Behavioural and Affective Functioning in Children after Mild Traumatic Brain Injury

Anna Sloan

Doctor of Psychology
(Clinical Neuropsychology)

Victoria University

2011

Behavioural and Affective Functioning in Children after Mild Traumatic Brain Injury

Ann Sloan
BAppSc(Psych)(Hons)

Submitted in partial fulfilment of the requirements of the degree of Doctor of Psychology (Clinical Neuropsychology)

School of Social Sciences and Psychology
Victoria University
Melbourne, Australia
November 2010

ABSTRACT

Previous research investigating affect and behaviour following mild Traumatic Brain Injury (mTBI) in children has produced variable results. It has been suggested that following a mTBI children may experience transitory "post-concussion" symptoms but subsequently will make a full recovery. In contrast, other studies have reported changes in children's behaviour and affect lasting even years post injury. The current study aimed to further document the impact of mTBI on behaviour and affect in children. This prospective study reports on a sample of 26 children aged between 6 and 12 years. The children were assessed at baseline, one week, three months and a subgroup at 12 months post injury. No changes were found over time on the standardised measures of behaviour and affect with the Behavioural Assessment System for Children, Second Edition (BASC2). However, on the BASC2 the children with pre-existing problems displayed higher incidence of scores in the 'At Risk' or 'Clinically Significant' range on the Externalising Problems composite scale in comparison to the children with no pre-existing problems. A qualitative question was also administered to parents. Approximately half of the whole sample reported some change in their child's mood or behaviour at one week post-injury and approximately one quarter continued to report changes at three months post injury. It was also investigated whether the children who had problems or changes reported at three months post-injury differed from the other children on any pre-morbid factors, however, no significant results were found. The overall conclusions drawn from the study were that the group of children referred to the study had a higher proportion of children with pre-existing problems than that expected in the general population. Further, these children differed pre-morbidly from those without pre-existing problems on standardised behavioural measures. While no changes were found over time on standardised measures of behaviour and affect, subjective parental report suggested that in fact there may have been more subtle changes in some children's behaviour up to 3 months post-injury. These findings are worthy of further systematic investigation.

DECLARATION

I, Ann Sloan, declare that the Doctor of Psychology (Clinical Neuropsychology) thesis entitled "Behavioural and Affective Functioning in Children after Mild Traumatic Brain Injury" is no more than 40,000 words in length including quotes and exclusive of tables, figures, appendices and references. This thesis contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work.

Signature: Date: 8/11/2010

ACKNOWLEDGEMENTS

I would like to thank the following people for everything they have done to make this thesis possible.

Firstly, I would like to thank my supervisor, Dr Alan Tucker. His extensive knowledge in the area, unyielding support and encouragement has not only enabled me to undertake this task, but even enjoy it.

My parents' belief in me was instrumental in me embarking on, and completing, this journey. I cannot thank them enough for this, and all the assistance they have given me along the way. I am also extremely grateful to my brother, friends and colleagues who have given me timely distractions and words of encouragement whenever I needed them.

My partner, Ross, has experienced this journey at close proximity. His support has been unwavering and I am especially grateful for his good humour and acts of kindness that have got me through all the ups and downs.

A special thank you goes to Dr De Villiers Smit and the other staff at the Northern Hospital for their enthusiasm for this research and all the referrals they made. Also, thank you to Joanne Yacoub for assistance with the data collection and all her efforts with the collaborative aspects of this study.

Finally, I would like to express my sincere gratitude to the children and families who generously volunteered to participate in this study. They let us into their homes and lives and without their contributions this study would not have been possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1: Introduction

1.1. Overview and Consequences of Traumatic Brain Injury (TBI) in Children

The structure and function of the brain continues major development after birth and into adulthood. Both intrinsic physical brain changes and brain-environment interactions contribute to the development of children's cognitions, behaviour, personality, social and emotional functioning. A disruption to this process has the potential to change the trajectory of a child's development which could result in significant consequences for normal development. More broadly, changes in any aspect of children's development can have an impact on family, education and society in general.

Traumatic Brain Injury (TBI) is a significant contributor to morbidity and mortality in the population. Fortune and Wen (1999) reported that in Australia over the period of one year 199 out of every 100,000 children between the age of 5 and 14 years experienced a TBI. Experiencing a TBI in childhood has the potential to cause many ongoing psychological consequences (Kaufmann, Fletcher, Levin, Miner & Ewing-Cobbs, 1993; Massagli, Fann, Burington, Jaffe, Katon & Thompson, 2004; Max, Levin, Landis, Schachar, Saunders, Ewing-Cobbs et al., 2005; Max, Levin, Schachar, Landis, Saunders, Ewing-Cobbs et al., 2006). Research on the effect of TBI has broadly focused on two areas; the effect TBI has on cognition and the effect it has on behaviour, psychosocial functioning and affect (Anderson, Catroppa, Moore, Haritou & Rosenfeld, 2001; Ponsford, Willmott, Rothwell, Cameron, Ayton, Nelms et al., 1999; Hawley, Ward, Magnay & Long, 2002).

Traumatic Brain Injury is an umbrella term that incorporates many different types of physical brain insults. The term Traumatic Brain Injury differs from just any insult to the brain that occurs following birth (an acquired brain injury, eg. a stroke) in that it involves an outside force exerting a trauma on the brain (eg. an acceleration-deceleration head movement; Ponsford et al., 1999). Traumatic Brain Injury can refer to an injury that only damages a specific area of the brain (focal damage) or to an injury that causes diffuse axonal damage. It can also refer to a closed head injury where the skull remains intact or

an open head injury where the skull is penetrated (Ommaya & Gennarelli, 1974). Any area of the brain can be affected in a TBI, however, the frontal and temporal lobes are particularly vulnerable to diffuse injury due to the damage caused by them moving on the rough tentorial plates that hold them in place (Bigler, 2007). A loss of consciousness is considered due to injuries that affect the brain-stem and related areas that mediate arousal (Ommaya & Gennarelli, 1974). Long axons that are involved in high-level associative functions are also considered to be vulnerable to diffuse axonal injury (Willer & Leddy, 2006). Subtle diffuse damage is not always detectable on brain imaging such as MRI. Further, secondary brain damage can occur following a TBI such as that due to herniation caused by oedema, or by ischemia or intracranial haemorrhage (Silver, McAllister & Yudofsky, 2005; Skoglund & Nellgard, 2005). There are many causes of TBI including falls, motor vehicle accidents and violence (Skoglund & Nellgard, 2005). Given the varied types of injuries and the different impacts they can have on the brain it is clear TBIs are not a uniform event and that they can have a wide-ranging and complicated impact on an individual.

1.2. Defining Severity of TBI

Most commonly TBI is classified by the severity of the injury rather than the location or any other factor. Severity can be measured in many different ways but generally it refers to the impact that the injury has on an individual's brain function. The most common descriptions of severity in the literature are mild, moderate and severe. However, the definition of what constitutes a mild, moderate or severe TBI and how it is measured varies considerably between studies and reflects inconsistent clinical and research approaches in this area.

TBI is known to be associated with a number of functional changes. Immediately following a TBI an individual may suffer a period of loss of consciousness (Willer & Leddy, 2006). This refers to a period where the individual is unresponsive to stimuli. The length of the loss of consciousness can vary considerably from a few seconds to days or weeks. In addition, both retrograde and anterograde amnesia is also associated with TBI. It is not uncommon for an individual to be unable to remember the events that occurred

directly before the TBI, which is referred to as retrograde amnesia. Further, once an individual regains consciousness following the TBI there is often a period of time when the individual is unable to reliably encode new information; this is referred to as anterograde amnesia. In the context of a TBI this period of amnesia following the injury is referred to as Post Traumatic Amnesia (PTA) and can vary considerably from minutes to days, weeks or months (Shores, Marosszeky, Sandanam & Batchelor, 1986; Symonds, 1928).

TBI severity is often defined in terms of the length of loss of consciousness, the score the child received on the Glasgow Coma Scale (GCS; a measure of level of consciousness), or the duration of Post Traumatic Amnesia (PTA). The values assigned to each of these descriptors of severity can vary. For example, some research studies define a loss of consciousness of less than 30 minutes as mild TBI, whereas others deem that less than 20 minutes constitutes a mild TBI (McKinlay, Dalrymple-Alford, Horwood & Fergusson, 2002; Ponsford et al., 1999). Further, in some studies the children may not even have to lose consciousness at all and only be suspected of suffering concussion to be classified as experiencing a mild TBI (mTBI; McKinlay et al., 2002). The wide variability in what may be classified as a mTBI has been criticised with suggestion that subcategories should exist within the diagnosis of a mTBI to better capture the severity of the injury with an aim to better understand the impact of different levels of severity (Ruff, 2005). Attempts have been made to devise sub-categorisation schemes for mTBI, however, these have not been widely adopted in the literature at this point and thus the utility of these scales is not yet clear (Ruff, 2005).

1.3. The Effect of TBI on Adults: An Overview

As well as the short term impact of TBI, there is an extensive body of clinical knowledge and literature on the longer term associated changes. The literature on the effect of TBI on adults highlights the impact that such an injury can have on a developed brain and the associated consequences.

