INTRODUCTION

Growing up is often perceived as a time for playing, learning and making friends. However, for children who have sustained a traumatic brain injury (TBI), this is seldom the reality. TBI is one of the most common causes of death and long-term disability in the pediatric population (Babikian & Asarnow, 2009). The most common causes of TBI involve transportation and falls, and these two causes account for more than 50% of all pediatric cases (Yeates, 2010). Pediatric TBI results in significant disability caused by sustained neurocognitive impairments that manifest in the form of cognitive and behavioural deficits (Babikian & Asarnow, 2009). For children with TBI, these deficits cause daily challenges in academic and interpersonal functioning that may result in frustration and inappropriate behaviour. (Mayfield & Homack, 2005; McDonald & Flanagan, 2004). Children often deal with such stressors through active behaviours directed towards the outside world, resulting in displays of aggression, defiance and impulsivity (Reber, Allen & Reber, 2009). Such externalizing behaviour problems have been commonly reported for children who have sustained a TBI (Max et al., 2005). Investigating the mechanisms that influence the emergence of such behavioural problems is needed so that the everyday implications of TBI in childhood can be better understood.

In normally developing children, the ability to effortfully rein in behavioural impulses has obvious implications for precluding externalizing problems (Eisenburg, Fabes, Guthrie, & Reiser, 2000; Eisenburg et al., 2009). Martel et al. (2007) found that deficits in children's inhibitory control were related to the presence of externalizing behaviour problems. The voluntary control of action, or inhibition, is regarded as a vital aspect of behaviour, because it allows a child to change decisions during an action and make the best choice possible. In this way, a child's ability to inhibit various responses and control impulses influence behavioural regulation and could help explain the presence of certain behaviour problems (De Haan et al., 2007). Although the relation between inhibition and externalizing problems has been researched in other pediatric populations, no studies that investigate this specific relationship have been conducted in the pTBI population. Therefore, the extent to which TBI influences the relationship between response inhibition and externalizing problems still needs to be established.

In the TBI literature, inhibition and behavioural outcomes have usually been investigated as separate entities. Inhibitory control is generally considered as one of the fundamental constituents of executive function (EF) (Barkley, 1997; Miyake et al., 2000). Thus, when response inhibition is studied in children with TBI, it has usually been studied within a wider range of executive dysfunction and it is therefore difficult to determine what the specific relationship between response inhibition and childhood TBI is without introducing confounds. In the same manner, various studies have reported a number of behaviour problems following childhood TBI (e.g., Chapman et al., 2010), but few have investigated the mechanisms that contribute to externalizing behaviour in particular. Post-injury externalizing problems are of specific concern, because studies have reported that both children and adults who have sustained a TBI are prone to display relatively more externalizing behaviours than internalizing behaviours (Ylvisaker et al., 2007). This may be because as a child gets older, increasing academic and social demands and expectations for self-regulation can exacerbate the level of frustration and externalizing problems. Thus, singling out response inhibition as a domain of EF and singling out externalizing behaviour from the wider range of behavioural sequelae can serve to clarify their relation to childhood TBI. Because of the evidence that the ability to inhibit responses will influence the presence of externalizing behaviour in normal children, research is needed to establish whether the same accounts for children who have sustained a TBI. This research therefore investigated post-injury response inhibition as a particular domain of EF to determine whether it is related to the presence of externalizing behaviour such as aggression in children who have sustained a traumatic brain injury.

Externalizing behaviour problems

Childhood behaviours marked by defiance, impulsivity, disruptiveness, aggression and overactivity are called *undercontrolled,* or *externalizing*. The distinctiveness of such features from behaviour patterns termed *overcontrolled,* or *internalizing*—evidenced by withdrawal, dysphoria, and anxiety—has been established in numerous investigations (e.g., Chapman et al., 2010) Most notably, externalizing problems are more stable than internalizing behaviours, carrying a worse prognosis as well as resistance to most forms of intervention.

Studies report a variety of externalizing behaviour problems after paediatric TBI. These include irritability and impulsivity (Chapman et al., 2010; Taylor, 2004), hyperactivity and social disinhibition (Feeney, 2003; Hawley, 2004), lack of insight regarding personal limitations, aggressiveness and poor temper control (Feeney, 2003; Kinsella, Ong, Murtagh, Prioi, & Sawyer, 1999) as well as immature behaviour compared to other children of the same age (Feeney, 2003). Studies have reported that externalizing behaviour problems such as aggression, temper outbursts and poor impulse control (Dooley et al., 2008) are relatively common after TBI. The most common psychiatric diagnoses that are identified following childhood TBI are oppositional defiant disorder (Max et al., 1998) and ADHD (Gerring et al., 1998; Levin et al., 2007; Max et al., 2005; Yeates et al., 2005). Such problems following childhood TBI identifies a trend that relates such rule-breaking behaviours and hyperactivity and impulsivity to pTBI.

Brain systems that are easily damaged in closed head injuries have been reported to be related to aggression and other externalizing symptoms (Feeney, 2003). Ylvisaker et al. (2007) explains that when frontal control mechanisms are unable to regulate limbic impulses, everyday frustrations or minor challenges that a child faces can cause aggressive or socially unacceptable responses. Such externalizing problems and their relation to childhood TBI are of interest because unlike cognitive symptoms that seems to improve post-TBI, these behavioural problems fail to resolve and seem to deteriorate in many cases (Schwartz et al., 2003).

Moreover, aggression is a specific aspect of externalizing behaviour that requires attention in pTBI research. Cole et al. (2008) found aggression to be one of the most serious psychiatric consequences of paediatric TBI. Post-injury aggression is of specific concern, because unlike other behavioural consequences that improves over time, Ylvisaker et al. (2007) states that aggression may worsen in children following TBI. Academic and social frustrations following a TBI can significantly exacerbate a child’s level of aggressive responses. Despite these serious consequences, the majority of literature on post-TBI aggression has focused on adults (Cole et al., 2008). Aggression may have more than one cause, or can be intensified due to a combination of causes. Children with TBI due to closed head injury may be susceptible to frontal lobe and diffuse brain injury (Feeney, 2003; Konrad et al., 2000). Kim (2002) argues cortical lesions can directly affect aggression or can be associated with poor adjustment and rehabilitation following a TBI. Irritability leading to aggression may result either from such a pathophysiologic change, or from an exacerbation of pre-traumatic aggression or poor self-monitoring. Cole et al. (2008) suggest that children who struggle with behavioural regulation, which is characterized by poor impulse control, are especially at risk for displaying reactive aggressive behaviours. Therefore, it can be expected that children who experience poor inhibitory control may potentially struggle with externalizing behaviour problems such as aggression. Although such studies identify a higher risk for children with poor behavioural regulation in displaying aggressive behaviour, the extent to which inhibition and aggression are correlated remains unknown. Research on this topic is needed in order to establish a better understanding of the mechanisms that are responsible for the emergence of post-injury aggression and inhibition, how they are related, as well as the possible factors that contribute to their development.

