

Parent Ratings of Social-Behavioral Functioning After Traumatic Brain Injury in Very  
Young Children

Crista E. Wetherington

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Approved by:

Committee Chair: Barbara H. Wasik, Ph.D.

Advisor: Stephen R. Hooper, Ph.D.

Reader: Desmond Runyan, M.D., Dr.P.H.

Reader: Steven Knotek, Ph.D.

Reader: William B. Ware, Ph.D.

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## ABSTRACT

Crista E. Wetherington: Parent Ratings of Social-Behavioral Functioning After Traumatic Brain Injury in Very Young Children  
(Under the direction of Dr. Barbara H. Wasik and Dr. Stephen R. Hooper)

Pediatric traumatic brain injury (TBI) can result in a myriad of negative outcomes, but little is known about the effects of early TBI on social-behavioral functioning. Using parent report on the Child Behavior Checklist (CBCL), the current study compared social-behavioral outcomes of 3-year-olds who sustained a TBI prior to the age of 2 to a typically-developing comparison group.

The study addressed the following questions: 1) Do parent ratings of the social-behavioral functioning of preschoolers who sustained mild and moderate/severe TBI as very young children differ significantly from parent ratings of typically developing preschoolers? 2) Do groups of preschoolers with mild and moderate/severe TBI differ significantly from a group of typically-developing children in their observed incidence of behavioral problems based on parent ratings? 3) What child-, family-, and injury-related variables (e.g., developmental level, maternal education, injury severity) predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI? No group differences emerged between the Mild TBI (n=31), Moderate/Severe TBI (n = 20), and Typically-Developing (n = 31) Groups on the CBCL; group means were average. In exploratory analyses, the TBI Group as a whole did not differ from the Typically-Developing Group on the CBCL. When breaking apart the Moderate/Severe Group in exploratory

analyses, the Moderate Group demonstrated a non-significant trend toward greater impairment in overall development, adaptive behavior, and social-behavioral functioning. Exploratory regression equations revealed Glasgow Coma Scale and the Self-Report Family Inventory Leadership scale as predictors of Externalizing Problems; overall developmental level significantly predicted Internalizing Problems.

Findings suggest that as preschoolers, children who sustained TBI at a very early age do not differ significantly in their social-behavioral functioning from one another or a comparison group. It is premature to infer that preschoolers do not evidence social-behavioral dysfunction after early TBI. Future research must use larger samples to develop models for identifying children who might evidence social-behavioral problems post injury. Longitudinal research is needed to assess whether the lack of findings at age three might be related to environmental and task demands that may emerge. Limitations and suggestions for future research are discussed.

To: My family

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## ABBREVIATIONS

CBCL.....	Child Behavior Checklist (1½ -5 years)
CHI.....	Closed head injury
CT.....	Computed Tomography
GCS.....	Glasgow Coma Scale
IDEA.....	Individuals with Disabilities in Education Act
IDEIA.....	Individuals with Disabilities Education Improvement Act
LOC.....	Loss of consciousness
MRI.....	Magnetic Resonance Imaging
Mullen ELC.....	Mullen Early Learning Composite
OI.....	Orthopedic injury
SES.....	Socioeconomic status
SIB-R.....	Scales of Independent Behavior, Revised
SRFI.....	Self-Report Family Inventory
TBI.....	Traumatic brain injury



## CHAPTER I

### INTRODUCTION

#### Overview

##### *Traumatic Brain Injury*

Traumatic brain injury (TBI) can have a devastating impact on the lives of individuals of all ages. Children who sustain TBI are often faced with significant disruptions to development, particularly if they are in critical stages of skill acquisition when the injury occurs. The trauma associated with an injury can create significant stress for both the child and the family. This burden can be profound and may exacerbate impairment or negative outcomes.

While many children do incur significant sequelae in their cognitive, motor, and emotional functioning following TBI, many do not. Although it is not always clear what differentiates these groups of children, an understanding of the factors which contribute to or protect against negative outcomes has unfolded. For example, injury severity seems to be a strong and consistent predictor of outcomes across a variety of domains. Research continues to measure variables which may be significant contributors to outcome after TBI, with findings suggesting that premorbid ability and family functioning also contribute to outcomes post injury (Donders & Ballard, 1996; Rivara et al., 1996).

One functional domain that appears to be vulnerable to TBI is social-behavioral functioning. In general, positive social-behavioral functioning reflects age-appropriate thoughts and actions. When social-behavioral functioning is impaired or delayed, children

lack the resources to interact optimally with others and with their environments. Problems such as attentional difficulties, aggressive behavior, impaired social problem-solving skills, hyperactive behavior, anxiety, and depression are just some examples of the ways in which impairments in social-behavioral functioning can manifest following a TBI, with many children experiencing difficulties in multiple areas.

The preschool years are a critical time for developing coping resources necessary for later in life. Failure to establish these important skills can result from biological variables, a lack of experience, or a neurological insult to the brain. Trauma to the brain at an early age could impact the development of social-behavioral skills by occurring while many of these skills are in developmental ascendance. Such an impairment could evolve because: 1) the injury itself involves areas of the brain critical for aspects of social-behavioral functioning; 2) the stress of the trauma impacts the child emotionally such that he or she is not able to return to preinjury levels of social-behavioral function; 3) the family incurs such stress as a result of the injury and associated sequelae (e.g., hospital bills, job insecurity, loss of partner, anxiety over child's well-being, guilt over the injury) that parents are not able to provide the child with the tools needed to promote positive social-behavioral growth.

Literature regarding the social-behavioral outcomes of preschool TBI is limited. While data have begun to emerge on cognitive and developmental functions after TBI in early childhood (Ewing-Cobbs, Miner, Fletcher, & Levin, 1989; Ewing-Cobbs et al., 1997; Ewing-Cobbs et al., 1998; Morse et al., 1999), little is known about the impact of TBI on social-behavioral functioning. A better understanding of behavioral outcomes would facilitate designing interventions, monitoring progress, and detecting difficulties—even later-onset problems—as early as possible. The current study addressed the need for more information

about social-behavioral outcomes in preschoolers after TBI. Specifically, parent ratings of social-behavioral functioning of preschoolers at three years of age, and at least one year after TBI, were compared to parent ratings of a matched group of typically developing children.

The years between birth and age 5 or 6 are a time of rapid development, marked by the emergence of many important skills and milestones. Children whose development is disrupted by TBI during this stage of life may display negative outcomes (Ewing-Cobbs, Duhaime, & Fletcher, 1995) ranging from deficits in overall development (Ewing-Cobbs et al., 1997) to specific difficulties in areas such as language (Morse et al., 1999). TBI appears to manifest itself somewhat differently in preschoolers than in older children, due in part to the fact that preschoolers are in various stages of skill acquisition. Given that older children evidence disruption in areas of social-behavioral functioning (Dennis, Guger, Roncadin, Barnes, & Schachar, 2001; Donders & Ballard, 1996; Kirkwood et al., 2000), it follows that preschool-aged children might also display difficulty in their social behavior after TBI. Moderating factors, such as time of injury (Dennis et al., 2001), gender (Donders & Woodward, 2003), family functioning (Rivara, et al., 1996), race (Yeates et al., 2002), and injury-related variables (Ewing-Cobbs et al., 1997) are important predictors of TBI outcome in general, and likely are related to the outcomes observed in social-behavioral functioning in preschool children.

### Previous Research

Literature of the past two decades has placed increasing emphasis on understanding how TBI impacts the development of children. While it was believed that social-behavioral dysfunction was one sequela of TBI in school-age children, research did not specifically

target this domain until the last 15 to 20 years. The literature concerning social-behavioral functioning in school-aged children is more abundant now, but is still not clear.

Considerable research suggests social-behavioral impairment after brain injury in children (Basson et al., 1991; Dennis et al., 2001; Donders & Ballard, 1996; Feeney & Ylvisaker, 2003; Fenwick & Anderson, 1999; Green, Foster, Morris, Muir, & Morris, 1998; Janusz, Kirkwood, Yeates, & Taylor, 2002; Kinsella, Ong, Murtagh, Prior, & Sawyer, 1999; Kirkwood et al., 2000; Max et al., 1998; Milders, et al. 2003; Schretlen, 2000; Schwartz et al., 2003; Taylor et al., 2002). Other research, however, has not found support for extensive behavioral dysfunction post injury (Anderson et al., 2001; Fay et al., 1994; Fletcher, Ewing-Cobbs, Miner, Levin, & Eisenberg, 1990; Hayman-Abello, Rourke, & Fuerst, 2003).

#### *Developmental Outcomes in Very Young Children Following a TBI*

Research concerning the developmental outcomes of infants, toddlers, and preschoolers after TBI is limited. What is available suggests that TBI in young children may impact academic, motor, and cognitive functions, with impairments often persisting long past the injury (Anderson et al., 2001; Donders & Ballard, 1996; Kinsella et al., 1999; Max et al., 1998; Schwartz et al., 2003). Further, the type of TBI (i.e., inflicted versus noninflicted) may dictate the severity of subsequent sequelae. For example, inflicted TBI (e.g., Shaken Baby/Shaking-Impact Syndrome, physical abuse) appears to result in more significant limitations than deficits observed in noninflicted TBI (e.g., falls, motor-vehicle accidents, pedestrian injuries; Ewing-Cobbs et al., 1997). The very young age of children who sustain inflicted TBI, their neurological vulnerability, and the associated diffuse nature of injury likely contribute to these negative outcomes (Ewing-Cobbs et al., 1995).

### *Social-behavioral Outcomes Following Pediatric TBI*

The social-behavioral outcomes following TBI in very young children have not been reported. What is known comes largely from work with adults and school-age children. Trauma in general has been linked to overall behavioral dysfunction (Basson et al., 1991), and a number of studies have related TBI to subsequent behavior problems in school-age children (Donders & Ballard, 1996; Green et al., 1998). Deficits in social-behavioral functioning in school-age children after TBI include compromised adaptive behavior skills (Green et al., 1998; Max et al., 1998), decreased social competence (Max et al., 1998), and deficits in attention and response inhibition (Fenwick & Anderson, 1999). Social problem-solving deficits (Janusz et al., 2002) and difficulties with internalizing behaviors (Kirkwood et al., 2000) have been noted in school-age children. TBI also has been linked to increased psychiatric disorder (Brown et al., 1981). Age (Dennis et al., 2001), severity of injury (Anderson et al., 2001; Janusz et al., 2002; Kinsella et al., 1999), socioeconomic status (SES; Taylor et al., 2002; Yeates et al., 2004), and preinjury functioning (Schwartz et al., 2003) have been shown to significantly predict social-behavioral outcome. The effects of TBI on these domains may continue to exist long-term. For example, Schwartz et al. (2003) found behavior problems 4 years post injury to be related to severity and SES.

Other pediatric research has found that social-behavioral functioning, while sometimes more impaired than that of control groups, may not yield pervasive and persistent problems after TBI (Fay et al., 1994; Fletcher et al., 1990). Children who sustained TBI were not more likely than an orthopedically-injured control group to have cold relationships with parents as adolescents (Wade et al., 2003), nor were children more likely to be classified as anything other than a normal psychosocial subtype after TBI (Hayman-Abello et al., 2003). Many

children seem to be rated in the average range of psychosocial functioning after TBI (Fay et al., 1994; Fletcher et al., 1990). Children may fall within the average range, however, and still exhibit social-behavioral functioning almost a full standard deviation below what is expected, suggesting that these areas should be monitored. The implications of such findings are that children are either not as impaired in their social-behavioral functioning as other research might suggest or that subtle differences exist and persist, but may be overlooked because a child appears to be functioning in the normal range.

Because of the different outcomes TBI tends to yield in very young children versus older children on measures other than social-behavioral functioning (Kriel et al., 1989), and the different mechanisms of injury in younger children (Ewing-Cobbs et al., 1995), it cannot be assumed that preschoolers demonstrate the same patterns in their social-behavioral outcomes post injury as school-aged children. Understanding how young children with TBI differ from other 3-year-olds in their social-behavioral status would provide valuable information about the effects of TBI. Further, recognizing specific characteristics of young children with TBI who manifest behavior problems would permit early identification and intervention, possibly ameliorating negative outcomes. Unfortunately, no known research has specifically targeted social-behavioral outcomes in children injured in infancy and early childhood. Discrepant findings regarding behavior dysfunction in older children make it even more important to study preschool outcomes in this area so as to increase our understanding of the developmental continuity of such dysfunctions.

### Current study

The current study examined social-behavioral functioning in preschoolers with traumatic brain injury (TBI) relative to a group of typically developing preschoolers. Data were collected on a sample of children in North Carolina who sustained TBI prior to their second birthday. Home visits near the children's third birthday included developmental assessments and a thorough parent interview. The parent interview provided information about family functioning, the child's adaptive behavior, and parent ratings of social behavior.

The comparison group was comprised of typically developing preschool children, recruited from preschools, daycares, and Head Start centers in central North Carolina and southeastern Virginia. Parent ratings on the Child Behavior Checklist were used to determine if the profile of preschool children with TBI differed from that of the typically developing preschoolers with respect to social-behavioral problems.

### Statement of Purpose

Positive social-behavioral functioning is a key component of overall development. Problems in areas such as aggression, attention, depression, and anxiety have the potential to impact negatively on multiple areas of functioning. In addition, such problems tend to persist over time, increasing the likelihood that children will encounter concomitant problems. For these reasons, and given the research suggesting that TBI may lead to more negative outcomes in younger children than in older children, it is important for the social-behavioral functioning of preschoolers after TBI to be examined carefully.

The current study sought to add valuable information to an area where much research is needed. By investigating the social-behavioral functioning of preschoolers after TBI in

relation to typically developing preschool children, it was expected that critical information would be gained about social-emotional functioning post injury and early indications of potential areas of concerns. Early referral and identification of children who may develop significant behavioral dysfunction after TBI may be pivotal in preventing or minimizing long-term difficulties.

The complexity of the recovery process and later onset of certain disorders also suggest that early identification might allow supports to be in place before the child even demonstrates significant symptoms of behavioral dysfunction. The findings of this study have implications for early identification, early intervention, programming, and parent and teacher education.

### Questions and Hypotheses

To address the current lack of scientific knowledge and research on the social-behavioral outcomes of preschoolers after TBI, this study compared parent ratings on the Child Behavior Checklist (1½ - 5) of young children at age 3 years who sustained mild and moderate/severe traumatic brain injury prior to age 2 to a group of typically developing children, aggregately matched on age, gender, race, and maternal education. The study will address the following questions:

**1) Do parent ratings of the social-behavioral functioning of preschoolers who sustained mild and moderate/severe TBI as very young children differ significantly from parent ratings of typically developing preschoolers?** It is hypothesized that preschoolers with mild and moderate/severe traumatic brain injury will be significantly impaired in their social-behavioral functioning relative to children in a typically-developing group on parent ratings on the early childhood version of the Child Behavior Checklist. It is also hypothesized that



an effect for severity will be found, with children in the Moderate/Severe TBI Group demonstrating more difficulties in their social-behavioral functioning than children in the Mild TBI and Typically-Developing Groups. Specifically, it is expected that children with TBI will be more impaired than the Typically-Developing Group on all three CBCL composite scales (Internalizing Problems, Externalizing Problems, and Total Problems) and on some individual scales.

**2) Do groups of preschoolers with mild and moderate/severe TBI differ significantly from a group of typically-developing children in their observed incidence of behavioral problems based on parent ratings?** That is, does a significantly higher proportion of preschoolers with mild TBI or moderate/severe TBI evidence difficulties in their social-behavioral functioning at or above the 90th percentile? It is hypothesized that a higher proportion of children in the Mild and Moderate/Severe TBI Groups will demonstrate social-behavioral functioning that is at or above the 90th percentile (T-score > 63) relative to a group of typically-developing children, based on parent ratings of social-behavioral functioning.

**3) What child-, family-, and injury-related variables (e.g., developmental level, maternal education, injury severity) predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI?** It is hypothesized that injury severity and maternal education will be significant predictors of social-behavioral functioning as measured by the CBCL Internalizing, Externalizing, and Total Problem scores.

## CHAPTER II

### LITERATURE REVIEW

#### Introduction

Despite extensive research regarding a host of medical, developmental, and behavioral outcomes after pediatric traumatic brain injury (TBI), existing literature has not adequately addressed the social-behavioral functioning of preschoolers who have sustained a TBI. Literature on social-behavioral outcomes after school-age TBI reveals mixed findings (Anderson et al., 2001; Basson et al., 1991; Donders & Ballard, 1996; Fay et al., 1994; Hayman-Abello et al., 2003; Janusz et al., 2002; Kirkwood et al., 2000; Schwartz et al., 2003; Yeates et al., 2004). While this research is not consistent, it suggests a trend people in the field of TBI have long suspected—that many children do suffer adverse social-behavioral consequences of TBI (Basson et al., 1991; Janusz et al., 2002; Kirkwood et al., 2000).

In response to the critical need for literature about preschool social-behavioral functioning after TBI, the goals of the current study were to 1) **compare parent ratings of social-behavioral outcomes of preschoolers who sustained mild and moderate/severe TBI as very young children to social-behavioral outcomes of typically-developing preschoolers**, 2) **compare the frequency of social-behavioral dysfunction between these groups based on parent ratings**, and 3) **determine what child-, family-, and injury-related variables predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI**. To provide a literature-based rationale for conducting the study, the following chapter reviews recent literature including definitions and prevalence

rates of TBI, the developmental areas potentially affected by TBI (e.g., school-age and preschool-age outcomes in the areas of neurocognition, social-behavioral functioning, academic performance, and recovery/long-term follow-up), variables influencing recovery following TBI, and the brain development and specific mechanisms of traumatic brain injury in infants and children between birth and two years of age.

### Definition of TBI

Multiple definitions of TBI abound, with subtle differences being evident between them, depending on the emphasis of the person or organization publishing the definition. Kraus, Rock, & Hemyairi (1990) defined TBI as “physical damage to, or functional impairment of, the cranial contents from acute mechanical energy exchange exclusive of birth trauma.” The Brain Injury Association of America defines TBI as the following:

“Traumatic brain injury is an insult to the brain, not of a degenerative or congenital nature but caused by an external physical force, that may produce a diminished or altered state of consciousness, which results in an impairment of cognitive abilities or physical functioning. It can also result in the disturbance of behavioral or emotional functioning. These impairments may be either temporary or permanent and cause partial or total functional disability or *psychosocial maladjustment* [italics added].” (Definition adopted by the Brain Injury Association Board of Directors, February 22, 1986, retrieved from [http://www.biausa.org/Pages/types\\_of\\_brain\\_injury.html](http://www.biausa.org/Pages/types_of_brain_injury.html), May 13, 2006.)

A key part of this definition is that TBI must be caused by an external physical force and that congenital conditions do not constitute TBI. Initially identified as a distinct category of disability under the Individuals with Disabilities in Education Act (IDEA) of 1990, TBI has remained a classification under which students may receive special education services in subsequent reauthorizations (e.g., IDEA 1997 and IDEIA 2004). The definition of TBI has remained consistent throughout these reauthorizations:

“An acquired injury to the brain caused by an external physical force, resulting in total or partial functional disability or both, that adversely affects a child’s educational performance. Traumatic brain injury applies to open or closed head injuries resulting in impairments in one or more areas, such as cognition; language; memory; attention; reasoning; abstract thinking; judgment; problem-solving; sensory, perceptual, and motor abilities; psychosocial behavior; physical functions; information processing; and speech. Traumatic brain injury does not apply to brain injuries that are congenital or degenerative, or to brain injuries induced by birth trauma.” (Knoblauch & Sorenson, 1998; retrieved May 14, 2006 from <http://www.ericdigests.org/1999-4/ideas.htm>.)

The requirement that TBI impair school performance distinguishes IDEIA’s definition of TBI from that of other organizations. Any special education classification requires that the disability adversely affect a student’s ability to learn. However, unlike other IDEIA classifications, the dynamic aspect of recovery from traumatic brain injury requires close monitoring of the student’s progress, particularly in the first 1 to 2 years after injury—even if sequelae are not immediately apparent. Furthermore, both definitions allude to “psychosocial” impairment or maladjustment as possible sequelae of TBI. Identification and a better awareness of psychosocial outcomes are important for a thorough understanding of TBI. While much remains to be learned about recovery from TBI in the preschool years, what is known about school-age TBI suggests that children demonstrate differential recovery curves which may be related to factors such as severity, premorbid abilities, socioeconomic status (SES), and family functioning.

### Prevalence

Approximately 100 per 100,000 individuals of all ages incur TBI annually; 52,000 of these injuries result in fatalities (NIH Consensus Development Panel, 1999). An estimated 2.5 million to 6.5 million people currently live with the effects of TBI. Although more prevalent in individuals between the ages of 15 and 24 years, TBI affects 180 out of every 100,000

children under the age of 15 years (Kraus, 1995). It is especially disturbing that TBI is the leading cause of death and long-term disability in children and adolescents, with over 30,000 children a year being disabled for life as a result of a TBI (Langlois, Rutland-Brown, & Thomas, 2004).

### *Prevalence of TBI in Preschoolers*

The majority of individuals who sustain TBIs are over the age of 5 years, but preschool-aged children may be at increased risk of negative outcome because of their neurodevelopmental status and associated neurological vulnerability (Ewing-Cobbs et al., 1998). Early literature hailed the plasticity of the young brain as protection against the negative outcomes associated with TBI in older children and adults, but more recent research suggests that early TBI can be quite detrimental to development (Ewing-Cobbs et al., 1998). Kraus et al. (1990) studied epidemiological data of head injury from infancy through young adulthood. Of 1,234 documented head injuries in San Diego County in 1981, 239 (19%) were in children under the age of 5. Hahn et al. (1988) found that over 40% of children admitted to a Chicago hospital for head injury during a 5-year period were under 3 years of age. A disproportionate number of head injuries in children under 2 years appears to be inflicted (i.e., the result of abuse; Duhaime, Alario, Lewander, Schut, & Sutton, 1992). Of the 152 serious or fatal TBI cases in children under 2 years identified in North Carolina between 2000 and 2001, just over half ( $n = 80$ ) were inflicted (Keenan et al., 2003).