1.3.1. Studies of the Effects of Moderate to Severe TBI

Mathias and Wheaton (2007) conducted a large meta-analytic review investigating attention and information-processing speed following severe TBIs in adults. Electronic databases PsycINFO and PubMed were searched comprehensively for the period between January 1980 and November 2005. Studies were included if they met the following criteria: they were published in a journal and were written in English; they had a control group matched for age, gender or education; tests were administered to both groups; did not use case studies; included a severe TBI group based on a GCS less than 8, more than 24 hours loss of consciousness and/or posttraumatic amnesia greater than 24 hours; reported results in a way that allowed for conversion to effect sizes; participants were between the ages of 16 and 65 and were excluded if they had a previous history of head injury, motor, visual or language impairments, substance abuse or psychiatric illness. Of 2971 articles identified, 41 were deemed appropriate following application of inclusion and exclusion criteria. Findings reported impairment in speed of information processing between TBI and control groups on a number of different measures. Significant effect sizes were also seen on measures of attention span, selected or focused attention and sustained attention or vigilance. A more moderate effect size was seen for divided attention following severe TBI.

The impact that age, level of education and duration since injury may have on the reported results of attention and speed of information processing was also investigated. None of these variables were found to impact significantly on the findings suggesting that the attention and speed of processing deficits commonly occur following a severe TBI and that these deficits are persisting and independent of what age the injury occurred at in adulthood and what background level of education the individual had. Unfortunately other variables such as pre-morbid intellectual functioning and socio-economic status were unavailable.

Memory deficits have also been frequently reported in the adults who have suffered a moderate to severe TBI. Vakil (2005) conducted a large review of studies investigating memory deficits following moderate to severe TBIs in adults. Specific search strategies

and inclusion and exclusion criteria were not described in the article. Studies included were reported to have clear inclusion of moderate to severe TBI groups, case reports were generally excluded. Each study was broadly categorised on the basis of whether it took a clinical or theoretical perspective of memory functioning. Specific results from 68 studies were reported, however, the actual number of studies used in the review may have been much larger, since this was not reported. Moderate severity was defined as GCS 9-12, coma length between 20 minutes and 36 hours and PTA 1 to 7 days. Severe TBI was defined as GCS 3-8, coma duration longer than 36 hours and greater than 7 days PTA. The review concluded that memory deficits are indeed common in this population. However, the deficits are usually not characteristic of an amnesic syndrome. Rather, memory deficits in this population were thought to be characterised more by poor planning and organization when encoding, and later when retrieving information. Thus, poor memory was thought to be reflective of impairments in other aspects of cognition including executive functioning, attention and speed of information processing.

Given the range and severity of cognitive difficulties often experienced following moderate to severe TBIs it is not surprising that poorer employment outcomes have also been reported in individuals in this group (Coetzer, Hayes & Du Toit, 2002). Further, many other activities of daily living such as money management have been found to be affected for as long as 24 years post injury (Colantonio, Ratcliff, Chase, Kelsey, Escobar & Vernich, 2004). The clear deficits in cognition and the functional impact of moderate to severe TBIs in adults highlights the significance of such an event and the high risk of a poor outcome.

1.3.2. Studies of the Effects of Mild TBI

In a review of research on mild Traumatic Brain Injuries (mTBI) in adults Ruff (2005) reported that approximately 80% to 90% of individuals who suffer a mTBI seem to make a good recovery. However, it appears that a remaining 10% to 20% continue to suffer problems following mTBI. While this is only a minority, given the frequency of mTBI this could still translate into a large number of individuals (Ruff, 2005). While there is a general consensus that a proportion of those who suffer a mTBI will have

ongoing problems the nature and underlying cause of those problems is still being debated in the literature.

A number of studies have documented ongoing cognitive and affective changes in some individuals following mTBI. In a review Busch and Alpern (1998) documented a number of studies that indicated that depression, or symptoms of depression, occurred in a proportion of individuals following mTBI. In a large prospective study using computerised records Fann, Burington, Leonetti, Jaffe, Katon & Thompson (2004) investigated the incidence of psychiatric illness in adults following a TBI. The presence of a psychiatric illness was determined by whether an individual had a diagnosis of a psychiatric illness, filled a prescription for medication for a psychiatric illness or used a psychiatric service. Psychiatric illnesses were recorded in categories including "acute reaction to stress or adjustment reaction", "alcohol or drug intoxication, withdrawal, or dependence", "depression" and "malaise or fatigue" (Fann et al., 2004). It was found that in comparison to controls, individuals who suffered a mTBI were more likely to suffer a psychiatric illness up to 3 years post injury. The individuals who had a psychiatric illness prior to the injury were at increased risk of having ongoing problems following a mTBI. Post traumatic stress disorder has also been commonly reported in adults following a mTBI (Feinstein, Hershkop, Ouchtlerlony, Jardine, & McCullagh, 2002). While the evidence is quite consistent that a proportion of those who suffer a mTBI display ongoing affective disturbances, there is also literature documenting ongoing cognitive disturbances. Hess, Marwitz and Kreutzer (2003) conducted a prospective study of adults who suffered a mTBI. Their participants were assessed 2 weeks post-injury and found to have impairments in learning, memory, motor speed, dexterity and speed of information processing. It was also found that more than 1 year after a mTBI a group of individuals still had reduced speed of processing reflected in less word generation when compared to healthy controls (Raskin & Rearick, 1996).

Ruff (2005) summarised two main perspectives on the underlying cause of ongoing problems following mTBI. One view is that these individuals have suffered physical damage to the brain which may not be detectable on imaging but has an impact on the

individual's cognition, behaviour and affect. Support for this notion comes from animal studies which have demonstrated microscopic brain damage on autopsy that was not evident on brain imaging following only a minor brain insult (Ruff, 2005). The other perspective on the underlying cause of ongoing problems following mTBI is that a proportion of those who suffer a mTBI have pre-existing psychological problems which are exacerbated due to their reaction to the injury. Rush, Malec, Brown and Moessner (2006) studied individuals who had suffered either a mTBI, a moderate to severe TBI or an orthopaedic injury (OI). It was reported that the presence of depression contributed to poorer functional outcome in all groups. However, there was not a significant difference in depression between the TBI and OI groups. This finding supports the idea that psychological reactions to trauma may impact emotional adjustment and in turn affect functional outcomes.

The notion that a proportion of individuals who suffer a mTBI will develop persisting changes in cognition, affect and behaviour raises questions over the appropriateness of comparing averaged group data (Ruff, 2005). If only 10% of the group are exhibiting problems and the group as a whole is compared to a control group it is possible that as a group no significant differences will be found. However, such an approach may miss the potential significant impact of the mTBI on a sub-group of individuals. The presence of problems such as depression following TBI has been shown to correlate with functional outcomes and thus it is important to detect these problems where they do occur (Rush et al., 2006). The research on the effects of mTBI in adults also serves as a model for the effect on children. If changes that occur following mTBI in adults can lead to depression, other emotional/affective abnormalities and cognitive changes it is possible that the same outcomes may occur in children.

1.4. The Effect of TBI on Children

A TBI in adulthood physiologically reflects an injury to an essentially developed brain. Thus, the literature on adults may not directly apply to children as a TBI in childhood occurs in the context of a brain that is still developing. While some skills and levels of functioning are achieved, a large amount of development is still expected. An

insult to the brain in childhood may result in a loss of skills but also may impact on the development of new skills and thus change the developmental trajectory.

1.4.1. Prevalence of Moderate to Severe TBI

In the Australian population it is estimated that the overall incidence of TBI over one year is 141 per 100,000 people across the whole life span. Eleven percent of these cases are admitted to hospital for over 1 week. This suggests that while the majority of TBIs are mild, and only receive a small amount of medical attention, a proportion of the injuries are in the moderate to severe category and require significant medical attention. Of the 25,000 cases of TBI admitted to Australian hospitals over the period of one year, 224 did not return to previous levels of consciousness. Although this is a minority of those who suffered a TBI these statistics demonstrate that significant morbidity and mortality can be associated with severe TBIs (O'Connor, 2002).

1.4.2. Prevalence of Mild TBI

It has been estimated that seventy-five to eighty percent of TBI experienced by children in industrialised countries are probably mild in severity (Mathias, Beall & Bigler, 2004; Ponsford, Willmott, Rothwell, Cameron, Ayton, Nelms et al., 2001). However, clinical reports indicate that it is likely that many of these children are not admitted to hospital and receive variable assessment, treatment and support. An analysis of Australian hospital data from the Australian Institute of Health and Welfare over the period of one year from 1997 to 1998 estimated the incidence of TBI to be over 25,000; this accounted for 7% of hospitals injury admission over the year (O'Connor, 2002). The data did not include details on the severity of TBIs; however, nearly 70% of cases admitted to hospital only stayed for one night suggesting that the majority of these injuries were mild. An extensive search of the published literature did not reveal any data on the incidence of Australian children who suffered a TBI and did not present to a hospital. Clinical reports suggest that most children do not receive medical attention for a mild TBI and may only present if symptoms persist or if behavioural changes are noticed, even months or years after the event. Of these individuals an unknown proportion may present to general medical practitioners, neuropsychologists, speech pathologists and

paediatricians. Further, the secondary impacts of mTBI in children may affect family functioning, schooling and society in general. Thus, the actual impact of mTBI on the individual, their family, the health system and society in general is very unclear.

1.4.3. The Effect of TBI on Cognitive Functioning in Children

Studies of cognitive functioning following TBI in children have examined areas such as memory, executive functioning, attention and intelligence (Anderson & Pentland, 1998; Levin & Hanten, 2005).