Executive function and TBI

Executive function is collectively defined as "the control or self-regulatory functions that organize and direct all cognitive activity, emotional response and overt behaviour" (Gioia & Isquith, 2004, p. 139). In children, impairments in executive functioning are often manifested as problems in learning and regulating behaviour in school and social situations (Ylvisaker & Gioia, 1998). Deficits in EF occur frequently after childhood TBI. Levin and his colleagues have studied executive function extensively (see Levin & Hanten, 2005), and have found that children with TBI display deficits on a variety of tasks that assess executive functions such as working memory, inhibitory control, and planning (Yeates et al., 2010). In their review of the literature on executive function following TBI in children, Levin and Hanten (2005) state that the neurobehavioural consequences of TBI in children arise to a great extent from the "maldevelopment of frontally guided, distributed networks mediating the set of higher order cognitive abilities known as executive functions" (Levin & Hanten, 2005, p. 80).

Rieger & Gauggel (2002) report that clinical descriptions of patients with TBI often include features associated with deficits in EF such as poor impulse control, impaired attention and decreased cognitive flexibility. Over the past decade, research on executive function in TBI has begun to examine not only performance in terms of cognitive skills, but also on various aspects of emotional and behavioural regulation (Levin & Hanten, 2005). EF has been recognized as closely related to everyday adaptive activities and self-regulation (Grattan & Eslinger, 1992; Gioia & Isquith, 2000). Levin and Hanten (2005) state that these aspects have not been studied as extensively as traditional performance-based executive function tests, and therefore more research in this area is needed.

TBI impairs executive functioning, which is an essential feature of self-regulating behaviour (Gioia & Isquith, 2004). This may lead to difficulties in self-monitoring (Mayfield & Homack, 2005) and response inhibition tendencies (Konrad et al., 2000). An essential component of the executive system is the control of interference, which includes the ability to inhibit competing information and actions. This is especially relevant to pediatric TBI, because individuals with TBI have documented difficulties in tests of executive performance, such as inhibition. (Gioia & Isquith, 2004). In addition to deficits in cognitive flexibility and planning skills, Yeates (2010) reported that children who have sustained a TBI, particularly those with more severe TBI, have consistently demonstrated executive deficits that extend to their emotional and behavioural regulation as well. Thus, EF has been linked to such broader difficulties in social and behavioural adjustment (Slomine et al., 2002; Yeates, 2010).

Inhibition

One frequently mentioned disability in the context of EF is inhibition (Levin & Hanten, 2005; Rieger & Gauggel, 2002; Slomine et al., 2002). Levin et al. (2004) have found that a TBI sustained in childhood is likely to influence a child's capacity for inhibition. The presence of problems in inhibition following TBI is supported by various studies that indicate significant deficits in post-injury executive functioning (Konrad et al., 2000; Levin & Hanten, 2005).

Inhibition is a process that allows one to delay or prevent a prepotent response (Barkley, 1997; Konrad et al., 2000) and the ability to inhibit or not act on an impulse (Gioia & Isquith, 2001). It is a component of executive control that plays a central role in the self-regulation of behaviour (Konrad et al., 2000). Children need executive control to inhibit strategies that become inappropriate when goals or task demands change or errors occur. Schachar & Logan (1990) describe that deficient inhibitory control is revealed by impulsive behaviours such as answering before sufficient information is available, allowing attention to be captured by irrelevant stimuli, or failing to correct obviously inappropriate responses. In their review of the literature, Levin & Hanten (2005) found that inhibition is relevant to academic and psychosocial domains of outcome in addition to self-regulatory skills in everyday functioning. Gioia & Isquith (2004) have reported that children with poor inhibitory control are at risk for displaying high levels of physical activity, inappropriate physical responses to others, a tendency to interrupt and disrupt group activities, and a general failure to "look before leaping".

In their study on inhibitory control in children with attention deficit hyperactivity symptoms, Catale & Meulemans (2009) found that from a clinical perspective, inhibition processes can lead to several cognitive and behavioural dysfunctioning (e.g. impulsiveness). Whether this is similar for children who have sustained a traumatic brain injury remains less established in the literature, since studies have shown various inconsistencies in their findings. For example, Konrad et al. (2000) found that children with moderate to severe TBI performed poorly on both a go-no-go task and a task that involved stopping ongoing responses. In contrast, Schachar et al. (2004) found that response inhibition was only impaired in severely injured children who had developed secondary ADHD.

Studies investigating inhibition in children following TBI have used a wide variety of different paradigms such as the Stop-Signal Task (e.g., a go-no-go task involving withholding a response) and delayed response tasks (Konrad et al., 2000; Leblanc et al., 2005; Levin et al., 2004) and the Stroop paradigm (e.g., Pritchard & Neuman, 2009). Effective ways of measuring inhibition can also be through verbalizing a sematically incongruent response and surpressing recall of information that is no longer relevant (Levin & Hanten, 2005; Slomine et al., 2002). According to Levin et al. (2004), previous studies of inhibition in pediatric TBI have been limited to using either a single task or comparing two forms of inhibition across tasks that vary in their demand on other abilities, thus introducing confounds.

Behavioural regulation

Behavioural regulation enables metacognitive processes to successfully guide active, systematic problem solving, and more generally, supports appropriate self-regulation (Gioia & Isquith, 2004). Previous studies have linked behavioural self-regulation and control to behaviour problems in children. Eisenburg, Guthrie and Fabes (2000) found that behavioural dysregulation predicted externalizing behaviour problems such as conduct disorder. Also, an injury sustained in childhood resulted in relatively greater behavioural problems compared to persons injured in adulthood (Levin & Hanten, 2005). Levin and Hanten (2005) reported that performance-based studies of behavioural regulation are rare, though a number of studies have used observational methods or questionnaires to address issues relating to children's regulation of their own behaviour in everyday situations. The Behaviour Rating Inventory of Executive Function (BRIEF) is such a parent rated questionnaire that was developed to provide a window into the everyday behaviour associated with specific domains of self-regulated problem solving and social functioning (Gioia & Isquith, 2004).

Predictors of outcome

One of the difficulties of TBI research is that there seems to be a wide range of inconsistencies in outcome and various facets (both neurocognitive and psychosocial) that influence such sequelae. In a study by Yeates (2010), cognitive and somatic symptoms (e.g., fatigue, headache, inattention) tended to decline in the first year, whereas emotional and behavioural symptoms (e.g., aggression, impulsivity) tended to increase over time, especially in children with severe TBI and in those with poor family functioning. Post-injury externalizing behaviour problems such as aggression have been associated with multiple etiological factors (Cole et al, 2008), whereas fewer studies have reported the range of factors that influence response inhibition. Cole et al. (2008) found that increased injury severity, lower SES, high levels of family stress and pre-injury behaviour problems are associated with an increased risk for post-injury aggressive behaviours. In contrast, Ylvisaker et al. (2007) found that externalizing behaviour problems such as aggression was rather unrelated to injury factors, family functioning or pre-injury characteristics.