Langlois et al. (2004) have provided the most comprehensive prevalence information regarding TBI in early childhood using data from the time period between 1995-2001. For preschool children between birth and 4 years of age, they reported approximately 200,000

visits to Emergency Departments following a TBI, 15,000 hospitalizations, and approximately 1,100 deaths. Of the visits to the Emergency Department, about 62% of patients were male and 79% were Caucasian. The primary reason for visits to the Emergency Departments was falls (54.2%). Of young children hospitalized due to TBI, over 61% were male and about 56% were Caucasian. Similar to Emergency Department visits, falls continued to be the primary cause of hospitalization (40.7%), with about 11% resulting from motor vehicle traffic incidents, and about 7% secondary to assaults. Motor vehicle-traffic incidents (45.4%) and assaults (31.7%) were the primary causes of brain-injury related deaths in children birth to age 4 years.

#### *Biological Bases of Traumatic Brain Injury in Very Young Children*

Both the maturational state of the brain between the ages of birth and 2 years as well the mechanisms of injuries common in this age group result in neurological outcomes that are different from those observed in older children and adults. An understanding of these biomechanical factors is important for conceptualizing how TBI can affect the functioning of very young children.

#### *Developing Brains, Developing Bodies*

Certain aspects of the anatomy of very young children make them more vulnerable to the negative effects of TBI. Young children have proportionally larger heads than older children and adults (Hooper & Mills, 2004). The disproportional distributions of the head, neck, and trunk result in TBI impacting the bodies and brains of very young children differently (Ewing-Cobbs et al., 1995). For example, neck muscles may not yet be strong enough to

protect the head and brain stem from injury as well as they would in older individuals. The developing skulls of infants have soft membranes (i.e., sutures and fontanelles) that differ significantly from the rigid skulls of adults, contributing to the differential impact of TBI (Goldsmith & Plunkett, 2004). Other characteristics of the skull and brain that make infants especially susceptible to injury are the skull's thinness and pliability, the brain's softness, a lack of a myelin sheath for many axons, a flatter base of the skull, immature neck muscles, and a large, shallow subarachnoid space (Case, Graham, Corey Handy, Jentzen, & Monteleone, 2001).

### *Biomechanics of Traumatic Brain Injury*

TBI results from one or more of three forces: 1) tension, during which tissue tears apart; 2) compression, which consists of brain tissue being pushed together, and 3) shearing, at which time one tissue slides over another (Snow & Hooper, 1994). Injuries can be characterized by either acceleration-dependent factors or nonacceleration-dependent factors. Acceleration, deceleration, and rotational injuries are examples of acceleration-dependent factors, while crushing injuries typify nonacceleration-dependent factors.

When a sudden external force comes into contact with more slowly moving brain tissue, an acceleration injury results (Snow & Hooper, 1994). Deceleration injuries occur when the head is moving and strikes a stationary object, with damage to the brain possible at both the site of injury (coup) and the site opposite the injury (contrecoup). Rotational injuries are characterized by the movement of the brain on the brain stem and can lead to shearing and tearing of vertically intended cerebral tissue (e.g., neural connections between the brain stem and frontal cortex).

Ewing-Cobbs et al. (1995) describe contact forces and inertial forces that are similar to these acceleration-dependent factors and nonacceleration-dependent factors. Contact forces occur when a head and an object come into contact; injury to the scalp, skull, and/or brain results. Contact injuries tend to result in focal neurological dysfunction. In contrast to contact forces, inertial forces occur when the brain incurs a sudden, sometimes violent, rapid movement. This type of injury results in translational (linear) and rotational injuries (i.e., the brain rotates around the axis). Although translational injuries tend to be more benign, inertial injuries generally result in shearing, widespread injury, and global deficits (Ewing-Cobbs et al., 1995). Falls sustained by very young children often result in translational injuries that tend to be milder than inflicted injuries, which are primarily rotational.

Goldsmith and Plunkett (2004) describe impulsive and impact loading as the two mechanisms of TBI. Impulsive loading occurs when motion to a part of the body other than the head results in movement of the head, with the head rotating on the cervical spine; the brain and skull move at different rates. Impact loading, on the other hand, takes place when the head hits a nonmoving object or when a moving object strikes the head.

#### *Etiology of TBI in Very Young Children*

Traumatic brain injury in infants and toddlers usually results from falls, motor vehicle crashes, crushing injuries, and abuse (Ewing-Cobbs et al., 1995). Due to the disproportionate number of children in the youngest age group who sustain inflicted TBI (i.e., TBI that is the result of abuse), it will be described in greater detail. Falls tend to produce injuries of translational force that result in focal dysfunction, but with relatively good outcomes. Motor vehicle crashes often cause rotational injuries in the brain that are



much more diffuse and severe. Crushing injuries, where the skull is crushed by an object or force, are rarer, but can result in a wide range of outcomes. Many children do survive this type of injury without severe dysfunction. Rotational acceleration-deceleration injuries, which characterize inflicted injuries, are rarely found in noninflicted TBI in the preschool years. Typically, these types of injuries are associated with child abuse.

A substantial number of children under the age of 2 years have sustained inflicted, nonaccidental injuries caused by abuse (Duhaime et al., 1992). In an examination of 100 children under the age of 2 at the time of brain injury, Duhaime et al. found that 24% of the children had inflicted injuries and an additional 32% had injuries considered suspicious. The authors suggested that accidental blunt head injury in this age group tended to result in minimal negative outcomes, with the exception of those secondary to falls and motor vehicle accidents.

Keenan et al. (2003) prospectively studied the incidence of both inflicted (i.e., abuse) and noninflicted (i.e., motor vehicle accidents, pedestrian accidents, falls) TBI in early childhood in a population of children injured in North Carolina between 2000 and 2001. During the first 2 years of life, the incidence of inflicted TBI was 17.0 per 100,000 person-years with the incidence higher in the first year of life than the second (29.7 vs. 3.8 per 100,000 person-years). Inflicted TBI was more likely to occur in boys than in girls, and was more common in children of young mothers, of non-European-American heritage, and with multiple births. Such findings demonstrate that the incidence of TBI in young children is substantial, and highlight the importance of conducting the current study of preschoolers with TBI.

*Inflicted Versus Noninflicted TBI.* Inflicted TBI is thought to occur when an inexperienced caregiver or a caregiver with limited coping skills is caring for an infant who is difficult to soothe and cries continuously for a period of time. When other strategies to calm the infant do not work, the caregiver becomes frustrated and shakes the baby. In many cases, the first time shaking occurs, the insult to the brain is enough to quiet the baby, but not enough that significant changes in behavior are noticed. Because the shaking has quieted the infant previously, the caregiver likely is reinforced to repeat this strategy. Longer, more vigorous shaking may result in the rotational acceleration-deceleration injuries observed in very young children. A disproportionate number of TBIs in very young children are the result of abuse or inflicted injury, often referred to as shaken-baby or shaking-impact syndrome.

It is difficult to know precisely how inflicted injuries happen as mechanisms of injury are not always clear. Alexander, Levitt, and Smith (2001) discuss the likely etiology of inflicted injury. They suggest that

“the perpetrator holds the child by the chest so that they face each other, compressing the chest while violently shaking the infant to and fro. Infants are usually held off the floor and shaken back and forth at full arm extension, but a toddler may be too heavy to lift. In these instances, the adult may straddle the recumbent child and shake it, gripping primarily the upper torso. In this instance, the child’s skull frequently impacts against the floor as the shaking proceeds...Shaking probably lasts a maximum of 20 seconds, with up to 40-50 shakes. In most cases, the time period of shaking is probably 5-10 seconds (10-30 shakes)...The precise manner whereby the brain is injured appears to depend, in part, on repetitive oscillations...the complex interplay between various accelerations and repetitive movements may determine the pattern and severity of brain injury (p. 52).”

The primary mechanism of inflicted injuries has been described as “a non-accidental inflicted injury probably involving rapid angular acceleration-deceleration forces of a major magnitude” (Duhaime, Christian, Moss, & Seidl, 1996), with the associated “rotational acceleration-deceleration forces” resulting in more severe TBI. In addition to the back and

forth movement, which results in repeated acceleration and deceleration in inflicted TBI (Case et al., 2001), many believe that an impact frequently accompanies shaking.

Rotation of the brain within the brain cavity is the most common mechanism of inflicted injuries (Case et al., 2001). Since rotational injuries are thought to result in diffuse and global impairment in general (Ewing-Cobbs et al., 1995), it follows that inflicted injuries often result in significant impairment. Associated with rotational injuries are shearing, which causes diffuse axonal injury, and tearing, which leads to hemorrhaging; both can result in significant impairment of neurologic functioning. Children under the age of 4-5 years are more vulnerable to shearing injuries than older children and adults due to their stage of brain development in the early years (Case et al., 2001). Brain swelling is often evident with shearing injuries, and this process also can cause secondary brain injury.

The high incidence of inflicted TBI in the youngest age group as well as the specific maturational stage of the developing brain leads to potentially different presentations and sequelae of TBI in infants and preschoolers than in older children and adults. For example, in a sample of preschool children, tests of intellectual functioning suggested that 45% of children with inflicted TBI and 5% of children with noninflicted TBI were functioning in the mentally deficient range (Ewing-Cobbs et al., 1998). An understanding of the etiology of injuries in the early years and biomechanics of injury to the young brain are important for a thorough grasp of the effects of TBI on development and subsequent developmental outcomes.

#### TBI Outcomes in School-Age and Preschool-Age Children

Theoretical frameworks are important for conceptualizing the impact of TBI on outcomes in children of all ages. A developmental perspective is useful for its acknowledgement of a

child's stage of life, which can be particularly helpful during the preschool years (Anderson & Yeates, 1997; Donders & Ballard, 1996; Lazar and Meladino, 1995). The interaction between recovery and expected development can strongly influence long-term outcome. This emphasis is especially important when children sustain TBI early in life, as the foundation for much knowledge and the emergence of many major processes transpire during this time. Trauma to the brain in young children has the potential to disrupt skills at the time of the injury as well as impact skills that have not yet been developed (Gil, 2003). A developmental perspective is also important when considering that premorbid functioning can predict behavioral outcome after TBI (Donders & Ballard, 1996), with early injuries impacting functioning later in a child's life.

Research during the past two decades has illustrated the negative impact that TBI can have on a variety of outcomes including neurocognition (Anderson, Catroppa, Rosenfeld, Haritou, & Morse, 2000; Ewing-Cobbs et al., 1997; Jaffe et al., 1993; Kinsella et al., 1997; Verger et al., 2001), social-behavioral functioning (Basson et al., 1991; Donders & Ballard, 1996; Kinsella et al., 1999; Schwartz et al., 2003), academic performance (Catroppa & Anderson, 1999; Ewing-Cobbs et al., 2004), and recovery/long-term outcome (Anderson, Catroppa, Morse, & Haritou, 1999; Catroppa & Anderson, 2004; Ewing-Cobbs et al., 2004; Jaffe et al., 1993). These outcomes are reviewed below, with a particular focus on social-behavioral findings.

### *Outcomes of TBI in School-Age Children*

#### *Neurocognitive Outcomes in School-Age Children*

Neurocognitive outcomes have varied widely in school-age children and have included both positive and negative outcomes across general and specific neurocognitive domains.

Following a TBI, weaknesses in intellectual functioning have been reported (Jaffe et al., 1993; Verger et al., 2001), with specific problems being noted in visual memory, visual-spatial abilities, and executive functions (Verger et al., 2001). In addition, factors such as severity of injury, premorbid functioning, SES, and age at injury can affect these outcomes (Catroppa & Anderson, 2004). For example, in a group of 68 children who were between 8 and 12 years old at the time of study enrollment, TBI severity influenced WISC-III Full Scale IQ scores and showed a trend toward a dose-response relationship for language, but was not significantly related to expressive language, language comprehension, or memory skills (Catroppa & Anderson, 2004). In that sample, recovery varied by domain, with the entire TBI group improving in their memory functioning over the 2-year follow-up, but declining in their comprehension.

Specific deficits have been noted in areas of language and attention after TBI in school-age children. For example, Chapman et al. (2001) reported that children with severe TBI tended to struggle in their verbal discourse skills more than children with mild/moderate injuries, but demonstrated better recovery of this skill over a 3-year follow-up. Problems with attention also seem to be more common after severe TBI (Dennis et al., 2001; Fenwick & Anderson, 1999). Dennis and colleagues (2001) studied both attentional-inhibitory control and social-behavioral regulation in 105 children with mild, moderate, and severe closed head injuries. Age at injury and time since injury best predicted attentional-inhibitory control; injury severity and frontal lobe functioning moderated by injury severity predicted social discourse. Children with mild head injury and children with mild injuries to other parts of the body were rated similarly on attention by teachers using the Connors Rating Scale (Wrightson, McGinn, & Gronwall, 1995).

### *Social-Behavioral Outcomes in School-Age Children*

While parents, teachers, and caregivers have long provided informal reports of social-behavioral difficulty after pediatric TBI, only recently has research begun to address this important outcome systematically. Attention to the topic, however, has not yielded clear conclusions about the nature of social-behavioral functioning after injury.

Some research suggests that TBI results in impaired social-behavioral functioning (Anderson et al., 2001; Basson et al., 1991; Dennis et al., 2001; Donders & Ballard, 1996; Feeney & Ylvisaker, 2003; Fenwick & Anderson, 1999; Green et al., 1998; Janusz et al., 2002; Kinsella et al., 1999; Kirkwood et al., 2000; Max et al., 1998; Milders et al., 2003; Schretlen, 2000; Schwartz et al., 2003; Taylor et al., 2002), while other studies do not support such findings (Hayman-Abello et al., 2003). Still other research suggests that while TBI groups, especially severe TBI groups, are more impaired than comparison groups in their social-behavioral functioning, parental ratings of behavior fall in the average range (Anderson et al., 2001; Fay et al., 1994; Fletcher et al., 1990; Kinsella et al., 1999). Furthermore, even investigators who have found support for impairments post injury do not agree upon the nature of the deficits or on the variables that may predict such outcomes.

Researchers have found associations between social-behavioral outcome and factors such as trauma with and without head injury (Basson et al., 1991), premorbid functioning (Donders & Ballard, 1996; Schwartz et al., 2003), injury-related variables such as lesions on CT/MRI scan, and longer time in coma (Donders & Ballard, 1996), age at injury and time since injury (Dennis, 2001), severity of injury (Janusz, et al., 2002), and socioeconomic status (Kirkwood et al., 2000). Difficulties with social problem-solving skills (Janusz et al., 2002) and internalizing behavior (Kirkwood et al., 2000) also are evident.

*Psychiatric Disorders.* Rutter's (1981) early review of literature on pediatric brain damage suggested that brain injury has the potential to result in both intellectual impairment and psychiatric disorder in children. Although injury site did not appear related to outcome, behavioral function preinjury strongly predicted psychiatric disorder after severe injury. Rutter concluded that severity more strongly influences cognitive than behavioral outcomes.

Brown et al. (1981) also found evidence relating injury severity to psychiatric disorder. Children who had sustained severe head injury demonstrated behavioral disturbance at a rate that was three times that of a control group, with these disturbances persisting over time. Brown and colleagues identified preinjury behavior as predictive of behavior at follow-up, but could not detect a clear pattern for explaining behavioral outcomes.

When compared to children with orthopedic injuries (OI), children who sustained TBI between the ages of 6 and 12 years were more likely to present with depressive symptoms 6 months after the injury according to parent ratings on the Child Behavior Checklist (Kirkwood et al., 2000). A year after injury, the difference between the groups persisted, but had waned. Despite between-group differences, mean scores of both groups fell in the average range. A greater proportion of children in the TBI group evidenced internalizing problem scores greater than the cut-score of 63 (4% of the OI group, 18% of the moderate TBI group, and 24% of the severe TBI group). In contrast to parent ratings, children's reports of their own depressive symptoms on the Children's Depression Inventory did not differ between the groups.

*Adaptive Behavior.* Another strategy for exploring social-behavioral outcomes has been to examine adaptive behavior following TBI. The negative effects of TBI on adaptive behavior

functioning are apparent (Fletcher et al., 1990), even 2 years post injury (Max et al., 1998), with severity of injury influencing the extent of impairment of adaptive behavior (Fletcher et al., 1990; Max et al., 1998). Two years following TBI, children between the ages of 5 and 14 years at the time of a severe injury were more likely to be rated lower on adaptive behavior (Max et al., 1998), with the specific areas of communication and socialization negatively affected. Parent ratings of social competence scores were in the clinically significant range. The variables of family dysfunction, presence of psychiatric disorder in the child, and lower intellectual ability predicted adaptive functioning.

*Social Behavior.* TBI may impact social functioning in peer interactions (Janusz et al., 2002) and the warmth of parent-child relationships (Wade et al., 2003). Deficits in social problem solving skills appear to be another outcome of TBI, especially of severe TBI (Janusz et al., 2002) and in families with fewer resources (Yeates et al., 2004). Janusz and colleagues followed 35 children with severe TBI, 40 with moderate TBI, and 46 with orthopedic injuries who sustained injuries between the ages of 6 and 12 years. Assessments 4 years post injury indicated that children with severe TBI tended to use lower-level problem-solving strategies and less sophisticated reasoning skills to evaluate strategies than children in the orthopedic group. Implications of these findings extend to potential difficulties in social interactions that children may demonstrate after TBI, as effective problem solving strategies are a key element of interpreting and responding appropriately in social interactions.

*General Behavioral Outcomes/Ratings.* Despite the apparent link between TBI and poor developmental outcomes, trauma in and of itself might play a role in determining outcomes.



For example, physical trauma, regardless of whether it involved a head injury, has been associated with significantly higher parent ratings of behavior problems for children who underwent emergency appendectomy (Basson et al., 1991). Using questions from the Child Behavior Checklist, and a rather unique sample (i.e., a group with multiple injuries but not head injury, a group with multiple injuries including mild head injury, and a pediatric appendectomy group), Basson and colleagues asked parents to rate any new behaviors their child displayed after trauma or appendectomy. Results suggested that behavior problems emerged post-trauma in 35% of children without head injury and in 28% of children with head injury. In addition, 30% of the children without head injury and 48% of the children with head injury demonstrated “substantial psychobehavioral change” after the injury. In contrast, none of the appendectomy patients demonstrated behavior problems or psychobehavioral change. No clear behavioral trends emerged. However, a striking discrepancy was evident between the proportion of children who showed behavioral difficulty and the 10% actually referred for professional services by a physician. The investigators emphasized the importance of physician screenings to identify problems soon after injury and the need to act on significant findings.

#### *Factors that Contribute to Social-Behavioral Outcomes in School-Age TBI*

*Premorbid Functioning.* Factors related to premorbid social-behavioral functioning have been found to predict outcomes in competence in leisure activities, interpersonal relationships, and school performance (Donders & Ballard, 1996). Donders and Ballard used parent ratings on the Child Behavior Checklist to assess behavioral and psychological adjustment preinjury (i.e., rated at the time of injury) and roughly one year post injury in a

group of 50 6- to 16-year-olds who sustained moderate to severe TBI. Preinjury ratings indicated that only 10% of the sample fell in the clinically significant range on the total competence scale prior to TBI, while 48% were significant on this index after the injury. Factors related to the injury itself (e.g., lesions on CT/MRI scan and longer time in coma), as well as premorbid social-behavioral functioning, predicted outcomes in competence in leisure activities, interpersonal relationships, and school performance.

*Severity.* Considerable research has shown the extensive effects of severity of injury on a variety of outcomes. Level of severity may differentiate between significant impairment and relatively typical functioning after TBI. Of particular interest for the current study is the amount of research substantiating the link between injury severity and social-behavioral outcomes in school-aged children. Behavioral disturbance, for example, seems significantly more likely after severe TBI (Brown et al., 1981; Kinsella et al., 1999), with severity impacting adaptive behavior outcomes as well (Max et al., 1998; Taylor et al., 2002). In addition, severity appears to be a significant predictor of behavioral difficulties (Schwartz et al., 2003; Taylor et al.) and behavior changes post injury (Schwartz et al.). In one study, degree of injury predicted social discourse skills in children with closed head injury, with more severe injury being associated with poorer social discourse (Dennis, 2001). In another study, social problem solving skills also appear to be more impaired four years post injury for children with severe TBI, relative to children with moderate TBI and orthopedic injuries (Janusz et al., 2002).

Although many findings have linked increased severity with the higher incidence of behavior problems, Anderson et al. (2001) found the incidence of behavior problems in a

group of children who sustained severe TBIs between the ages of 2 and 12 years to be somewhat lower than that of mild and moderate groups. Anderson et al. (2001) speculated that one reason for this finding may be related to decreased mobility in the severe group as a result of the injury, resulting in fewer opportunities to demonstrate behaviors such as hyperactivity, impulsivity, or aggression.

In contrast, Kinsella et al. (1999) reported that children with severe injuries were significantly more likely than children with mild-moderate injuries to show clinically elevated scores on ratings of behavioral functioning one year post injury. Significant group differences at the 2-year follow-up assessment also were evident, with children in the severe group being rated by parents as having more behavioral difficulties than those in the mild-moderate group. Moreover, ratings of half the children in the severe group suggested behavior problems in the clinically significant range. At preinjury (i.e., rated at time of injury), 3 months, 1 year, and 2 years post injury, 8%, 5%, 14%, and 13% of the children in the mild-moderate group fell in the clinically significant range of functioning. For the severe group, proportions were 17%, 17%, 42%, and 50% for the same time points.

In another study, parent report yielded average scores on the CBCL and Vineland Adaptive Behavior Scales, but significant differences between severity groups (Fletcher et al., 1990). Parents of 45 children with mild, moderate, and severe TBI rated preinjury behavior on the Vineland Adaptive Behavior Scales and the Child Behavior Checklist at the time of injury (i.e., before post injury outcomes could be known); post injury functioning was rated at 6- and 12- month follow-ups. The group with severe head injury exhibited more problems in school and social activities than children whose injuries were mild or moderate. Composite scores on internalizing problems, externalizing problems, activities, social, and

school domains were in the average range for all groups, although the severe group engaged in fewer activities than the less-severely injured groups. In addition, children in the severe injury group showed declines over time in their adaptive behavior scores, a trend not noted in the mild and moderate injury groups.

