PERCEPTIONS OF EXECUTIVE FUNCTIONING IN YOUNG CHILDREN FOLLOWING TRAUMATIC BRAIN INJURY

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PERCEPTIONS OF EXECUTIVE FUNCTIONING IN YOUNG CHILDREN

FOLLOWING TRAUMATIC BRAIN INJURY

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ABSTRACT

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Pediatric traumatic brain injury (TBI) poses significant challenges for children as they begin or reenter school. Impaired executive functioning is a particularly debilitating consequence of a TBI. Related deficits can adversely impact a student’s ability to independently complete daily living skills, appropriately interact with peers, and successfully complete academic tasks. This study examined whether or not teachers and caregivers provided different ratings of executive functioning of young children following a traumatic brain injury using the Behavior Rating Inventory of Executive Functioning (BRIEF) and the BRIEF-Preschool Version. Pre-injury baseline data was collected shortly after injury and post-injury data was obtained at approximately 6 months, 12 months, and 18 months from the date of injury. Results indicate that teachers and caregivers provide similar ratings of executive functioning of young children who have sustained a TBI, which may help educational teams determine how to best support students when returning to school after a TBI.
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INTRODUCTION

Perceptions of Executive Functioning in Young Children

Following Traumatic Brain Injury

Traumatic Brain Injury (TBI) impacts approximately half a million children every year and it is the most common cause of unintentional death and long-term disability in children in the United States (Kennedy et al., 2008; Ornstein, et al., 2009; Yeates & Taylor, 2006). TBI is defined as a disruption in brain functioning that is directly related to the head being struck or penetrated by an external object or force (Brain Injury Association of America [BIAA], 2011; Centers for Disease Control and Prevention [CDCP], 2010). The brain may sustain insult through a variety of means such as disease, oxygen depletion, and congenital defects, but only injuries that are acquired through physical trauma meet the requirements for this medical definition (Jantz & Coulter, 2007). In addition, not every strike to the head will result in reduced brain functioning and thus be considered a TBI (BIAA, 2011). It is important to note that some states, such as Ohio, have adopted a broader definition of TBI to use when determining eligibility for special education services (Ohio Department of Education, 2008).

TBI is a complex condition with no two individuals experiencing identical symptoms or deficits (Bales, Wagner, Kline & Dixon, 2009). This especially holds true for the pediatric population, as brain development is incomplete at this point. The years between birth and age 5 involve significant brain growth, attainment of essential
developmental milestones, and advancements in fundamental skill acquisition (Wetherington & Hooper, 2006). Children who sustain a TBI during this critical period may suffer serious short-term and long-term ramifications in cognitive, academic, psychomotor, and behavioral functioning (Gerring, et al., 2009). The interplay of numerous factors including the site and severity of injury, the age of child at injury, the premorbid functioning of the child, and the level of support structures the child already has in place at the time of injury greatly determines the degree of recovery following a TBI (Gil, 2003; Goldstrohm & Arffa, 2005; Woodrome, et al, 2011).

Executive dysfunction, deficits in one’s ability to manage cognitive processes and behavior, can be especially disabling for young students (Horton, Soper, & Reynolds, 2010). Despite the adverse impact TBI can have on executive functioning (EF), no known study has examined teacher and caregiver perceptions of EF in young children following a TBI. The current study attempted to address this by comparing caregiver and teacher ratings of children post-TBI using the Behavior Rating Inventory of Executive Function (BRIEF) at four separate points in time: pre-injury baseline, 6 months post-injury, 12 months post-injury, and 18 months post-injury.
Chapter I

Literature Review

Incidence

Traumatic Brain Injury (TBI) is currently the leading cause of morbidity and mortality in children and young adults (Kennedy et al., 2005). It is believed that the number of persons suffering with TBI related disabilities will further increase as individuals become more likely to survive their injuries due to ongoing advancements in the fields of medicine and technology (Krpan, Levine, Stuss & Dawson, 2006). The CDCP (2010, 2011) estimates there are 1.4 million new cases of TBI every year in the United States and nearly half a million children 0 to 14 years of age are treated in the emergency room annually for TBI. The highest incidence of TBI related visits to the emergency room, hospitalizations, and deaths combined occurs in male children 0 to 4 years of age. However, these estimates are believed to be an underrepresentation of the true incidence of TBI due to the undetermined number of individuals who may sustain an injury, but do not seek medical care (CDCP, 2010).

A longitudinal study conducted by McKinlay et al. (2008) assessed the prevalence of TBI in a sample of over 1000 participants from birth to age 25. Results indicated that over 30% of those involved in the study were reported to have sustained some level of TBI by their 25th birthday and that the average yearly rate of children ages 0 to 5 who sustained a TBI was 1.85 per 100. This statistic is higher than commonly reported, which is due to the study’s consideration of TBI incidences that do not require emergency room
visits or hospitalization. Additional incidence reports suggest that 150 per 100,000 incidences of TBI pertain to very young children ages 1 to 4 (Arroyos-Jurado, Paulsen, Ehly, & Max, 2006). The childhood mortality rate for TBI is estimated to be 10 for every 100,000 injured (Goldstrohm & Arffa, 2005). The childhood mortality rate for TBI is estimated to be 10 for every 100,000 injured (Goldstrohm & Arffa, 2005).

Approximately 50% of all cases of TBI are a result of motor vehicle and bicycle accidents; 30% of cases are reported to have occurred due to sports-related incidents or falls; and the remaining 20% are incurred through violent acts (Hooper et al., 2004). Approximately 61% of young children hospitalized for TBI are male (Wetherington & Hooper, 2006) and African American children ages 0 to 4 are twice as likely to be hospitalized or die from a TBI as are Caucasian children of the same age (Langlois, Rutland-Brown, & Thomas, 2005). The vast majority of head injuries are mild in severity with as many as 75% of injuries falling in this category (CDCP, 2003).