Hawley (2004) observed that children who had sustained both mild and severe TBI displayed an equal amount of post-injury behaviour problems. In contrast, Anderson et al. (2006) found significantly higher levels of behaviour disorders following severe TBI in comparison with moderate brain injury. For children with severe TBI, behavioural problems remained constant and failed to resolve over time, despite recovery in cognitive domains (Chapman et al., 2010). Konrad et al. (2000) found significant deficits in response inhibition in children who have sustained moderate to severe TBI. However, Levin et al. (2004) found that inhibiting responses was relatively intact after TBI, indicative of the inconsistency in outcome in studies on response inhibition following TBI, indicating that the impact of injury on inhibition needs to be investigated.

Suskauer & Huisman (2009) report that a TBI sustained in childhood has more severe impact on behaviour and functioning compared to a TBI sustained in adulthood, because the paediatric brain and skull is still in a process of development and young children are still in the process of establishing skills and consolidating knowledge. Levin et al. (2004) found TBI sustained in childhood to be more likely to affect a child's capacity to control impulses and to override pre-potent responses than in adult TBI cases. Wells et al. (2009) indicated that older children experience fewer problems and restrictions in social functioning, because an older child has had more of an opportunity to learn how to self-regulate behaviour. The prevalence of externalizing behaviour problems increases with age at injury following a TBI (Ylviskaer et al., 2007).

Specific Aims and Hypotheses

In summary, there is evidence to suggest that a TBI sustained in childhood may lead to externalizing behaviours as well as executive dysfunctions such as inhibition. However, the relationship between externalizing behaviour and response inhibition as a specific aspect of executive dysfunction, and how this relationship differs as a function of injury severity, still needs to be established. Based on the conclusions drawn from the literature, the possibility that externalizing behaviours could be related to deficits in EF such as response inhibition should be considered and investigated. Limited literature is available on post-injury response inhibition in children following TBI (Konrad et al., 2000). Since studies have shown contrasting findings on the influence of injury severity on post-injury response inhibition and variance in the rate of externalizing behaviours, the study compared the outcome of three groups of different injury severity, namely mild, moderate and severe TBI against a group comprised of typically developing (TD) children to determine whether the degree of response inhibition and externalizing behaviours vary as a function of injury severity.

Therefore, this study firstly hypothesized that the level of externalizing behaviour, executive function and response inhibition will differ as a function of injury severity in children who have sustained a traumatic brain injury. Secondly, it was hypothesized that the level of externalizing behaviour will be related to the level of executive dysfunction and response inhibition ability in children who have sustained a traumatic brain injury. Lastly, it was hypothesized that an ecological valid measure of inhibition, namely the BRIEF would be related to children's performance on standard neuropsychological tests of response inhibition.

In summary, the study formulated the following hypotheses:

Hypothesis 1: Significant between-group differences in the level of (a) externalizing behaviour, (b) executive function and (c) response inhibition.

Hypothesis 2: Significant correlations between externalizing behaviour and (a) inhibition as measured by the BRIEF and (b) between externalizing behaviour and neuropsychological tests of response inhibition.

Hypothesis 3: Significant correlations between the level of inhibition as measured by the ecologically valid measure of inhibition on the BRIEF and performance on standard neuropsychological tests of response inhibition.

METHODS

Research Design and Setting

This study adopted a quantitative, quasi-experimental cross-sectional comparison of four groups, namely mild, moderate, and severe TBI groups as well as a group consisting of typically developing children (*n*=6). A correlational design was incorporated to establish the relationships between particular variables in order to determine the presence of post-injury response inhibition and externalizing behaviour problems in children following a TBI. Data collection and testing took place in the Developmental Clinic at Red Cross Children's Hospital and in the Neurology Ward at Groote Schuur Hospital. Two severe TBI children were tested at the Psychology Department at the University of Cape Town, and one participant was tested at a children's home situated in Khayelitsha. The independent variable (IV) of the study was the level of injury severity with four levels, namely mild, moderate and severe TBI and TD. The dependent variables (DVs) consisted of the outcome scores from the CBCL, the BRIEF and the children's performance on the neuropsychological test battery.

Participants

Eighteen children diagnosed with TBI between the ages of 8 and 14 years participated in the study. Participants were recruited based on injury severity; 6 mild, 6 moderate and 6 severe TBI children participated in this study. Adelson (2010) have identified difficulties in obtaining adequate sample sizes as a logistical challenge in paediatric TBI research. Therefore, the sample size was small, due to limited availability of these patients. Participants for the study were recruited by consulting the trauma register for records of admission of children who have been admitted to the hospital after having sustained a TBI. Scores on the Glasgow Come Scale (GCS) were obtained from these patient admission forms completed upon arrival at Red Cross Children's Hospital. The GCS scores were used to classify children with TBI into the three severity groups as indicated by the medical records of these patients. Mild TBI corresponds to a GCS score of 13 or higher, moderate injury corresponds to a GCS score between 9 and 12, and severe injury to a GCS score of 8 or less (Johnson et al., 2009).

Six typically developing (TD) children within the same age range were recruited to participate in this study as a control group. These participants were recruited from local communities in the Western Cape by means of random and snowball sampling. People were approached on the basis of a child being present in their care, thus a stratified random sampling technique was used. Participating caregivers were asked if they knew other suitable TD children that would be willing to take part in the study. Babbie and Mouton (2008) have identified this type of snowballing effect to be suitable when limited members of a population are obtainable, as in this case for the sample of matched controls. The TD group were representative of the three TBI groups in that they were in the same age range, had the same male to female ratio, as well as similar socio-economic status. The parents of both the TBI and the TD groups also participated in the study by completing behavioural questionnaires. The basic demographic characteristics of the three TBI groups (n=6 in each group) and the TD group (n=6) are presented in *Table 1*.

Inclusion and exclusion criteria

Exclusion criteria for the participants included previously known or diagnosed neurological, psychiatric or developmental disorders and a post-injury period of at least 9 months. Inclusion criteria for the children included a requirement to understand, read and converse in basic English in order for the EF test battery to be administered. Both male and female participants were recruited, however since boys are about twice as likely to sustain TBI as girls (Yeates, 2010); there were significantly more boys that participated in the study than did girls. Of the total sample, only one participant in the severe TBI group was unable to read English and therefore his 4 of his 6 scores on the response inhibition test battery could not be included, however the information from the parent questionnaires were used for this participant. Although not all caregivers spoke English as their home language, all of the parents were able to adequately understand and read English, and could therefore competently provide information on children's behaviour.

Table 1. Demographic Characteristics of the Present Sample

Variable	**TD** **(*n* =6)**	**Mild** **(*n* = 6)**	**Moderate** **(*n* = 6)**	**Severe** **(*n* = 6)**
Age (years)				
Range	8-14	8-12	9-13	8-14
Mean (SD)	10.83 (2.32)	10.83 (1.60)	10.67 (1.51)	12.00 (2.53)
Sex (Females: Males)	1:5	1:5	0: 6	1:5
Race: (Black African: Coloured: White)	0: 6: 0	0: 6: 0	0: 6: 0	0: 6: 0
Home Language: (English: Afrikaans: Eng/Afr)	2:2:2	3:1:2	2:4:0	1:2:3
Family Income Bracket: (per annum)				
Children's Home	0	0	0	1
R0	0	0	1	0
R1-R5000	1	1	0	0
R5001 – R25000	0	2	1	1
R25000 – R100 000	0	1	2	1
R100 000+	2	1	1	1

Note. There was missing data on household income for eight of the participants due to incomplete forms.