After administering a comprehensive neuropsychological battery to 98 pairs of 6- to 15-year-old children with TBI and matched controls, Fay et al. (1994) found that moderately- and severely-injured children performed significantly lower than controls on 40 out of 53 variables 3 years after the injury. Parent ratings of behavior indicated a dose-response relationship between injury severity and behavior problems, even though mean scores on the subscales of the Child Behavior Checklist for all three groups of children were within the average range. These findings by Kinsella et al. (1999), Fletcher et al. (1990), and Fay et al. (1994) suggest that although children are functioning in the average range, they are not doing as well in their social-behavioral functioning as age-matched peers.

*Age.* Fletcher et al. (1990) did not find significant differences in behavioral outcomes as a result of age when they compared children who sustained TBI younger than 7 years to those who sustained TBI when they were older than 7 years. Their results suggested greater effects of age on adaptive behavior than social-behavioral functioning, with older children demonstrating lower composite scores on the Vineland Adaptive Behavior Scales. Anderson, Catroppa, Morse, Haritou, & Rosenfeld (2005) reported age effects for their sample of children who sustained a closed head injury between 2 and 7 years of age. They found that children who were younger at the time of testing tended to have poorer selective attention and slower general response speed.

*Socioeconomic Status (SES) and Family Functioning.* Socioeconomic status and family functioning also have been found to be important to outcomes in school-age children following a TBI. Logically, it would seem that greater educational, financial, and general family resources would facilitate the recovery process. For example, Taylor et al. (2002) found that lower levels of SES were associated with increasing differences between children with TBI and children with orthopedic injuries, suggesting that socioeconomic status may further exacerbate negative effects of TBI. Their group of children with severe TBI demonstrated impairments relative to an orthopedically-impaired group in some areas of behavioral, adaptive behavioral, and academic functioning. An interesting interaction was found for the relationship between recovery and family stress, however. Specifically, positive gains in the severe TBI and orthopedically impaired groups were related to low levels of family stress; in contrast, the moderate TBI group demonstrated better gains when high family stress was reported.

Long-term follow-up of children who sustained TBI between the ages of 6 and 12 years revealed negative social outcomes relative to an orthopedically-impaired (OI) group four years post-injury (Yeates et al., 2004). Family environment factors such as low SES, limited family resources, and poor family functioning exacerbated negative outcomes in the TBI group. Path analyses suggested that specific neurocognitive impairments and social problem solving deficits contributed to these negative social outcomes. Children who were not white, who were of lower SES, and who had poorer premorbid functioning had lower ratings on social competence scores. The children in the TBI groups had more difficulty with social problems than the OI group, but children with fewer family resources had a particularly difficult time in this domain.

In another four-year follow-up study, Schwartz et al. (2003) provided evidence of both behavior problems and behavior changes in their sample of school-age children. Both severity and socioeconomic status predicted whether children demonstrated behavioral difficulties after the injury. Consistent with previous work, limited family resources predicted behavioral risk status in this group, while injury severity and premorbid behavior problems also significantly predicted which children were most at-risk for negative behavioral outcomes. These findings have important implications for the current study and provide support for examining what variables might predict behavioral difficulties in preschool-aged children (Question 3).

In a unique study, Hayman-Abello et al. (2003) provided a subtype analysis of the social-behavioral functioning of children following a TBI. This study indicated that of the 75% classified as one behavioral subtype or another, more children between the ages of 12 and 18 years (35%) were classified in the normal subtype than any other subtypes. Fewer were considered to be having difficulty with attention (15%), delinquency (11%), and withdrawal-somatization (9%), according to their profiles of parent ratings on the CBCL. One important facet of this study was how psychosocial problems were operationally defined. For this study, a T-score below 67 was considered to be in the normal range, while 67-70 indicated borderline functioning and 70 or above was classified as clinically significant. In this regard, the functioning of a child with a score of 66 would be in the average range, despite the fact that his or her behavior would be over 1.5 standard deviations from the mean expected for other children his or her age. These criteria may have increased the probability that the group failed to exhibit any behavior problems when subtle problems may actually have been present. In this study, children were not excluded due to premorbid behavior problems, and

preinjury estimates of behavior were not available. Severity was not found to be related to subtype classifications. In general, the findings from this research suggest that, as a group, children do not exhibit “pathological psychosocial functioning” after TBI.

### *Recovery/Long-Term Follow-up in School-Age Children*

Recovery of function after pediatric TBI does not follow a predictable trajectory, thus rendering expectations for clear pathways to recovery overly simplistic. Like many outcomes, recovery itself seems to be differentially affected by injury severity. Some findings have suggested more complete recovery of memory and less impaired memory overall in mildly injured children than in children with severe and moderate impairments (Anderson et al., 1999). In contrast, others have found support for increased recovery of function in a severe group (Ewing-Cobbs et al., 2004), although the level of function may be lower. A finding related to age at injury also was of particular interest (Ewing-Cobbs et al., 2004). Children sustaining a TBI at an older age showed an increased rate of recovery via growth curves, but children injured at a younger age showed a decreased rate of recovery, suggesting a worrisome recovery rate for young children. School-aged children often show significant recovery during the first 1 to 2 years after injury, with some additional recovery possibly occurring beyond the two-year time point. In contrast, a TBI in preschool-aged children may disrupt the developmental ascendancy of many skills, thus changing the developmental course of those functions as well as associated abilities.

Differential recovery of language functioning was evident in one study as a result of injury severity (Catroppa & Anderson, 2004). A dose-response relationship was found in the language recovery of children between the ages of 8 and 12 years at the time of TBI.

Children in the severe TBI group performed substantially worse than children in the mild TBI group on FSIQ, reading ability, similarities, and verbal fluency, but on not adaptive behavior, expressive skills, comprehension, or language processing tasks. Two years following injury, the severe TBI group had demonstrated considerable recovery of function. Preinjury communication skills, SES, age at injury, and vocabulary score on the WISC-III predicted language and literacy skills at the 24-month follow-up.

Ewing-Cobbs et al. (2004) found significantly greater rates of recovery in academic performance for a severe group over time relative to normative expectations. Despite these gains, however, deficits persisted two years post injury. While arithmetic skills fell below normative expectations, they demonstrated improvement during the first year after the injury that slowed after that year. These findings suggest that following a TBI, children might benefit from interventions that target both academics and the underlying cognitive abilities that impact these academic skills.

Similarly, injury severity appeared related to recovery of language as well in a group of 5- to 10-year-old children with TBI (Chapman et al., 2001). While the severe group demonstrated more impairment in verbal discourse, both the severe and moderate/mild groups showed improvements over time.

Jaffe et al. (1993) found a relationship between severity and neurobehavioral functioning, and a relationship between severity and recovery, even when excluding children whose premorbid IQ was less than 75. Participants who were the most seriously injured demonstrated the greatest deficits in nonverbal intelligence immediately after injury, but showed the greatest recovery of the three groups in this area. Although children with the most severe injuries had significantly lower scores one year after injury, the scores were still



in the low average to average range; however, the severe group also showed the most variability.

### *Outcomes of TBI in Preschool-Age Children*

Rutter (1981) suggested that children are especially sensitive to extensive damage to the brain between infancy and 2 years of age because the brain is in a state of rapid growth. While the incidence of TBI is lower in preschool children than in school-aged children and adults, data suggest that morbidity is higher (Kriel et al., 1989). During the preschool years, skills develop at a rapid rate. Disruption of the developmental trajectories of these skills could be particularly devastating for long-term outcomes. Although relatively little research has focused on the specific developmental, preacademic, and social-emotional outcomes of preschoolers who have sustained traumatic brain injuries, these studies recognize the potentially negative impact of TBI on development. Given both the rapid development of the preschool years, and the neurological vulnerability of very young children, it is not surprising that TBI in the early years could have a detrimental impact on a plethora of neurocognitive outcomes (Anderson et al., 1999; Anderson et al., 2000; Ewing-Cobbs et al., 1997; Ewing-Cobbs et al., 1989; Ewing-Cobbs et al., 1998; Morse et al., 1999).

*General Developmental/Intellectual.* Severity of injury appears to be a strong indicator of developmental status and intellectual functioning after closed head injury (CHI) in infants, toddlers, and preschoolers (Ewing-Cobbs et al., 1989; Ewing-Cobbs et al., 1997; Ewing-Cobbs et al., 1998; Morse et al., 1999). For example, Ewing-Cobbs et al. (1989) showed that CHI in early childhood adversely impacted overall cognitive skills in children between the ages of 4 and 64 months. Combining several different measures of development and

intelligence (i.e., Bayley Scales of Infant Development, Stanford-Binet Intelligence Scale, McCarthy Scales of Children's Abilities), children with severe injuries demonstrated significantly lower performance than children with mild-moderate injuries, both at baseline and at an 8-month follow-up. Composite IQ at a two-year follow-up revealed that children with severe injuries continued to lag behind children with mild-moderate CHI. The severe group, however, did demonstrate a greater rate of recovery over time. Further, Morse et al. (1999) reported that children who sustained moderate/severe TBI between the ages of 4 and 6 years performed worse than a control group on nonverbal intellectual ability.

*Language.* Similar to findings related to developmental status and intellectual ability, language outcomes seem closely tied to the severity of injury, especially in preschool TBI. In one of the few studies conducted to date, Ewing-Cobbs et al. (1989) showed that the expressive language scores of very young children, who sustained TBI between 4 and 64 months of age, differed significantly based on severity of injury. The severe TBI group performed worse than the mild-moderate group at baseline and at an 8-month follow-up. Results also suggested that children injured prior to 31 months exhibited a greater degree of expressive language dysfunction than children injured when they were older than 31 months. Receptive language also was affected by severity, with the severe group demonstrating more deficits than the mild-moderate group in this area.

Similarly, Morse et al. (1999) found lower verbal comprehension abilities in children with moderate and severe TBI using a small sample of children injured between the ages of 4 and 6 years. Although this group of children was older than Ewing-Cobbs' group at the time of injury, results were similar. The verbal comprehension of the severe group was significantly

lower than that of the control group, with a trend toward the severe group performing below the mild group as well.

In a case study of a 17-month-old who sustained a TBI, Trudeau et al. (2000) noted that language skills appeared to benefit from the recovery process, with intact preinjury functioning being particularly useful. Despite an initial decline, the target child demonstrated a rapid rate of recovery, eventually placing the size of her lexicon and rate of new word acquisition on par with those of controls. The target child's above average language skills prior to the injury likely served as a protective function, supporting the idea that premorbid functioning and preinjury ability are important predictors of outcome after TBI.

*Motor.* In addition to impairments in language and cognition, motor development also appears impacted after preschool TBI (Ewing-Cobbs et al., 1989; Ewing-Cobbs et al., 1997; Ewing-Cobbs et al., 1998). Children who sustained severe TBI between the ages of 4 and 64 months demonstrated differential motor outcomes based on severity, with the mild-moderate group demonstrating better outcomes than the severe group (Ewing-Cobbs et al., 1989). Severe TBI was related to more deficits in motor functioning (Ewing-Cobbs et al., 1997); low average motor skills were found after TBI in children between the ages of 0 and 6 years at the time of injury (Ewing-Cobbs et al., 1998).

*Social-Behavioral.* Few studies have examined the social-behavioral outcomes following TBI in the preschool period. With the available literature suggesting specific impairments in cognitive and motor functioning after TBI in the early years, social-behavioral disruption also would be expected to accompany these deficits. Support for this latter suspicion is

bolstered by the large number of findings suggesting this linkage in the school-age population. It is difficult, however, to predict the exact nature of social-behavioral functioning after preschool TBI, in large part due to the variability in emergent social and behavioral functioning during this developmental epoch. Further, variables such as young age at injury, a relative lack of time to build good skills for coping with trauma, and family factors, particularly in cases of abuse, also will likely affect social-behavioral functioning in a negative fashion. These variables may exert an influence on social-behavioral domains even above and beyond what is observed in older children due to the disruption of typically developmental trajectories for social and behavioral functioning.

Anderson et al. (2001) studied the relationship between injury severity and behavioral outcome in children between the ages of 2 and 12 years who had sustained a TBI. The inclusion of children between the ages of 2 and 5 years in this study makes it particularly relevant to the current study of the social-behavioral functioning of preschoolers after TBI. Behavior ratings by parents on the Rowe Behavioral Rating Inventory indicated neither preinjury differences between the groups nor a significant effect of severity on outcome measures. Ratings revealed behavior profiles in the normal range of functioning for 80% of the children in the group. This high proportion of behavioral profiles in the normal range is surprising given the extent of impairment typically reported in other domains post injury. Interestingly, the proportion of children in the mild and moderate groups with behavior problems was greater than that of the severe group. Children who evidenced “documented psychiatric disturbance” were not included in the study, an exclusionary criterion that may contribute to different findings compared to other similar studies. Preinjury behavior status, as well as physical impairment and family functioning post injury, were found to predict

behavior outcomes. Age at injury was not found to be a significant predictor of family functioning, child adaptive behavior, or child post injury behavior status.

Most recently, Anderson et al. (2005) reported that children who sustained a severe closed head injury between the ages of 2 and 7 years demonstrated lower accuracy and slower processing on tests of attention and processing abilities 30 months post injury. Group differences also emerged on the Personality Inventory for Children, with children in the moderate and severe groups showing more problems on sections of the Internalization and Somatic Symptoms scales than the mild TBI and control groups.

Some studies have included young children in samples with older children (Anderson et al., 2001; Fletcher et al., 1990), and some research has included behavioral measures in assessment of children injured during the preschool years (Anderson et al., 2006). Studies have not, however, focused specifically on preschool social-behavioral outcomes in children injured in infancy and very early childhood. A child's social-behavioral function is linked closely to other processes within the child; external factors also interact with the child's behavior. Understanding the complex interactions between these domains and the bidirectional or transactional influences these factors exert on one another provides information about the child's needs. For example, a child who is anxious after TBI and lives in a chaotic home may become more anxious, have difficulty paying attention in school, and get lower grades. These lower grades might contribute to the child's discouragement and the belief that he or she is not capable of succeeding in school. The feelings may serve to further lower his or her self-image, and increase the risk for internalizing behaviors.

The lack of available information about social-behavioral outcomes after preschool traumatic brain injury necessitates more research. While such information is needed to add

to the literature, the potential applications of such research are especially critical. Important areas that could benefit from increased knowledge of social-behavioral functioning are early identification for service delivery, program planning, family education, and professional development programs for teachers and other educators.

Findings suggest that TBI at a young age may be worse than previously thought and that brain reorganization (i.e., plasticity) may not adequately protect the young brain from the negative impact of trauma (Anderson et al., 2006). Severity (Anderson & Catroppa, 1999; Ewing-Cobbs et al., 2004), age at injury (Kriel et al., 1989), and etiology (Ewing-Cobbs et al., 1998) all seem to influence outcome.

*Recovery/Long-Term Follow-Up.* Recovery after preschool TBI probably differs greatly from recovery in school-age children due to the developmental differences in the two age groups. While some research suggests that school-age children demonstrate significant recovery in the first year or two after injury, insufficient research on preschool recovery precludes similar conclusions for this group.

When examining intellectual ability, language, and memory acutely and 12 months after injury in children with head injury, Anderson et al. (1997) found comparable levels of recovery across groups. Children in the severe group demonstrated pervasive difficulties in language and intelligence that persisted over time. Membership in the severe group, younger age at injury, and lower premorbid ability predicted poorer outcome 1 year after injury.

Memory functioning did not differ as a result of TBI severity in a group of 2-7 year-olds when measured within 3 months of injury (Anderson et al., 1999). However, recovery did differ by level of severity, with children in the severe and moderate groups demonstrating

flatter recovery curves. Differences between groups emerged over time; at the 12 month follow-up, memory functioning of the severe and moderate groups was significantly lower than that of the mild group and controls. A greater proportion of children with severe TBI demonstrated memory impairment 12 months post injury. These findings highlight the importance of the long-term follow-up of children who have sustained TBI, with a particular emphasis on understanding how severity and recovery impact outcomes over time.

In another study by Anderson et al. (2000), severity of TBI influenced memory function as well as recovery in children who sustained closed head injury (CHI) between the ages of 2 and 7 years. Severe TBI was associated with poorer performance on intellectual tests and on some memory and learning tasks, but not on immediate memory function. Mild injuries were associated with more positive recovery of memory capacity.

### *Factors That Affect Outcome in Preschool TBI*

As described in the review of factors that affect social-behavioral functioning, a variety of mechanisms, such as race, age, gender, and SES, have been hypothesized to moderate or mediate the effects of TBI. The influences of these variables on outcome and recovery from preschool TBI are discussed.

#### *Severity*

A dose-response relationship between severity and a variety of outcomes is prevalent in the school-age TBI literature. In the preschool literature, severity of TBI has been linked to intellectual functioning (Anderson et al., 2000; Morse et al., 1999), flatter recovery curves (Anderson et al., 1999), and memory impairment over time (Anderson et al., 1999; Anderson

et al., 2000). Other research has suggested that severity is related to adaptive behavior functioning. Unlike Arroyos-Jurado, Paulsen, Merrell, Lindgren, and Max (2000), Catroppa and Anderson (1999) did not find a link between severity and adaptive behavior. Severe closed head injury in young children was related to impairments in intelligence, motor, and language functioning acutely and 8 months post injury compared to children with mild-moderate injuries (Ewing-Cobbs et al., 1989). Recovery in all areas was evident at the 6-month follow-up, but did not continue at the same rate, with rapid flattening of the recovery curve being apparent after that time point. This study excluded children who had been abused, possibly affecting the representativeness of the sample and underestimating the extent of severity in the youngest age group.

Other research suggests lower IQ and reading scores post injury relative to a control group (Chadwick, Rutter, Brown, Shaffer, & Traub, 1981). A group of children with severe TBI demonstrated greater recovery than other groups, with some children showing recovery as late as the second year of follow-up. Despite recovery, however, the same sample of children exhibited long-term, persisting deficits on WISC performance and visual-motor/visual-spatial tasks, despite recovery during the first year (Chadwick, Rutter, Shaffer, & Shrout, 1981). These nonverbal deficits were more pronounced than verbal deficits. Klonoff, Clark, and Klonoff (1993) also reported that severity and sequelae of injury influenced recovery and persisting intellectual sequelae in their sample of children even 23 years post injury.

### *Gender*

Gender may moderate memory performance following TBI (Donders & Woodward, 2003). In a sample of 70 children with TBI and 70 matched controls, gender moderated the



effect of TBI on memory with the Wide Range Assessment of Memory and Learning Screener (WRAML-S). Boys with TBI demonstrated worse memory than both girls with TBI and controls. Girls outperformed boys on processing speed, suggesting that memory, as measured by the WRAML-S, may rely upon components of processing speed, working memory, or both. When processing speed was covaried in the analyses, girls still performed better than boys, but the discrepancies reflected trends rather than statistically significant differences. Children in the control group did not demonstrate these differences in memory functioning based on gender. Consequently, gender is a key variable to study with respect to outcome from preschool TBI.

### *Age*

It is important to understand how age influences TBI outcomes to determine both expectations for social-behavioral functioning in preschoolers and the extent to which knowledge about social-behavioral functioning in school-aged children can be extrapolated to younger children. In addition, differences in brain development would suggest a differential response to injury as a result of age. Gronwall, Wrightson, & McGinn (1997) reviewed the literature on preschool head injury and suggested that, unlike recovery shown by adults after head injury, young children's deficits tend to persist, with late-emerging difficulties often evident (i.e., injuries lying silent until challenged).

Kriel et al. (1989) found age to be an important predictor of cognitive and motor outcome after closed head injury (CHI). Children older than 6 years of age at injury demonstrated better outcome than younger children. Unlike some other studies, Kriel and colleagues included children who had been abused, and found that this group of children had more

negative outcomes. When the abused children were excluded from analyses, outcomes between the groups were more similar, regardless of age. These results imply that mechanism of injury, rather than age alone, negatively impacts outcome.

Early literature may have suggested more positive outcomes after injury at a young age; however, Dennis (2000) explained plasticity in the developing brain as structural and functional, and emphasized the importance of the recovery of old skills as well as the acquisition of new skills. Unlike early literature suggesting that plasticity protects young children from negative outcomes of traumatic brain injury, Dennis cited more recent research suggesting that children may actually be more vulnerable to central nervous system (CNS) insult at earlier ages. This increased vulnerability may result from a limited repertoire of acquired skills upon which young children can rely when insult occurs.

Age effects also may be observed long after injury. For example, adults who sustained TBI as preschoolers were more inclined to be employed full-time if their injury occurred after the age of 4 and if they had better performance on tasks tapping attentional abilities (Nybo & Koskiniemi, 1999). School performance, however, did not reliably predict work status.

#### *Race and Socioeconomic Status (SES)*

Race and socioeconomic status (SES) are two factors that have been found to influence behavioral sequelae and family functioning in various pediatric populations. Lower socioeconomic status appeared to be associated with more adverse behavioral sequelae in children after TBI compared to children with orthopedic injury (OI; Taylor et al., 2002). A family's social capital (i.e., a family's resources in the form of social support networks) also

was found to be related to child outcome, with greater social capital associated with success in the preschool years (Runyan et al., 1998). In that study of at-risk children (Longitudinal Studies of Child Abuse and Neglect Consortium), social capital provided a buffer against potentially negative outcomes.

In another study, Yeates, Taylor, Woodrome, et al. (2002) found race to moderate family burden and psychological distress in parents above and beyond the influence of SES. Yeates et al. compared a sample of white and black children with moderate to severe TBI to a group of children with orthopedic impairment and found that black and white families differed in their coping strategies as well as in stress levels at different points in time after the injury. Although parents of black children reported less stress than the parents of white children shortly after injury, at 6- and 12-month follow-ups, the parents of black children evidenced greater levels of stress. With regards to differences in coping strategies, the black families tended to rely more on religion, mental disengagement, and denial after a child in the family sustained a TBI. The white families, however, tended to use an approach of acceptance.