**TBI Classifications**

TBI is classified into two general categories: open-head injuries and closed-head injuries. Open- head injuries, also known as penetrating injuries, occur when a foreign object pierces the skull, negatively impacting the underlying brain structures (Jantz & Coulter, 2007). Brain damage associated with open-head injuries is generally localized and the resulting sequelae greatly depend upon which areas in the brain are in the path of the penetrating object or piece of displaced skull. Adjacent brain structures may also be impacted due to secondary injury effects such as swelling, infection, or bleeding (Jantz & Coulter, 2007).
Closed-head injuries are sustained when the brain is adversely impacted by an external force, but the skull remains intact. This form of TBI can result from either an impact injury or an inertial force injury. Impact injuries take place when the head is stationary and is struck by an object in motion, such as a thrown baseball. Damage sustained from this type of injury is referred to as a focal injury and commonly involves two points in the brain: insult at the original point of impact, a coup injury, and damage that is sustained as a consequence of the brain rebounding off the opposite side of the skull, a contracoup injury (Jantz & Coulter, 2007; Monfore, 2005).

The second type of closed-head injury is an inertial force injury, also known as an acceleration/deceleration injury. Inertial injuries result when a person in motion collides with a stationary object, as is the case in many motor vehicle accidents. Inertial force injuries can impact the brain in a variety of ways. The previously described coup and contracoup injuries are a frequent consequence of inertial force injuries as the head strikes against a hard object, such as a car’s dashboard or windshield. In addition, diffuse axonal injury may occur due to the rotation and movement of the brain within the confines of the skull. This type of movement often causes stretching and distortion of axons and related neural networks throughout the brain and can significantly interfere with how the brain functions. As a result, generalized neurobehavioral deficits may occur, which can adversely impact functional development (Gil, 2003; Monfore, 2005).

**Severity of TBI**

The severity of TBI is classified as mild, moderate, or severe, although there is no single agreed upon definition for these classifications (Von Hahn, 2003). Various methods are employed in assessing TBI severity, but the Glasgow Coma Scale (GCS) is
one of the most commonly utilized tools. The GCS rates factors such as an individual’s motor response, verbal response, and level of eye opening within the first 24 hours post-injury. Scores range from 3-15 with higher scores indicating greater degrees of functioning and thus less impairment. The GCS is an empirically validated measure for determining TBI severity; however, it demonstrates a lower degree of reliability when used with preverbal child populations (Jantz & Coulter, 2007).

Mild head injuries are the most common type of TBI and may account for upwards of 75% of all head injuries (Hooper, 2006; Kwok, Lee, Leung & Poon, 2008). Individuals are considered to have suffered a mild TBI if they have sustained a traumatic event causing a reduction in brain functioning and either a loss of consciousness for 30 minutes or less, a GCS score of 13-15 at the 30 minute post-injury marker (Kwok, Lee, Leung & Poon, 2008), or a duration of post-traumatic amnesia lasting no longer than 30 minutes (Von Hahn, 2003). Mild head injuries with subsequent brain abnormalities as shown on a computerized axial tomography scan (CT-Scan) are labeled as complicated mild head injuries. Although all injuries that fall in this general category are labeled as mild, individuals who sustain an uncomplicated or complicated mild TBI may still suffer significant adverse consequences from their injury, especially in the domains of attention and concentration (Langlois, Rutland-Brown, & Thomas, 2005).

Head injuries are considered to be moderately severe when GCS scores are between 9 and 12 and when the duration of unconsciousness or post-traumatic amnesia is between 1 to 24 hours (Von Hahn, 2003). Secondary effects such as hematomas (pooling of blood outside of the blood vessels) and edema (swelling) are common with a moderate TBI and may cause further impairment. The ramifications of injuries at this level of
severity are similar to those incurred with a mild TBI and include memory deficits, problem solving dysfunction, difficulties with attention, and behavioral concerns (Semrud-Clikeman, 2001).

Severe TBI involves a loss of consciousness or post-traumatic amnesia of more than 24 hours and a GCS score of 3-8 (Von Hahn, 2003). Individuals sustaining this level of injury typically require emergency medical services and approximately 50% of children who incur a severe TBI will not survive. Individuals who do survive frequently have additional injuries and experience much greater levels of cognitive, physical, and neuropsychological impairment than do those who sustain mild to moderate head injuries (Semrud-Clikeman, 2001).

**TBI and Plasticity**

It was once believed that the immature nature of a young child’s brain served as a protective factor upon sustaining a TBI. Developing brains are considered to be more plastic than fully mature brains, meaning that they are able to reorganize both structurally and functionally upon insult. As a result of this phenomenon, it was thought that young children who sustain a TBI may be able to recover functional losses more readily than adult counterparts (Gil, 2003). However, researchers are now learning that plasticity may not offer the same degree of protection against long-term deficits as once thought (Goldstrohm & Arffa, 2005; Nadebaum, Anderson, & Catroppa, 2007).

Pediatric head injuries that occur during this highly critical period of development may in fact result in more significant impairment as abilities that support current and future behavioral and academic skill acquisition are interrupted. It is argued that processes in an active stage of development at the time of injury are among those most
susceptible to dysfunction after insult (Muscara, Catroppa, & Anderson, 2008). Research supporting this assertion demonstrated that very young children who sustained head injuries performed significantly worse on measures of cognitive ability than did children who were older and whose brains were more fully developed at the time of their injury. McKinlay, Grace, Horwood, Fergusson, and MacFarlane (2009) found that young children who sustain a more severe mild TBI are likely to experience long-term, adverse behavioral outcomes following their injury including Attention Deficit Hyperactivity Disorder, Oppositional Defiant Disorder, and Conduct Disorder.

It is also important to note that the extent of resulting cognitive and behavioral deficits may not be fully apparent within the first few months following a TBI, but rather emerge over time. Therefore, the degree of neurobehavioral and cognitive recovery in young children post-TBI may not be discernible until the child is older and is required to develop more complex skills (Gil, 2003). As such, it is recommended that young children who sustain a TBI be regularly assessed while in school and through early adulthood when brain development reaches full maturation (Muscara, Catroppa, & Anderson, 2008).