Measures

Post-injury externalizing behaviour problems in children were evaluated in terms of parent- rated assessment. The study measured externalizing behaviour problems by using the parent form of the Child Behaviour Checklist (CBCL). EF scores, provided by the BRIEF were used to identify problems in executive function, behavioural regulation and inhibition. Parent-rated assessments and tasks assessing the child's ability directly were used in tandem to form a more comprehensive evaluation of the child's post-injury functioning. A response inhibition test battery was compiled to measure the ability to control certain impulses and to inhibit certain responses. Children were assessed by their performance on the test battery, comprised of two subtests of the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan & Kramer, 2001) and the Inhibition subtest of the NEPSY-II (Korkman et al., 2007).

Demographic Information and developmental history

The parents of the children were asked to fill in a Parent information questionnaire and asset index (Appendix B) form including general information, household income, parental education and employment as well as material and financial resources, which served as an indication of demographics and socio-economic background. A pediatric neuropsychology developmental questionnaire was administered (Appendix C) in order to attain information on the child's pre-injury functioning.

Externalizing behaviour

Behavioural functioning was assessed by having parents complete the Child Behaviour Checklist (CBCL; Achenbach, 1991). This measure was also included in studies by Chapman et al. (2010) and Fay et al. (2009). The CBCL is a 118-item scale with good reliability in assessing externalizing behavioural problems for children between the ages of 4–18 years (Schwartz et al., 2003). Clinically significant behavioural problems are defined as a T-score greater than 63 on the CBCL Behaviour Problem Scale (Chapman et al. 2010; Kinsella et al., 1999). Achenbach (1991) recommends this cut-off score as a means for optimizing classification into clinical versus nonclinical groups. T scores related to individual aspects of externalizing behaviour will be evaluated on the aggression scale, rule breaking scale and the externalizing behaviour subscale.

Executive Function

Parents completed the parent form of the Behaviour Rating Inventory of Executive Function (BRIEF), with the school-age version for children 5-18 years of age. The BRIEF is a standardized 86-item parent rating of children's executive functioning that demonstrates high levels of internal consistency and stability (Chapman et al., 2010). The

BRIEF was developed to provide a window into the everyday behaviour associated with specific domains of self-regulated problem solving and social functioning (Gioia & Isquith, 2004). T-scores obtained for the BRIEF were used to interpret the child's *level* of executive functioning in different domains as reported by parents on the BRIEF rating form. These scores are linear transformations of the raw scale scores (M=50, SD=10). For the various BRIEF clinical scales used, *T* scores at or above 65 were considered as having potential clinical significance, as suggested by the BRIEF Professional Manual (Gioia, Isquith, Guy, & Kenworthy, 2000). Scores on the Inhibition scale and the Behaviour Rating Inventory (BRI) were examined. A test battery comprised of two subtests of the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan & Kramer, 2001) and the Inhibition subtest of the NEPSY-II was administered as a direct measure of executive function (EF) and response inhibition in particular. The D-KEFS is a standardized measure of key components of EF, normed for individuals between the ages of 8 and 89. It is comprised of 9 subtests, of which only the Verbal Fluency Test and the Colour-Word Interference Test were administered. The Colour-Word Interference Test was selected as a measure of EF, because it is based on the Stroop Test (1935/1992), which assesses the ability to inhibit an over-learned verbal response. The Stroop Paradigm is a widely recognized measure of response inhibition (Molfese et al., 2010; Catale & Meulemans, 2002). In the Stroop task, the names of colours are printed in another colour (e.g., the word "red" is printed in green ink). Participants are asked to name the colour of the ink (i.e., green) and thus, to inhibit the automatic process of reading (red). The number of errors on two of the four conditions were used as a measure of response inhibition. Repeated errors indicate an inability to inhibit a prepotent response. Such error types are commonly associated with frontal or diffuse brain damage. (Delis, Kaplan & Kramer, 2001). The number of uncorrected and self-corrected errors on Condition 3 (Inhibition) and Condition 4 (Inhibition/Switching) of the Colour-Word Interference Test were used as a measure of the participant's ability to inhibit prepotent verbal responses. According to the D-KEFS manual, an analysis of errors committed in these conditions is helpful as an estimate of the severity of an examinee's impaired performance on the test (Delis, Kaplan & Kramer, 2001).

The NEPSY-II (Korkman et al.,

2007) is a comprehensive, co-normed, and multidomain neuropsychological battery designed for assessing neurocognitive abilities in preschoolers, children, and adolescents. It is a flexible battery of 32 subtests that permits the administration of specific subtests, groups of subtests, or the entire battery. The Inhibition subtest of the NEPSY-II was used as a measure of response inhibition in this study. The Inhibition and Inhibition/Switching scaled scores were used to measure response inhibition ability.

Procedure

Caregivers of potential participants were contacted telephonically. On the day of testing, parents/caregivers of the participants were given an information sheet in which the research was introduced and explained. Consent was then obtained from parents or legal guardians (Appendix A). Written assent was also obtained from the participant before testing commenced (Appendix A).

This study followed ethical guidelines for research using human subjects as outlined by the University of Cape Town (UCT). Approval was obtained from the Department of Psychology's Research Ethics Committee and the Faculty of Health Sciences Human Research Ethics Committee (HREC REF: 278/2010).

The participants completed the response inhibition test battery in a single session, while the parent/guardian filled out the behavioural questionnaires. The subtests of the D-KEFS and the NEPSY-II were administered according to the procedure outlined in the test manuals. It took no more than half an hour to complete the test battery. A quiet room, free of distractions was used for the test procedure. Parents/guardians were allowed to be present during the testing if they so wished.

Table 2. Behavioural questionnaires and neuropsychological tests used in the study

Measure	Reference	Domain Tested	Score Used
Behavioural questionnaires			
Child Behaviour Checklist (CBCL)	Achenbach, 1991		
Aggressive behaviour		Externalizing behaviour	T-scores
Rule-breaking behaviour		Externalizing behaviour	T-scores
Externalizing Problems		Externalizing behaviour	T-scores
Behaviour Rating Inventory of EF (BRIEF)	Gioia et al., 2000		
Inhibit		Inhibition	T-scores
Behavioural Regulation Index (BRI)		Behavioural regulation	T-scores
Response inhibition test battery			
D-KEFS Colour-Word Interference	Delis et al., 2001		
Condition 3: Inhibition		Inhibition	Total errors scaled score
Condition 4: Inhibition/Switching		Inhibition/Switching	Total errors scaled score
NEPSY-II Inhibition Subtest	Korkman et al., 2007		
INI: Inhibition		Inhibition	Combined scaled score
INS: Inhibition/Switching		Inhibition/Switching	Combined scaled score

Statistical Analysis

All statistical analyses were completed using Statistical Package for the Social Sciences (SPSS) version 18.0. Descriptive statistics were used to determine the variability in the set of scores, to provide an indication of the clinical characteristics of children in the study as well as to characterize the performance on the response inhibition test battery. The main analyses concerned between-group differences in response inhibition and externalizing behaviours such as rule-breaking behaviour, aggression and total externalizing behaviour in accordance with the CBCL (Achenbach, 1991).