### *Family Functioning*

A careful examination of what is known about family functioning and TBI outcomes is important for the proposed study. Family functioning predicts outcomes in areas such as adaptive behavior (Max et al., 1998) and child self-report of behavioral functioning (Kirkwood et al., 2000). Conversely, parent report of behavioral functioning (Kirkwood et al., 2000) did not seem affected by family functioning. Family stress also moderated gains in outcome after TBI (Taylor et al., 2002). Furthermore, children's psychosocial functioning, especially at young ages, would be expected to be closely tied to family stress, burden, and

overall adjustment. Family functioning and adaptation served as measures and predictors of outcome after TBI. In a group of children with severe TBI, better outcomes were associated with low levels of family control and high levels of expressiveness (Rivara et al., 1996). In addition, preinjury family functioning predicted outcome at 3 years.

Consistent with findings about the positive effects of social capital (Runyan et al., 1998), Kinsella et al. (1999) found that child behavioral outcome soon after injury (but not at follow-up) was predicted by (1) whether the primary caregiver had a partner and (2) how the parent reacted to the injury. The parent's ability to cope with the injury seemed to influence the child's behavioral response to the injury. Preinjury behavioral functioning contributed to variance in behavioral ratings 3 months, 1 year, and 2 years after TBI. Knowledge about the relationship between family functioning and behavioral outcome after TBI could be useful in designing treatments and interventions.

Similarly, relationships between injury severity and caregiver stress have been reported in a sample of children with severe TBI, moderate TBI, and orthopedic injuries (Wade et al., 2002). In addition, Yeates et al. (1997) found that preinjury family environment and family functioning accounted for a significant amount of the variance in outcome for children between the ages of 6 and 12 years at injury on measures including nonverbal IQ, visual-motor integration, memory and learning, social-behavioral functioning, and adaptive behavior. In high-functioning families, preinjury family environment served as a buffer, protecting the child from negative outcomes; in lower-functioning families, the family environment exacerbated the effects of the TBI.

While any type of illness or injury might be expected to impact a parent's level of stress, TBI seems to result in higher levels of parental stress than does orthopedic injury (Wade,

Taylor, Drotar, Stancin, & Yeates, 1998). One year post injury parents reported experiencing more stress after their child sustained a TBI than an orthopedic injury. In addition, parents of children in the severe TBI group demonstrated more psychological symptoms than parents of children with orthopedic injuries at baseline, 6 month, and 12 month follow-ups. Over time, stress diminished for the severe and moderate TBI groups, but it diminished more sharply for the orthopedic group.

Max et al. (1998) reported that factors such as family dysfunction, child psychiatric disorder, and intellectual impairments mediated adaptive behavior in a severe TBI group. Despite greater impairments, children in the severe group were generally within the average range on scales of adaptive functioning. Kirkwood et al. (2000) found that family functioning moderated scores on a child self-report measure, but not on a parent-report measure, in a study of internalizing behaviors after TBI. These findings underscore the importance of collecting information from multiple sources when assessing child and family functioning.

Family stress moderated outcome in groups of children after TBI or orthopedic injury in a surprising way in one study (Taylor et al., 2002). Low family stress was correlated with positive gains in the severe TBI and orthopedic groups, while high family stress was associated with positive gains in the moderate TBI group. In addition, children with severe injuries from less stressed families demonstrated increased recovery of math skills.

Existing literature illustrates clearly the variety of negative effects pediatric traumatic brain injury can have. While preschool research is not yet as comprehensive as school-age literature, emergent data suggest that injury at a young age has the potential for significant adverse outcomes. A significant deficit in the preschool TBI literature is evident with respect

to knowledge about social-behavioral functioning post injury, and the current study will address this gap in the TBI literature.

## CHAPTER III

### METHODS

#### *Participants*

This study examined the social-behavioral functioning of 51 preschoolers who sustained TBI prior to the age of 2 years and a group of 31 typically-developing children with no identified developmental delays or frank neurologic impairment. Details pertaining to the demographic and other related variables for the samples can be seen in Table 1. All participants were recruited for participation in accordance with The University of North Carolina Institutional Review Board Procedures and a copy of the approval letter can be seen in Appendix I.

*TBI Group.* Participants were enrolled in the TBI Group by prospective sampling from all 9 hospitals in North Carolina with a Pediatric Intensive Care Unit between 2001 and 2004. Children who were North Carolina residents and less than 2 years of age at the time of their TBI were eligible for the study. Participants were enrolled in the study for telephone interviews at 1 and 2 years post injury. Families who participated in these telephone interviews were invited to enroll their children in the portion of the study consisting of a home visit and developmental evaluation. Participants averaged approximately 3 years of age at the time of this follow-up; this sample included 52 children. One child was excluded from this group due to missing data on the Child Behavior Checklist, bringing the size of the TBI group to 51 for all analyses. Characteristics of families who participated in the home

visit were compared to those who were eligible but did not participate. The groups were comparable with respect to proportion of children sustaining inflicted injuries, gender, race, injury severity, age at injury, and maternal variables (e.g., education, marital status, age at child's injury).

To be eligible for the study children needed to have sustained a nonpenetrating TBI documented by CT scan, MRI scan, or neuropathology (Keenan et al., 2003). Exclusionary criteria included presence of skull fractures, but not intracranial injury. Children in this group were identified as having sustained a mild ( $n = 31$ ), moderate ( $n = 10$ ), or severe ( $n = 10$ ) brain injury based on Glasgow Coma Scale (GCS) scores at the time of injury. Levels of severity were consistent with GCS classifications, whereby scores of 3-8 signify severe injury, 9-12 indicates a moderate injury, and 13-15 is a mild injury. Mechanism of injury (i.e., inflicted vs. noninflicted) was determined by the treating team at each hospital. These records were reviewed by physicians involved in the research project.

*Typically-Developing Group.* Children in the Typically-Developing Group were recruited from preschools and daycare centers in central North Carolina and southeastern Virginia. Participants ( $n = 31$ ) were aggregately matched to the TBI sample by maternal education. Participants were matched as closely as possible on the variables of gender, race, and age as well, but because maternal education is highly correlated with socioeconomic status and tied to important child-related outcomes, this variable was prioritized when matching the groups.



## *Procedures*

*TBI Group.* Graduate student assessors and registered nurses were thoroughly trained in the use of instruments and procedures before beginning data collection. Once families had been identified and consented to participate in the study, a home visit was scheduled for a date near the child's third birthday. Two assessors traveled to each family's home; one explained the study further to the parent, obtained signed consent, and conducted the parent interview while the other completed the child assessment. The child assessment included a developmental assessment and a preacademic measure. The parent interview focused on demographic information as well as parental perceptions of the child's social-behavioral functioning, temperament, and adaptive behavior. The instruments were administered in a standardized method in accordance with test manual guidelines. If the parent had difficulty understanding a questionnaire or trouble reading it, the assessor respectfully offered to ask the questions aloud. Responses obtained are considered valid, as every effort was made to ensure that the parents understood the questionnaires and that assessments were administered according to standardized procedures. Of the 48 participants with available data on respondents at the home visit, almost all parent respondents were female, and most were biological mothers (64.7%). Adoptive parents comprised 13.7% of the respondents; 11.8% of the respondents were foster parents related to the child, and 3.9% were non-related foster parents.

*Typically-Developing Group.* Parents of children from the community (e.g., daycares, preschools, Head Start centers, word of mouth) were provided with information about the study and asked for their permission to enroll their children in the research study. These

study descriptions for the community settings were approved by The University of North Carolina Institutional Review Board and can be seen in Appendices II and III. If parents provided written permission for their child's participation, the child completed a developmental assessment at the preschool or daycare or in a testing room at local child development clinic. The parents were provided with questionnaires, either by sending them home through the child's daycare, through the mail, passing them out at parent meetings, conducting interviews in person, or conducting interviews over the phone. Most respondents in the Typically-Developing Group were biological mothers (80.65%) but several fathers (9.67%) and one grandmother (3.23%) also completed questionnaires. Of the 31 children in this group, two (6.45%) were adopted; these questionnaires were completed by the adoptive mothers.

### *Measures*

*Social-Behavioral Functioning.* The *Child Behavior Checklist (1½ to 5 years)* (CBCL; Achenbach, 2000), a parent-completed rating scale, measures the behavior of preschool children relative to age-expectations. The 99 items on the CBCL are scored on a 3-point Likert scale (i.e., 0 = not true, 1 = somewhat or sometimes true, 2 = very true or often true) and gauge the parent's or other caregiver's opinions about the frequency with which the child engaged in a variety of behaviors within the past two months. Responses to these items yield scores for domains including: Emotional Reactivity, Anxiety/Depression, Somatic Complaints, Withdrawal, Sleep Problems, Attention Problems, and Aggression. Ratings also yield composite scores for Internalizing Problems, Externalizing Problems, and Total

Problems. These scores are reported as T-scores with a mean of 50 and a standard deviation of 10, with higher T-scores reflecting more social-behavioral difficulties.

The CBCL has good psychometric properties and sensitivity for detecting problems, an important characteristic given that children with TBI may show variable functioning in different social-behavioral areas. Attention to both internalizing and externalizing behaviors is important because difficulties in these areas can manifest quite differently. For example, it is possible that unless parents and physicians are alert, internalizing behaviors might be overlooked. Despite some limitations inherent in a rating scale (e.g., the forced-choice responses, closed-ended questions), the CBCL has demonstrated good reliability and validity (Rescorla, 2005). Test-retest Pearson correlations fell in the .80s and .90s on the scales and at .90 for the Total Problems composite. The Child Behavior Checklist has been widely used in research, including several studies examining the effects of TBI on social-behavioral functioning in school-aged children (Donders & Ballard, 1996; Max et al., 1998; Papero, Snyder, Gotschall, Johnson, & Eichelberg, 1997). For the purposes of this study, problematic behavior in a particular area is indicated by functioning at or above the 90<sup>th</sup> percentile (i.e., a T-score  $\geq$  63).

*Developmental Assessment.* Developmental functioning of the TBI and typically-developing groups was assessed through standardized, individual assessments using the *Mullen Scales of Early Learning* (Mullen, 1995). The Mullen yields an overall developmental quotient from scores on scales measuring visual reception, fine-motor skills, expressive language, and receptive language. This developmental quotient, or Early Learning Composite (ELC), was employed for subject description and in data analyses. The

developmental quotient is a standard score with a mean of 100 and a standard deviation of 15, with higher scores reflecting more intact development. Test-retest reliability of the Mullen was .76 for the cognitive scales for the 25 -56 month age group.

*Adaptive Behavior.* The *Scales of Independent Behavior-Revised, Early Development Form* (SIB-R) is a 40-question scale that assesses a child's adaptive behavior and independent daily living skills (Bruininks, Woodcock, Weatherman, & Hill, 1996). On the SIB-R, parents rate their children's ability to perform certain tasks (i.e., 0 = never; 1 = does, but not well; 2 = does fairly well; 3 = does very well). These tasks encompass communication, self-care, and socialization domains. Ratings on the SIB-R yield a standard score (M = 100, SD = 15) which reflects a child's adaptive behavior relative to an age-matched normative sample. Test-retest reliability on the SIB-R Early Development Form was .97.

*Family Functioning.* The Self-Report Family Inventory (SRFI; Beavers, Hampson, & Hulgus, 1990) is a 36-item scale that assesses an individual's current perception of his or her family's functioning in the domains of Family Health/Competence, Conflict, Cohesion, Expressiveness, and Directive Leadership. The parents of children in the study rated each item on a 5-point Likert scale, ranging from "Fits our household very well" to "Doesn't fit our household at all." According to Beavers et al. (1990), the Health Competence scale is made up of 19 items and measures family affect, parental coalitions, problem-solving abilities, autonomy and individuality, optimistic versus pessimistic views, and acceptance of family members. The Conflict scale consists of 12 items that tap overt and subtle conflict,

such as arguing, blaming, fighting openly, acceptance of personal responsibility, unresolved conflict, and a negative feeling tone. The Cohesion scale was comprised of 5 items that focused on family togetherness, satisfaction received from within the family, and spending time together. The three items that made up the Leadership index measured parental leadership, directiveness, and degree of rigidity of control. Finally, the Emotional Expressiveness subscale included 6 items that targeted verbal and nonverbal expression of warmth, caring, and closeness.

*Maternal Education.* Maternal education for this study was based upon report provided on the Hollingshead Index. The Hollingshead Index is a measure of income, education, and employment (Hollingshead, 1975) where the scale for education was as follows: 1 = less than 7<sup>th</sup> grade, 2 = 9<sup>th</sup> grade, 3 = 10<sup>th</sup> or 11<sup>th</sup> grade, 4 = high school graduate, 5 = partial college, 6 = college graduate, 7 = postgraduate.

#### *Preliminary Data Analysis*

Preliminary analyses compared the TBI and typically-developing groups on chronological age, gender, race, Mullen ELC, adaptive behavior, and maternal education to determine whether the groups differed systematically on these variables. If differences between the groups were evident, and the variable had the potential to confound the results, these variables were covaried in subsequent analyses.

### *Question 1*

**Do parent ratings of the social-behavioral functioning of preschoolers who sustained mild and moderate/severe TBI as very young children differ significantly from parent ratings of typically developing preschoolers?**

### *Hypothesis 1*

It is hypothesized that preschoolers with mild and moderate/severe traumatic brain injury will be significantly impaired in their social-behavioral functioning relative to children in a typically-developing group on parent ratings on the early childhood version of the Child Behavior Checklist. It is also hypothesized that an effect for severity will be found, with children in the Moderate/Severe TBI Group demonstrating more difficulties in their social-behavioral functioning than children in the Mild TBI Group and Typically-Developing Group. Specifically, it is expected that children with TBI will be more impaired than the comparison group on all three composite scales (Internalizing Problems, Externalizing Problems, and Total Problems) and on some individual scales.

Available research suggests negative overall outcomes after TBI in early childhood (Ewing-Cobbs et al., 1997) and behavioral dysfunction after school-aged TBI (Kirkwood et al., 2000; Schwartz et al., 2003), including greater internalizing problems (Kirkwood et al., 2000). Although research has not specifically targeted the social-behavioral outcomes of children injured at very young ages, based on what is known, children with TBI are expected to evidence greater problems in their social-behavioral development.

### *Data Analysis 1*

Scores on the individual and composite scales of the CBCL for the Mild, Moderate, and Severe TBI Groups were compared to those of the Typically-Developing Group using

ANCOVA or MANCOVA with Early Learning Composite on the Mullen as a covariate. SPSS was used to conduct all statistical analyses.

### *Question 2*

**Do groups of preschoolers with mild TBI and moderate/severe TBI differ significantly from a group of typically-developing children in their observed incidence of behavioral problems based on parent ratings?** That is, does a significantly higher proportion of preschoolers with mild TBI or moderate/severe TBI evidence difficulties in their social-behavioral functioning at or above the 90th percentile?

### *Hypothesis 2*

Existing research on school-age children has found evidence of increased incidence of social-behavioral dysfunction in TBI groups (Kinsella et al., 1999; Kirkwood et al., 2000). It is hypothesized that a higher proportion of children in the Mild and Moderate/Severe TBI Groups will demonstrate social-behavioral functioning that is at or above the 90<sup>th</sup> percentile (T-score  $\geq$  63) relative to a group of typically-developing children, based on parent ratings of social-behavioral functioning.

### *Data Analysis 2*

The incidence of parent-reported behavior dysfunction in the three groups (Mild TBI, Moderate/Severe TBI, and Typically-Developing) was compared using Pearson's Chi-square analyses in crosstabs in SPSS. An alpha level of .005 was used for these comparisons, employing a Bonferroni correction for the 10 analyses (i.e., .05/10).

### *Question 3*

**What child-, family-, and injury-related variables (e.g., developmental level, maternal education, injury severity) predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI?**

### *Hypothesis 3*

Based on available literature of the outcomes of school-aged children after TBI, it is hypothesized that injury severity and maternal education will be significant predictors of social-behavioral functioning as measured by the CBCL Internalizing, Externalizing, and Total Problem scores.

### *Data Analysis 3*

Preliminary analyses for this hypothesis explored correlations between variables selected a priori and the primary scales. These variables included family and demographic variables such as maternal marital status, maternal education, family functioning, gender, and race; child variables such as adaptive behavior, developmental level, and chronological age; and injury-related variables such as mechanism of injury, severity of injury, loss of consciousness greater than 3 days, age at injury, and time since injury. Variables that were most correlated with outcome on the composite scales of the CBCL (Internalizing, Externalizing, and Total Problem T-scores) were included as predictor variables in separate regression equations for each of the three composite scales of internalizing, externalizing, and total problems. A ratio of 10 cases for each variable included in the equation was maintained to permit confidence in the regression analyses and subsequent regression weights.



## CHAPTER IV

### RESULTS

#### *Preliminary Analyses*

Several one-way analysis of variance tests were conducted to evaluate potential group differences (Mild TBI vs. Moderate/Severe TBI vs. Typically-Developing Group) with respect to child's age at testing, overall developmental level/IQ, maternal education, and adaptive behavior. For each of these ANOVAs, the independent variable (i.e., TBI status) included three levels: mild TBI, moderate/severe TBI, and no TBI (the typically-developing comparison group). Chi-square tests using Pearson's Chi-Square value were run to compare the groups on the variables of race and gender. Independent samples t-tests were conducted at an alpha level of .05 to compare the Mild TBI and the Moderate/Severe TBI Groups with respect to age at injury and time since injury.

*Chronological age.* A one-way ANOVA revealed significant group differences on the mean age of the children at testing,  $F(2, 79) = 12.074, p < .001$ . Follow-up testing with Tukey's HSD test indicated that both the Mild and Moderate/Severe TBI Groups differed significantly from the Typically-Developing Group ( $p < .001$ ). The mean age of participants in the Moderate/Severe TBI Group ( $M = 3.25$  years,  $SD = 0.27$ ) was significantly younger than that of the Typically-Developing Group ( $M = 3.68$  years,  $SD = 0.35$ ). The Mild TBI Group ( $M = 3.33$  years,  $SD = 0.38$ ) was also significantly younger than the Typically-

Developing Group. Because the groups are within comparable stages of development, this difference in age is not expected to influence scores systematically. Therefore, despite these group differences, the variable of age was not covaried in subsequent analyses.

*Early Learning Composite (ELC).* The Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups differed significantly in their level of overall development based on the Early Learning Composite score of the Mullen Scales of Early Learning,  $F(2, 79) = 18.850, p < .001$ . Follow-up testing with Tukey's HSD test revealed differences between the Typically-Developing and Moderate/Severe Groups ( $p < .001$ ) as well as between the Mild and Moderate/Severe Groups ( $p < .001$ ). The Moderate/Severe TBI Group was functioning significantly lower on the Mullen ELC ( $M = 63.65, SD = 15.98$ ) than the Typically-Developing Group ( $M = 94.32, SD = 18.71$ ). The mean score for the Moderate/Severe Group fell in the deficient range, indicating significant impairments, while the Typically-Developing Group obtained a mean score in the average range. The Moderate/Severe Group also demonstrated significantly lower overall development than the Mild Group ( $M = 89.35, SD = 18.82$ ), whose scores were in the low average range. Because overall development can be an important factor in social-behavioral functioning, scores on the Mullen were covaried in later analyses.

*Adaptive Behavior.* Scores on the Scales of Independent Behavior—Revised (SIB-R), which yields a standard score ( $M = 100, SD = 15$ ), ranged from 12 – 144 for the entire sample. Because of this broad range, the values were Winsorized, or truncated, so that all scores on the SIB-R fell within 2.5 standard deviations of the mean of 100 (i.e., 62.5-137.5).

Therefore, all scores below 62.5 were recoded as 62.5, while all scores above 137.5 were recoded as 137.5. A one-way ANOVA revealed that the three groups differed in their adaptive behavior, based on parent report on the SIB-R,  $F(2, 79) = 17.003, p < .001$ . Follow-up testing with Tukey's HSD test indicated differences between the Moderate/Severe TBI group and the Mild TBI Group ( $p < .001$ ) as well as between the Moderate/Severe TBI Group and the Typically-Developing Group ( $p < .001$ ). The Moderate/Severe TBI Group demonstrated the lowest functioning in their adaptive behavior skills ( $M = 82.15, SD = 25.74$ ); the Mild TBI ( $M = 104.60, SD = 21.11$ ) and Typically-Developing Groups ( $M = 116.52, SD = 15.82$ ) had higher levels of independent daily living skills. Because the Mullen Early Learning Composite and the SIB-R are so highly correlated (.632), the SIB-R was not entered as a covariate into subsequent analyses.

*Maternal Education.* An ANOVA revealed no significant differences between the three groups on the dimension of maternal education,  $F(2, 79) = 1.281, p < .283$ . On average, the mean education ranged from completion of high school to partial college. Mothers of the children in the Mild TBI Group had a mean level of education of 4.61 ( $SD = 1.20$ ); the mean level of maternal education for the Moderate/Severe TBI Group was 4.60 ( $SD = 1.05$ ). The mean of the Typically-Developing Groups was 5.03 ( $SD = 1.20$ ). In general, maternal education for the entire sample indicated that most of the mothers had achieved a high school degree and perhaps some post high school education/training.

*Race and Gender.* A chi-square test did not reveal significant group differences in ethnic composition (Caucasian versus non-Caucasian),  $\chi^2(2, N = 81) = 5.520, p < .063$ . Similarly, no group differences emerged for gender,  $\chi^2(2, N = 82) = 3.012, p < .222$ .

*Age at Injury.* An independent samples t-test was run to compare the Mild and Moderate/Severe TBI Groups with respect to age at injury. The groups did not differ,  $t(49) = 1.874, p < .067$ . The Mild Group was .49 years at injury ( $SD = .57$ ) and the Moderate/Severe Group was .81 years ( $SD = .62$ ).

*Time Since Injury.* Another independent samples t-test assessed whether the Mild and Moderate/Severe TBI Groups differed in the amount of time that had elapsed between their injury and their follow-up assessment near their third birthday. The groups differed on this measure,  $t(49) = -2.492, p < .016$ . For the Mild TBI Group, more time had elapsed from the time of injury to follow-up testing ( $M = 2.81, SD = .35$ ) than for the Moderate/Severe Group ( $M = 2.45, SD = .69$ ).