Educational Services for Students with TBI

The original version of U.S. Public Law 94-142 passed in 1975, also known as the Education of All Handicapped Children Act (EHA), did not recognize TBI as a qualifying category for granting students special education services. Thus, in the past, many children either did not have their educational needs met or were required to qualify under criteria established for another exceptional child classification (Hooper, 2006). In 1990, TBI was included as a special education disability category in Public Law 101-476,
which also renamed the EHA the Individuals with Disabilities Education Act (IDEA) (United States Department of Education, 2011). IDEA paved the way for students with TBI to obtain necessary educational supports based on the existence of their disabling injury (Gil, 2003). TBI is defined in IDEA as an acquired brain injury directly resulting from an external physical force to the head. In order to meet the educational definition, the injury must also result in some degree of disability or impairment that adversely impacts a student’s educational performance (United States Department of Education, 2011). Numerous, but not all, students will require educational support services authorized through IDEA upon sustaining a TBI.

Despite the relatively high incidence of TBI and the provisions for educational supports offered through IDEA, functional declines often remain undetected by teachers and caregivers following this type of injury (Sesma, Slomine, Ding, McCarthy & The Children’s Health After Trauma Study Group [CHATSD], 2008). Approximately 86% of professional educators report that schools are lacking in the dissemination of information pertaining to the diverse needs of the pediatric TBI population (Mohr & Bullock, 2005). In addition, many educators underestimate the true number of TBI cases in the general student population and consider it to be a low incidence disability (Bullock, Gable and Mohr, 2005). Bullock, Gable and Mohr (2005) report that more than 3% of all students have sustained some form of TBI. Therefore, it is critical that those employed in the schools be cognizant of how children may change due to their injuries and what needs they may have when entering school for the first time or returning to school after a TBI (Arroyon-Jurado, Paulsen, Ehly, & Max, 2006). Deidrick and Farmer (2005) point out that without appropriate educational supports, children in the TBI population who have
lingering deficits may face adjustment problems as they attempt to reenter academic and social settings.

**Functional Implications of TBI**

There is still much to learn about the long-term effects of TBI in the pediatric population (Nadebaum, Anderson, & Catroppa, 2007); however, it is understood that a broad range of negative outcomes can occur when normally developing children sustain a TBI (Wetherington & Hooper, 2006). Children may experience related dysfunction in the areas of intelligence, executive functioning, memory, learning, processing speed, academic performance, perception, language processing, psychomotor functioning, emotional regulation, and behavioral functioning (Allen, et al., 2010; Tsaousides & Gordon, 2009). As may be expected, cognitive deficits are more pronounced in young children who have sustained a severe TBI than they are in children with moderate or mild TBI (Gerrard-Morris, 2010). Furthermore, great variation exists in the duration of present cognitive and behavioral dysfunctions within the pediatric TBI population, but it is widely acknowledged that the negative sequelae will likely persist long after the acute stage of recovery (Yeates & Taylor, 2006).

Children who sustain a mild TBI may possess deficits that are evident only when attempting to perform certain skills. Dysfunction may normalize within 12 months from the time of injury for those with mild injuries; nevertheless, complete recovery of function does not occur for roughly 10 – 15% of these children (Hajek et al., 2010; Hoskison et al., 2009). Deficits continue past the acute stage of recovery for approximately 50% of individuals with a moderate TBI and children who sustain this level of injury may experience more pervasive dysfunction than is typically involved with
a mild TBI. The majority of individuals with a severe TBI generally experience long-term extensive disability across numerous domains (Hoskison et al., 2009; Limond & Leeke, 2005). As such, TBI has widespread implications for children in terms of subsequent long-term functioning and academic achievement (Kennedy, 2008).

**Executive Functioning**

Disruptions in executive functioning (EF), a collection of superordinate cognitive processes that allow for purposeful, independent goal-directed behavior, are a particularly debilitating consequence of TBI for children as they attempt to successfully begin or reenter school (Nadebam, Anderson, & Catroppa, 2007; Sesma, Slomine, Ding, McCarthy & CHATSG, 2008). Individuals rely on EF to guide and manage behavioral, emotional, and cognitive tasks, particularly when presented with novel situations or problems. Impairment in this dimension can lead to problems in a child’s ability to “initiate, plan, set goals, monitor performance, anticipate consequences and respond flexibly and adaptively” (Tsaousides & Gordon, 2009, p. 175). As a result, executive dysfunction may be one of the most disabling of all cognitive deficits as it can pose serious consequences for students in virtually every aspect of life including independence in completing daily living skills, peer social interactions, and academic performance (Bales, Wagner, Kline, & Dixon, 2009; Sesma, Slomine, Ding, McCarthy & CHATSD, 2008; Tsaousides & Gordon, 2009). In addition, Ylvisaker et al. (2005) contend that what is commonly perceived to be negative cognitive outcomes post TBI may actually be impaired executive functioning over cognitive processes and not the specific cognitive functions themselves. As a result, executive dysfunction in students post TBI may go undetected.
In a recent study, 18 – 38% of children in a TBI sample demonstrated significant adverse effects in EF following their injuries. It was further concluded that EF related disabilities are “among the most frequently reported areas of cognitive impairment after TBI” (Sesma, Slomine, Ding, McCarthy & CHATSD, 2008, p 1687). Young children appear even more vulnerable to functional declines in EF as maturation in this domain is protracted and damage resulting from head trauma may prevent further development of these processes (Horton, Soper, & Reynolds, 2010; Sesma, Slomine, Ding, McCarthy & CHATSD, 2008). Forms of executive dysfunction are highly heterogeneous, but revolve around several interrelated subdomains including working memory, inhibition, shifting, planning, metacognition, decision making, and discourse processing. Social cognition and behavioral self-regulation have been added more recently to this list as they are believed to be integrally related (Kennedy et al., 2008, Levin & Hanten, 2005).