1.4.3.1. Studies of the Effects of Moderate to Severe TBI

The impact of a moderate to severe TBI on children's cognition has been demonstrated in many studies to be significant. Levin, Hanten, Zhang, Swank, Ewing-Cobbs, Dennis et al. (2004) have shown that children who sustained a severe TBI exhibit a decline in their working memory between 1 and 2 years post injury. Executive functioning has also been shown to deteriorate after a moderate to severe TBI in children relative to a control group (Ewing-Cobbs, Prasad, Landry, Kramer & DeLeon, 2004). Widespread cognitive deficits were found in a prospective study with a 6-month follow up of children who had suffered a severe TBI (Ong, Chandran, Zasmani & Lye, 1998). When compared to children with mild to moderate TBI, and to an orthopaedic injury control group, children with a severe TBI showed significant deficits in performance and verbal skills as well as memory and learning as measured by the Weschler Intelligence Scale for Children, Third edition (WISC-III) and the Wide Range Assessment of Learning and Memory (WRAML). Not surprisingly the majority of the severely injured children were reported by the parents to have deteriorated in their school performance. Willmott, Anderson & Anderson (2000) conducted assessments on 33 children who had sustained a moderate TBI at least 2 years prior to the time of data collection. They found that compared to normative data the children displayed mild delays in spelling and arithmetic and performed poorly on measures of attention. Furthermore, eighteen months post injury children who had suffered a severe TBI were found to have significantly poorer planning abilities than those who had suffered a mild to moderate TBI or a control group (Pentland, Todd & Anderson, 1998).

1.4.3.2. Studies of the Effects of Mild TBI

The cognitive impact of mTBI in childhood has received little attention in comparison to the effects of more severe injuries. Recent evidence suggests that following a mTBI children may experience ongoing cognitive impairments. These impairments have been have been found to be in attention, speed of information processing, executive functioning, visual processing and various aspects of memory (e.g. prospective and working memory; Anderson, Catroppa, Rosenfeld, Haritou & Morse, 2000; Brosseau-Lachaine, Gagnon, Forget & Faubert, 2008; Catale, Marique, Closset & Meulemans, 2009; Levin et al., 2004; McCauley & Levin, 2004; Mathias et al, 2004; Petersen, Scherwath, Fink & Kock, 2008). However, the results are not conclusive with a number of studies failing to detect changes on neuropsychological assessment (Ponsford et al., 1999; Satz, Zaucha, McCleary, Light & Asarnow, 1997). Ong et al. (1998) reported that on measures of intelligence, learning and memory children who had suffered a mild to moderate TBI were no different from orthopaedic controls. However, 18.5% of the mild to moderate TBI group were reported to have deteriorated performance at school compared to 3.7% of the control group. This suggests that while no differences were detected on global neuropsychological measures such as Full Scale Intelligence Quotient (FSIQ), perhaps some more subtle deficits were in fact present and having an impact on the child's functioning. Ponsford et al. (1999) conducted a comprehensive prospective study of children who suffered a mTBI at 1 week and 3 months post injury and compared their performances to a matched control group. No differences were found between the groups on measures of intelligence, memory, attention and speed of information processing. However, on specific measures of high level attention such as selective and divided attention Catale et al. (2009) reported changes 12 months post-mTBI in comparison to controls. Reduced high level visual processing has also been reported 12 weeks post injury in comparison to controls (Brosseau-Lachaine et al., 2008). The varied findings may be due to methodological differences across the studies including varied measures of severity, inclusion criteria and the neuropsychological tests used to measure cognitive functioning. Further research is necessary to better understand whether changes in cognition do occur following a mTBI and if they do, which aspects of cognition are affected and under what circumstances.

1.4.4. Studies of Behavioural/Affective Outcomes Following TBI in Children

1.4.4.1. Studies of Moderate-Severe TBI in Children

It has been well established that moderate to severe TBIs in children will cause a range of ongoing behavioural, affective and psychosocial problems. For example, it has been found that severe TBI in childhood is associated with a significantly reduced level of adaptive functioning (Fletcher, Ewing-Cobbs, Miner, Levin & Eisenberg, 1990). Moderate to severe TBI has also been linked to deterioration in psychosocial functioning and an increased risk of experiencing depressive symptoms (Donders & Ballard, 1996; Kirkwood, Janusz, Yeates, Taylor, Wade, Stancin et al., 2000; Luis & Mittenberg, 2002). Using the Child Behaviour Check List (CBCL) in a prospective study Ong et al. (1998) reported a significant difference in somatic complaints, socialising, thoughts, attention, delinquent behaviour and aggressiveness between severe and mild to moderate TBI and the severe and orthopaedic control groups 6 months post-injury. No difference was found between the mild to moderate TBI and the orthopaedic control group. These results show that severe TBI has a profound effect on a child's functioning. Willmott et al. (2000) found that parents reported symptoms of inattentive behaviour on the CBCL in children more than 2 years after they had suffered a moderate TBI. In a large prospective study Yeates, Swift, Taylor, Wade, Drotar, Stancin et al. (2004) found children who suffered a moderate to severe TBI had poorer social outcomes (measured using the CBCL and the Vineland Adaptive Behaviour Scale) than a control group up to four years post-injury. Those who suffered a severe TBI had worse outcomes than those who suffered a moderate TBI. Interestingly, the poorer outcomes in these groups were found to be exacerbated by poorer family functioning and less resources. Overall, there is a body of literature documenting significant and ongoing behavioural and affective disturbances in children who suffer a moderate to severe TBI.

1.4.4.2. "Post-Concussion Syndrome" Following Mild TBI

It is widely acknowledged that mTBI is associated with acute symptoms (resolving over days or weeks after the injury) that have often been referred to as "Post-Concussion Syndrome" (Farmer, Singer, Mellits, Hall & Charney, 1987; Prior, Kinsella, Sawyer, Bryan, & Anderson, 1994; Satz, 2001; Willer & Leddy, 2006). There is variability in

what is considered to be post-concussion syndrome in the research and clinical domain (American Psychiatric Association, 2000; Boake, McCauley, Levin, Pedroza, Contant, Song et al., 2005; World Health Organisation, 1992). In general, symptoms commonly associated with post-concussion syndrome include somatic symptoms such as headache, nausea, vomiting, dizziness, sensitivity to light or noise, numbness or tingling, blurred vision and tinnitus. Neurobehavioural symptoms include drowsiness, fatigue, depression, irritability and sleep disturbances and cognitive symptoms including feeling "slowed down" or "dazed", poor concentration and memory have also been reported (Willer & Leddy, 2006).

1.4.4.3. Studies of Mild TBI in Children

In contrast with the broad consensus in the literature on the acute "post-concussion" symptoms following a mTBI, the research on the longer term outcomes has produced more variable results with the issues being approached from several different perspectives and using varied methodology. Some studies have not demonstrated any long term consequences of mTBI in childhood, suggesting children make a full recovery and do not suffer from any ongoing problems (Goldstrohm & Arffa, 2005; Prior, Kinsella, Sawyer, Bryan, & Anderson, 1994; Satz, 2001). However, clinical reports and some prospective studies suggest that children may still experience ongoing cognitive, behavioural and psychosocial difficulties (Anderson et al., 2000; Hawley, Ward, Magnay & Long, 2002; 2004; Levin et al., 2004; Mathias et al, 2004; McCauley & Levin, 2004; McKinlay et al., 2002; Massagli et al., 2004).

Massagli et al. (2004) investigated incidence of psychiatric illness in children following mTBI in a large prospective cohort study of computerised records from the Group Health Cooperative of Puget Sound region of Washington State, United States of America. The health organisation served approximately 450,000 community members and was representative of the region's population. Psychiatric illness was identified using ICD-9-CM codes in the computerised records. The diagnoses that were included in the study were: acute reaction to stress or adjustment reaction; alcohol or drug intoxication, withdrawal or dependence; anxiety; depression; hyperkinetic syndrome of childhood;

malaise or fatigue; organic psychotic mental disorders; organic non-psychotic mental disorders; schizophrenia, hallucinations, or paranoia; somatoform disorders; and other psychiatric disorders. They found that children with no recent psychiatric history were significantly more likely to experience a psychiatric illness after experiencing a mTBI. Of the range of disorders they studied, hyperactivity was the most prevalent problem reported following mTBI. The participants were not directly assessed in the study so the results could be explained by the possibility that the children who appeared to develop a psychiatric illness after suffering a mTBI may have always had the problems and they were only detected as a result of the child presenting for medical attention for the TBI. This would mean the computer records would only show the existence of a psychiatric illness after the TBI, despite it always being there. However, it is not just studies of computerised records that have reported a difference in children's behaviour after mTBI.

Hawley et al. (2002; 2004) conducted a study of children admitted to North Staffordshire Hospital Trust in the United Kingdom. Questionnaires were sent to parents of all children who had been admitted with a TBI in the 6 years prior to the study. More than 50% of children injured in the time frame of the study participated in the follow-up yielding 525 participants; 419 of which were mildly, 57 moderately and 49 severely injured. The questionnaires were designed based on problems commonly identified by adults following TBI and from the literature on childhood TBI. It aimed to investigate whether other injuries were suffered at the time of the TBI, what information and follow-up care they received, social service input, return to school issues, changes in the child, employment post-injury and effects on the family. They found that following a mild TBI 20% of parents reported changes in personality, 19% reported problems keeping up with schoolwork, 24% reported poor concentration and 35% reported they were more argumentative with siblings. This large study systematically demonstrated that many parents believe that their child had changed even 6 years after only a mild TBI. The ability to draw causal inferences from this study is limited by its lack of baseline measurement and an appropriate control group such as a non-injured group of children from the cohort whose parents completed the same questionnaire. Given that this study only began following up children many months or years after the injury a baseline

measurement of pre-injury behaviour would have been impossible. It is possible that parents recollection of the child's pre-injury behaviour and changes since were distorted given the amount of time since the injury or biased by other factors associated with an injury such as trauma. Despite these shortcomings, this is one of the few attempts to conceptualise which negative outcome may be associated with mild TBI in children and given the large sample size the findings should be considered as an important contribution to our understanding of this issue.