### *Question 1*

**Do parent ratings of the social-behavioral functioning of preschoolers who sustained mild and moderate/severe TBI as very young children differ significantly from parent ratings of typically developing preschoolers?** It was hypothesized that preschoolers with mild and moderate/severe traumatic brain injury would be significantly impaired in their social-behavioral functioning relative to children in a typically-developing group on parent ratings on the early childhood version of the Child Behavior Checklist. It was also

hypothesized that an effect for severity would be found, with children in the Moderate/Severe Group demonstrating more difficulties in their social-behavioral functioning than children in the Mild TBI Group and Typically-Developing Group. Specifically, it was expected that children with TBI would be more impaired than the Typically-Developing Group on all three composite scales (Internalizing Problems, Externalizing Problems, and Total Problems) and on some individual scales.

Three analysis of variance tests were run to determine whether the Mild, Moderate/Severe, and Typically-Developing Groups differed from one another on the composite scales of Internalizing, Externalizing, and Total Problems on the Child Behavior Checklist. Because these outcome variables correlate strongly with one another (i.e., test items may load on more than one of these scales), separate ANCOVAs were selected over a MANCOVA test. The Early Learning Composite score on the Mullen was entered as a covariate to control for between-group differences on the Mullen. Covarying on this variable helps ensure that any differences can be attributed to group membership and not overall developmental level.

Assumptions necessary for ANCOVAs were evaluated prior to running these analyses and appear to be met (Lomax, 2001). First, it can be assumed that errors are random and independent and that no systematic pattern of errors is present. Residual error plots did not indicate violations of this assumption. Second, analyses were run to evaluate homogeneity of variance. Levene's test for homogeneity of variance was significant on the scales of externalizing problems, withdrawal, attention, and aggression, suggesting that variability on these measures differed as a result of group membership. The ANCOVA test is considered robust to violations of this assumption, given that the ratio between the size of the largest and smallest groups is no more than 1.5 (Lomax, 2001). For this study the ratio between the

largest and smallest groups is 1.55 and sample sizes are moderate, suggesting that violation of the homogeneity of variance assumption should not over-inflate Type I or Type II errors. Third, visual inspection of bar graphs revealed relatively normal distributions on each of the outcome variables for all groups.

Fourth, for an ANCOVA, the regression of the dependent variable on the independent variable must be linear. Next, it is necessary that the covariate be measured without error. Given the psychometric properties of the Mullen, which include good reliability and validity, this assumption was met. The final assumption related to the homogeneity of regression slopes. None of the three dependent variables has significant interactions with the covariate (ELC). Therefore, the assumption of homogeneity of regression slopes was met.

*Internalizing Problems.* A visual examination of the CBCL Internalizing Problems summary score revealed that most cases in each group fell in the average range (see Figure 1). The Moderate/Severe Group had several scores that fell greater than one standard deviation above the mean (i.e., signifying more difficulty in this area), while the Mild and Typically-Developing Groups had several cases falling above and below the average range. An ANCOVA, with Mullen ELC as a covariate, was run to determine whether parent ratings of internalizing problems in their preschoolers differed with respect to group status (e.g., Mild TBI, Moderate/Severe TBI, Typically-Developing Group). The test revealed no significant differences between groups,  $F(2, 76) = .758, p < .472$ , with an effect size of  $\eta^2 = .020$ . Adjusted and unadjusted means and standard deviations for each of the groups on the CBCL can be found in Table 2. A line graph reflecting the unadjusted group means for all the major outcome variables can be found in Figure 2.

*Externalizing Problems.* A second ANCOVA was attempted to analyze between-group differences on the Externalizing Problems composite score. This ANCOVA revealed a significant interaction between the covariate (Mullen ELC) and group membership, suggesting that these data do not meet the assumption of homogeneity of regression slopes and rendering the test uninterpretable. However, a visual inspection of the mean scores in Table 2 suggested that all groups fell close to the mean of the normative group. A visual inspection of a histogram graph (see Figure 3) revealed that most scores in all groups fell at or just below the mean, with fewer falling outside the average range.

*Total Problems.* Visual inspection of the histogram (see Figure 4) for the Total Problems summary score suggested that most cases in all groups were within the average range, with several in the Typically-Developing Group falling more than a standard deviation below the mean (i.e., indicating good social-behavioral functioning). A third and final ANCOVA targeted group differences on the Total Problems composite score on the CBCL. This ANCOVA indicated no significant group differences for overall behavioral problems, based on parent report,  $F(2, 76) = 2.710, p < .073$ , with an effect size of  $\eta^2 = .067$ . It should be noted that this ANCOVA approached significance with the scores following in the hypothesized direction. Specifically, the Typically-Developing Group was described as having better social-behavioral functioning than both the Mild and Moderate/Severe TBI Groups. The Typically-Developing Group yielded a mean score that was just below the mean of the normative group while both TBI Groups fell just above the mean of the normative group.

*Individual Scales.* A multivariate analysis of covariance (MANCOVA) was run to test between-group differences on the seven individual scales of the CBCL (e.g., Emotional Reactivity, Anxiety/Depression, Somatization, Withdrawal, Sleep Problems, Attention Problems, and Aggression). A line graph of these scale means by group can be found in Figure 5.

When testing for the assumption that the covariance matrices of the groups are equal, Box's M produced a significant result, suggesting that the covariance matrices are not equivalent and should not be pooled into one matrix. According to Tabachnick and Fidell (2001), Box's M can be overly sensitive, with MANCOVAs robust to violations of this assumption if the sample sizes are equal. Since the sample sizes are similar, it is assumed that the MANCOVA is robust to violations of this homogeneity assumption. The data set was inspected and analyzed to determine whether it met the assumptions of MANOVA set forth by Tabachnick and Fidell (2001). For this sample, more cases than dependent variables are present in each cell. The distributions of the means of the individual scales are assumed to be multivariately normally distributed. While no specific test measures multivariate normality well, because the data are univariately normally distributed, no problems with multivariate normality were anticipated. Assumptions of linearity, homogeneity of regression, reliability of covariates, and the absence of multicollinearity and singularity also were met. An outlier was identified in the data set. To keep this case in the data set but ensure that it did not inflate error rates, scores for all cases on the CBCL that fell 3 standard deviations (i.e., a T-score of 80) from the mean were recoded so that they were within 3 standard deviations from the mean.



Pillai's trace (PT) for the MANCOVA revealed a significant interaction between the Mullen ELC and the groups, suggesting that the MANCOVA could not be interpreted. Because the scales of Attention and Aggression appeared to be responsible for this interaction, a second MANCOVA for the remaining 5 scales was run. This MANCOVA was not significant,  $PT = .216$ ,  $F(10, 140) = 1.697$ ,  $p < .087$ ,  $\eta^2 = .108$ , suggesting that the groups do not differ on the individual scales of the CBCL. A visual inspection across all these scales revealed that the means of all three groups tended to fall just above the normative mean, but within the average range. A trend was noted for the Moderate/Severe TBI Group to show fewer somatic complaints, but more symptoms of withdrawal.

### *Question 2*

**Do groups of preschoolers with mild and moderate/severe TBI differ significantly from a group of typically-developing children in their observed incidence of behavioral problems based on parent ratings?** That is, does a significantly higher proportion of preschoolers with mild TBI or moderate/severe TBI evidence difficulties in their social-behavioral functioning at or above the 90th percentile? It was hypothesized that a higher proportion of children in the Mild and Moderate/Severe TBI Groups would demonstrate social-behavioral functioning at or above the 90th percentile (T-score > 63) relative to a group of typically-developing children.

The three groups were compared using chi-square tests to determine whether the incidence of children whose parents rated their behavior at or above the 90<sup>th</sup> percentile on the CBCL differed by group membership. These analyses were run for each of the seven individual

scales and the three composite scores on the CBCL. The proportions of children in each group whose ratings reflected social-behavioral dysfunction can be found in Table 3.

The groups did not differ in the frequency with which they experienced significant Internalizing Problems,  $\chi^2(2, N = 82) = 3.612, p < .164$ . Incidence of Externalizing Problems was also similar between the groups,  $\chi^2(2, N = 82) = 2.910, p < .233$ . Similarly, Total Problem frequency was comparable,  $\chi^2(2, N = 82) = .132, p < .936$ .

On individual scales, the groups again did not show any significant differences in the frequency of parent-reported behavior problems at or above the 90<sup>th</sup> percentile. Chi-square results were nonsignificant for Emotional Reactivity,  $\chi^2(2, N = 82) = .191, p < .909$ ; Anxiety,  $\chi^2(2, N = 82) = .281, p < .869$ ; Somatization,  $\chi^2(2, N = 82) = .613, p < .736$ ; Withdrawal,  $\chi^2(2, N = 82) = 4.089, p < .129$ ; Sleep Problems,  $\chi^2(2, N = 82) = 2.205, p < .332$ ; Attention Problems,  $\chi^2(2, N = 82) = 1.126, p < .569$ ; and Aggression,  $\chi^2(2, N = 82) = 1.918, p < .383$ .

### *Question 3*

What child-, family-, and injury-related variables (e.g., developmental level, maternal education, injury severity) predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI? It was hypothesized that injury severity and maternal education would be significant predictors of social-behavioral functioning as measured by the CBCL Internalizing, Externalizing, and Total Problem scores.

First, correlations between each of the outcome measures and variables selected a priori (marital status, adaptive behavior, developmental level, maternal education, family functioning, race, age at testing, mechanism of injury, severity of injury, loss of conscious

greater than 3 days, age at injury, and time since injury) were run. Variables that were at least moderately correlated with CBCL outcomes (i.e.,  $r \geq .30$ ), as well as those variables which might be expected to predict behavioral outcomes based on existing literature, were considered for inclusion in regression equations. Correlations between these variables can be found in Table 4.

Internalizing Problems significantly and moderately correlated with developmental level and correlated weakly with the SIB-R standard score and maternal education ( $< .290$ ). The Externalizing Problems score correlated significantly with maternal education and with the Leadership scale of the SRFI. Variables such as maternal employment, SRFI Conflict, loss of consciousness, and GCS were weakly ( $< .290$ ) correlated with externalizing problems. For the Total Problems score, maternal education emerged as significantly and moderately correlated. The index score on the Hollingshead, the SRFI Leadership scale, the SRFI Conflict scale, the SRFI Cohesion scale, and the Early Learning Composite score on the Mullen were weakly correlated with Total Problems.

Because the TBI group consisted of 51 participants, a maximum of 5 variables were chosen to be entered into each regression equation to maintain a 10:1 case to variable ratio. Three variables were chosen to be entered into each of the regression equations because of literature and research implicating them as important predictors of child outcome and social-behavioral functioning. These three variables, overall developmental quotient (Mullen ELC), maternal education, and Glasgow Coma Scale score, tap the areas of overall child functioning, family functioning, and severity of injury. In addition, one or two more were chosen based on correlations between the specific outcome measures and the predictor variables. For Internalizing Problems, no additional variables were included. Although the

SIB-R score was weakly correlated with Internalizing Problems, it was strongly correlated with the Mullen ELC; adding it into the regression equation, therefore, would not contribute new variance. For the Externalizing Problems equation, SRFI Leadership was added. For Total Problems, SRFI Leadership and SRFI Conflict were included. Because of the exploratory nature of these regressions and the small sample sizes, the results of the overall regression equations will not be interpreted. Instead, variables that may predict outcomes on the CBCL will be discussed so that future research might have a beginning model from which to work and test using new data.

The regression equation for Internalizing Problems yielded the Mullen ELC as a significant predictor variable (see Table 5). Both GCS score and SRFI Leadership emerged as significant predictors of Externalizing Problems on the CBCL (see Table 6). No predictor variables emerged as significant for the Total Problems score (see Table 7).

#### *Additional Exploratory Analyses*

Once the primary data analysis plan was executed to address the research questions and associated hypotheses, several additional exploratory data analyses were conducted to determine the presence of any trends in the data that may be fruitful for hypothesis testing with a larger group. In that regard, because no differences were found between the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups on the primary questions targeted by this study, the TBI Groups were collapsed to determine if, on the whole, their social-behavioral functioning differed from that of the Typically-Developing Group.

ANCOVAs, with Mullen ELC as the covariate, were run to assess group differences on each of the composite scales on the CBCL as well as the individual scales. The groups did

not differ in the mean scores for Internalizing Problems,  $F(1, 79) = .344, p < .559$ . As on previous ANCOVAs, an interaction was evident on the Externalizing scale, so the groups could not be compared in their Externalizing Problems with the Mullen ELC as a covariate. An interaction emerged for the Total Problem ANCOVA as well, suggesting that it should not be interpreted. A MANCOVA was conducted for the individual scales of the CBCL, but did not reveal any significant results,  $PT(5, 72) = .021, p = .904$ .

The lack of findings of differences between the groups on the CBCL suggested that perhaps collapsing the Moderate and Severe TBI Groups was not warranted. Descriptive statistics demonstrated a clear trend for the Moderate Group to have lower developmental level and adaptive behavioral functioning and higher scores on the CBCL (i.e., indicating more behavioral problems). Additional ANCOVAs were run to determine whether these observed differences in the descriptive statistics were indicative of significant between-group differences when comparing all four groups (e.g., Mild TBI, Moderate TBI, Severe TBI, and Typically-Developing Group). Because of the different cell sizes ( $n_{mild} = 31, n_{moderate} = 10, n_{severe} = 10, n_{typical} = 31$ ), the results of the ANCOVA should be interpreted cautiously.

These ANCOVAs yielded covariate/group interactions on the dependent variables of Internalizing Problems and Externalizing Problems. For Total Problems, the groups were not significantly different when controlling for developmental quotient,  $F(3, 74) = 2.467, p < .069, \eta^2 = .091$ , but there was a trend for the Moderate TBI Group to be consistently higher on all the CBCL summary scales. A MANCOVA was run to examine differences between the four groups on the scales of the CBCL, but produced a significant interaction between the covariate and group membership. When run without Attention Problems and Aggression, no group differences emerged,  $PT = .329, F(15, 207) = 1.699, p < .053, \eta^2 = .110$ . Despite no

significant group differences being evident, a clear trend for the Moderate TBI Group to have higher scores on the CBCL scales was noted. The exception to this trend was the Withdrawal scale, for which the Moderate and Severe TBI Groups had comparable scores that were higher than those of the Mild TBI and Typically Developing Groups. Means for each of the four groups on the Mullen Early Learning Composite and on the Child Behavior Checklist can be found in Table 8. Line graphs of the means can be found in Figure 6.

To gain a better understanding of the descriptive characteristics of the data set, analyses were conducted to examine the proportion of children in each of the TBI groups who had sustained an inflicted injury. A chi-square analysis revealed significant differences in the proportionality of group membership by injury mechanism,  $\chi^2(2, N = 51) = 8.997, p < .011$  (see Table 9). Of the 10 children in the Severe Group, 5 had sustained inflicted injuries. In the Moderate Group, 9 of the 10 children had sustained inflicted injuries. Only 11 out of 31 children in the Mild Group had injuries that were inflicted. An additional chi-square analysis did not reveal differences in the racial composition of the groups based on mechanism of injury,  $\chi^2(2, N = 50) = .720, p < .396$ .

Chi-square analyses also did not reveal significant differences by mechanism with respect to the proportion of children demonstrating significant overall behavioral problems on the CBCL,  $\chi^2(2, N = 51) = .690, p < .406$  (see Table 10). When examining the incidence of overall behavioral problems at or above the 90<sup>th</sup> percentile rank in terms of injury severity, the chi-square analysis also was not significant,  $\chi^2(2, N = 51) = 3.414, p < .181$ , but did reveal a notable finding. Of the 8 children who evidenced significant overall behavioral problems, 3 were in the Moderate Group and 5 were in the Mild Group; none were in the

Severe Group. Similar trends emerged for Externalizing Problems, with the frequency of Internalizing Problems more evenly distributed between the groups.

The three severity groups evidenced some differences in racial composition,  $\chi^2(2, N = 50) = 6.133, p < .047$  (see Table 11), but the mild, moderate, and severe groups were comparable in their gender composition,  $\chi^2(2, N = 51) = 2.121, p < .346$  (see Table 11).

To understand better the role of maternal education in behavioral dysfunction in preschoolers after TBI, the frequency of children who evidenced significant impairments (i.e., at or above the 90<sup>th</sup> percentile) was compared to whether mothers were less educated (i.e., scores of 1, 2, or 3 on the Hollingshead, suggesting that they had not completed high school), were moderately educated (i.e., scores of 4 or 5; reflected completion of high school or partial college), or were well educated (i.e., scores of 6 or 7; reflected completion of college or post graduate work). Significant group differences did not emerge on these chi-square analyses for most of the CBCL scales. Somatic Complaints and Attention Problems, however, were tied to maternal education. On the Somatization scale, of the 8 children whose mothers fell in the “less educated group”, 3 had significant ratings, compared to 2/33 and 1/6 in the “more educated” and “well educated” groups. This chi-square statistic was significant,  $\chi^2(2, N = 50) = 6.270, p < .043$ . The chi-square test for Attention Problems also was significant,  $\chi^2(2, N = 50) = 8.333, p < .016$ , with 4 out of the 8 children demonstrating significant problems in this area if their mothers were less educated, 3 out of 35 showing problems in their mothers were more educated, and just 1 out of 7 evidencing significant attention problems if their mothers were well-educated.

## **CHAPTER V**

### **DISCUSSION**

The current study examined whether preschoolers who had sustained traumatic brain injury at a very young age demonstrated impaired social-behavioral functioning relative to a group of typically-developing peers. An important area of development, social-behavioral functioning contributes to a child's ability to interact effectively with his or her environment. As a result, social-behavioral dysfunction may relate to struggles in other areas of development, necessitating a better understanding of the effects of early TBI on social-behavioral functioning in preschool children.

The preschool years span an important stage of rapid development. Disruptions during this time period would be expected to result in poor outcomes in a variety of areas of development. Current literature on outcomes after TBI in the early years is limited, but research does implicate lags in overall development (Ewing-Cobbs et al., 1989; Ewing-Cobbs et al., 1997; Ewing-Cobbs et al., 1998; Morse et al., 1998), language (Ewing-Cobbs et al., 1997), and memory skills (Anderson et al., 1999; Anderson et al., 2000). Some of these findings are consistent with the school-age TBI literature which suggests deficits in language (Catroppa & Anderson, 2004; Chapman et al., 2001), memory (Anderson et al., 1999; Anderson et al., 2000), intellectual functioning (Jaffe et al., 1993; Verger et al., 2001), and visual-spatial abilities (Verger et al., 2001) after TBI in older children and adolescents.

While previous research has examined social-behavioral functioning post injury in school-aged children, no known research has targeted behavioral outcomes of preschoolers injured



as very young children. The current study sought to address this gap in the literature by comparing children who sustained TBI between birth and 2 years of age to a comparison group of typically-developing children on parent ratings of social-behavioral functioning. One strength of this study was in the sample ascertainment. The TBI group was comprised of an epidemiologically-based sample in the state of North Carolina. Comparing this sample to a demographically-matched comparison group permits conclusions about the effects of TBI on social-behavioral functioning above and beyond the influence of demographic variables. The following discussion focuses on the results of the study, comparing the findings to hypotheses established a priori. Possible interpretations of the findings, limitations of this study, and suggestions for future research also will be addressed.

### *Question 1*

**Do parent ratings of the social-behavioral functioning of preschoolers who sustained mild and moderate/severe TBI as very young children differ significantly from parent ratings of typically developing preschoolers?** It was hypothesized that preschoolers with mild and moderate/severe traumatic brain injury would be significantly impaired in their social-behavioral functioning relative to children in a typically-developing group on parent ratings on the early childhood version of the Child Behavior Checklist. It was also hypothesized that an effect for severity would be found, with children in the Moderate/Severe TBI Group demonstrating more difficulties in their social-behavioral functioning than children in the Mild TBI and Typically-Developing Groups. Specifically, it was expected that children with TBI would be more impaired than the Typically-Developing Group on all

three CBCL composite scales (Internalizing Problems, Externalizing Problems, and Total Problems) and on some individual scales.

Preliminary data analysis revealed a significant difference between the groups on the Mullen Early Learning Composite. Previous findings have shown overall developmental levels and/or IQ to be related to social-behavioral difficulties, particularly as these levels begin to fall below the average range (Chadwick et al., 1981). Consequently, this variable was covaried in the subsequent group comparisons in an effort to control for the impact of this variable on social-behavioral functioning.

Specifically, the obtained findings did not support the proposed hypotheses, with no significant differences emerging between the groups on Internalizing or Total Problems. Significant interactions were noted in the ANCOVA between the covariate (i.e., Mullen Early Learning Composite) and the Externalizing Problems scale, and on the MANCOVA between the covariate and some individual scales (i.e., Attention, Aggression), preventing these analyses from being interpreted. For these CBCL scales, a visual inspection of the scores revealed a trend for the Mild and Moderate/Severe Groups to demonstrate more impaired social-behavioral functioning than the Typically-Developing Group on the summary scales.

### *Question 2*

**Do groups of preschoolers with mild and moderate/severe TBI differ significantly from a group of typically-developing children in their observed incidence of behavioral problems based on parent ratings?** That is, does a significantly higher proportion of preschoolers with mild TBI or moderate/severe TBI evidence difficulties in their social-

behavioral functioning at or above the 90th percentile? It was hypothesized that a higher proportion of children in the Mild and Moderate/Severe TBI Groups would demonstrate social-behavioral functioning that was at or above the 90th percentile (T-score > 63) relative to a group of typically-developing children.

To ensure that group mean comparisons did not obfuscate potential behavioral problems evidenced by individual members of the TBI group(s), the frequency of clinically significant behavior problems for each group was compared. Consistent with ANCOVA results, the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups did not differ in the proportion of participants who fell at or above the 90<sup>th</sup> percentile on the domain scales or composite scores of the CBCL.