**Executive Functioning Subdomains**

**Working memory.** Working memory is the “ability to monitor, process and maintain task-relevant information on-line” in order to be able to respond to current environmental demands (Mandalis, Kinsella, Ong & Anderson, 2007, p 684). Mandalis, Kinsella, Ong and Anderson (2007) note that new learning can be considerably inhibited in individuals with TBI as a result of impaired working memory processes. This core executive function is necessary for various higher level cognitive functions and further development of complex cognitive and academic skills including reading and writing, mathematical computation, and language comprehension (Conklin, Salorio, & Slomine, 2008; Mandalis, Kinsella, Ong & Anderson, 2007). Students who demonstrate working memory deficits may have significant problems in maintaining attention, processing new
information, and forming new memories, which are all vital to the learning process (Hoskinson, Moore, Hu, Orsi, Kobori & Dash, 2009).

**Inhibition.** Inhibition pertains to one’s ability to maintain cognitive control and it occurs in many forms. Inhibition is employed when a powerful, yet no longer relevant response is intentionally suppressed, when a behavior already in action is stopped, when individuals restrain the retrieval of extraneous memories that do not pertain to the current situation, and when distracting environmental elements are purposely ignored. Inhibition is frequently compromised in children who have sustained any degree of TBI. It is now understood that the inferior frontal cortex is responsible for a person’s ability to overcome a prepotent response (Aron, 2008) and that dysfunction in inhibition may also result in the future development of Attention Deficit Hyperactivity Disorder secondary to TBI (Levin & Hanten, 2005). Students exhibiting difficulty with inhibition in the classroom may experience significant deficits in being able to filter out environmental distractions, as well as maintaining focus on a single concept.

**Shifting.** Shifting, which is also termed switching, is the capacity to intentionally transfer attention from one condition to another in an alternating fashion (Aron, 2008; Levin & Hanten, 2005). It is believed that in order to successfully accomplish this skill, one needs to simultaneously maintain sufficient levels of working memory and inhibition. Children who sustain a pediatric TBI may demonstrate notable impairment in this process as shifting is believed to have a longer developmental trajectory than some of the other executive functions. Therefore, young children who have a head injury while this skill is developing may have long term shifting deficits (Levin & Hanten, 2005). The academic
ramifications of shifting deficits can be significant as students attempt to intermittently shift their attention from one task to another.

**Planning.** Successful problem-solving requires the ability to foresee several steps ahead and to manage the individual actions necessary to achieve a desired goal. This process has been simply termed *planning* and is observed in children as young as four years of age. Severity of TBI has a direct relationship with the degree of planning dysfunction experienced in children with head injuries. Planning deficits also become more salient as the complexity of problems and required steps for solution increase (Levin & Hanten, 2005). A reduction in the ability to maintain prospective memories, memories pertaining to future plans or objectives, is also a frequent consequence upon sustaining a pediatric TBI, which further complicates the planning functions in those with head injuries (Ward, Shum, McKinlay, Baker & Wallace, 2007). Children with TBI demonstrate difficulties in employing planful problem solving strategies and instead are more likely to engage in escape or avoidant types of coping (Krpan, Levine, Stuss, & Dawson, 2007; Krpan, Stuss, & Anderson, 2011). Consequently, students may struggle when formulating a plan for completing an assignment and face difficulties when attempting to implement the desired steps.

**Metacognition.** Metacognition is another core EF domain, which pertains to the ability to monitor and self-evaluate one’s own cognitive processes. This ability begins to emerge around the age of four or five and continues to develop through adolescence. Children who sustain head trauma frequently experience deficits in a variety of metacognitive tasks including the ability to detect, explain, and correct anomalies in sentences; following unambiguous directions; and correctly estimating the ease of
learning involved in a task (Levin & Hanten, 2005). Bivona et al. (2008) found that in a TBI sample, metacognitive self-awareness was significantly correlated with other executive functions such as inhibition, shifting, and planning, as well as with the ability for individuals to benefit from external feedback. Furthermore, it has become evident that individuals with TBI may fail to even recognize limitations in brain functioning imposed by their injury. The educational implications are that metacognitive dysfunction may result in significant disruption in academic performance as students struggle to understand the problems they face as a result of incurring a TBI (Bivona et al., 2008).

**Decision making.** Age related factors involved in decision making include selection of processes employed to make informed decisions, degree of willingness to engage in risk taking, and the nature of errors frequently committed in this process. Children who sustain pediatric TBI rarely have had sufficient time to fully develop mature decision making abilities prior to their injury. It is believed that brain trauma, especially lesions in the orbitofrontal region, interfere with the ability to remain flexible in decision making, which is necessary for one to alter decisions based on environmental feedback (Levin & Hanten, 2005). Children who experience deficits in this area may have difficulty in recognizing various factors that need to be taken into consideration when deciding how to proceed with an assignment and they may not be able to successfully change a previously made decision upon receiving new information.

**Discourse processing.** Discourse processing relies on a complex interaction of cognitive and linguistic abilities that, when successfully combined, allows for analysis of language. In summarization of connected language, one must be able to ignore extraneous details, prioritize information in terms of importance, and hold these details in
working memory. Most typically performing young children have not yet developed the skills necessary to be able to accurately summarize a simple paragraph without omitting significant details. Sustaining a TBI prior to development of this skill may inhibit or seriously limit its eventual growth. Studies indicate that children with severe TBI typically have considerable deficits in the ability to grasp the gist of a passage and that they commonly only retain lower level details from stories (Levin & Hanten, 2005).