Catale et al. (2009) assessed a group of children (aged 6 to 12 years), recruited from a Belgium health care service 12 months following a mTBI. The difficulty of recruitment in clinical research is highlighted in this study; of the 106 potential children identified only 15 participated in the study after strict exclusion criteria were applied and a number of participants declined involvement. Participants were assessed 1 year post-injury using cognitive measures and parent rating scales. Parents were asked to complete the 48-item Connors Parents Rating Scale (CPRS-R) twice; once in relation to their child's behaviour before the mTBI and once regarding the child's behaviour over the 12 months since the mTBI. This approach is somewhat limited in that parent's memory of their child's behaviour over 12 months ago may be distorted. However, this method still allowed a comparison of pre and post injury behaviour. The results were converted to z-scores by comparing them to normative data and the z-scores were compared before and after the mTBI. It was reported that the children's behaviour before the mTBI was in the normal range on all factors of the CPRS-R. However, post-injury there was a significant increase on the impulsive hyperactive index with no difference on the other indices (conduct problems, learning problems, psychosomatic and anxiety). On cognitive testing differences were also detected in comparison to a closely matched control group 12 months post injury. Differences were seen in high level attention abilities, particularly selective attention. The presence of changes in specific aspects of behaviour and cognition suggests that while more global changes in functioning following a mTBI are unlikely, changes in specific aspects of behaviour and cognition may occur. Further, this study suggests that these occur even when controlling for pre-existing problems (Catale et al., 2009).

McKinlay et al. (2002) conducted a large prospective cohort study in the Christchurch region of New Zealand. Data were available on a cohort of 1265 children in the region who were born in a 4 month period in 1977. Annual interviews were conducted with the parents in which details of head injuries were investigated. Strict and objective inclusion criteria for mTBI were used to separate children who had, and had not, suffered a TBI between the ages of 0 and 10 years. The mTBI group was also divided into inpatient and outpatient groups which was considered to reflect the severity of the mTBI. Pre and post-injury data was collected through the course of the study from a wide range of sources including parental interview, teacher report, testing and medical records. They found that children who suffered a mild TBI that required a brief hospitalisation experienced significantly more behavioural and psychosocial deficits including hyperactivity and attention problems as well as conduct disordered behaviour than those in the same cohort who had not suffered any injury to the brain or those who had suffered a mild TBI that had not required any hospitalisation. These findings were still present when statistically controlling for confounding variables such as socio-economic status of the family. This is an extremely robust study as it has access to an appropriate control in the other children in the cohort and to unbiased pre-injury data from the routine yearly interviews and testing. As well as highlighting which aspects of children's behaviour may be expected to change following a mTBI, this study demonstrates an important difference between severity of mTBI. The fact that differences were seen in children who had been admitted to hospital and those who had not suggests an important issue. That is, a mTBI in childhood may have lasting and serious consequences, however, if the TBI is not severe enough to have at least some, albeit minimal, impact on brain structures then it may not have lasting effects. These potentially negligible incidents should not be included as a TBI, or should be considered separately for the purpose of this type of research. Determining whether a TBI has had any impact on brain structures in this field is extremely difficult as brain imaging rarely will detect any changes even if they had occurred. The method used in this studied to separate out those who met the criteria for mTBI into those were or were not admitted to hospital seemed to be effective in this instance.

Ponsford et al. (1999) undertook a prospective study of Australian children between the ages of 6 and 15 years who suffered a mild Traumatic Brain Injury. One hundred and thirty children who suffered a mTBI were compared with 96 children in a control group who had suffered minor injuries to areas of the body other than the head. Severity of injury was assessed on the children's admission to hospital. They were deemed eligible for inclusion in the study if they suffered a TBI with less than 30 minutes loss of consciousness, a Glasgow Coma Score of 13-15 when presenting to the hospital or a PTA period of less than 24 hours. Children were excluded if they displayed focal neurological signs or required a general anaesthetic. Children who were found to have pre-existing problems including previous head injuries, learning difficulties or psychological or neurological problems were not excluded from the study. Overall the mTBI group had a higher percentage of previous head injury, neurological or psychological problems and learning difficulties than the control group. However, the differences were not significant. Behavioural measures used were the Child Behaviour Checklist (CBCL), Rowe Behaviour Rating Inventory (ROWE BRI), Vineland Adaptive Behavior Scales (VABS) and the Postconcussion Syndrome Checklist (PCSC). Approximately half of the mTBI and control groups were assessed 1 week following their injury using the CBCL and the ROWE BRI to determine pre-injury behaviour and the PCSC to determine injury related symptoms 1 week post-injury. These measures were repeated as well as the VABS administered to all participants 3 months post-injury. No group differences were found between the mTBI and control group on the CBCL and ROWE BRI at baseline or 3 months post injury. At 3 months post-injury no differences were detected between groups of the VABS. At 1 week post-injury the mTBI group reported significantly more headaches, dizziness and fatigue than did the control group on the PCSC. At 3 months post injury there was no significant difference between the control and mTBI group on the PCSC. However, at 3 months post-injury 17% of the children in the mTBI group were identified as having significant problems based on having a high rating on the PCSC, ROWE BRI, CBCL or concern from the parent or researcher. In comparison, only 1% of the control group exhibited problems based on the same criteria. An analysis was run to determine how the subgroup of children with problems differed from the children who

did not have problems 3 months post-injury. It was found that the subgroup of children with problems had significantly higher scores on the PCSC, CBCL and the ROWE BRI at 3 months post-injury than the mTBI children without problems. These groups did not differ on their performance on neuropsychological tests, injury severity (as measured by duration of PTA) or gender. However, the groups did differ on a number of measures of pre-morbid functioning. The problem group had significantly higher incidence of previous TBI, pre-morbid stressors, learning difficulties and neurological or psychological problems. Of these factors, history of a previous TBI and pre-morbid stressors discriminated best between the two groups.

These findings corroborate two themes in the research on mTBI in children. Firstly, as a group, children who experience a mTBI tend to have more pre-existing problems than children who have not experienced a mTBI. Second, there seems to be a subgroup of children who continue to display behavioural problems well after the typical post-concussion symptoms would be expected to have resolved. Ponsford et al. (1999) did not report whether there had been changes in the behaviour of the children who continued to display problems from the baseline measurement to the 3 month follow up. Presumably this is because baseline data were not collected for all the children in mTBI group. It is still unclear in the literature whether the children who display problem behaviour following a mTBI in fact displayed the behaviour pre-morbidly and it was simply detected due to their involvement in the study, or whether these children's behaviour has actually changed following their mTBI. However, it is interesting that these findings parallel those in the adult literature; a proportion of children appear to display ongoing problems, the nature of which is not yet well understood (Ruff, 2005).

A strength of this study was the inclusion of a well matched control group of children who had suffered an injury to their body other than their head. By including such a group they were able to control for changes in the children's behaviour that may be related to the trauma of experiencing an injury. A comprehensive evaluation of the control groups behaviour and affect was conducted using standardised rating measures and the parents' report 3 months post-injury. Using these techniques, less than 1% of the group were

identified as having any "post acute" problems. This finding suggest that higher proportions of ongoing problems in children who have suffered a mTBI are not simply due to problems that are common in otherwise healthy children, or due to trauma associated with an injury. What is still not clear in the literature is why children who suffer a mTBI are more likely to have pre-existing problems and what the contribution of these pre-existing problems are to the children's ongoing problems. Further, it is also still unclear whether some children do, in fact, experience changes in their behaviour or affect following a TBI, and if they do, the nature of that change.

In general the research suggests that not all children who experience a mTBI will experience ongoing symptoms, however, it seems that some children may experience behavioural and affective changes. For appropriate care to be given to these children it is important to gain an understanding of the incidence, duration and nature of such deficits and in which children they occur. It is still yet to be understood what the mechanisms behind the changes are and what leads one child to be affected in the long term and not another.

1.4.5. Interrelationship Between Cognitive and Behavioural/Affective Changes Following TBI

As demonstrated in the research described above, studies on the effect of TBI generally regard cognitive and behavioural/affective changes as separate entities. It is possible that changes in one aspect of an individual (ie. their behaviour/affect) may occur in the absence of changes in another aspect (ie. their cognitive functioning; Ponsford et al., 1999). For the purposes of research this is a logical distinction to make: behaviour is generally measured through self or others' ratings of observed or perceived behaviour/affect, whereas cognition is generally measured through objective tests which are thought to reflect particular aspects of brain functioning. However, it is important to consider the interrelationship between these aspects of an individual's presentation. In research on individuals who are suffering affective disturbances such as depression, but have not experienced a TBI, changes in cognition including mental flexibility, scanning and verbal fluency, have been report (Veiel, 1997). Further, some symptoms associated

with affective disturbance can also be interpreted as reflecting cognitive dysfunction. For example, poor attention can be considered to be associated with symptoms of depression or as a cognitive impairment (Veiel, 1997). Conversely, impairments in cognition can have a marked impact on an individual's behavioural presentation. Individuals who meet the criteria for Attention Deficit Hyperactive Disorder have impairment on both neuropsychological testing and behavioural observations (Seidman, 2006). Thus, while cognition and behaviour/affect are studied as separate entities it is important to consider their interrelationship as it is possible that changes in both can occur as a product of physical brain changes, such as those that may occur in a TBI. Symptoms associated with a TBI such as feeling slowed down or having poor concentration could be considered as disturbances in cognition or in behaviour/affect. Even if the underlying cause is shown not to be physical but rather a psychological reaction to trauma following a TBI, changes in both behaviour and cognition are possible. Catale et al. (2009) found that following a mTBI children had disturbances in their selective attention on cognitive testing and an increase in impulsive/hyperactive behaviour on behavioural rating measures. It is reasonable to conceptualise that changes in a child's ability to selectively focus their attention and ignore distracter information could have a marked impact on their behaviour. With impairment in that specific aspect of cognitive functioning conceivably causing an impulsive and hyperactive behavioural presentations. This study highlights the important point that cognitive changes can have a direct impact on behavioural and emotional functioning. While the relationship between cognitive and behavioural/affective changes following TBI is complex to understand and study it is important that it be considered to avoid being overly simplistic in conceptualising the findings in this field of research.