While few studies have specifically targeted behavioral outcomes after TBI at very early ages, the literature has provided considerable evidence suggesting social-behavioral impairments after brain injury in the school-age years (Basson et al., 1991; Dennis et al., 2001; Donders & Ballard, 1996; Feeney & Ylvisaker, 2003; Fenwick & Anderson, 1999; Green et al., 1998; Janusz et al., 2002; Kinsella et al., 1999; Kirkwood et al., 2000; Max et al., 1998; Milders et al., 2003; Schretlen, 2000; Schwartz et al., 2003; Taylor et al., 2002). Some emergent evidence also suggests that children injured between the ages of 2 years and 7 years will display more impairment in certain aspects of their behavior 30 months post injury (Anderson et al., 2006).

*Additional Exploratory Analyses for Question 1.* With the regrouping of the TBI Group by three levels of severity (e.g., Mild, Moderate, and Severe vs. Mild and Moderate/Severe), children across these different severity groups did not differ in the proportions of clinically

significant behavioral problems reported by parents. Surprisingly, though, none of the children with severe injuries displayed significant overall behavioral problems, which might provide further support for the idea that children with the most severe injuries might not have enough overt behavior to evidence dysfunction in their social-behavioral functioning.

Implications of these findings suggest that the most severe group should be monitored for overall development and adaptive behavioral functioning, while the other groups should be monitored on these domains as well as in their social-behavioral development.

It is also possible that this finding is related to a morbidity/mortality effect, whereby the most severely injured children did not survive the injury, suggesting that the remaining children in the severe group had the potential for better outcomes despite low GCS scores. Another possibility is that the children in the severe group were monitored more carefully because of the extent of their injuries and that this close monitoring and intervention may have ameliorated outcomes. Studying service provision and physicians' protocols for monitoring infants and preschoolers after injury would provide important insight into this trend.

Finally, measurement questions also require consideration. Some literature has suggested the presence of different outcomes following TBI depending on the instrument used. Green et al. (1998) found differential results for anxiety and attention problems on the Diagnostic Interview for Children and Adolescents, Revised (DICA-R) and the Child Behavior Checklist. Further, the DICA-R, the CBCL, and the Vineland Adaptive Behavior Scales (VABS) yielded different rates of maladaptive behavior in the sample. Another measurement question relates to the sensitivity of the GCS to determine the various levels of severity. The GCS was designed to assess eye opening, verbal, and motor responses post

injury as an assessment of overall alertness and responsiveness. It was not, however, developed with very young children in mind and may not be sensitive to subtle differences between severity groupings in the preschool population.

### *Summary for Questions 1 & 2*

The findings of the current study are not consistent with the bulk of research on social-behavioral functioning after TBI in the school-age population, and they do not align with the growing research suggesting negative cognitive/developmental outcomes in preschool children following a TBI. In fact, the available literature does suggest that a study of social-behavioral functioning should have yielded more in the way of social-behavioral difficulties. A more thorough understanding of why the results of these studies vary is important for accurately conceptualizing how TBI impacts social-behavioral development in early childhood. This understanding is critical for developing appropriate interventions and treatments, knowing how and when such resources should be utilized, and for predicting which children will evidence dysfunction post injury.

Results from the current study are consistent with findings of average social-behavioral ratings reported in several studies (Anderson et al., 2001; Fay et al., 1994; Fletcher et al., 1990; Kinsella et al., 1999), but do not reflect group differences. Further, while it only emerged as a trend, the tendency for the Severe TBI Group to have less impaired social-behavioral functioning than either the Mild or Moderate Groups was consistent with findings by Anderson et al. (2001) who found their Severe Group (injured between the ages of 2 and 12) to have a lower incidence of behavioral problems post injury.

Several possible explanations exist for the lack of significant findings both for group means as well as incidence of dysfunction for these first two questions. It is quite possible that behavioral outcomes after early TBI differ from both other preschool TBI outcomes as well as from school-age behavioral outcomes. The preschool years are a unique stage in the amount of rapid development that occurs, making it difficult to map a clear developmental trajectory after early trauma. In addition, social-behavioral outcomes differ from neurocognitive outcomes both in how they are measured (e.g., social-behavioral functioning in early childhood typically is based on parent observations) as well as in how they develop. Factors related to recovery after injury, the development of executive functioning abilities, task demands as a function of developmental stage, late effects of TBI, the use of parent report, environmental demands, and small sample sizes may have contributed to the lack of differences found.

One possibility for the lack of group differences is that preschool TBI groups truly show no impairments in their social-behavioral functioning after sustaining mild and moderate/severe injuries as infants and very young children. If this scenario were true, it would suggest either that 1) no behavior difficulties emerge after early TBI or 2) behavioral problems are present, but diminish during the recovery period and no longer impact the child at the age of 3 years. Additionally, it could be that a child's development is monitored more closely after a TBI and that environmental supports are in place to address signs of behavioral problems when they begin to emerge and/or to accommodate differences in an acceptable fashion. Such an explanation would provide positive support for intervention services soon after injury.

The issue of recovery is critical when following children of any age after a TBI. Although premorbid or acute behavioral functioning data are not available for this sample, the use of a matched typically-developing comparison group was employed to provide a means of comparing the TBI group to expected development. It is possible that the children in the TBI group displayed significant behavior problems or behavior changes immediately after the injury, returning to age-appropriate behavioral functioning by the time of the assessment. An average of 2.5 years had elapsed between the TBI and the developmental assessment, suggesting a significant amount of time during which recovery could occur. If recovery post injury followed such a course, the results would be encouraging, and would underscore the impact of the recovery period as well as the importance of close monitoring during this time. Accurately detecting social-behavioral problems is essential in early intervention, particularly after a significant trauma such as a TBI, and measuring such development closer to the time of injury might be critical (e.g., joint attention in infancy, etc.).

The similarity between the groups on the CBCL also might be related to an interaction between skill acquisition and the task and environmental demands that a 3-year-old faces. Preschoolers are not expected to have sophisticated executive functioning, relying instead on the significant structure provided by the environment. Therefore, the effects of the TBI on behavior may lie dormant until the school years when children are presented with tasks and experiences that place increased demands on their executive functions. While uninjured children are acquiring these skills and successfully managing their behaviors, the TBI group may begin to demonstrate behavioral dysregulation secondary to their injury. Such a progression would support findings by Barlow et al. (2005), who studied the late effects of TBI in infancy. In this group of children who sustained inflicted TBI at an early age, just

over half demonstrated behavioral problems that manifested when they were 2 and 3 years old.

Another important element to consider is that the current study was based solely on parent report of behavior in the home. Assessment did not include direct observation of the child's behavior, nor did it tap a child's response to a structured preschool or school environment. It is possible that parents of children with TBI have a different frame of reference than parents of typically-developing children. After a serious, potentially life-threatening TBI, parents would be relieved that their children had survived and possibly more forgiving and/or tolerant of misbehavior and noncompliance. Observed misbehavior might be considered injury-related and beyond the child's control. Conversely, some parents may lack knowledge about typical child development, assuming that their child's behavior is age-appropriate and not realizing the impact of the TBI on development. Another possible explanation is that parents have handled post injury behavior problems by employing effective behavior management strategies or by compensating for them. If this explanation were true, children in the TBI group might evidence significant difficulty upon entering school, where the environmental and academic demands are greater and the teacher has normal development as a frame of reference.

Another explanation relates to the relatively small sample size employed in this study, and may have precluded stronger findings. Because the moderate and severe groups were pooled together for these major analyses, subtle differences between the two groups may have been overlooked or were unable to be detected.

A complex interaction may exist between injury severity, overall development, and preschool children's tendency to evidence social-behavioral dysfunction. It is possible that



covarying for these group differences in developmental level precluded any differences from being found with respect to CBCL outcomes. Alternatively, several of the children in the moderate and severe groups may have been so impaired that they did not engage in much behavior at all, making it virtually impossible for them to show “deficits” in some areas of their social-behavioral functioning (e.g., hyperactivity). In addition, many of the children with the most debilitating injuries likely did not survive the injury. It is also possible that differences in the metric used prevented severity groups from being accurately determined. Finally, observed difficulties in social-behavioral outcomes after TBI may not be a result of the traumatic brain injury itself, but related to other factors.

Additionally, environmental changes may have provided a behavioral intervention that facilitated more positive social-behavioral outcomes. Several of the children who sustained TBI as the result of abuse were removed from their homes and were living with foster parents (relatives and non-relatives) and adoptive parents. Other children who sustained inflicted injuries remained in their natural home, but no longer had contact with the perpetrator. This removal from the home or removal of a perpetrator from the home likely served as an important intervention at a critical time. Although data are not available in this study to examine how home environment post injury may have impacted outcome, it is possible that by being removed from their homes, some of the children in the inflicted TBI group were provided with increased stability that may have contributed to improved outcomes. Keenan et al. (2003) found that children who sustained inflicted injuries were more likely to be the products of a multiple birth, were born to young mothers, and were of non-European American descent. Incidence of inflicted injury appeared to increase after a natural disaster (Keenan et al., 2004), suggesting that chaos outside the family may tax a family’s resources

and level of functioning, putting young children at an increased risk for TBI. This information highlights the effects of forces within and outside the family on injury risk, and fits with the idea that changes in the environment—positive or negative—may impact outcomes.

In general, these findings may suggest that while insult to the brain at an early age is responsible for disruptions in overall development, family characteristics and demographic variables likely play a significant role in determining post injury behavioral dysfunction.

### *Question 3*

**What child-, family-, and injury-related variables (e.g., developmental level, maternal education, injury severity) predict Internalizing, Externalizing and Total Problem scores on parent ratings of the CBCL in preschoolers after TBI?** It was hypothesized that injury severity and maternal education would be significant predictors of social-behavioral functioning as measured by the CBCL Internalizing, Externalizing, and Total Problem scores.

While the small group size and exploratory nature of this study preclude generalization of the findings of regression equations, the third question of this study sought to determine what variables might predict social-behavioral outcomes after TBI in the early years. Developing a model predicting behavioral outcomes at 3 years of age would provide physicians and other health care professionals with a means of identifying early which infants and toddlers would be at risk for negative sequelae from an early TBI.

It will be necessary for future research to examine more carefully potential predictors of social-behavioral outcomes after TBI in the early years. Results from the current study

showed that for the Internalizing Problems composite score on the CBCL, overall development emerged as a significant predictor of functioning. Glasgow Coma Scale (GCS) and SRFI Leadership were significant predictors of Externalizing Problems on the CBCL. No variables significantly predicted the Total Problems score. The finding that GCS predicted Externalizing Problem scores is consistent with a broad base of pediatric TBI literature that severity of injury influences outcome (Brown et al., 1981; Dennis, 2001; Janusz et al., 2002; Kinsella et al., 1999; Max et al., 1998; Schwartz et al., 2003; Taylor et al., 2002); it is surprising, however, that injury severity was not predictive of Internalizing and Total Problems as well.

The emergence of the SRFI Leadership score as a significant predictor of Externalizing Problems in the regression equation supports research by Yeates et al. (2004). Their study found that poor family functioning exacerbated poor social outcomes in a TBI group relative to an orthopedically-impaired group. The Leadership index is comprised of three questions which assess a family's recognition of a clear family leader and the strength of leadership from adults in the family. It could be argued families with strong leaders set clearer and more consistent limits, providing structure and control that might help prevent acting out behaviors. Similarly, Kinsella et al. (1999) found that family variables, such as whether the primary giver had a partner and coping variables (e.g., ability to cope, parent reaction to injury) significantly predicted child behavioral outcome acutely; however, these findings were not sustained over time. In families with single parents, however, it is possible that leadership scores were high (i.e., with only one adult in the home, the role of leader was easily established) but organization may have been low. Such a situation would make the relationship between leadership scores and externalizing behaviors less clear.

*Additional Exploratory Analyses for Question 3.* When examining the possible predictors, it was curious that maternal education did not significantly correlate with the dependent measures on the CBCL. Even though maternal education does not appear to be a significant predictor of negative behavioral outcomes, when comparing mothers who are “less educated” (< high school), “moderately educated” (high school completion and/or some college), and “well-educated” (college graduate and/or postgraduate) a disproportionate number of children who evidence significant problems on the Somatic and Attention Problems scales have mothers in the less educated group. While future research is necessary to explore this trend, a better understanding of explanations for it might be useful for conceptualizing behavioral dysfunction after early TBI. Low maternal education is correlated with a host of other chronic stressors including low income, single parent status, multiple jobs, limited social mobility, and unsafe living situations. In addition to these stressors, having a child with TBI or other special needs might further challenge an individual’s coping resources and parenting skills. These findings underscore the importance of employing a family-centered approach when intervening with young children after TBI. Mothers who are less educated might also be more cognitively limited or less cognitively flexible, having a difficult time adapting to the needs of a child with a significant impairment.

### *Summary for Question 3*

Although limited in their interpretability and generalizability, the regression equations examined in Question 3 highlight some interesting predictors of Internalizing, Externalizing and Total Problem scores on the Child Behavior Checklist. Significant correlations were

noted between Internalizing Problems and the Mullen ELC. The Externalizing Problems score was significantly correlated with maternal education and SRFI Leadership. Finally, the Total Problems T-score correlated significantly with maternal education. Three predictor variables were entered into all equations, regardless of their correlation with the outcome variable, because of theory and literature that support their importance in predicting outcomes in other areas. These three variables (Mullen ELC, maternal education, and GCS) reflected child characteristics, family characteristics, and injury characteristics. Mullen ELC emerged as a significant predictor of Internalizing Problems, while GCS score and SRFI Leadership predicted Externalizing Problems. No variables significantly predicted Total Problems.

#### Limitations

While the current study focused on an important but understudied area of TBI in infancy and early childhood, limitations specific to the study and difficulties inherent in studying this population exist and will be discussed so that they may be addressed by future research. Limitations for the current study include the small sample sizes for the moderate and severely injured groups and disparate sample sizes with respect to severity of injury; a lack of information about premorbid and acute functioning, and the CBCL as the only measure of social-behavioral functioning. Despite matching on important demographic variables, the groups differed regionally. The TBI Group lived in a variety of rural, urban, and suburban areas throughout the state of North Carolina. The comparison group, on the other hand, tended to be more suburban in its composition and was limited to a city and a town in North Carolina as well as a city in Virginia. Future research might address this limitation by inviting children in the TBI group to “bring a friend” when participating in the study, which

might help capture comparison children similar to the TBI Group on this regional dimension. While the CBCL has been widely used in research and is a reliable, valid instrument, inclusion of another measure or a direct sampling of a child's behaviors would have provided additional useful information.

Specific issues arise when collecting data on preschoolers with TBI. First, it often can be difficult to tease apart the effects of recovery from expected development. Typical development in the early years happens at a quick pace and usually with significant "unevenness," with many functions emerging in rapid succession. The recovery of function after injury in school-age children in certain areas can be rapid and difficult to predict. Second, because of the changing developmental needs of the preschool population, using the same assessment tool over time (e.g., from birth to early childhood) can be difficult. Most instruments that tap the functioning of very young children have a limited ceiling; many tests that span a broader age range do not have a floor low enough to permit obtaining information about the most impaired children. These limitations make longitudinal tracking more difficult with this population. Third, measures of behavior in preschoolers must rely heavily on parent observation and rating; in contrast to older children and adults, preschoolers have a limited ability to self-report. Discrepancies found in family and patient ratings with adults (Dwyer & Segalowitz, 1996) suggest that the patient and caregiver(s) have differing perceptions of the patient's abilities; ratings by only the patient or only the caregiver may not provide as thorough an assessment. Such findings suggest that multiple respondents, perhaps via a multi-rater, multi-setting, multi-instrument design, might provide a more complete picture of social-behavioral functioning post injury.

Another limitation inherent in studying children injured at such a young age is the difficulty measuring behavioral functioning in infants. The closest approximation would be through the use of temperament measures, followed by CBCLs or other behavioral measures once the child is older.

### Future Directions

The current study has addressed a largely neglected area of TBI research. Findings suggest that traumatic brain injury in the very early years may not result in the extent of behavioral dysfunction predicted by school-age TBI literature or with what is known about general developmental outcomes in preschoolers following a TBI. While such findings may suggest that TBI incurred at a young age does not adversely affect social-behavioral development in the preschool years, more research is warranted to confirm these findings and address some of the limitations of the current study. A larger sample size would allow more extensive regression analyses, permitting the development of a predictive model of behavioral outcomes. This methodology would be useful for providing physicians with guidelines for care and monitoring of young children after TBI. Ideally, information on premorbid developmental and social-behavioral functioning would be collected acutely after injury, with follow-up testing occurring at regular intervals, especially during the recovery period. More information about the services, interventions, and supports the children receive after TBI would provide useful insight about the types of formal and informal interventions that might mediate outcomes. Future research should also follow these children longitudinally to determine whether the more structured, academically demanding environment of school brings latent social-behavioral impairments to the surface.

Item analysis of the CBCL or similar measures might be useful for determining whether particular items predict dysfunction, assisting in the development of a brief screener that could assess social-behavioral functioning. Similarly, the development of a screening measure that could predict long-term outcome would be useful for designing interventions soon after the injury and would permit appropriate interventions that target the specific needs of individual children. For example, some children with behavior dysfunction might benefit more from home visiting, family interventions, and parent training while other children might need help with the underlying cognitive deficits that impact these functions.

Professionals eventually must be able to provide teachers and parents with a more precise range of developmental expectations immediately after injury, throughout the recovery process, and beyond. Given the variability of recovery, late-emerging difficulties, and persistent problems, closely monitoring children after TBI via formal developmental surveillance programs is key. Referrals for the child and family to receive additional intervention services may also be warranted.

Additional topics that future TBI research could examine include how the level of parenting stress and a parent's perception of injury (e.g., guilt, depression, relief that it was not worse) might affect behavior ratings. Teacher ratings of children's behavior in the school environment also would be insightful, possibly reflecting a child's response to the structured environment; such ratings would indicate how TBI impacts a child's response to the academic demands of preschool and peer relations.

A longitudinal study of outcomes after TBI at a very early age could encompass teachers' ratings of classroom behaviors, parent ratings, formal tests of executive functioning, and assessment of social skills/peer relations. Evaluating the psychological impact of early TBI



on the family, particularly for inflicted and preventable injuries, would be an important line of inquiry and could prove informative for gauging a family's needs and guiding interventions. Although difficult, a better understanding of post injury outcomes would be enhanced by prospective research that gathered data on premorbid social-behavioral functioning as well as acutely and through recovery.

*Intervention Research.* In addition to a dearth of research on social-behavioral outcomes in preschool TBI, general research on preschool outcomes after TBI often lacks a clear link to functional outcome and practical strategies for relating findings to interventions. Using TBI findings to develop guidelines for evidence-based practices would be an important step in helping professionals understand how best to intervene after an injury. Only through studies such as these will strategies for evidence-based best practices be generated and implemented. Such intervention studies could focus on parental report of difficult behaviors and could include implementation of a single subject design to assess an individual child's response to the interventions (e.g., Feeney & Ylvisaker, 2003). Should future research find that children with TBI show more behavioral problems after injury, intervention studies could design and implement a comprehensive treatment program and examine its efficacy. By comparing the response-to-intervention of children with TBI versus children with non-TBI behavioral problems, it would be possible to examine whether the TBI group responds differentially to treatment. Such a line of research could prove quite valuable, as many children with TBI, particularly in the early years, receive special education services in classrooms with children with general developmental delays. While children with developmental delays tend to evidence global lags in multiple aspects of development,

children with TBI may evidence more specific areas of need rather than global delay.

Further, preschoolers who have sustained a TBI may respond well to strategies implemented for children without TBI, but it is also possible that the underlying mechanisms and etiology of these disorders warrant differential intervention. At the very least, increased awareness for teachers and parents about 1) what to expect after TBI, 2) the changes that can occur during the TBI, and 3) the recovery curve would be useful.

Additionally, specifying exactly what differences exist between children with neurologically-based social-behavioral deficits and non-neurologic deficits would improve interventions. If the difficulties differ based on etiology, comorbid problems likely differ. Interventions should take such variations into consideration. For example, if areas important for facial recognition are impaired by TBI, a child might have negative social interactions. Such a child would need to be taught to attend to other cues, such as a speaker's voice, to detect the speaker's meaning. Children who are at risk for delayed development, however, may have not learned age-appropriate interactions because they do not understand what is being said. This group of children would benefit more from learning how interactions are structured and practicing in a role-play situation with an older peer or adult.

Jaffe et al. (1993) suggested basing interventions after TBI on both a psychoeducational model and a medically-oriented model to ensure that both academic skills and the underlying cognitive deficits are targeted. It is also important to consider social skills as a potential area of difficulty for children injured at an early age. Janusz et al. (2002) suggested that inefficient problem strategies after school-age TBI may be related to difficulty with appropriate social interactions; however, such hypotheses have yet to be tested for preschool children who have sustained a TBI.

Intervention research targeting best practice guidelines might support the use of a case manager to follow a child and his or her family through the recovery process, helping with transitions in life and (pre)school, assisting in navigating the school system/day care setting, and supporting the family's adjustment to injury. A case manager could coordinate respite care and provide parent education about behavior management techniques, limit setting, and developmentally appropriate expectations. If family functioning variables, such as strong leadership, are predictive of behavioral outcomes, empowering the adults in the family to become stronger leaders in their family might also promote positive social-behavioral development. Studying whether children benefit more from close contact with a primary care physician, a TBI outpatient clinic, home visiting from nurses, parenting groups, and social supports from parents could provide useful information about where to target services.

*Prevention.* Injury prevention is a key dimension of TBI intervention research. While studying the after-effects of TBI will provide valuable information, it is also important to reduce the incidence of preventable TBI. A number of areas could be addressed through prevention. Educating new parents about the consequences of shaken baby syndrome and discussing strategies for coping with crying and difficult infant behavior would target reducing the incidence of inflicted TBI. More intensive interventions for at-risk groups (e.g., young parents/young males, families with limited resources) might also prove useful. These interventions could include home visiting by nurses or other professionals trained in infant development and family systems theory, linking families with new parent support groups, and helping parents become connected to social supports in their community. Encouraging parents to provide adequate supervision of their young children would be an important

strategy for preventing pedestrian accidents. Finally, monitoring proper safety restraints and car seats has the potential to reduce TBIs incurred in motor vehicle accidents.