**Social cognition.** Effective development of social skills relies on social cognition or the ability to recognize the intentions, thoughts, and beliefs of others. Included in this definition is the capacity to empathize with others, utilize social cues, assess and problem-solve problematic social situations, and determine the possible consequences of social related behaviors (Levin & Hanten, 2005). Muscara, Catroppa and Anderson (2008) report that children who incur neurocognitive deficits due to TBI demonstrate poorer social functioning than do healthy children. It is believed that this relationship is mediated by a lack of social problem-solving skill development due to head trauma. In addition, children with TBI have been shown to have more difficulty recognizing auditory and visual emotional cues (Schmidt, Hanten, Li, Orsten, & Levin, 2010). Interference in the development of these abilities can have notable consequences for students in fostering and maintaining peer relationships (Levin & Hanten, 2005).

**Behavioral self-regulation.** Behavioral self-regulation has recently been recognized as one of the EF domains. Similar to the other processes discussed, behavioral self-regulation develops long past adolescence. Young children beginning to self-regulate demonstrate a pattern whereby they have more difficulty complying with requests to initiate or sustain behavior than they do with instructions to cease
inappropriate behavior. It is believed that prefrontal damage is largely responsible for
dysfunction in this domain. Individuals with TBI display an elevated degree of
behavioral self-regulated problems when compared with non-injured persons, which can
manifest through depressive symptoms, maintaining a fewer number of friends, and
poorer overall psychosocial outcomes (Levin & Hanten, 2005). The academic
ramifications are significant as children who have difficulty regulating their behavior
must be continuously be redirected, thus, reducing the amount of time teachers can spend
engaged in classroom instruction.

**Performance monitoring.** Performance monitoring is also considered a core
executive function and refers to one’s ability to identify errors in performance and to
implement modifications for correction. The ability to monitor and regulate behavior
allows one to adapt to changing environmental conditions, resulting in improved task
performance. For example, typically performing children tend to slow their response rate
in a timed assessment if they receive input that their given responses are incorrect.
Children who demonstrate impairment in performance monitoring skills do not engage in
similar strategies as successfully as healthy controls (Ornstein et al., 2009). In a study
conducted by Ornstein et al. (2009), participants with pediatric TBI demonstrated
deficient performance monitoring skills utilizing a speeded choice reaction time test. The
implications for academic performance are numerous and students exhibiting impaired
performance monitoring abilities may require a wide variety of educational
accommodations and interventions (Ornstein et al., 2009).
Measure of Executive Functioning

Measuring EF in young children following a TBI is complicated by several factors. First, EF processes have yet to reach full maturity in healthy children of this age and, as such, it is difficult to know if deficiencies are due to the skill not yet fully developing or if noted deficits are the result of head trauma. In addition, developmental trajectories within the various domains and between individual children are highly diverse, which adds more complexity in assessing EF processes in this population (Levin & Hanten, 2005). Furthermore, traditional EF tests are often highly structured and administered in settings that provide minimal distraction. Results using these measures may indicate artificially high levels of EF in children as the testing situation is not commensurate with the child’s real world demands (Sesma, Slomine, Ding, McCarthy & CHATSD, 2008).

The Behavior Rating Inventory of Executive Function (BRIEF) is a questionnaire created to evaluate a child’s EF in everyday activities both at home and in the classroom. The inventory, which is described as a ecologically valid means of assessing EF, has been shown to be a highly reliable and valid measure of EF in both healthy children and in children following a TBI (Gioia, Isquith, Guy, & Kenworthy, 2000; Muscara, Catroppa, & Anderson, 2008). The assessment tool was created based on a thorough synthesis of information regarding the brain basis of EF and what is known about developmental factors that exert additional influence on these processes (Plake, Impara, & Spies, 2003).

Several versions of the BRIEF were created to obtain ratings of EF in children at various ages and from different reporters. The original form of the BRIEF offers both parent and teacher questionnaires that provide EF clinical scores for children ages 5 to 18
in the following areas: inhibition, shifting, emotional control, initiating, working memory, planning, organization of materials, and monitoring. These eight scores are then combined to formulate a Global Composite score, which is believed to provide insight into an individual’s overall level of EF. The parent form was designed to be completed by a caregiver or other guardian and, ideally, should be completed by both parents whenever possible. The teacher version of the BRIEF is intended to be completed by an adult who has more than one month’s worth of daily contact with the student in an educational setting (Gioia, Isquith, Guy, & Kenworthy, 2000; Plake, Impara, & Spies, 2003).

Another form of this measure is the Behavior Rating Inventory of Executive Function – Preschool Version (BRIEF-P), which was developed from the original BRIEF. The BRIEF-P can be completed by both teachers and caregivers to rate children ages 2 years, 0 months to 5 years, 11 months. Clinical scores are the same as those included on the BRIEF except the initiating, organization of materials and monitoring clinical scales are omitted as these skills are not regularly demonstrated by typically developing students of this age. The BRIEF-P allows for the calculation of Global Composite scores, which are comparable with composite scores from other forms of the BRIEF. All versions of the BRIEF can be administered by individuals who carefully read the administration and scoring guidelines presented in the manual and should only take approximately 10-15 minutes to complete (Gioia, Isquith, Guy, & Kenworthy, 2000; Plake, Impara, & Spies, 2003).
Reason for Proposed Study

Existing research examining the impact of TBI on EF in very young children is lacking on several points. First, it is unclear whether or not young children who sustain a TBI experience the same EF disturbances as those encountered by children whose brains are more fully developed at the time of their injury. This lack of understanding is primarily due to the fact that the majority of studies on this topic utilize single samples that are greatly heterogeneous in terms of age. This design does not allow for the determination of how brain maturation at different points in time impacts EF following a TBI (Levin & Hanten, 2005). Second, available research employing EF measures often utilizes a single administration, thus not allowing one to determine if executive dysfunction ratings are steady across time (Sesma, Slomine, Ding, McCarthy & CHATSG, 2008).