1.4.6. Effect of Age at Time of Injury on Cognition and Affect

Understanding the effect of TBI on a child is in some regards more complicated than adults as children are undergoing a process of rapid development. In children, not only could the TBI result in a loss of skills, as it could in adults, but it could have an impact on the child's ability to develop new skills that would otherwise have developed normally into adulthood. Historically it has been thought that children are more resistant to the

impact of brain trauma than adults as the potential for further development gives their brain the plasticity to overcome insults (Aram & Ekelman, 1986). However, these assertions have been based on specific cortical lesions and were not investigated in regard to TBI. More current research on TBI suggests that in fact the earlier the age of injury the worse the long term outcome (McKinlay et al., 2002; Taylor & Alden, 1997). It is thought that a TBI may result in a decreased ability for a child to learn new skills and acquire knowledge and as a result change the trajectory of their development so as time passes they fall further behind their peers (Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2005). Anderson et al. (2005) found that children who suffered a moderate to severe TBI displayed poorer cognitive functioning up to 30 months post injury if the TBI occurred before the age of 7 years. This result was not found in the children who suffered a mTBI, however, this may be due to a lack of sensitivity of the measures that were used to try to detect changes in this type of injury rather than the lack of changes at all. Executive functions, or higher-order cognition, such as planning, organization, inhibition, set-shifting and regulation are thought to be relatively late to develop. The immaturity of these cognitive functions in children may make them particularly vulnerable to insult. Anderson et al. (2001) reported that clinical observation suggests that suffering a TBI may affect these skills. Poor executive functioning may have an impact on a child's ability to learn and interact with their environment as well as on their behaviour. Consistent with this assertion is the finding by McKinlay et al. (2002) who reported that children who suffered a mild to moderate TBI were more likely to display psychosocial deficits if the injury occurred before the age of 5 years. Research to date has not been able to sufficiently explain the impact that the age of injury may have on the development of these skills and behaviours, however, the evidence suggests that injuries at an earlier age have a worse prognosis than those that occur in older children. Given the complexities of affective functioning, early changes in affective development may actually result in marked long term difficulties.

1.4.7. Relationship Between Socioeconomic Status and Outcomes Following TBI

Research on mTBI in childhood has not consistently investigated socioeconomic status, and where it has been documented, variable approaches have been taken to operationalising it (Hawley et al., 2004; McKinlay et al., 2002; Ponsford et al., 1999). Socioeconomic status in children can be assessed on the basis of their parents' level of education, occupation and income (Hauser, 1994). Socioeconomic status has been found to be related to outcomes following TBI in childhood. Kirkwood et al. (2000) found that children who lived in more disadvantaged homes displayed exacerbated symptoms of depression following moderate or severe TBI. Hawley et al. (2004) also reported a significant impact of socioeconomic status on general outcomes following TBI in children. It is possible that a TBI makes these children more vulnerable to the development of problems but that good support and facilities can be to some extent be protective. These studies highlight the importance of considering socioeconomic status in the groups that are included in this field of research.

1.4.8. Pre-Injury Characteristics

There is a body of literature suggesting that children with behavioural problems, particularly externalising disorders such as Attention Deficit Hyperactive Disorder (ADHD) and Oppositional Defiant Disorder are more likely to suffer accidental injury (Brehaut, Miller, Raina & McGrail, 2003; Lalloo, Sheiham & Nazroo, 2003; Rowe, Maughan & Goodman, 2004; Schwebel, Speltz, Jones & Bardina, 2002). Brehaut et al. (2003) conducted a population based study and found that children were at significantly higher risk of injury if they suffered a pre-morbid behavioural disorder. Children in the study were considered to have a pre-morbid behavioural disorder if they were prescribed methylphenidate, a medication commonly prescribed to children with ADHD. Common sequelae of ADHD are impulsive and hyperactive behaviour. These characteristics in a child could conceivably put them at higher risk of suffering an injury. Lalloo et al. (2003) also conducted a large study using a more detailed measure of behaviour, the Strengths and Difficulties Questionnaire (SDQ). Of all the scales, hyperactivity was most related to

the risk of both major and minor accidents, even after controlling for socio-economic, demographic and family variables.

Most mTBIs would be considered accidental injuries. Consistent with the aforementioned research, there is also suggestion that children who suffer this kind of specific accidental injury are more likely to have pre-existing behavioural or psychosocial problems than the general population (Goldstrohm & Arffa, 2005; Massagli et al., 2004; Olsson, Le Brocque, Kenardy, Anderson & Spence, 2008; Ponsford et al., 1999). Goldstrohm and Arffa (2005) found that preschool aged children who suffered a mild to moderate TBI had higher rates of pre-morbid behavioural difficulties, poorer academic development and lower pre-morbid cognitive functioning than a control group of children who had suffered no injury.

1.5. Post Traumatic Stress Disorder (PTSD) Following TBI

Another issue that needs to be considered when investigating outcomes following mTBI is that of Post Traumatic Stress Disorder (PTSD). Experiencing a TBI may be considered a traumatic event. PTSD involves being exposed to a traumatic event, persistent re-experiencing of the event, avoidant behaviour associated with the trauma and increased arousal (American Psychiatric Association, 2000). These symptoms need to be present for a period of greater than 1 month and need to cause significant distress or disruption to functioning. It has been argued that PTSD and TBI cannot co-occur because the loss of memories for an event associated with TBI makes persistent re-experiencing of the event impossible to meet the diagnosis of PTSD (Klein, Caspi & Gil, 2003). However, the symptoms of PTSD have been documented in many cases of individuals who have suffered a TBI. It has been argued that PTSD may be possible to develop in the absence of comprehensive memories of the event due to 'islands of memories' for the event, memories from before or after the event, implicit memories related to the traumatic event or memories constructed from what the individual had heard or seen about the incident (Kennedy, Jaffee, Leskin, Stokes, Leal & Fitzpatrick, 2007). Mather, Tate and Hannan (2003) demonstrated that mild PTSD symptoms occurred frequently up to 4 months after children were involved in a road traffic accident. However, when children

were separated on the basis of whether they had experienced a mTBI or not, no differences were seen in frequencies of PTSD. This finding suggests that children who experience a mTBI in a traumatic event such as a motor vehicle accident can develop PTSD, however, the PTSD seems to be related to the traumatic experience rather than the brain injury specifically. Goldstrohm and Arffa (2005) compared a group of children who had suffered no injury to those who had suffered injuries to parts of their body other than their brain. The children in the injury group had generally been involved in an incident such as a fall, rather than a motor vehicle accident. While no direct measure of PTSD was recorded, measures of anxiety and withdrawal in the child were taken and no differences were seen between the groups. It is possible that incidents such as falls would be less traumatic than a motor vehicle accident and as such symptoms of PTSD would be less likely in these groups. In general, distinguishing between PTSD and TBI as causative events for changes in affective functioning is quite problematic.

1.6. Methodological Aspects of Studies of Mild TBI in Children

The inconsistency of results in the research on mild TBI in children may be due to the varied methodological approaches used. The following are some of the issues that may have a significant impact on the results obtained in studies in this area.

1.6.1. Measurement of Severity of TBI

1.6.1.1. Measurement of Consciousness

Following TBI it is common that an individual experiences a period of loss of consciousness or at least a period of reduced consciousness. Severity of TBI can be measured by a number of methods. Duration of loss of consciousness, and Glasgow Coma Scale are two measures that have been frequently used to measure severity.

1.6.1.1.1. Loss of Consciousness

It has been well documented that an extended period of loss of consciousness is associated with a more severe injury and a poorer prognosis (Jennett, 2002). However, duration of loss of consciousness is often hard to measure as people do not remember and witnesses can be unreliable. Further, often an individual may display some signs of

consciousness, but be far from fully conscious. Once an individual reaches some level of consciousness their functioning is best described using scales such as the Glasgow Coma Scale and measurement of the duration of the loss of consciousness is no longer applicable.

1.6.1.1.2. Glasgow Coma Scale (GCS)

The GCS was first published by Teasdale and Jennett (1974) as a research tool to group individuals together who had similar severity of injuries and who were thus likely to have similar prognosis. The scale was designed to assess individuals who had suffered a brain injury at the severe end of the spectrum as they were coming out of a state of coma. It assesses very basic physiological responses that may still be present when someone is minimally conscious. The GCS describes in objective terms graded responses in three domains; eye opening, motor response and verbal response. Due to the simplicity and the objectiveness of the scale it is easy to use as an assessment protocol and a communication tool in hospitals and other medical settings. Thus, since its design it has been widely adopted in the medical field to assess injury severity. Due to the widespread adoption of the GCS it has also been used in many studies investigating TBI, including studies on mTBI. However, the utility of the scale in this group of individuals is questionable. The major concern with its use in this group is that it is possible to sustain a mild TBI involving either focal or diffuse cortical damage and gain a full score on the GCS. Thus, because the scale only assesses basic physiological responses it does not differentiate injuries that are at the milder end of the spectrum well (Jennett, 2002).