The variance of the outcome measures were calculated through analysis of variance (ANOVA) to determine whether these dependent variables differed across the four groups. Levene's test for homogeneity was not significant for all analyses that was conducted, thus the assumptions of homogeneity of variance and independence of observations that underlie parametric statistical tests were upheld.

Given the number of analyses conducted, an increased possibility of Type I error occurs. However, this has to be balanced against the fact that the sample size is small (n = 24), which therefore results in reduced power. For this reason, it was decided that adjusting alpha to control for Type I error would be overly conservative, and the statistical significance was set at a level of α = 0.05.

Further analyses were performed to investigate whether executive dysfunction and response inhibition could be related to the presence of externalizing behaviour problems. Calculation of the effect size of these correlations was estimated with the Pearson's correlation coefficient (*r)* which provided an indication of the magnitude of the relationship between these variables. The correlational analyses were divided into three parts. First, a correlation was run to establish whether externalizing problems correlated with EF scores on the BRIEF. Second, a correlation was run to establish whether externalizing problems correlated with performance in response inhibition as measured by the test battery. Lastly, a correlation was run to establish whether EF scores on the BRIEF was related to performance on the response inhibition test battery.

RESULTS

Externalizing behaviour problems

Three scales on the CBCL were evaluated, namely Aggressive Behaviour, Rule-Breaking Behaviour and Externalizing Problems. T-scores on the CBCL greater than 63 were used to identify clinically significant behaviour problems. *Figure 1* shows the number of participants with clinically significant problems as indicated in each subdomain of behaviour across the different groups. The Moderate group had the highest number of participants with clinical problems on all three scales. Contrary to what was expected, the TD group had more participants with clinically significant problems than the Mild group in both the Aggressive Behaviour and Externalizing Problems subscales. For Rule-Breaking behaviour, both the TD and the Mild group did not present any cases with clinically significant problems.

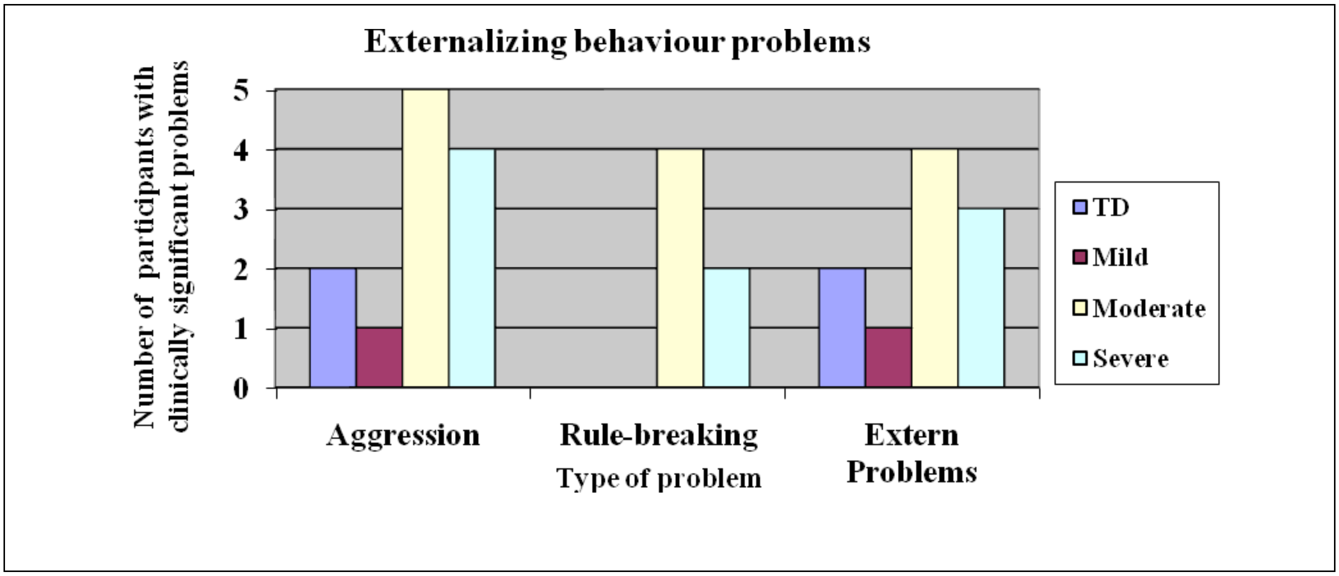

Figure 1. The number of participants with clinically significant problems in aggression, rule-breaking and total externalizing behaviour problems across the groups.

A one-way ANOVA single factor design was conducted to determine group differences on scores in each of the three scales of Externalizing behaviour on the CBCL. No statistically significant between-group differences were found in Externalizing Problems ($F(3, 20) = 2.142$, $p = .127$, $\eta^2 = .243$), rule-breaking behaviour ($F(3, 20) = 2.061$, $p = .137$, $\eta^2 = .236$) or aggression ($F(3, 20) = 1.25$, $p = .319$, $\eta^2 = .158$). The magnitude of the effect sizes were small for all three analyses (all below .3). A calculation of power indicated that with the current sample size, the chance of finding a significant difference between the groups for externalizing behaviour is 46%, 28% for

Aggressive Behaviour and 45% for Rule-breaking Behaviour. Table 3 displays the mean scores and standard deviations for each group's externalizing behaviour.

Table 3. Mean scores and standard deviations for externalizing behaviour across groups

Groups	Aggressive Behaviour	Rule-breaking behaviour	Externalizing Problems
TD (*n* = 6)	62.67 (8.33)	54.17 (4.75)	60.17 (7.5)
Mild (*n* = 6)	59.00 (9.46)	58.33 (4.93)	58.00 (7.01)
Moderate (*n* = 6)	67.83* (6.01)	63.67* (9.67)	67.00* (6.03)
Severe (*n* = 6)	64.17* (7.89)	58.83 (5.98)	63.00* (5.25)

Note. Means are presented with standard deviations in parentheses. *T-scores above 63 indicate clinical behaviour problems.

EF as measured by the Behaviour Rating Inventory of Executive Function (BRIEF)

Figure 2 shows the number of clinically significant problems on the two scales used from the BRIEF for each group. The severe group had the highest rate of clinical problems on the Inhibit scale, whereas the moderate group had slightly more clinically significant problems on the BRI. The TD group had the lowest number of clinically significant problems on the BRI, whereas the TD group and the mild group had an equal number of participants with clinically significant problems on the Inhibit scale.