Another significant limitation in the existing research on EF in the pediatric TBI population is that many studies employ EF measures in a structured assessment situation, which does not place as high a demand on a child’s EF as do situations that occur in a child’s home or school environment. Therefore, EF assessments given in a structured setting may result in artificially high scores suggesting that a child is functioning at a higher level than what actually occurs when the child is faced with real life home and school demands (Sesma, Slomine, Ding, McCarthy & CHATSG, 2008). Furthermore, childhood TBI studies that do employ measures that are thought to better reflect a child’s daily EF, such as the BRIEF, are limited by that the fact that ratings are typically only obtained from caregivers. For example, Maillard-Wermelinger et al, (2009), Muscara, Catroppa and Anderson (2008b), and Nadebaum, Anderson, and Catroppa, (2007) all
examined the long-term EF of school-aged children following a head injury through the use of the parent version of the BRIEF, but not the teacher version. Vriezen and Pigott (2002) relied solely on parent ratings on the BRIEF to help determine whether or not performance based measures of EF assessed the same EF domains as those measured on the BRIEF. Sesma, Slomine, Ding, McCarthy and CHATSD (2009) obtained parent ratings on the BRIEF to determine the prevalence of executive dysfunction in children following a TBI and the relationship between degree of EF deficits and severity of injury.

Mares, McLuckie, and Schwartz (2007) opted to conduct a comparison study using the BRIEF that examined teacher and parent ratings of EF in a sample of children diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). The researchers concluded that teachers consistently reported students as displaying greater levels of executive dysfunction than did parents, possibly indicating that EF deficits are more pronounced in the school setting or that teachers are better equipped to recognize executive dysfunction in children. Group difference studies that compare teacher and caregiver BRIEF ratings of EF in children following a TBI are lacking; however, it is speculated that similar findings would result as EF is impacted by both ADHD and TBI (Mares, McLuckie, & Schwartz, 2007; Sesma, Slomine, Ding, McCarthy & CHATSG, 2008). The current investigation is designed to account for several of the aforementioned concerns by examining the impact of TBI on EF in young children through a comparison of teacher and caregiver EF ratings at four periods in time.
Chapter II

Method

Research Question

The research question investigated in this study was whether or not teachers and caregivers differ in their perceptions of EF in young children who have sustained a TBI at four separate points in time: baseline, 6 months post-injury, 12 months post-injury, and 18 months post-injury. It was hypothesized that there would be a difference in how teachers and caregivers rate the EF of young children with head injuries. The null hypothesis was that such differences do not exist.

Research Design

An inferential quasi-experimental research design examining group differences was used to compare teacher and caregiver ratings of EF in young children post-TBI at four points in time. This design was selected due to the inability to randomly assign participants to experimental groups. The independent variable was the evaluator’s relationship with the child (i.e. teacher or caregiver). The dependent variable was the Global Executive Composite scores obtained utilizing the three versions of the BRIEF (BRIEF-P, BRIEF- Parent Version, and BRIEF- Teacher Version). Caregiver and teacher ratings were matched based on the individual student being rated and a separate analysis was conducted for each point in time due to limitations posed in the existing in the data set.
Participants

A convenience sample comprised of 102 caregivers and 92 teachers was utilized for this study. Participants were preselected due to their inclusion in an existing data set provided by Cincinnati Children’s Hospital Medical Center in Cincinnati, Ohio. Information obtained included caregiver and teacher EF ratings of young children following a TBI, but was void of any personal information that would allow one to identify the participants involved in the study or the children they rated.

The general composition of caregivers who provided EF ratings ranged in age from 21 – 56 years old. Mothers of preschool aged children with head injuries made up 92% of the caregiver group and fathers and grandmothers comprised the remaining 8%. Close to 70% of caregivers reported that they were married and 58% indicated that they were employed at least part-time. Basic demographic information was unavailable for participants in the teacher group as it was not requested by Cincinnati Children’s Hospital Medical Center during the data collection process. In addition, each child was likely rated by at least two different teachers due to the fact that the data were collected over a period of a year and a half as children moved from one grade to the next.

At the time of injury, the children being rated were between 3 years, 0 months and 7 years, 0 months of age with a mean age of 4 years, 11 months. Fifty-two percent of those injured were males and 38.4% were females; the sex for 8.7% of the preschoolers was not provided. Most children were identified as being Non-Hispanic/Latino (94.1%). Close to 4% were said to be Hispanic/Latino and 2% did not provide ethnic identification. Most children were Caucasian (65.7%) and the remaining children were African American (34.3%). No children rated in the study were identified as American
Indian, Native Alaskan, Asian, Native Hawaiian or belonging to any other racial group.

The breakdown for the levels of TBI severity sustained by children included in this study was mild (14.7%), complicated mild (42.2%), moderate (20.6%) and severe (22.5%). The range of Glasgow Coma Scale ratings following injury ranged from 3 to 15 with the highest percentage being 15 (32.4%).

**Instrument**

Three versions of the BRIEF were utilized to gather information regarding caregiver and teacher perceptions of EF in preschool aged students who sustained a TBI. Caregivers and teachers completed the BRIEF-Preschool Version questionnaire for children who were between the ages of 2 years, 0 months and 5 years, 11 months. Once children reached the age of six, teachers were asked to fill out the BRIEF-Teacher Version and caregivers completed the BRIEF- Parent Version, which are both designed to be used for students 5 to 18 years of age. All three versions provide Global Executive Composite scores that can be used to compare EF ratings across all three versions of the inventory. Raw scores on the BRIEF are converted into T-scores ($M = 50, SD = 10$) that can be used to compare an individual score with those obtained in the standardized sample. Greater levels of executive dysfunction are indicated by higher T scores and those that are 65 or greater indicate a possibility of clinical significance (Gioia, Isquith, Guy, & Kenworthy, 2000).

The authors of the BRIEF state that the measure was standardized utilizing a normative sample based on the current demographic composition of the United States. A group profile for children with TBI was also constructed and comparisons were made with healthy controls. Children were matched for various demographic characteristics.
including age, socioeconomic status, and gender. Results showed that children who sustained a severe pediatric TBI demonstrated significant global dysfunction when compared with both the normal controls and with children who had sustained a mild to moderate TBI (Gioia, Isquith, Guy, & Kenworthy, 2000).