1.6.1.2. Measurement of Post Traumatic Amnesia (PTA)

Following a TBI individuals may or may not experience a loss of consciousness, or a period of impaired consciousness as measured by the GCS. It has also been widely observed that following a TBI, once an individual has regained consciousness, there is frequently a period that follows in which the individual is confused and disoriented. This period of disorientation was first described as Post Traumatic Amnesia by Symonds (1928). PTA is now conceptualized as the period of time following a TBI where the individual has regained consciousness but is unable to encode new memories. PTA is

thought to be a direct measure of the impact of the TBI on the individual's cognitive functioning. The longer the duration of PTA the more severe the injury is considered to be. It is possible to have a GCS of 15 (a perfect score) and still be in PTA, thus highlighting its sensitivity over the GCS (Ponsford, Facem, Willmott, Rothwell, Kelly, Nelms et al., 2004).

1.6.1.2.1. Galveston Orientation and Amnesia Test (GOAT)

Retrospective and subjective assessment of the duration of PTA is argued to be unreliable as individuals may have 'islands of memories' which may present as the individual being able to reliably encode information (Ponsford et al., 2004). Thus, the best measures of the duration of PTA are objective tests of the individual's ability to encode new information. In order to try systematically and objectively measure duration of PTA the Galveston Orientation and Amnesia Test was developed (Levin, O'Donnell & Grossman, 1979). The GOAT requires the individual to respond to a number of questions about their orientation to person, place and time and in regards to autobiographical information. The number of errors scored is compared to normative data to determine if the individual is in PTA. This measure adequately covers the individual's level of orientation. However, it does not directly test an individual's ability to encode new information. Rather, it ascertains what events the individual can recall since the injury. This method has a major drawback in that individuals may be able to recall small pieces of information, 'islands of memories', but not be able to reliably encode new information. Thus, someone may still be suffering from anterograde amnesia, but score high enough on the GOAT to be considered out of PTA.

1.6.1.2.2. Children's Orientation and Amnesia Test (COAT)

The GOAT was designed for use in the adult population; however, PTA also occurs in children following TBI. In an effort to systematically measure PTA in children the Children's Orientation and Amnesia Test (COAT) was developed (Ewing-Cobbs, Levin, Fletcher, Miner & Eisenberg, 1990). The COAT is similar to the GOAT but for use with

children; it contains questions that evaluate whether the child is orientated to person, place and time. In addition, it also incorporates some very brief measures of memory function; it asks the child to remember the examiner's name and digit span forwards is administered. As with the GOAT the number of errors are scored and compared to normative data to determine if the child is in PTA. While the COAT makes some efforts to formally assess memory function it is still quite limited in this regard.

1.6.1.2.3. Westmead PTA Scale

A scale that has been developed to assess PTA and which overcomes many of the weaknesses of the GOAT and the COAT is the Westmead PTA scale (Shores et al., 1986). The Westmead PTA scale comprises questions that determine whether the individual is oriented to person, place and time as well as memory tests in which the individual has to remember a series of pictures and the examiners name and face. Thus, the scale directly and objectively assesses orientation and memory to determine if an individual is still in PTA. The original administration of the scale is to administer it daily until the individual gains a full score for three days in a row indicating that they are out of PTA. This system of administration works well for severely injured individuals who are in hospital and PTA for days or weeks. However, for the more minor injuries this method is inappropriate as they often do not stay in hospital longer than a few hours and PTA can resolve within hours. Ponsford et al. (2004) administered the scale hourly to an adult population following a mild TBI in the emergency ward. The individual was considered no longer in PTA when they completed 3 successive errorless trials. This method was found to correlate highly with other measures of injury severity such as GCS and retrospective measures of PTA. The same method was applied successfully to children (aged 7 to 15 years) in a study of mild TBI (Ponsford et al., 1999).

1.6.2. Measures of Behavioural and Affective Outcome Following Mild TBI in Children

The measures used to determine functional outcomes after mild TBI also vary widely. This variation in measurement may account for some of the inconsistency in the results of studies of children with TBI. Scales such as the Vineland Adaptive Behaviour Scale

(VABS) and the Child Behaviour Checklist (CBCL) have been used frequently in this area of research. They have shown significant deficits in children with moderate to severe TBI but not those with mTBI (Anderson et al., 2001; Fletcher et al., 1990; Ong et al., 1998).

1.6.2.1. Vineland Adaptive Behaviour Scale (VABS)

Vineland Adaptive Behaviour Scales were designed to differentiate between normal and impaired individuals on a range of age appropriate measures of adaptive and social functioning (Sparrow, Balla & Cicchetti, 1984). It uses normative data to detect significant deviations from normal in adaptive functioning based on an individual's age. The VABS most common contemporary use is to aid in the diagnosis of Intellectual Disability. Children with an Intellectual Disability are functioning below the second percentile, and hence in the severely disabled range. Following a severe TBI an individual may have a reduction in everyday adaptive functioning that is in this range. However, this deviation in functioning is much more extreme than what would be expected following a mTBI. Thus changes that may occur in this group are less likely to be detected by such a scale.

1.6.2.2. Child Behaviour Checklist (CBCL)

The CBCL is another scale that has been commonly used in previous studies of children to measure outcomes following TBI (eg. Goldstrohm & Arffa, 2005; Ong et al., 1998). The CBCL was designed to measure behavioural problems in children (Achenbach, 1991). The parent/guardian or teacher rates various behaviours on a likert scale which yields overall measures of behaviour, social and emotional functioning of the child. The results are then compared to a large normative sample to detect significant deviations in behaviour. This scale is thus useful to detected marked deviations in a child's behaviour. Research has shown that following a moderate to severe TBI in children the CBCL can detect significant deficits (Anderson et al., 2001; Fletcher et al., 1990; Ong et al., 1998). However, the CBCL has also been criticised for not being sensitive enough to detect behavioural changes following mTBI (McKinlay et al., 2002). Given that the scale was not design to assess changes following TBI it is not surprising that it may not detect subtle, sub clinical changes that may be present following mTBI.

1.6.2.3. Glasgow Outcome Scale (GOS)

The GOS was designed specifically to measure outcomes of individuals following TBI (Jennett & Bond, 1975). The scale is very brief and divides outcomes into very broad categories, namely: dead, vegetative state, severe disability, moderate disability and good recovery. This scale has been reported to be useful in determining outcomes following severe TBI, however, it lacks detail or explanatory value when it comes to differentiating subtle deficits that may persist following mTBI. Further, this scale was designed for use in the adult population and has limited utility with children (Hawley et al., 2004).

1.6.2.4. King's Outcome Scale for Childhood Head Injuries

The King's Outcome Scale for Childhood Head Injuries (KOSCHI) was based on the GOS but specifically revised to measure changes that may occur to children following TBI (Crouchman, Rossiter, Colaco, & Forsyth, 2001). Like the GOS the scale is quick and simple to administer. The scale uses the same groupings as the GOS however, it expands the categories 'severe disability', 'moderate disability' and 'good recovery' into 2 further categories each so as to make the scale more sensitive to minor symptoms that may persist. This scale has been used successfully to detect changes in children following mild TBI (Hawley et al., 2004). However, while the scale may be able to detect changes at the mild end of the spectrum it does little to describe or further classify these changes. That is, children with any minor residual problems with learning and/or behaviour all get grouped into one category and no attempt is made to further explore the symptoms.

1.6.2.5. Connors Parent Rating Scale - Revised

The 48-item version of the Conners Parents Rating Scale (CPRS-R) has also been used to detected changes based on parent report 1 year following a mTBI (Catale et al., 2009). Parents rate 48 symptoms which form 5 indexes: conduct problems, learning problems, psychosomatic, impulsive hyperactive and anxiety (Conners, 1997). When comparing pre- and post- injury ratings the impulsive hyperactive index was significantly higher 1 year following the mTBI (Catale et al., 2009).

1.6.2.6. Other Methods Used to Detected Change Following Mild TBI

McKinlay et al. (2002) used a combined version of the Rutter and Connors maternal report questionnaire asking questions relating to attention, hyperactivity and conduct disordered behaviour to measure psychosocial outcomes. Alternatively, indicators of psychiatric illness such as using a psychiatric service, being diagnosed with a psychiatric illness or filling a prescription for psychiatric medication have been successfully used to identify changes after mild TBI (Massagli et al., 2004).

1.6.2.7. Behavioural Assessment System for Children 2nd Ed. (BASC2)

The Behavioural Assessment System for Children 2nd Ed. (BASC2) is a scale which has good psychometric properties (Reynolds & Kamphaus, 2004). The BASC2 and its predecessor the BASC have been widely used in clinical and research child psychology (Beg, Casey & Saunders, 2007; Doyle, Ostrander, Skare, Crosby & August, 1997; Flanagan, 1995; Gladman & Lancaster, 2003; Graziano, Reavis, Keane & Calkins, 2007; Jarratt, Riccio & Siekierski, 2005; McGlamery, Ball, Henly &, Besozzi, 2007; Ostrander, Weinfurt, Yarnold & August, 1998; Sandoval & Echandia, 1994; Steele, Richards, Benson, Corbin & Cushing, 2008).