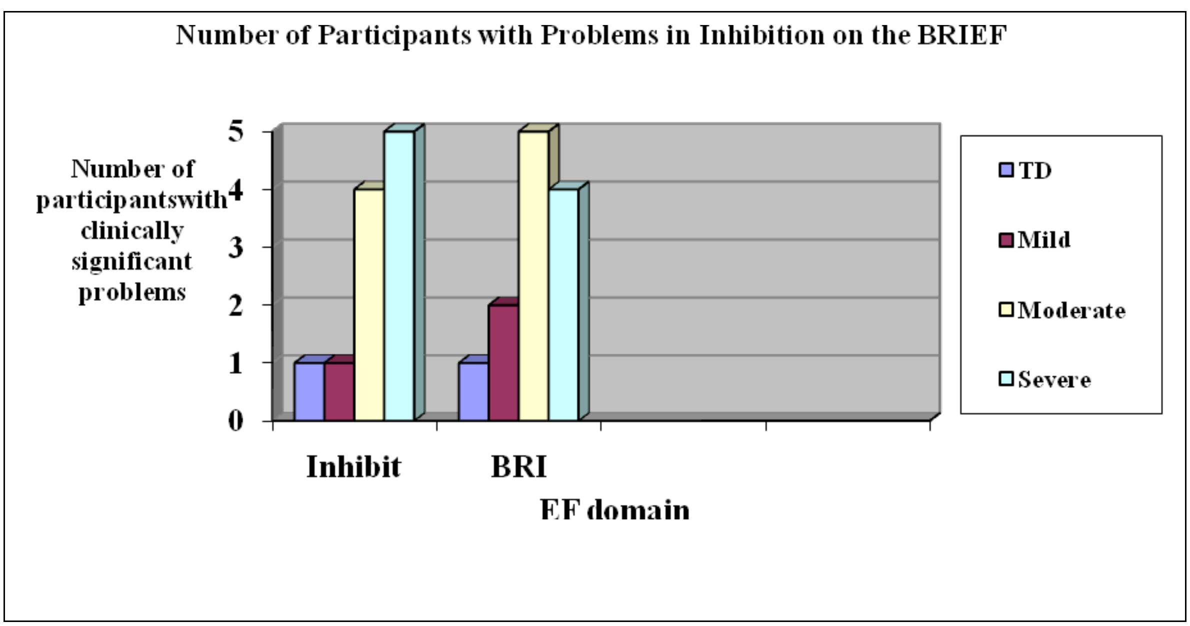

Figure 2. The number of participants with clinically significant problems in inhibition across the groups as measured by the BRIEF.

A one-way ANOVA single factor design was conducted to determine group differences on scores on the inhibition scales of the BRIEF. No significant between-group differences were found for the Inhibit scale ($F(3, 20) = 2.12$, $p = .130$, $\eta^2 = .241$) or the Behavioural Regulation Index ($F(3, 20) = 2.07$, $p = .136$, $\eta^2 = .237$). From looking at the effect sizes, we can see that they are both below.3, indicative of a small effect. Table 4 shows the mean scores of inhibition as measured by the BRIEF.

Table 4. Mean scores and standard deviations for executive function on the BRIEF across groups

Groups	Inhibit	Behavioural Regulation Index (BRI)
TD (*n* = 6)	57.00 (9.44)	59.33 (6.12)
Mild (*n* = 6)	57.16 (13.25)	61.66 (12.54)
Moderate (*n* = 6)	65.66* (12.61)	70.5* (11.16)
Severe (*n* = 6)	73.00* (15.63)	72.83* (13.49)

Note. Means are presented with standard deviations in parentheses.*T-scores above 65 indicate clinical behavioural problems.

Response inhibition test battery

A one-way ANOVA single factor design was conducted to determine group differences in response inhibition as measured by the D-KEFS Colour-Word Interference Test for Inhibition and Inhibition/Switching. Statistically significant between-group differences in performance on the D-KEFS were found for the Inhibition/Switching condition ($F(3, 19) = 3.26$, $p = .044$, $\eta^2 = .340$) but not for the Inhibition condition. Tukey's post hoc analysis indicated that the biggest difference in performance on the

Inhibition/Switching task was between the TD group (8.33 (2.42)) and Severe group (4.83 (2.13), p = .033). The results of the one-way ANOVA comparing Inhibition/Switching performance between groups is presented in Table 5 and the means and standard deviations for performance on the response inhibition test battery is presented in Table 6.

Table 5. One-way ANOVA summary table for total errors in D-KEFS Inhibition/Switching

	SS	df	MS	F	p	η^2	Observed Power ($\alpha = .05$)
Group	99.55	3	33.18	3.26	.044	.340	.65
Error	193.67	19	10.19				
Total	293.21	22					

ANOVA did not produce any significant between-group differences in performance on the Inhibition ($F(3, 19) = 1.27$, p = .312, η^2 = .16) or Inhibition/Switching ($F(3, 19)$ = 2.15, p = .126, η^2 = .24) tasks of the NEPSY-II Inhibition subtest.

Table 6. Means and standard deviations of scaled scores for response inhibition task performance

	D-KEFS Colour-Word Interference Test		**NEPSY-II Inhibition subtest**	
	Inhibition	Inhibition/ Switching	Inhibition	Inhibition/Switching
Groups				
TD (n = 6)	9.00 (2.19)	8.83 (2.85)	8.16 (3.18)	8.33 (2.42)
Mild (n = 6)	8.33 (4.08)	7.5 (2.25)	5.16 (3.34)	5.5 (3.08)
Moderate	8.5 (4.18)	6.67 (4.50)	7.33 (3.14)	5.83 (2.48)

(n = 6)				
Severe (n = 6)	7.8 (4.32)	3.00 (2.54)	5.33 (3.14)	4.83 (2.13)

Note. Means of the scaled scores are presented with standard deviations in parentheses.

Pearson product correlation coefficients were estimated to determine whether externalizing behaviour was related to executive function or response inhibition in the present sample. The correlational analyses were divided into three parts. First, a correlation was run to establish whether externalizing problems correlated with inhibition scores on the BRIEF. Second, a correlation was run to establish whether externalizing behaviour correlated with response inhibition as measured by the test battery. Lastly, a correlation was run to determine whether inhibition scores on the BRIEF correlated with response inhibition as measured by the test battery.

Externalizing behaviour problems and inhibition as measured by the BRIEF:

Pearson's correlations were conducted for the variables Inhibit, Behavioural Regulation Index (BRI), Externalizing Problems, Aggressive Behaviour and Rule-breaking Behaviour. As it was hypothesised that externalizing behaviour problems would be positively correlated with a child's level of inhibition dysfunction, all correlations were run as one-tailed tests. Inspection of the intercorrelation matrix (see Table 7) revealed statistically significant correlations between all variables except between Rule-breaking Behaviour and Inhibit. Externalizing Problems were positively correlated with both domains measured on the BRIEF, namely scores on the Inhibit (r = .60, p = .001) and BRI (r = .59, p = .001) scales which means that high scores on the CBCL are accompanied by high scores on the BRIEF. Aggressive behaviour was also positively correlated with both domains of the BRIEF, namely Inhibit (r = 65, p = .000) and BRI (r = .62, p = .001).

Table 7. Intercorrelations between externalizing behaviour and EF as measured by the BRIEF

Variable	Inhibit	BRI	Ext. Problems	Aggressive Behaviour	Rule-Breaking

Inhibit	-				
BRI	.91**	-	.		
Ext. Problems	.60*	.59*	-		
Agg.Behaviour	.65*	.62*	.92**	-	
Rule-Breaking		.38*	.68**	.37*	-

*$p < .05$. **$p < .01$. BRI = Behaviour Regulation Index.