The BRIEF demonstrates high internal consistency reliability with alpha coefficients falling between .80 and .98 for the scales and indexes. Test-retest reliability is also high with caregiver coefficients ranging from .78 to .90 and teacher correlations falling between .65 to .94. Interrater reliability coefficients across teacher and caregiver ratings are lower and range between .06 and .28, which is likely due to the fact that home and school environments offer varied opportunities and expectations for behavioral performance (Gioia, Isquith, Guy, & Kenworthy, 2000; Plake, Impara & Spies, 2003).

The content validity of both the original and preschool versions of the BRIEF was addressed during the development of the measures. Pediatric neuropsychologists were consulted during this process to help determine the appropriateness of fit for each item in its intended scale. Throughout the BRIEF’s development, interrater agreement was assessed for each item-scale pairing and the scales were modified accordingly (Gioia, Isquith, Guy, & Kenworthy, 2000; Plake, Impara & Spies, 2003). The authors of the BRIEF note that the majority of the items included in the scales demonstrated a high degree of interrater agreement (Gioia, Isquith, Guy, & Kenworthy, 2000). The authors of the BRIEF state that determining the measure’s construct validity was impeded by a lack of existing EF rating scales specifically intended for children that could be used for comparison. However, the authors provide evidence that the individual scales included on
the BRIEF correlate with other well-known measures of attentional and behavioral functioning.

**Data Collection**

The EF data from the BRIEF-P, BRIEF-Teacher Version and BRIEF-Parent Version used in this study was previously collected by researchers at the Cincinnati Children’s Hospital Medical Center in Cincinnati, Ohio. Many children were not in formal school settings at the time of their injury, which is when pre-injury baseline data were collected. In these instances, daycare provider ratings were used in place of teacher ratings. Follow-up ratings were obtained at 6 months post-injury, 12 months post-injury, and 18 months post-injury. All raters completed the BRIEF-P for children up to 5 years, 11 months of age. Once children turned 6 years of age, caregivers completed the BRIEF-Parent Version and teachers completed the BRIEF-Teacher Version.
Chapter III

Results

Multiple paired-sample *t* tests were conducted to determine if group differences exist between teacher and caregiver ratings of EF in young children who sustained a TBI. At the time of injury or shortly thereafter, ratings of pre-injury EF were collected to serve as a baseline measure. Subsequent ratings were collected, on average, at 6 months post-injury, 12 months post-injury, and 18 months post-injury. Teachers and caregivers were matched based on the child they rated. The number and composition of matched pairs differed at each point in time due to a lack of consistency in responders across time. In addition, individuals completing the teacher rating form changed as children left daycare to attend a formal school setting or as they advanced in grades. These limitations do not allow data to be analyzed across time; however, there were a sufficient number of matched pairs to complete separate analysis of teacher and caregiver BRIEF ratings at the above mentioned four points in time.

Baseline

A baseline paired-samples *t* test was conducted to evaluate whether or not 39 matched pairs of teachers and caregivers rated preschooler pre-injurious EF differently. The results indicate that the mean caregiver BRIEF Global Executive Composite Score (*M* = 51.90, *SD* = 2.25) does not significantly differ from the mean teacher BRIEF Global Executive Composite Score (*M* = 51.67, *SD* = 1.67), *t*(38) = .014, *p* > .05. The standardized effect size index was small (*d* = .02) with considerable overlap in the
distributions for the EF ratings (see Figure 1). The 95% confidence interval for the mean difference between the two sets of ratings was -4.28 to 4.74.

Figure 1. Boxplots of BRIEF parent and teacher baseline global executive composite scores.

Six Months Post-Injury

Six month post-injury BRIEF ratings from 49 matched teacher caregiver pairs also showed similar results. A second paired-samples t test was conducted to evaluate whether teachers and caregivers as a whole viewed preschooler EF following a TBI differently at the six month marker. The results indicate that the mean caregiver BRIEF Global Executive Composite Score ($M = 52.92, SD = 12.19$) did not significantly differ
from the mean teacher BRIEF Global Executive Composite Score ($M = 55.63$, $SD = 17.14$), $t(48) = -1.28$, $p > .05$. The standardized effect size index was small ($d = -0.18$) with considerable overlap in the distributions for the EF ratings (see Figure 2). The 95% confidence interval for the mean difference between the two sets of ratings was -7.19 to 1.77.

Figure 2. Boxplots of BRIEF parent and teacher 6 month post-injury global executive composite scores.
Twelve Months Post-Injury

The third data collection period took place approximately 12 months post injury and resulted in responses from 38 matched teacher caregiver pairs. Once again, similar results occurred. A paired samples \( t \) test was conducted to determine if a significant difference existed between teachers and caregiver ratings of EF in preschool aged children 12 months post-injury. The results indicated that differences were not significant. The mean caregiver BRIEF Global Executive Composite Score \( (M = 52.89, SD = 14.25) \) did not significantly differ from the mean teacher BRIEF Global Executive Composite Score \( (M = 52.58, SD = 12.73) \), \( t(37) = -.145, p > .05 \). The standardized effect size index remained small \( (d = -0.02) \) with extensive overlap in the distributions for the EF ratings (see Figure 3). The 95% confidence interval for the mean difference between the two sets of ratings was -4.72 to 4.09.
Figure 3. Boxplots of BRIEF parent and teacher 12 month post-injury global executive composite scores.

