on the characteristics of the injury.
- Recovery after moderate to severe injury can take up to 12 months with the greatest gains being seen within this time
 - After this point, less steep curve of progress
- Following this point, social supports and access to resources have a greater influence on functional recovery than injury severity.



Types of Injury

- Executive functions are associated with activity in the **prefrontal cortex**.
- Deficits in executive functioning common due to high probability of injury to frontal systems
- Prefrontal areas and frontal systems particularly vulnerable to TBI
 - Diffuse Axonal Injury (DAI)
 - Focal Cortical Contusions (FCC)
- However, these functions are highly dependent on connections throughout all other areas of the brain (Anderson, 2002).



Cognitive Functioning in TBI

- Research has found that following moderate to severe TBI in pediatric samples, some recovery in cognitive domains including general intellectual functions, processing speed, attention, memory, and visual-perceptual skills can be seen over time.
- However, impacted individuals appear to lag behind expectations in the development of key executive skills.



Executive Control System

- **Attentional Control**
 - Selective attention
 - Inhibition
- **Cognitive Flexibility**
 - Working memory
 - Conceptual transfer
 - Use of feedback
- **Goal Setting**
 - Planning
 - Organization
 - Problem Solving
 - Conceptual reasoning
- **Information Processing Speed**
 - Efficiency
 - Fluency



Types of Attention

- **Span**
 - Simple, passive
- **Focused**
 - Purposefully allocated
- **Selective**
 - Distinguishing and focusing on a stimulus among distractors
- **Sustained**
 - Vigilance
- **Alternating**
 - Shifting
- **Divided**
 - Working with multiple streams of information



Attention Regulation

- An individual's ability to attend to a specific stimulus
- This also involves the ability to filter out or ignore extraneous information from the environment (e.g., ignoring background noise when listening to a lecture or conversation)
- For some individuals, it is difficult to filter out unrelated or unimportant stimuli which can cause them to miss out on important information in their environment.
- Also dependent on an individual's interest and motivation.



Inhibition

- The ability to “put the breaks” on an impulse or action.
- Individuals who struggle with inhibition are often described as **impulsive**.
- Weaknesses in this area can take the form of verbal impulsivity (e.g., butting into conversations) and physical impulsivity (e.g., fidgeting).
- At times, low inhibitory control can be related to emotional outbursts as individuals may have difficulty regulating their initial reactions to emotionally loaded situations.



Set-Shifting and Mental Flexibility

- The ability to consider alternative solutions to everyday issues and use feedback from one's environment to guide behavior
- Not a synonym for multitasking, refers to being able to fluidly transition from one area of focus to another
- Also involved in:
 - Mentally shifting focus between task goals
 - Generating abstract rules to solve novel problems



Initiation

- This refers to an individual's ability to independently begin a specific task.
- Not necessarily defiant or oppositional. At times, individuals who have difficulty in this area can be motivated to complete a task but may become overwhelmed, unsure of where to start, have difficulties prioritizing tasks, or may become distracted.



Monitoring

- This can be broken down into ***performance*** monitoring and ***behavioral*** monitoring.
- **Performance Monitoring** refers to an awareness of the quality of one's execution of a given task or general work quality.
- **Behavioral Monitoring** refers to one's understanding of the social-cause and effect of one's behavior. In other words, how our behavior impacts those around us.



Working Memory

- Working memory encompasses the ability to register and maintain either auditory or visual information as well as the ability to mentally manipulate this information.
- For example, being able to recall a list of instructions as well as the correct sequence of these steps to complete a given task.
- Allows individuals to string together thoughts and ideas in active memory as well as link these ideas with associated information in long term storage

Fenesi, Sana, Kim, & Shore (2014)

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The Myth of Bouncing Back

- ***Kennard Principle***

- The younger the individual at the age of injury, the greater likelihood for positive outcomes due to increased plasticity.

- ***Delayed Consequences***

- Growing into the deficit
- Access to resources and social supports essential for better functional outcomes



Development

- Rapid growth in core executive skills occurs throughout pre-school with development of more complex, integrated skills continuing into adolescence and young adulthood.
- Middle childhood appears to be a period of rapid development of more complex executive skills including planning, organization, and self-regulation.
- This also corresponds with increasing demands on executive functioning skills for academic achievement.

Best & Miller, 2010 and Garon, Bryson, & Smith, 2008; Langberg, Dvorsky, & Evans (2013)



Recovery Trajectory

- Longitudinal studies indicate that improvements in earlier maturing skills (e.g., attentional control) often exhibit more robust improvements over time
- Later developing skills appear to be more vulnerable to early injury
- Poor Attention
- Limited Planning Skills
- Disinhibition
- Goal Neglect
- Limited Self-Regulation
- Inability to Generalize and Update Social Strategies
- Failure to Utilize Feedback to Guide Behavior
- Disorganization
- Limited Working Memory Skills

Executive Skill	Academic Example	Home Example
Planning	Preparing for long term assignments or exams	Making plans with friends
Organization	Keeping one's desk organized.	Keeping one's room neat and keeping track of belongings
Time Management	Completing and turning in assignments on time	Accurately estimating how long it takes to get ready each morning
Initiation	Independently begins classroom assignments	Able to initiate homework without prompting
Inhibition	Ability to resist impulses, not calling out in class	Waiting one's turn in conversations (i.e., not butting in).
Task Monitoring	Awareness of one's performance, checking work for mistakes	--
Behavior Monitoring	--	Ability to understand the effect one's behavior has on others