Externalizing behaviour problems and response inhibition as indicated by the test battery

Pearson's correlations were conducted between externalizing behaviour and performance on the response inhibition test battery. Contrary to what was expected, no significant relationships were found between any of these variables.

Inhibition as measured by the BRIEF and response inhibition test battery

No significant correlations were found between the inhibition scores measured by the BRIEF and response inhibition on the neuropsychological test battery. As has been indicated previously, the Inhibit and BRI scores were very highly correlated with each other. The D-KEFS Inhibition and Inhibition/Switching also significantly correlated (r = .63, p = .001), as did the NEPSY-II Inhibition and Inhibition/Switching (r =.76, p = .000). The NEPSY-II Inhibition correlated with the D-KEFS Inhibition/Switching (r =.43, p =.02), as did the NEPSY-II Inhibition/Switching and the D-KEFS Inhibition/Switching (r = .61, p = .001). It is interesting that the NEPSY-II Inhibition did not significantly correlate with the D-KEFS Inhibition (r = .29, p = .117). That fact that scores of inhibition on the BRIEF did not significantly correlate with any of the tasks in the response inhibition test battery needs to be investigated. Table 8 presents the correlations between subtests on the response inhibition test battery and inhibition scores the BRIEF.

DISCUSSION

This study aimed to investigate the level of externalizing behaviour and post-injury inhibition in children following TBI. Scores on the CBCL related to externalizing problems were used to determine whether post-injury externalizing behaviours were present in the current sample. The BRIEF served as an ecologically valid assessment of the level of inhibition and this study investigated whether these scores differed as a function of injury severity. In addition, a neuropsychological test battery was conducted and assessed to investigate the influence of injury severity on post-TBI response inhibition. Furthermore, the study investigated whether the level of externalizing behaviour was related to the real-world inhibition deficits as measured by the BRIEF, or to performance on the response inhibition test battery. It was also investigated whether this "real-world" assessment of inhibition correlated with response inhibition as measured by the neuropsychological test battery.

Injury severity and externalizing behaviours

For externalizing behaviours as measured by the CBCL subscales, the Moderate group had the highest mean of scores for Externalizing Problems (67.00 (6.03)), Aggressive Behaviour (67.83 (6.01)) as well as Rule-breaking Behaviour (63.67 (9.67)). This group also had the most participants with clinically significant problems on all three scales of the CBCL (see Figure 1). The fact that the Moderate group had higher mean scores than the Severe group was an unexpected finding, as it was hypothesised that more severe TBI would result in elevations on externalizing scales on the CBCL as found in previous studies such as by Chapman et al. (2010). In addition, contrary to what was expected, the TD group had a higher mean score than the Mild group for both externalizing problems and aggressive behaviour (see Table 3). It is likely that the small sample size together with within-group variations resulted in the inability to reach statistical significance when groups were compared. Indeed, between-group comparisons revealed no significant differences in the level of externalizing behaviours. However, both the Moderate and the Severe group had mean scores above 63 (see Table 3) which is indicative of the presence of clinically significant behaviour problems for these two groups in comparison with the TD and Mild group. This is consistent with findings by Chapman et al. (2010) who found that a clinical population of paediatric patients presented with greater levels of externalizing behaviour than the normal population. Therefore, the notion that the level of externalizing behaviour differs as a function of injury severity, although not statistically proven by this study, needs to be explored with larger sample sizes.

There may be a variety of reasons for such inconsistencies in externalizing behaviours across groups in the present study. Although Anderson (2010) has outlined that with increasing injury severity there is a higher risk for difficulties across a range of cognitive and behavioural domains, at individual level these trends may not necessarily apply. TBI as a population is not a homogenous group, and therefore the outcomes across injury severity are highly variable and it becomes difficult to determine predictive factors, especially when effect sizes are small as in the present study. For example, studies have found that pre-injury factors may contribute more to behaviour problems than injury severity. Chapman et al. (2010) found that effects of TBI on behavioural outcomes were moderated by less advantaged family environments and lack of physical resources. Chapman's findings that post-injury behaviour problems were much more likely to be present in children with TBI who had less advantaged environments raises the question about whether behavioural problems are a result of the environment or injury severity. A more in-depth analysis of the child in his/her wider environment is needed to establish the interactions of pre-injury factors and injury severity on behavioural outcomes. This study replicated findings by Ylvisaker et al. (2007) which was indicative of the notion that externalizing behaviour problems such as aggression are rather unrelated to injury severity. In addition, Hawley (2004) observed that children who had sustained both mild and severe TBI displayed an equal amount of post-injury behaviour problems. In contrast, Anderson et al. (2006) found significantly higher levels of behaviour disorders following severe TBI in comparison with moderate brain injury. This may reflect the possibility of a high level of pre-injury behaviour problems in the present sample. Studies by Yeates et al. (2010) have confirmed this notion, indicating that research on behavioural adjustment can be confounded by the high prevalence of pre-injury behaviour problems in children with TBI, thus a future implication for research in this domain would be to conduct more in-depth analysis of pre-injury characteristics.

Injury severity and inhibition as measured by the BRIEF

Mangeot et al. (2002) indicated that children who sustain TBI display significant deficits in executive functions such as inhibition and behavioural regulation. It was therefore expected that children with TBI in the present study would be more likely to show clinical elevation in inhibitory control on the BRIEF scales than the TD group. Between-group comparisons in the present study revealed that post-injury inhibition did not vary significantly as a function of injury severity. However, more subtle differences in groups can be observed by examining the mean scores. For inhibition as measured by the Inhibit scale and the BRI on the BRIEF, the severe group had the highest means on both scales, followed by the moderate group, the mild group and lastly the TD group who had the lowest mean scores (see Table 4). In addition, both the moderate and the severe group had mean scores above 65 (see Table 4), which is indicative of the presence of clinically significant problems for these two groups in comparison with the TD and mild group. This could provide support to the possibility that by using behavioural measure of inhibition such as the ecologically valid BRIEF in children following TBI, it may become more clear that inhibition varies as a function of injury severity and is manifested in everyday behaviour, with more severe TBI resulting in elevated scores on the Inhibit scale and the BRI as was found in previous studies such as Chapman et al. (2010). Such conclusions can only tentatively be drawn from the current study since the magnitude of the effect sizes for these analyses were small. A calculation of power indicated that with the current sample size, the chance of finding a significant difference between the groups for the Inhibit scale and the BRI is 46% and 45% respectively, thus further investigation using larger sample sizes with larger effect sizes are needed to confirm these assumptions.