Eighteen Months Post-Injury

The final data collection took place approximately 18 months post-injury and included 50 matched teacher caregiver pairs. Findings continue to follow the same pattern of being not significant. Results indicated that the mean caregiver BRIEF Global Executive Composite Score ($M = 51.82, SD = 13.43$) does not significantly differ from the mean teacher BRIEF Global Executive Composite Score ($M = 52.74, SD = 13.36$), $t(49) = -.437, p > .05$. The standardized effect size index was small ($d = -0.07$) with considerable overlap in the distributions for the EF ratings (see Figure 4). The 95% confidence interval for the mean difference between the two sets of ratings was -5.15 to 3.31.
Figure 4. Boxplots of BRIEF parent and teacher 18 month post-injury global executive composite scores.
Chapter IV

Discussion

This study examined whether or not caregivers and teachers differed in their BRIEF ratings of EF in young children who had sustained a TBI. TBI is the leading cause of long-term disability in the pediatric population and the number of students in schools who have sustained a TBI will most likely continue to increase as more children and adolescents survive their injuries. Knowledge of how parents and teachers rate students who have sustained a TBI is critical when gathering information that will determine how children in this population will be best served in an educational environment.

While studies such as the one conducted by Mares, McLuckie, and Schwartz (2007) demonstrated that teachers and caregivers provide significantly different ratings of EF in students with ADHD, no known study has examined whether this also holds true when rating young children who have sustained a TBI. It was hypothesized that findings from both studies would be similar since children in these two populations share many of the same difficulties in EF. Interestingly, analysis of the data does not support this belief. Results indicate that caregivers and teachers rate preschooler’s pre-injury and post-injury EF similarly. Any existing variation between ratings provided by the two groups at the four separate time periods was found to be not significant.

Results suggesting that teachers and caregivers have similar perceptions of EF in young children following a TBI may be viewed positively as schools and families work together in meeting the extensive needs of the pediatric TBI population. Agreement
between teachers and caregivers suggests that student behavior is stable across environments, which allows for a more consistent support structure to be established between home and school settings. In addition, early intervention following a TBI increases the likelihood of positive, long-term functional outcomes. When both families and school professionals are able to detect executive dysfunction in children following a TBI, less time is spent in identifying areas of concern and efforts can move more quickly toward employing much needed intervention services. While young children who have sustained a head injury benefit from consistent supports across settings and earlier intervention services, it is not yet clear as to why teachers and caregivers rate EF in young children with TBI similarly, but not children in the ADHD population.

Several factors unique to individuals with TBI may have been influential in why teachers and caregivers ratings of EF of young children with a TBI were found to be similar. First, even though children in the TBI and ADHD populations share similar EF deficits, those that result from a TBI are attributed to a distinct event that one can use to easily compare pre- and post- injury functioning. Due to the nature of ADHD, parents with children who have this disorder do not have an opportunity to compare their child’s EF with and without ADHD and, therefore, may consider these difficulties to be less severe or more typical in young children than they actually are. In addition, executive dysfunction in those with ADHD may not be fully apparent until young children have had time to significantly struggle in a more structured school environment or in grades that require them to demonstrate higher level EF skills.

Another possible reason that there was more congruency between teacher and caregiver ratings in this study than in the ADHD study is that the EF deficits may have
been more severe and thus more detectable to those who rated children with a TBI verses those who rated students diagnosed with ADHD. While the same types of concerns are commonly present in both populations, it is possible that the children being rated in the TBI study had greater levels of executive dysfunction than what was demonstrated by students in the ADHD study. Furthermore, it is likely that there was a great degree of home school partnership in preparing for students who had sustained a TBI to begin or return to school. It is possible that during this transition period caregivers and teachers kept in close contact and thus shared many of their concerns regarding a student’s EF, which would impact how they rated a child on the BRIEF. All these factors in isolation or in combination could have been influential in why teachers and caregivers rated the EF of preschoolers with a TBI in a similar fashion.

Limitations and Suggestions for Further Research

A significant limitation in conducting this study is that the data were already collected and, therefore, the research question had to fit within the confines of an existing data set. Consequently, it was not possible to gather missing data or to collect additional information from participants that would have proved beneficial in examining the research question. An explicit description of participant demographic composition was also lacking, which brings into question the external validity of the study. Random selection of participants was not an option due to the nature of the research study, which limits the ability to generalize the findings of this study to the larger pediatric TBI population as a whole. Finally, individuals who participated in this study were geographically isolated, which is another reason to question the generalizability of this study beyond those who live in a moderately sized Midwestern city.
The conducted study also suffers from several internal validity threats. Experimental treatment diffusion likely occurred as parents and teachers met to discuss concerns regarding how to best support students with TBI in the educational setting. Differential selection is also believed to have taken place during data collection, especially in respect to participants in the teacher group who had a much lower response rate than did participants in the caregiver group. Furthermore, experimental mortality is a concern with the teacher group as well since larger numbers of respondents were included in the first data collection interval when compared with the remaining three.

The limitations in this study point to opportunities for future research. Studies that include ratings for each of the clinical scales included on the BRIEF would provide more insight as to how parents and teachers rate the specific subdomains of EF. In addition, keeping raters consistent across time would allow one to determine if there are between group or within group differences in responses. Future work may also focus on comparing parent and/or teacher ratings of students with ADHD and TBI. Finally, increasing sample size and the diversity of the sample would allow for more generalization of findings to the larger pediatric population. While this is the only known study of its kind, it is hoped that these results will spur future research that examines this topic in greater detail.
Chapter V

Conclusion

Deficits in executive functioning, a collection of superordinate cognitive processes that allow for purposeful, independent goal-directed behavior, is a particularly debilitating consequence of traumatic brain injury (Nadebam, Anderson, & Catroppa, 2007; Sesma, Slomine, Ding, McCarthy & CHATSG, 2008). This is especially true as children begin or reenter school upon sustaining a traumatic brain injury. Measures such as the Behavioral Rating Inventory of Executive Function provide a means for evaluating a child’s executive functioning strengths and deficits both in the home and school environments. The current study examined whether or not teachers and caregivers differed significantly in how they rated preschool age students following a traumatic brain injury. Unlike research that has examined this same question with children in the ADHD population, teachers and caregivers included in this study were congruent in how they rated the EF of young children following a head injury. Professionals working with families and school personnel may be cautiously optimistic that teachers and caregivers are able to detect the same types and degrees of executive dysfunction in students following a traumatic brain injury. Future research is needed to determine if these findings can be replicated.
References