The BASC scales assess children's behaviour in the same manner as the Vineland Adaptive Behaviour Scales (VABS) and the Child Behaviour Check List (CBCL) by the parent or guardian of the child completing a range of questions that may be indicative of pathology. The BASC2 Parent Rating Scale correlates well with other behavioural measures including the Child Behaviour Checklist (Achenbach & Rescorla, 2001). Moderate to high correlations were found between the BASC2 and the Conners' Parents Rating Scale, Revised (Conners, 1997). Moderate to High correlations were also found between the BASC2 and the Behaviour Rating Inventory of Executive Functioning (Gioia, Isquith, Guy & Kenworthy, 2000). The BASC2 correlates highly with the original Behavioural Assessment System for Children Parent Rating Form (Reynolds & Kamphaus, 2004). As previously mentioned, the VABS and the CBCL have been

designed to detected significant deviations from normal in children's behaviour. It is possible that for this reason they may be less sensitive at detecting more minor deviations that may be seen following only a mTBI (McKinlay et al., 2002). The BASC2 may be more sensitive to changes following mTBI as it measures a wider range of both positive and negative behaviours that the child may exhibit. The BASC2 includes measures of activities of daily living, adaptability, atypicality, functional communication, leadership, social skills, and withdrawal, as well as measures of more severe behavioural concerns such as aggression, anxiety, attention problems, conduct problems, depression, hyperactivity and somatisation.

The BASC and BASC2 have been used to investigate, emotional functioning, behavioural problems, attention, executive functioning, theory of mind, repressive adaptive style and academic success. The scale has been used to successfully discriminate between clinical and non clinical groups as well as to provide behavioural profiles for a range of problems seen in children (Beg et al., 2007; Doyle et al., 1997; Flanagan, 1995; Gladman & Lancaster, 2003; Graziano et al., 2007; Jarratt et al., 2005; McGlamery et al., 2007; Ostrander et al., 1998; Sandoval & Echandia, 1994; Steele et al., 2008). Despite the large amount of research using this scale a comprehensive literature review did not reveal any studies using the BASC or BASC2 to measures outcomes following mTBI. Although this scale was not designed specifically to measure outcomes following TBI it evaluates many aspects of behaviour that have previously reported to be affected by TBI. For example, the scale includes measures of hyperactivity and attention problems both which have been reported to be adversely affected following mTBI (McKinlay et al., 2002). Because of the potential for this measure to be more sensitive to minor changes the use of the BASC2 to determine the effect of mild TBI in children it is worth some inquiry.

1.6.2.8. Qualitative Parent Report

As previously discussed the problem with many outcome measures used in TBI research is that they often have not been designed for detecting changes in this population. The reason changes are not detected may be that the measures are not sensitive enough rather than the changes are not present at all. A complementary

approach to the above predetermined scales is unstructured parent report which can be achieved by asking parents to describe any changes they have noticed. Parents generally have the most contact with their child and as a result are often in the best position to notice changes following such an injury. A limitation of this approach is that parents' opinions can be distorted from the trauma of the event. It is possible that parents may under report changes due to processes of denial and the desire to believe that the injury has not impacted on their child. Alternatively, parents may over-report symptoms due to their reaction from the trauma of the event, or from a desire to attribute concerning behaviour to a tangible cause when it may have actually predated the injury. Despite the potential pitfalls of this approach it has some advantages in a purely exploratory nature. If many parents are reporting similar changes and those changes are not elicited by formal questionnaires then this method of examination may be able to inform future research and development of questionnaires so as they may be more sensitive to the changes following TBI. Ponsford et al. (1999) used parental report as a method of detecting ongoing problematic behaviour in children following a mTBI. However, further details on what the parents actually reported and how that correlated with standardised measures of behaviour were not discussed.

1.6.3. Follow-up Period

The duration of follow-up in studies of mTBI in children varies significantly from as short as 3 months to up to 6 years post injury (Hawley et al., 2004; Ponsford et al., 1999). The number of times children are assessed following the injury also varies across studies with some only having one assessment and others assessing the children up to five times (Hawley et al., 2004; Levin et al., 2004). There is such variability in the results from the studies that it is hard to determine whether there are any changes over time. Of the studies that found significant changes following mild TBI the results appeared to be fairly steady over time. Massagli et al. (2004) reported psychiatric illness occurring up to 3 years after mild TBI. The highest incidence was reported in the first year post injury; however, the results were still significant in the second and third year. Hawley et al. (2004) followed participants for up to 6 years following the injury. The results found that the same level of symptoms were reported in individuals who were followed up within 1

year of the injury as those who were followed-up up to 6 years post injury. These findings suggest that if changes are present in the first year after the injury then they may continue to affect the individual for extended periods of time. However, if symptoms are not present in the first year then they are unlikely to develop or become worse after that period.

1.6.4. Baseline Measures

A further confounding variable that needs to be considered in these studies is the finding that children with pre-existing behavioural or psychosocial problems may actually be more likely to experience a TBI than those with no pre-existing problems (Goldstrohm & Arffa, 2005; Massagli et al., 2004; Ponsford et al., 1999). This is possibly because children with difficulties such as attention or behavioural problems are more likely than children without these difficulties to behave in a manner that may lead to a head injury (Goldstrohm & Arffa, 2005). For example, children with Attention Deficit Hyperactive Disorder displaying impulsive behaviour would find it more difficult to consider the consequences of climbing a tree than an individual without impulse control problems and as such is at a greater risk of falling from the tree and potentially sustaining a TBI. If the presence of pre-existing behavioural problems is not considered then the results from a study on TBI may simply reflect pre-injury difference in the children when compared to a control group. Ideally to control for these factors individuals would be assessed prior to experiencing the TBI. However, this would obviously be impossible without assessing a whole cohort and then waiting for those who sustain an injury. The most commonly used and practical method is to gain parental estimations of pre-injury behaviour. This method can also be flawed in that if the measure is administered a significant period of time after the injury then the parent's memory of the child may not reflect an accurate picture. Thus, the best method given practical constraints is to gain a parental report of pre-injury functioning at the time of the injury while the memory of how their child was functioning before the injury is salient in their mind. This measure can then be used to statistically control for pre-injury functioning and individual changes that may occur after the injury.

1.6.5. Control Groups

It is important in this area of research to have an appropriate control group in order to determine that the changes experienced after a TBI are due to the head injury and not to other factors such as age, development, socio-economic status and practice effects of testing. Two types of matched control groups have been used in previous research; a 'non-injured' control group or an 'other injury' control group. The non-injury control is usually a group matched for age, socioeconomic status and pre injury functioning. Individuals with pre-existing behavioural problems are usually excluded from these groups (Anderson et al., 2001). The other injury control groups have been used by some researchers to account for the effect of the trauma involved in having any kind of injury (Goldstrohm & Arffa, 2005). Goldstrohm and Arffa (2005) compared children with mild to moderate TBI with a 'non-injured' control group and to a 'other injury' control group. No differences in the children's behaviour were found between these three groups. This finding suggests that at a group level the trauma of experiencing a minor injury does not have a marked impact on a child's behaviour. Thus, a non-injured control group is likely to be just as appropriate as an other-injury control group in this type of research. A further advantage of using a non-injured control group is that parents compare their child to how they were before they had the injury. Thus, research that focuses on how children who experienced a TBI compare to similar children who did not experience a TBI is going to give a more accurate estimation of the child's capacity to return to their functioning before the injury. Ponsford et al. (1999) conducted a large study on Australian children between the ages of 6 and 15 years who sustained a mTBI. They used a matched control group who had experienced a minor injury to part of their body other than their head and did not exclude children with pre-existing problems as it was felt this is reflective of the population who are more likely to suffer a TBI. A thorough assessment of the control group 3 months-post injury using a number of measures of cognitive functioning, standardised behavioural rating scales, parents' report and researchers' observations found that less than 1% of the group displayed any ongoing problems. On tests where practice effects are expected it is important to have a control group to determine if a clinical group has not improved as much as the control group over time. However, on measures of behaviour where practice effects are not applicable the findings

from Ponsford et al. (1999) suggest that any changes significantly beyond 1% of the group is suggestive of problems beyond what would be expected in the absence of a TBI.

Another method of comparing children with a TBI to healthy controls is using tests with appropriate normative data. Normative data can give a sound and reliable measure of how a healthy child of a similar age should be performing on a certain task or scale. One advantage of using normative data over a matched control group is that generally the size of the groups is much larger than what is able to be practically collected in a matched control group. Comparisons with this group can also be used to determine if a child's behaviour is different from what would be expected given their age, if they had not experienced a TBI.

1.6.6. Exclusion Criteria

In order to best understand the impact that a TBI has on an individual it is important to study a group that has limited confounding variables and compare them to a group that is similar in every important way other than the presence of the TBI. Studies in the area have excluded children who have suffered a previous head injury, neurological disorder, developmental disability, or who have a history of psychiatric illness such as attention deficit hyperactive disorder prior to the injury (Anderson & Pentland, 1998; Massagli et al., 2004). Given the findings that children who suffer a mTBI are more likely to have pre-existing problems, by excluding those children you are actually changing the characteristics of the group that you would normally expected to experience such an injury. Some researchers have chosen to include children who have pre-existing problems (Ponsford et al., 1999). The other consideration for exclusion criteria is if the child experiences complications at the time of the injury such as requiring surgery in which a general anaesthesia is administered. This type of intervention may compound the effects of the mTBI and thus researchers may chose to exclude cases who have these complications (Ponsford et al., 1999). Regardless of the exclusion criteria it is important that they are applied to both the clinical and control group.