Executive Functioning and Social Adjustment

- Individuals with severe TBI often exhibit lower global adaptive skills
 - Particular weaknesses noted in ***social functioning*** and ***adjustment***.
- Research has indicated that the most pronounced deficits manifest in social adjustment
 - Social perspective taking and emotional labeling have been found to be reduced in TBI samples
- Some theories posit the presence of a supervisory system which is concerned with non-routine behavioral patterns
 - Also concerned in the development and application of strategies to manage novel situations

Schultz et al., 2016; Shallice, 2002



Mood and Executive Functioning

- Executive functioning has been found to be implicated in emotional and behavioral functioning.
- The ability to self-regulate when distressed, modify behavior based on social rules and situational demands, and tolerate frustration are all related to aspects of executive control.
- Additional complex social-emotional skills and behaviors have also been related to executive functioning including moral judgment and social competence.

Anderson (2002)

Driving

- Basic Functions
 - Attention & Concentration
 - Reaction Time
 - Visual Scanning
 - Spatial Perception
 - Visual-Motor Coordination
- Higher Order Skills
 - Tracking
 - Adjusting Speed
 - Maneuvering in Traffic
- Strategic
 - Planning the Route
 - Assessing Conditions
 - Timing

Executive Functioning and Academics

- Researchers have found that facets of executive functioning, particularly working memory, are related to academic achievement as early as **first grade**.
- Individuals proficient in these areas are able to keep track of assignment due dates, break-down and plan large projects, and manage time effectively.



Reading Comprehension

- Skilled readers must be able to:
 - Regulate attention and ignore distractors
 - Make associations between novel information and what has been previously learned
 - Maintain new information in active memory
 - Access planning skills to make inferences and predictions based on the text

Sesma, H. W., Mahone, E. M., Levine, T., Eason, S. H., Cutting, L. E. (2009)



Working Memory and Written Expression

- The visual-spatial sketchpad
 - Orthography
- Phonological loop
 - Sentence construction
- The central executive:
 - Coordinates selective attention
 - Maintains focus
 - Inhibits interference
- High working memory capacity related to more organized written output

Fenesi, Sana, Kim, & Shore 2014

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Mathematics

- Deficits in the visual-spatial sketchpad are related to weaknesses in math
- This particular skill set has also been related to numerical processing including:
 - Number magnitude
 - Mental estimation
 - Understanding spatial representations of numbers (e.g., on a number line)
- In addition, children with executive dysfunction can exhibit difficulties performing multi-step or complex equations (e.g., PEMDAS) due to errors in sequencing.

Bull, Epsy, & Wiebe (2008)



Note Taking and General Studying

- The act of taking notes requires an individual to:
 - Selectively attend to salient information
 - Maintain new information in active memory
 - Paraphrase this information
 - Inhibit interference
 - Shift set from reading to writing

What is a Neuropsychologist?

- Neuropsychologists specialize in the assessment and characterization of brain-behavior relationships.
- Assessment of neurocognitive functioning includes evaluation of intellectual functioning, language, nonverbal reasoning, dexterity and fine motor coordination, attention, executive functioning, memory, academic performance, and social-emotional states.
- This is performed using paper and pencil as well as computerized measures.



Recommendations

- Many recommendations take the form of compensatory strategies. In other words, children and adolescents are *explicitly* taught what others may implicitly understand.
- These techniques are meant to become part of an individual's daily life in order to optimize their functioning and circumvent underlying weaknesses.
- It is imperative to note that the key for any of these interventions to be successful is that they must be applied consistently and practiced repeatedly.
- Individuals with executive dysfunction benefit from having structure and routine implemented whenever feasible.



Home

- Implement structure and routine (e.g., daily routines for morning and before bed) whenever feasible.
- Model the strategies you use in order to stay organized (e.g., making lists, using a day planner, etc.).
- Help children to break larger goals down into smaller steps
- Have multiple sets of items that are easily lost (e.g., pencil case, makeup bag, etc.)
- Establish areas of the home to organize important objects (e.g., a hook for keys or a ring dish for important jewelry)
- Prioritize tasks by due date or importance level
- Keep a calendar in a commonly travelled part of the home



Homework

- Complete homework at the same time each afternoon and in the same place (preferably an area of the home with limited distractions). All necessary materials (e.g., pens, paper, rulers, etc.) should be kept organized in this area for easy access.
- Work in a quiet setting which is only used for studying
- Reduce access to “short term rewards” and distractions to increase on task behavior
- Keep separate color coded folders and notebooks for each class.
- Reduce distractions (e.g., silence phone and place it across the room)
- Use a timer to allow for brief, time limited breaks
- Record class lectures



Social and Interpersonal

- Allow for socialization with appropriate supervision
- Engage in activities to practice emotional labeling, perspective taking, and inferencing
- Facilitate emotional labeling by using appropriate language (e.g., “I see you’re upset, why don’t you take a cool off break and we can talk?”).
- Explicit and regularly reviewed behavioral expectations
- Developing a “routine for when the usual routine changes” can assist the child in adapting to unanticipated change.



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