Injury severity and response inhibition

Of the four tests administered to assess post-injury response inhibition in children who have sustained a TBI, only one of the four conditions revealed significant between-group differences, namely the Inhibition/Switching condition of the D-KEFS Colour-Word Interference Test. As hypothesised, the biggest difference was between the TD group (8.33 (2.4)) and the Severe group (4.83 (2.13)). This may provide support for the fact that certain aspects of response inhibition may be impaired following TBI. However, it is interesting that the neither the D-KEFS Inhibition condition nor the NEPSY-II Inhibition condition produced any between-group differences. Since the D-KEFS Inhibition/Switching condition is indicative of both verbal inhibition *and* cognitive flexibility (Delis et al., 2001), and since significant between-group differences were not found for "pure" response inhibition on the D-KEFS Inhibition and NEPSY-II Inhibition conditions, this could lead to two possible assumptions. Firstly, it may suggest that TBI rather impairs cognitive flexibility than response inhibition for children with more severe injuries since the Inhibition conditions did not produce any significant findings. Secondly, it may suggest that post-injury response inhibition does not vary as a function of injury severity, even though cognitive flexibility does vary across injury severity groups. This notion is supported by findings by Rieger and Gauggel (2002) who found no evidence of an inhibitory deficit in patients with TBI. As noted in the review of the literature however, studies have shown inconsistency in outcome and therefore additional research is needed that uses a wider variety of neuropsychological tests purporting to assess response inhibition. Since only one of the four conditions used in the neuropsychological test battery was found to produce significant between-group results, this study adds to notion that response inhibition as measured by neuropsychological tests are not strongly influenced by injury severity.

Slomine et al. (2002) has outlined various difficulties in measuring executive function that may be applicable to the current findings and help explain the inconsistencies in performance on the test battery. First, EF is a complex and dynamic processes, often difficult to capture in single test scores. Also, the structure imposed by the standardized testing situation often masks the deficits in EF, which means that poor performance on measures of EF may tap deficits in underlying cognitive skills rather than EF directly. This may also provide insight into why performance on response inhibition tests were not related to externalizing problems in the correlational analysis.

Externalizing behaviour problems and post-injury inhibition

This study investigated the relationship between externalizing behaviour and inhibition based on the evidence of the frequent co-occurrence and shared features between externalizing problems and executive dysfunction. It was hypothesised that externalizing behaviour and inhibition as measured by the BRIEF would be significantly correlated. This hypothesis was confirmed in that ssignificant positive correlations were found between the Inhibit scale and Externalizing problems as well as Aggressive behaviour (see Table 7). This indicates that post-injury inhibition ability is related to the level of externalizing problems and aggressive behaviour specifically that occur in children following a TBI. Since rule-breaking behaviour was not significantly correlated with levels of inhibition on the BRIEF, it can be concluded that inhibition is more related to aggressive behaviour than such other externalizing problems. This finding replicates what has been found by Mangeot et al. (2002) that parent ratings of the BRIEF were strongly related to measures of behavioural adjustment for children in all groups. Conversely, the response inhibition test battery did not produce any significant correlations with the level of externalizing behaviour in the present sample. This may suggest that functioning on such neuropsychological measures may not be related to everyday behavioural consequences of TBI. It can therefore be concluded that the behavioural manifestations of inhibition are related to more general measures of psychosocial and adaptive functioning than that of performance on neuropsychological testing. This finding is not surprising, since aspects of executive function such as inhibition and self-regulation presumably play a significant role in the everyday functioning of children with TBI (Gioia & Isquith, 2004).

Response inhibition test battery and ecological assessment of inhibition as measured by the BRIEF:

According to the third hypothesis, it was expected that there would be significant correlations between the level of inhibition as measured by the BRIEF and performance on the neuropsychological tests of response inhibition. No significant correlations were found between participants' performance on the response inhibition test battery and inhibition as measured by the BRIEF. This replicates findings by Mangeot et al. (2002) who reported that neuropsychological measures of executive functions demonstrated modest associations with parent ratings on the BRIEF. This could help explain the weak correlation between the neuropsychological tests and the parent-rated ecological assessment of inhibition in the present study.

There may be a number of reasons why performance on EF tests (such as the Colour-Word Interference Test and the NEPSY-II) do not always correlate with more ecologically valid assessments of EF (such as the BRIEF). Firstly, according to Mangeot et al. (2002), this may be because neuropsychological tests that claim to measure EF may have limited ecological validity. These neuropsychological tests may have limited ecological validity because unlike behavioural questionnaires assessing EF, they fail to relate to children's *everyday* functioning and therefore cannot be used to make assumptions or predict day-to-day impairments that occur following childhood TBI in the same way as such ecologically valid assessments (Silver, 2000). Therefore, trying to establish whether day-to-day executive deficits such as inhibition are related to performance on such neuropsychological tests may be problematic, as has been indicated by the findings in the present study. Secondly, the modest relationship between the BRIEF and neuropsychological tests could reflect shortcomings in the measures themselves. Some researchers (e.g., Naudebaum et al., 2007) have argued that cognitive and behavioural measures may tap slightly different aspects of EF. The BRIEF may be tapping aspects of behavioural functioning that fall outside the domain of executive functions, which could explain why scores on the BRIEF and the CBCL significantly correlated, but scores on the CBCL and the response inhibition test battery did not. In the same way, neuropsychological tests may not be sensitive to everyday manifestations of executive functions because according to Mangeot et al. (2002), the cognitive processes that they assess are too narrow or specific. What is more, because many neuropsychological tests are administered in a highly structured way, they fail to detect the more subtle deficits in executive function.

Limitations and Directions for Future Research

The results of the current study should be interpreted in light of several methodological limitations. The major limitation of this study is the small sample size. Small sample size and associated low statistical power meant that a significant difference in the degree of externalizing behaviours or response inhibition between the groups could not be achieved. Larger sample sizes will be able to produce more precise information, therefore future studies need to focus on obtaining greater sample sizes.

Another limitation involves the shared method variance associated with the use of multiple parent rating scales. The rating scales used in this study (i.e., the BRIEF and CBCL) were completed by one caretaker, typically the child's mother. According to Mangeot et al., (2002), the associations between ratings on the BRIEF and ratings of child functioning may have been inflated by the reliance on a single informant. Future studies using multiple informants would strengthen the conclusion that executive functions as measured by the BRIEF are associated with children's adaptive behaviour post-TBI. Ratings from teachers would be especially desirable, and could be obtained using appropriate versions of scales such as the BRIEF and the CBCL.

An additional complication is that children who suffer TBI are not representative of the healthy population, and are more likely to have pre-existing behavioural and learning problems as well as social disadvantage, especially in the South African population (Levin, 2004). These factors may impact negatively on recovery, and confound our ability to determine which post-injury difficulties are due to TBI and which might have predated injury. These unique characteristics also lead to challenges in selecting appropriate comparison groups for determining injury-related consequences, and differentiating them from pre-existing problems.

An investigation of post-injury response inhibition and externalizing behaviours in children who have sustained a TBI and the relationship between these sequelae allows for a better understanding of the implications of TBI on behavioural functioning. It suggests that deficits in inhibition and behavioural regulation as particular domains of EF is related to real-word functioning and behavioural sequelae. Therefore, since deficits in EF such as inhibition and behavioural regulation is related to externalizing behaviour problems such as aggression for children who have sustained a TBI, it is imperative that children with TBI be assessed for post-injury deficits so that appropriate treatment and rehabilitation strategies are put in place to ensure recovery and optimal post-injury functioning for these children. We can therefore conclude that because scores in externalizing behaviours were related to inhibition and behavioural regulation as measured by the BRIEF, but not response inhibition performance on the test battery, the relationship between externalizing behaviour and response inhibition as a specific aspect of EF requires further explanation.