From a public health perspective, being prepared for situations which may increase the incidence of TBI is also important. Natural disasters (Keenan et al., 2004), and other major events, such as parents returning from war and military conflict, may be related to increased incidence of inflicted injuries. Directing prevention to communities affected by natural disaster and military deployment could be instrumental in providing support to families and preventing TBI.

*Conceptual Frameworks.* TBI and related outcomes can be considered through multiple frameworks, but any model allowing a thorough understanding of the child's functioning must take into account the people, environment, and systems in which a child lives, as well as an understanding of typical development. Bronfenbrenner's (1986) ecological theory offers a conceptualization of the processes occurring within the child and in the child's environment. The bidirectional influences that these different domains exert on one another influence both the child and the environment. For preschoolers, the primary environment or ecological influence is the family. If resources are limited, negative outcomes would logically interact with environment, and then worsen even more. Extensive literature suggesting that family functioning predicts child outcomes supports the use of a model such as Bronfenbrenner's.

Sameroff's transactional theory (2000) is similar to Bronfenbrenner's ecological theory in that it attributes importance to the interaction between the child and the environment. Sameroff's model adds the element of change over time, a particularly important component

when considering the development and functioning of a group of children whose recovery may be so variable. In line with this theory is the idea that deficits post injury are not static, but are constantly changing, particularly early in the recovery process.

### Conclusions

The current study examined the social-behavioral functioning of preschoolers who sustained mild and moderate/severe traumatic brain injuries when they were younger than 2 years of age relative to typically-developing controls. No significant group differences in social-behavioral functioning emerged, with all groups falling in the average range on parent ratings on the Child Behavior Checklist (Question 1). Similarly, the groups did not differ in the frequency of cases in each group with parental behavior ratings at or above the 90<sup>th</sup> percentile on the individual or composite scales of the CBCL (Question 2). These findings were not consistent with hypotheses set a priori that children who had sustained TBI would demonstrate social-behavioral impairments relative to the comparison group. While the results are not in line with most of the school-age literature, they are consistent with some findings.

Additional exploratory analyses were run to determine whether differences existed when the entire TBI group was compared to the Typically-Developing Group or when the Moderate/Severe Group was analyzed as two separate groups. Again, no significant differences emerged on outcome measures. An unexpected, but clear trend for the moderate TBI group to show greater impairments in their overall development and in their social-behavioral functioning emerged when the moderate and severe groups were examined separately. Further inspection revealed that the moderate group was comprised almost

completely of children who had sustained inflicted injuries and were disproportionately of minority status. Although the groups do not appear significantly different with respect to behavioral outcomes, subtle impairments may exist in the TBI group. It would be premature to conclude that children do not display disruption in their social-behavioral functioning after a TBI; it is important that future research explore this area further.

Reasons postulated for the lack of findings include issues of recovery after injury, skill development, task demands in the preschool years, the use of parent report focused questionnaires, and small sample sizes for the moderate and severe groups. While preschool children who sustained early TBI demonstrated average social-behavioral development, nuances and subtleties may exist that have not yet been detected. These undetected differences may be a function of stage of development, with preschoolers not yet facing many of the social-behavioral or learning demands of a structured, formal school setting. The injury may have impaired areas of the brain responsible for skill sets preschoolers have not yet developed (e.g., executive functioning). If children with TBI evidenced impairments in their executive functioning, they would likely have a difficult time organizing themselves and, consequently, may manifest problems with emotional and behavioral regulation. While social-behavioral development may appear within normal limits at the age of 3, it is possible that this development would not keep pace with a typically-developing peer group and that deficits would emerge later in their developmental course.

Based on the findings of the current study and what is known about TBI in preschool and school-age children, it is recommended that TBI and recovery from TBI be considered from a family systems, developmental model. Children with TBI were not showing impairments in their social-behavioral functioning relative to a typically-developing peer group at 3 years

of age. However, because of the rapid development occurring during the preschool years, it is possible that the full effects of TBI at an early age were not yet observable. Future research which examines social-behavioral functioning as these groups of children become older would provide valuable insight about the effects of TBI over time.

Future research should target the longitudinal outcomes of children who sustain TBI at very young ages, examining premorbid functioning as well as acute functioning and the recovery process. It is through such research on outcomes and more research on interventions that children and families will be able to be served in a manner consistent with evidence-based, empirically supported services, promoting the best possible outcomes post injury.

Table 1:

## Demographic Variables for the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups

	Mild TBI	Moderate/Severe TBI	Typically-Developing Group	Group Comparison
Chronological Age***	3.33 (0.38)	3.25 (0.27)	3.68 (0.35)	TYP > Mild TBI TYP > M/S TBI
Early Learning Composite ***	89.35 (18.82)	63.65 (15.98)	94.32 (18.71)	TYP > M/S TBI Mild > M/S TBI
Scales of Independent Behavior—Revised***	104.60 (21.11)	82.15 (25.74)	116.52 (15.82)	TYP > Mild TBI Mild > M/S TBI
Maternal Education	4.61 (1.20)	4.60 (1.05)	5.03 (1.20)	NS
Caucasian	19 (63.33)	6 (30.00%)	17 (54.84)	NS
Female	17 (54.84%)	7 (35.00%)	11 (35.48%)	NS
Age at Injury (in years)	0.49 (0.57)	0.81 (0.62)	--	NS



Time since injury*		2.81 (.35)		2.45 (.69)		--		Mild > M/S TBI
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Note: \*p < .05; \*\* p < .01; \*\*\*p < .001.

Maternal Education was coded as follows: 1 = less than 7<sup>th</sup> grade; 2 = 9<sup>th</sup> grade; 3 = 10<sup>th</sup> or 11<sup>th</sup> grade; 4 = high school graduate; 5 = partial college; 6 = college graduate; 7 = post graduate.

Table 2:

Means, Standard Deviations, Effect Sizes, and Group Comparisons for the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups on the CBCL (with Early Learning Composite of the Mullen Scales of Early Learning as a Covariate)

		Mild TBI (n = 31)	Mod/Severe TBI (n = 20)	Typically- Developing (n = 31)	F-Tests (2, 76)	$\eta^2$	Group Comparison
Mullen ELC	M	89.35	63.65	94.32	--	--	--
	SD	18.82	15.98	18.71	--	--	--
<hr/>							
Internalizing Problems	M	51.42	53.70	48.06	0.758	.020	NS
	SD	10.12	8.64	11.93			
	Y <sub>adj</sub>	52.08	50.19	51.06			
<hr/>							
Externalizing Problems	M	53.68	51.80	48.39	--	--	--
	SD	10.71	13.69	12.23			
	Y <sub>adj</sub>	54.90	55.62	51.82			

Total	M	53.35	52.95	48.03	2.710	.067	NS
Problems	SD	9.80	10.18	12.73			
	Y <sub>adj</sub>	54.34	53.48	51.38			
Emotional	M	55.39	55.80	54.58	1.277	.034	NS
Reactivity	SD	6.73	6.80	7.13			
	Y <sub>adj</sub>	55.67	55.76	56.28			
Anxious/ Depressed	M	53.71	52.90	52.77	.639	.017	NS
	SD	4.27	4.69	5.90			
	Y <sub>adj</sub>	53.89	53.58	53.29			
Somatization	M	54.14	54.85	54.16	1.401	.037	NS
	SD	6.02	7.25	6.21			
	Y <sub>adj</sub>	54.28	50.33	55.87			

Withdrawal	M	54.79	60.60	54.19	2.119	.055	NS
	SD	5.97	9.38	6.52			
	Y <sub>adj</sub>	55.26	54.42	55.07			
Sleep Problems	M	57.39	54.60	55.97	.288	.008	NS
	SD	8.33	6.94	7.99			
	Y <sub>adj</sub>	57.63	52.75	57.31			
Attention	M	56.43	56.90	55.97	--	--	--
	SD	7.13	8.53	5.97			
	Y <sub>adj</sub>	57.01	58.31	56.31			
Aggression	M	56.93	55.35	54.00	--	--	--
	SD	8.64	8.51	7.75			
	Y <sub>adj</sub>	57.81	56.05	56.19			

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Note. For each composite scale, \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\*  $p < 0.001$

For individual scales, \* $p < .007$ ; \*\* $p < .001$ ; \*\*\* $p < .0001$  (Bonferonni corrections).

Data presented as: Mean (Standard Deviation). Lower scores reflect more intact social-behavioral functioning. Sample size for Typically-Developing Group = 31; Mild TBI Group = 31, Moderate/Severe TBI Group = 20;  $df = 2, 76$  for each composite scale and 10, 140 for individual scales.

Table 3:

Proportion of Children in Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups Whose Ratings Fall at or Above the 90<sup>th</sup> Percentile on the CBCL

	Mild TBI (n = 31)	Moderate/Severe TBI (n = 20)	Comparison (n = 31)	Pearson Chi-square	Group Comparison
Composite Scores					
Internalizing Problems	4/31 (12.90%)	5/20 (25%)	2/31 (6.45%)	.164	NS
Externalizing Problems	9/31 (29.03%)	3/20 (15%)	4/31 (12.90%)	.233	NS
Total Problems	5/31 (16.13%)	3/20 (15%)	4/31 (12.90%)	.936	NS
Individual Scales					
Emotional Reactivity	4/31 (12.90%)	2/20 (10%)	4/31 (12.90%)	.909	NS
Anxiety/Depression	2/31 (6.45%)	2/20 (10%)	2/31 (6.45%)	.869	NS
Somatization	3/31 (9.68%)	3/20 (15%)	5/31 (16.13%)	.736	NS
Withdrawal	4/31 (12.90%)	6/20 (30%)	3/31 (9.68%)	.129	NS
Sleep Problems	8/31 (25.81%)	2/20 (10%)	8/31 (25.81%)	.332	NS

Attention Problems	4/31 (12.90%)	4/20 (20%)	3/31 (9.68%)	.569	NS
Aggression	8/31 (25.81%)	3/20 (15%)	4/31 (12.90%)	.383	NS

Table 4:

## Correlations Between Outcome and Predictor Variables

	Internalizing Problems T-score	Externalizing Problems T-score	Total Problems T-score
Mullen Early Learning Composite	-0.2997*	-0.1173	-0.1991
SIB-R Standard Score	-0.2630	-0.0763	-0.1867
Mother's marital status	0.1338	-0.0345	-0.0037
Maternal employment	-0.0966	-0.2056	-0.1321
Maternal occupation	0.0644	-0.1744	-0.0899
Maternal education	-0.2290	-0.3141*	-0.3335*
SRFI Leadership scale	-0.1261	-0.2861*	-0.2387
SRFI Expression Scale	0.0060	0.0093	-0.0029
SRFI Cohesion Scale	0.0900	0.1369	0.1954
SRFI Conflict Scale	-0.0831	-0.2237	-0.2021
SRFI Health Competence Scale	-0.0803	0.0021	0.0085
Race	0.0233	-0.1731	-0.0762



Age at testing	0.1208	0.1423	0.1466
Intentionality	0.0533	-0.0383	-0.0125
GCS	-0.0451	0.1934	0.1252
LOC > 72 hours	0.1643	-0.1990	-0.0884
Gender	-0.0355	0.0816	0.0817
Age at injury	-0.0432	0.1827	0.1234
Time since injury	-0.0230	0.0092	0.0024

---

\*\* Correlation is significant at the 0.01 level (2-tailed)

\* Correlation is significant at the 0.05 level (2-tailed)

Table 5:

## Internalizing Problems Regression Coefficients

	Beta	t	Significance
Maternal Education	-.170	-1.218	.229
Mullen Early Learning Composite	-.320	-2.027	.048
Glasgow Coma Scale	.117	.752	.456

Table 6:

## Externalizing Problems Regression Coefficients

	Beta	t	Significance
Maternal Education	-.209	-1.480	.146
Mullen Early Learning Composite	-.247	-1.601	.116
Glasgow Coma Scale	.363	2.421	.020
Leadership (SRFI)	-.281	-2.013	.050

Table 7:

Total Problems Regression Coefficients

	Beta	t	Significance
Maternal Education	-.248	-1.689	.098
Conflict (SRFI)	-.151	-1.055	.297
Leadership (SRFI)	-.130	-.871	.389
Mullen Early Learning Composite	-.163	-1.158	.253

Table 8:

Unadjusted Means and Standard Deviations of Mild TBI, Moderate TBI, Severe TBI, and Typically-Developing Groups

	Mild TBI (n = 31)	Moderate TBI (n = 10)	Severe TBI (n = 10)	Comparison (n = 31)
Mullen ELC (covariate)	89.35 (18.82)	60.00 (4.45)	67.30 (5.58)	94.32 (18.71)
SIB-R	104.60 (21.11)	72.90 (17.40)	91.40 (30.10)	116.52 (15.82)
Internalizing Problems (CBCL)	51.42 (10.12)	56.20 (8.70)	51.20 (8.24)	48.06 (11.93)
Externalizing Problems (CBCL)	53.67 (10.71)	57.10 (16.34)	46.40 (8.14)	48.38 (12.23)
Total Problems (CBCL)	53.35 (9.80)	57.10 (12.22)	48.80 (5.59)	48.03 (12.73)
Emotional Reactivity (CBCL)	55.39 (6.73)	57.60 (8.02)	54.00 (5.12)	54.58 (7.13)
Anxious/Depressed (CBCL)	53.71 (4.27)	53.80 (5.55)	52.00 (3.71)	52.77 (5.90)
Somatization (CBCL)	54.14 (6.02)	56.90 (7.67)	52.80 (6.55)	54.16 (6.21)
Withdrawal (CBCL)	54.79 (5.97)	60.80 (7.35)	60.40 (11.48)	54.19 (6.52)

Sleep Problems (CBCL)	57.39 (8.33)	56.80 (8.72)	52.40 (3.86)	55.97 (7.99)
Attention Problems (CBCL)	56.43 (7.13)	59.70 (9.90)	54.10 (6.17)	54.09 (5.97)
Aggression (CBCL)	56.93 (8.64)	58.90 (10.77)	51.80 (2.97)	54.00 (7.75)

Table 9:  
Severity by Intentionality

	Intentional	Non-intentional	Total
Mild TBI	5	5	10
Moderate TBI	9	1	10
Severe TBI	11	20	31
Total	25	26	51

Table 10:

Incidence of Behavioral Problems at or Above the 90<sup>th</sup> Percentile on the CBCL (T-Score  $\geq$  63) by Severity Level

	Internalizing ( $\geq$ 90 <sup>th</sup> PR)	Externalizing ( $\geq$ 90 <sup>th</sup> PR)	Total Problems ( $\geq$ 90 <sup>th</sup> PR)
Mild TBI	4/31 (12.90%)	9/31 (29%)	5/31 (16.13%)
Moderate TBI	3/10 (30%)	3/10 (30%)	3/10 (30%)
Severe TBI	2/10 (20%)	0/10 (0%)	0/10 (0%)



Table 11:

Racial and Gender Composition for Mild, Moderate, and Severe TBI Groups

	Caucasian	Male
Mild TBI	19/30 (63.33%)	6/10 (60%)
Moderate TBI	2/10 (20%)	7/10 (70%)
Severe TBI	4/10 (40%)	27/51 (52.94)

Table 12:

Maternal Education by Frequency of CBCL Impairment

	Ratings $\geq$ 63 for Somatization	Ratings $\geq$ 63 for Attention Problems
Less educated	3/5 (60%)	4/8 (50%)
Moderately educated	2/33 (6.06%)	3/35 (8.57%)
Well educated	1/6 (16.67%)	1/7 (14.29%)

Figure 1:

Distribution of Scores by Group on Internalizing Problems Scale of CBCL

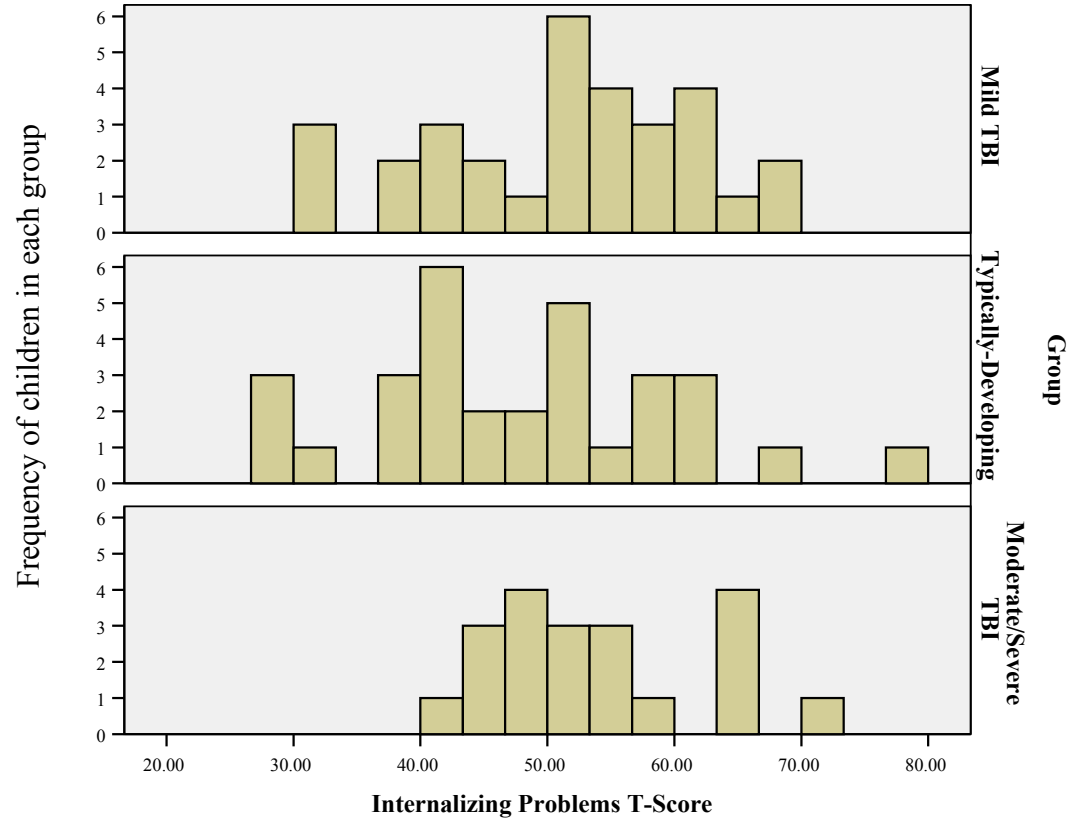


Figure 2:

Means for the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups  
on the Composite Scales of the Child Behavior Checklist

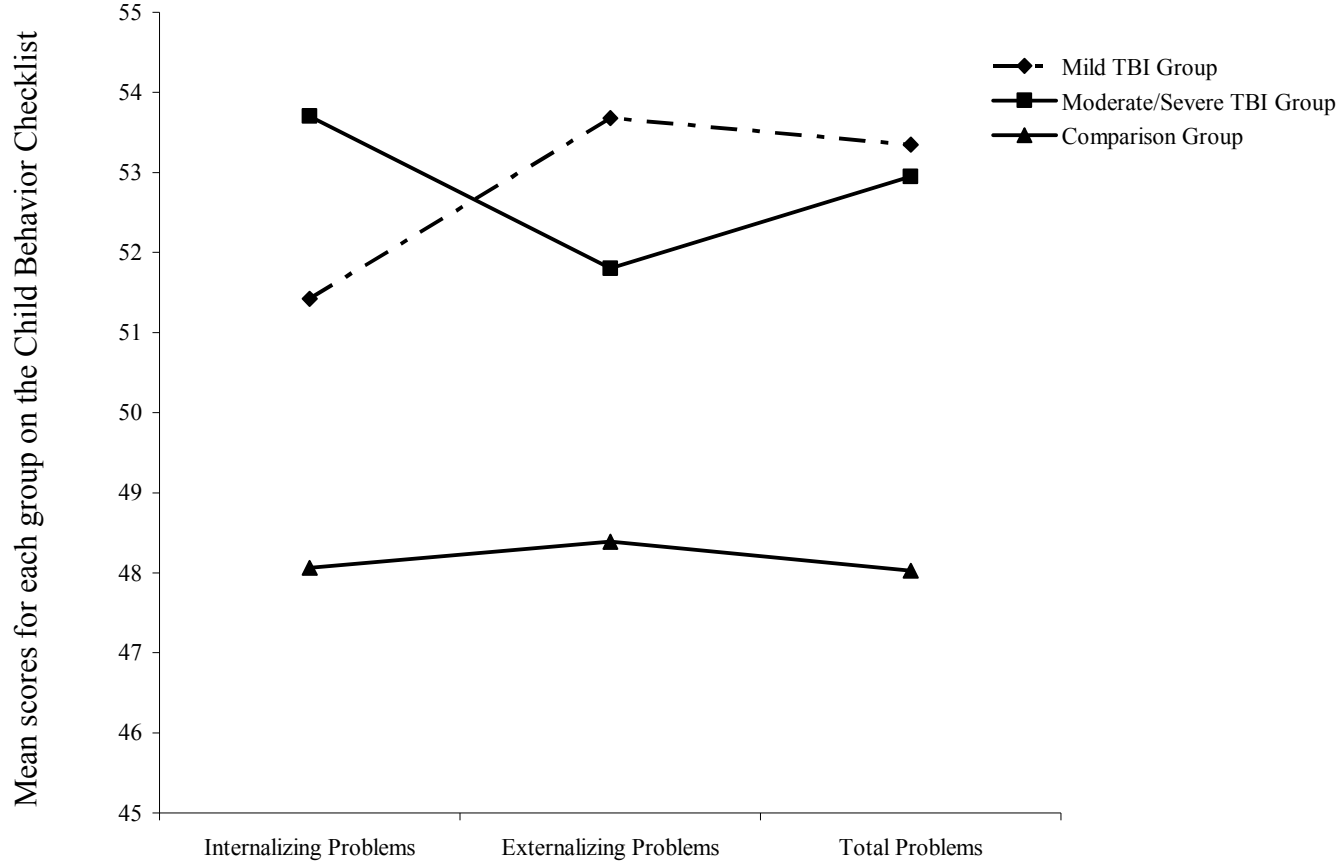


Figure 3:

Distribution of Scores by Group on Externalizing Problems Scale of CBCL

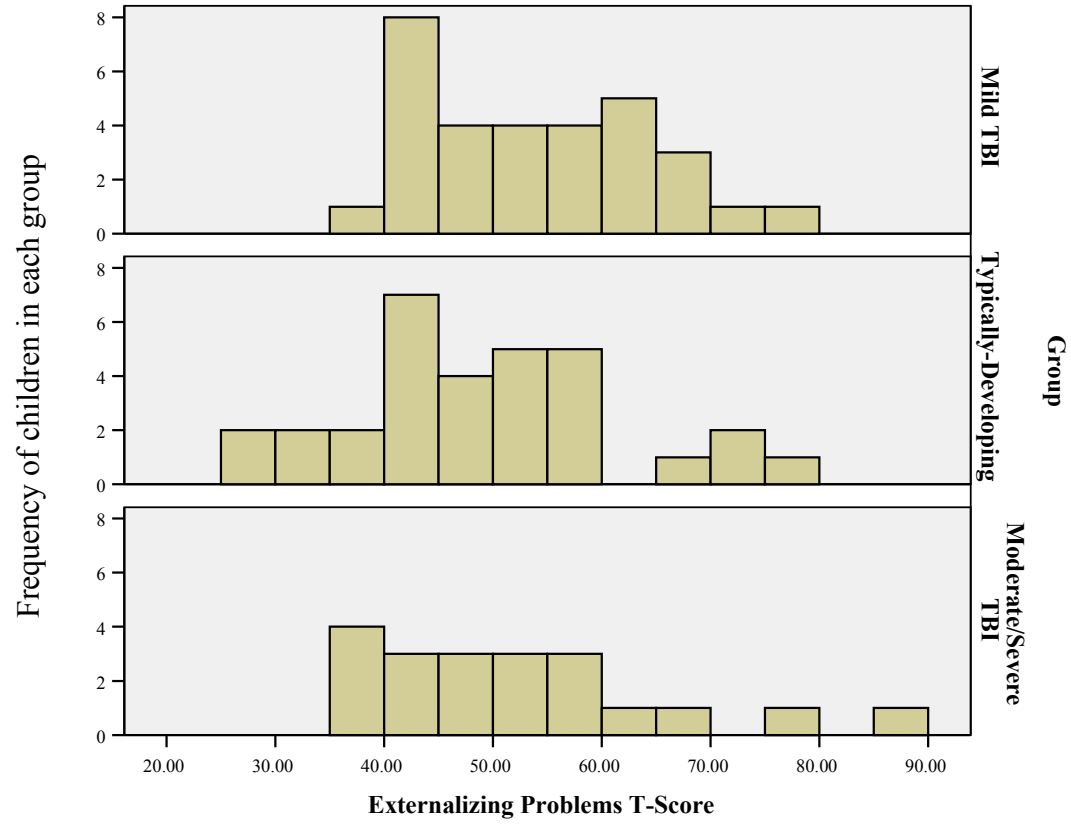


Figure 4:

Distribution of Scores by Group on Total Problems Scale of CBCL

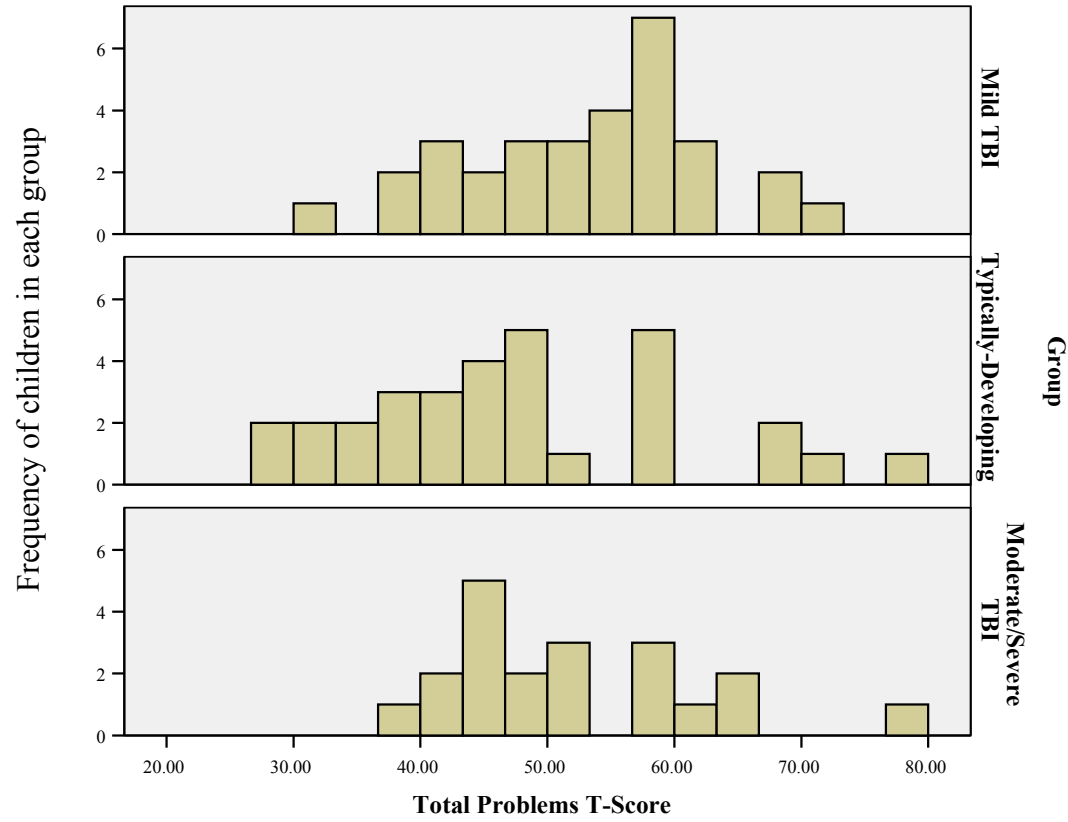


Figure 5:

Means for the Mild TBI, Moderate/Severe TBI, and Typically-Developing Groups on the Scales of the Child Behavior Checklist

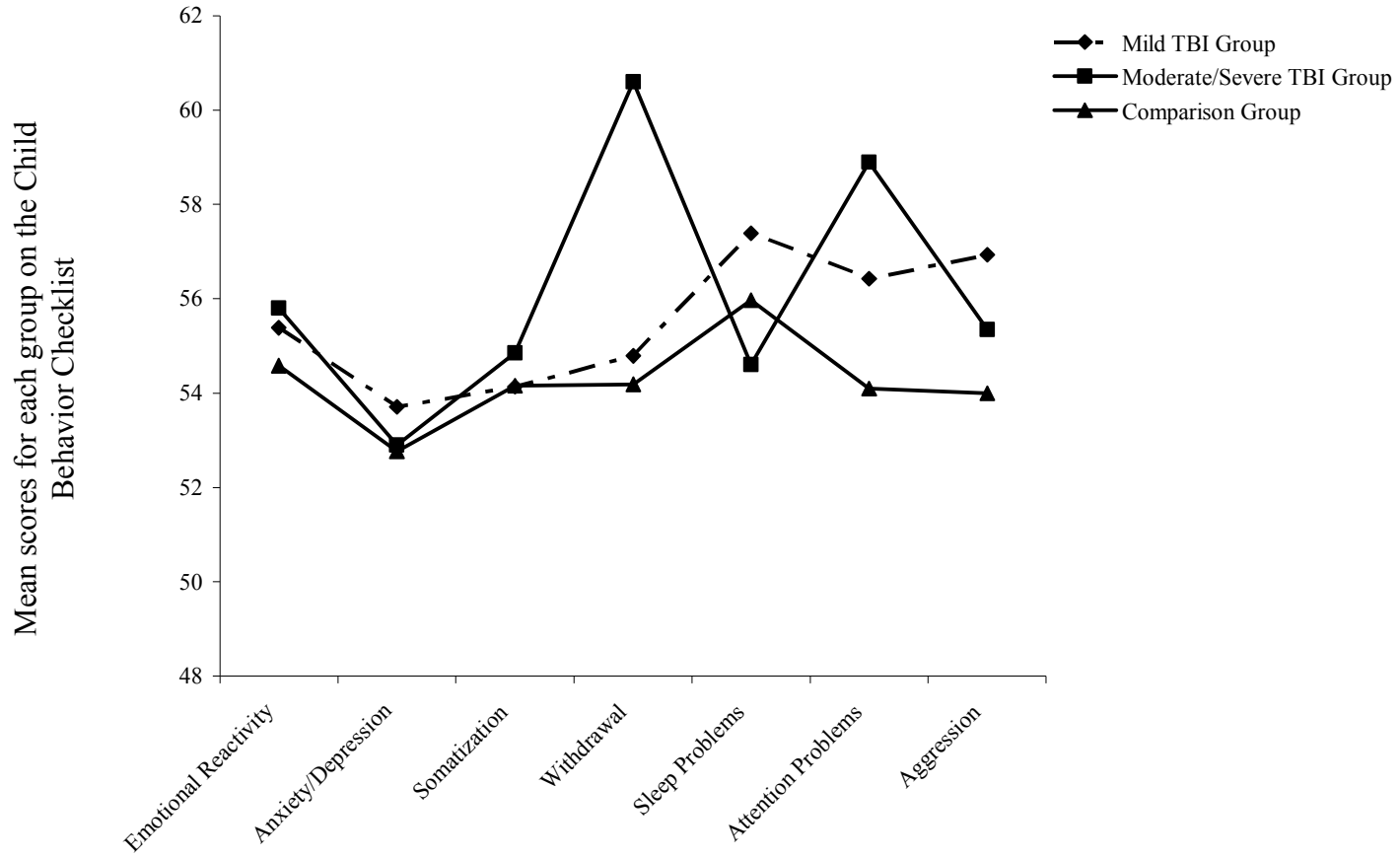


Figure 6:

Scores on the CBCL Composites for Mild TBI, Moderate TBI, Severe TBI, and Typically-Developing Groups

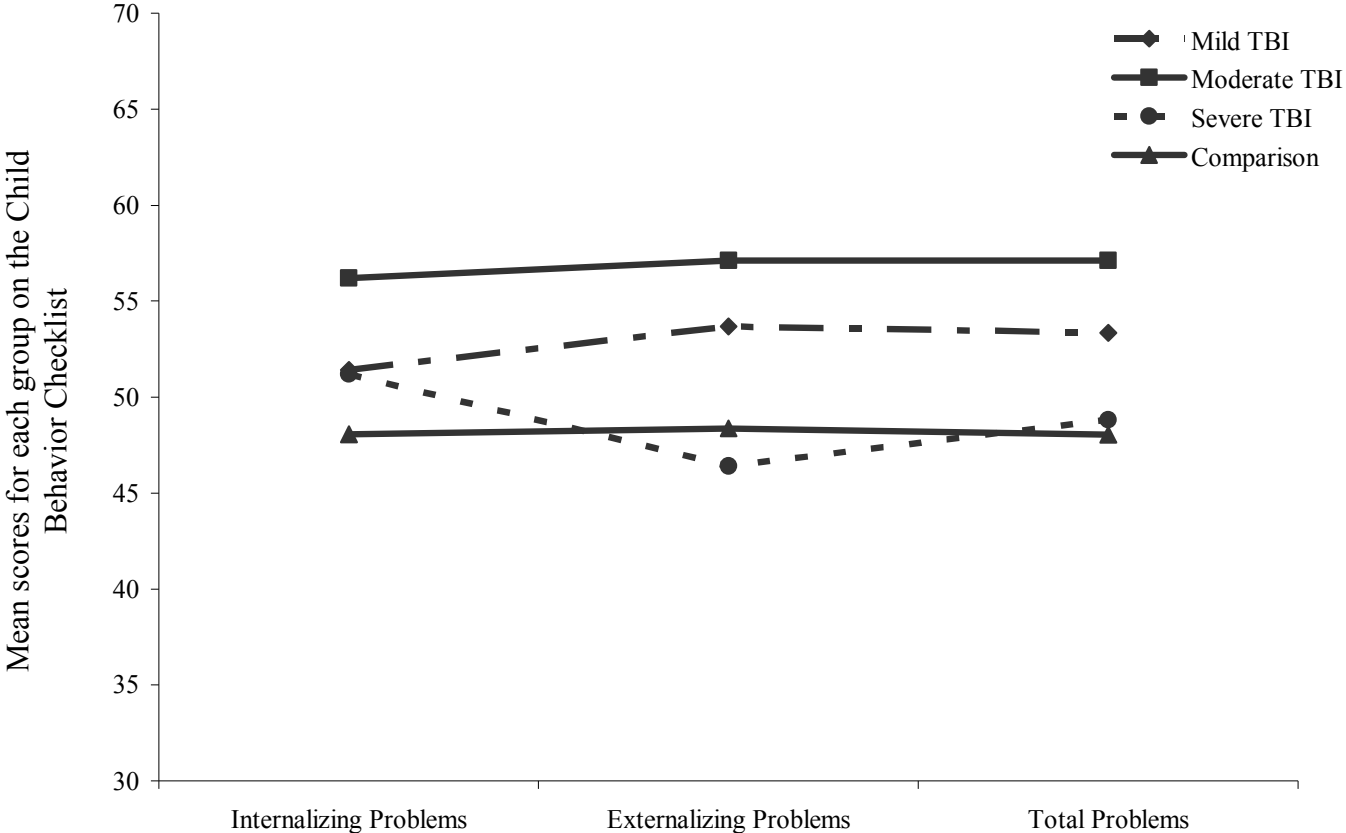
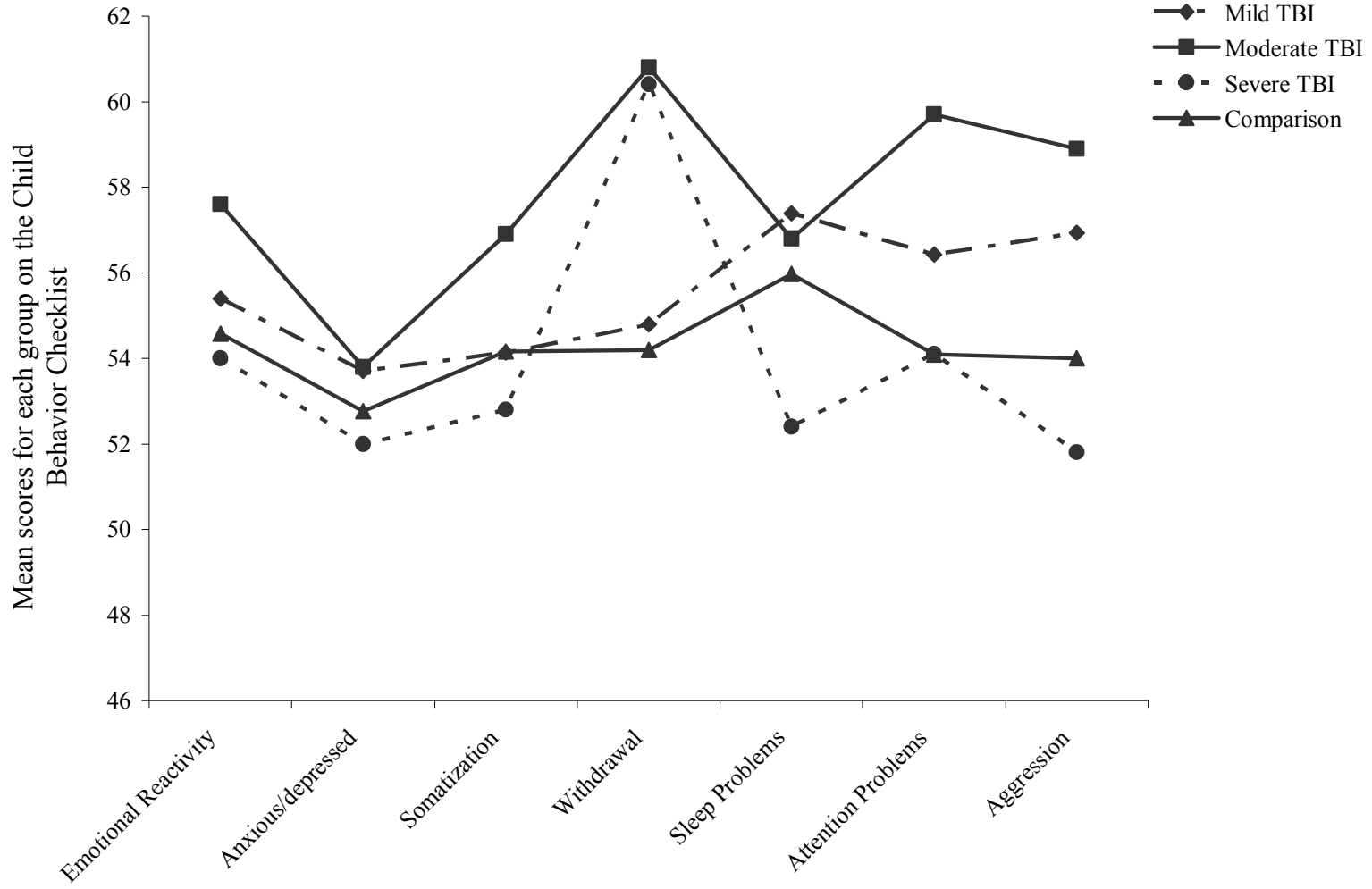




Figure 7:

Scores on the CBCL Scales for Mild TBI, Moderate TBI, Severe TBI, and Typically-Developing Groups



Appendix I: IRB approval letter



THE UNIVERSITY  
of NORTH CAROLINA  
at CHAPEL HILL

OFFICE OF HUMAN  
RESEARCH ETHICS

BEHAVIORAL INSTITUTIONAL  
REVIEW BOARD (IRB)

BANK OF AMERICA BUILDING  
SUITE 600  
CAMPUS BOX 3378  
CHAPEL HILL, NC 27599-3378

T 919.962.7761  
F 919.843.5576  
http://ohre.unc.edu

TO: *Crusta Wellesington*  
Stephen R. Hooper  
DEPARTMENT: Psychiatry  
ADDRESS: CB # 7255  
Campus  
DATE: 05/15/2005  
FROM: Behavioral Institutional Review Board  
IRB NUMBER: EDUC 2005-017  
APPROVAL PERIOD: 05/10/2005 through 05/09/2006  
TITLE: Development of Young Children with and without Traumatic Brain Injury  
SUBJECT: Expedited Protocol Approval Notice--New Protocol

The above research study has been reviewed and approved by the Behavioral IRB Chair or Co-Chair, on an Expedited basis, Category 2.

New approval     Renewal approval     Modification approval     Secondary data

Please note that, if checked, the following Federal regulations are applicable to this research study:

45 CFR 46.404 - The IRB finds that no greater than minimal risk to children is presented, and that adequate provisions have been made for soliciting the assent of the children and the permission of their parents or guardians, as set forth at 45 CFR 46.408.

45 CFR 46.116(d) - Approval of a consent procedure that does not include all of the elements of informed consent.

45 CFR 46.116(d)(1-4) - Criteria for waiver of the requirement to obtain informed consent has been satisfied.

45 CFR 46.117(c)(2) - Waiver of the requirement for documentation of written (signed) consent.

45 CFR 164.512 - Criteria for waiver of HIPAA Authorization has been satisfied.

45 CFR 164.508 - HIPAA Authorization Form approved.

\_\_\_\_\_

The above Approval Period informs you of the date that IRB approval expires for this research study. You will be notified in advance of this date to submit an application for renewal or termination of IRB approval.

Please note that IRB approval is required prior to any modifications being made to this research study.

If you have any questions or concerns about your study's approval, please contact the Behavioral IRB Office at 962-7761 or e-mail the office at aa-irb-chair@unc.edu. Thank you.

Approved by:

*Barbara Davis Goldman*  
Behavioral IRB Chair or Co-Chair

5-10-05  
Date of Approval

## Research study

Needed: Healthy 3 year-olds to participate in a research study.

What: A study comparing the development and behavior of about 50 healthy children to children who have had brain injuries.

The role of healthy preschoolers: Participation in one 30-40 minute testing session at the child's preschool or at a testing center in Chapel Hill. During the testing session the examiner will present the child with a variety of toys, such as blocks, books, and puzzles. She will structure the child's play in such a way that she will be able to learn about the child's development.

The role of parents of healthy preschoolers: Filling out 3 questionnaires (approximately 20 minutes) about child's behavior and general family functioning.

Compensation: A report containing helpful information about your child's development.

If you are interested in enrolling your child in the study, please contact me, Crista Wetherington, at (919)968-0270.

Crista Wetherington  
Ph.D. Candidate  
School Psychology Program  
University of North Carolina at Chapel Hill

Appendix III: Letter sent home for recruitment of typically-developing group

March 21, 2005

Dear Parents,

My name is Crista Wetherington and I am a doctoral student in the School Psychology program at UNC. For my dissertation, I plan to compare the development and behavior of healthy children to those who have had brain injuries. We will be able to learn more about the outcomes of children after brain injury by studying healthy children as well. I am writing to tell you a little about the study and invite your child to participate.

Attached you will find a detailed description of the study and answers to questions you might have about your child participating in this study. Here's a brief summary:

What: A study comparing the development and behavior of 53 healthy children to that of children who have had brain injury

The role of healthy preschoolers: Participation in one 30-40 minute testing session at your child's preschool or daycare center. During the testing session the examiner would present your child with a variety of toys, such as blocks, books, and puzzles. She would structure the child's play in such a way that she will be able to learn about your child's development.

The role of parents of healthy preschoolers: Filling out 3 questionnaires (approximately 20 minutes) about child's behavior and general family functioning.

Compensation: A report containing helpful information about your child's development.

If you are interested in enrolling your child in the study, please read through the attached form, sign it, and return the signed portion to your child's teacher. If you have any questions, feel free to contact me at (919)968-0270.

Thanks,  
Crista Wetherington  
Ph.D. Candidate  
School Psychology Program  
University of North Carolina at Chapel Hill

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