1.6.7. Limitations of Clinical Research on Mild TBI

It is evident in the foregoing discussion of issues that research into mTBI is complicated by its clinical nature. Research in the area relies on TBIs spontaneously occurring in the community and then trying to control as best possible for the multitude of other factors that could influence an individual's outcome. Satz et al. (1997) conducted a review of the literature on mTBI in children and discussed a number of design issues that need to be considered in this area of research. It was considered important to follow the children up for a reasonable period of time following the injury to understand any resolving or evolving problems. Including a control group or some form of comparison is also important to try to separate out the effect of the TBI from other changes that occur normally in childhood. As is evident from the discussion above, the definition of what constitutes a mTBI is not universally agreed and thus, it is important to clearly define what is considered a mTBI so the results can be understood in the context of how 'severe' the mTBI is. Given the impact that pre-injury factors can have on post-injury functioning it is also important to consider and control for these factors in some way. Satz et al. (1997) also discussed the need for a sample size which is large enough to create enough power to detect more subtle changes, when they do occur. Finally, the need for standardised assessment was also considered to be important. In order for knowledge in the field to progress it is important that studies and methods are replicable for both clinical and research purposes.

1.7. Present Study

1.7.1. Rationale

The literature on both adults and children who sustain moderate-severe TBIs consistently suggests that they will show changes in cognition, affect and behaviour. Studies of adults who have sustained a mTBI suggest that at least a proportion continue to display affective or behavioural problems beyond the acute period. However, there is still debate over whether the underlying mechanism for change is a psychological reaction to the trauma, actual physical changes to the brain, or a combination of both. Despite early suggestions that children who sustain mTBIs will make a full recovery, more recent prospective studies suggest that children may suffer adverse consequences in

the behavioural and affective domain. In particular five major studies have reported some form of change in children's behavioural and affective functioning following a mTBI (Catale et al., 2009; Hawley et al., 2002; Massagli et al., 2004; McKinlay et al., 2002; Ponsford et al., 1999). As with the adult literature these studies suggest that at least a proportion of children display behavioural and affective changes well beyond the acute period. However, the nature of these changes, which children they occur in, and the underlying mechanisms of change are still unclear. Widely varied methodological approaches have been previously adopted in this area of clinical research. The results from these studies have also been highly variable and thus, there is a lack of consensus in the literature as to the effects of mTBI on behaviour and affect in children.

1.7.2. Aim

The present study aims to further document the impact of mTBI in children. The study aims to determine if in a well defined group of children, using specific measures of injury severity and pre- and post-injury functioning, changes in behaviour and affect occur. Further if changes are found, the study aims to characterise the nature of these changes. These general aims will be explored through the following specific aims:

Aim 1: Changes in Behaviour or Affect following mTBI

The first aim of the study was to determine whether changes in behaviour or affect occurred following a mTBI in children on the BASC2 measures and a qualitative question. If changes were detected over time, the nature of the changes in behaviour and affect were characterised by examining the group BASC2 profile and the content of the qualitative responses across time.

Aim 2: Subgroup of Children with Behavioural or Affective Problems following mTBI

The second aim of the present study was to determine whether there was a subgroup of children who displayed behavioural or affective problems at 3 months post injury. If a

sub-group exists, the present study aimed to determine whether that group of children differed from the remainder of the sample on any of the following characteristics:

a. Presence of pre-existing problems
b. Pre-injury BASC2
c. Length of PTA
d. Loss of consciousness
e. Socio-economic status
f. Overall cognitive functioning

Chapter 2: Method

2.1. Participants

The total sample comprised 27 children between the ages of 6 and 12 years (Mean age: 10.03 years, Standard Deviation: 2.17 years). The participants were recruited from The Northern Hospital (Melbourne, Victoria, Australia) after suffering a mild Traumatic Brain Injury (mTBI) based on a Post Traumatic Amnesia (PTA) duration of less than 24 hours as measured by the Westmead PTA scale (Marosszeky, Ryan, Shores, Batchelor & Marosszeky, 1998). Twenty of the 27 participants were males.

All children who suffered a mTBI were referred by the treating clinician (mainly by consultant medical practitioners) in the Emergency Department at the Northern Hospital except for one participant from a general practitioner from a general medical centre in the Northern metropolitan region of Melbourne. Inclusion criteria for the study were based initially on the child presenting with history and evidence of a TBI, a Glasgow Coma Scale (GCS) score of 13 – 15 and other signs of a non-trivial head injury including some of the following: headaches, dizziness, nausea and sensitivity to light or noise. This was assessed by medical staff at the Northern Hospital. The child was also only included in this study if the parent was able to converse in English. To further verify the severity of the injury PTA was measured at the time of the first interview which was within 24 hours of the injury where possible; a PTA duration of less than 24 hours was classified as a mTBI. Nine children suffered a brief loss of consciousness at the time of the injury, however, loss of consciousness was not a requirement for inclusion in the participant group. Table 1 shows the causes of the TBIs and the frequency of each of these.

Table 1

Cause of Injury

Cause	n	%
Falls	13	48.1
Sports Injury	11	40.7
Cycling accident	2	7.4
Other	1	3.7

2.2. Assessment Instruments

The assessment instruments used fell into four broad categories; (a) standardised measures of injury severity; (b) standardised measures of overall cognitive functioning (intelligence); (c) parent rating measures of behavioural and emotional functioning; and (d) measures of demographic and background information.

2.2.1. Standardised Measures of Injury Severity

2.2.1.1. Glasgow Coma Scale (GCS)

The Glasgow Coma Scale (GCS) was administered by the medical practitioners to participants on their admission to the Northern Hospital (Teasdale & Jennett, 1974). This scale is a reliable and objective measure of level of consciousness. The scale comprises 15 items that measure gross physiological changes such as the ability to respond verbally, to open eyes and to respond with motor movements. The individual is given a score based on their best response in the domains of eye, verbal and motor response as seen in Table 2. The total score can range between 3-15; a score of 13-15 is generally considered to indicate a mild, 9-12 moderate and 3-8 severe TBI (Jennett, 2002).

Table 2
Glasgow Coma Scale

Best eye response (E)	1. No eye opening 2. Eye opening in response to pain 3. Eye opening to speech 4. Eyes open spontaneously
Best verbal response (V)	1. No verbal response 2. Incomprehensible sounds 3. Inappropriate words 4. Confused 5. Oriented
Best motor response (M)	1. No motor response 2. Extension to pain 3. Abnormal flexion to pain 4. Flexion/Withdrawal to pain 5. Localises pain 6. Obeys commands

2.2.1.2. Westmead PTA Scale

PTA duration was assessed using the Westmead Post Traumatic Amnesia (PTA) Scale (Marosszeky et al., 1998). The Westmead PTA Scale comprises of 12 questions. Seven questions relate to whether the individual is oriented to person, place and time. The remaining questions require the individual to recall or recognise the examiners name and face and three pictures of common objects that they had been shown at an early time. See Table 3 for the Westmead PTA scale questions. A person is considered to be out of PTA when they can reliable answer all questions correctly. Standard administration of the Westmead PTA scale is to administer the test daily until the individual reaches a perfect score for 3 consecutive days. While this method is appropriate for more severe injuries when the individual is often in PTA and in hospital for an extended period of time, it is impractical for mild to moderate injuries when the individual is discharged after a short period of time (Marosszeky et al., 1998). For this reason a modified version of the test was utilized. The patient was attempted to be assessed within 24 hours of the injury. The test was administered every hour until the participant obtained a perfect score on one trial indicating that they were no longer in PTA. The same method has been adopted by other researchers except they required a perfect score on two follow up trials (Ponsford et al.,

1999; Ponsford et al., 2004). Participants were included in the study if they had a PTA period of less than 24 hours (ie. Obtained a perfect score on the westmead PTA scale within 24 hours of their injury) indicating that they sustained a mild TBI. A very small number of children were unable to be assessed within the 24 hours following the injury. In these cases careful discussion with the referring consultant physician and the parents were conducted to ensure as best as possible that the child suffered only a mild TBI.

Table 3
Westmead Post Traumatic Amnesia Scale (Marosszeky et al., 1998)

1. How old are you?
2. What is your date of birth?
3. What month are we in?
4. What time of day is it, morning, afternoon or night?
5. What day of the week is it?
6. What year are we in?
7. What is the name of this place?
8. Do you remember my face?
9. What is my name?
10. Can you remember what the first picture I showed you was?
11. Can you remember what the second picture I showed you was?
12. Can you remember what the third picture I showed you was?

2.2.2. Overall Cognitive Function (Intelligence)

2.2.2.1. Wechsler Abbreviated Scale of Intelligence (WASI)

All participants' overall cognitive functioning was assessed using the two subtest form of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). This measure was chosen to provide a quick estimate of the child's Full Scale Intelligence Quotient (FSIQ) to screen for the presence of overall cognitive (intellectual) difficulties. The two-subtest form of the WASI uses the Vocabulary and Matrix Reasoning subtests and was administered in the standardised manner as described by Wechsler (1999). The average split-half reliability coefficient for the two-subtest FSIQ for children (aged between 6 and 16 years) on the WASI is 0.93 (Wechsler, 1999). Stability coefficient for the two-subtest FSIQ for children was reported to be .85. Correlation between the WISC-III and the two-subtest WASI FSIQ was .81 (Wechsler, 1999). The WASI does not provide as comprehensive an assessment of overall cognitive functioning as measures

such as the WISC-IV. However, it does provide an estimate of overall cognitive functioning which still has strong psychometric properties and is appropriate for screening purposes in research (Strauss, Sherman & Spreen, 2006). FSIQ scores (mean = 100, standard deviation = 15) were calculated and used in the analyses.

2.2.3. Behavioural and Affective Functioning

2.2.3.1. Behaviour Assessment System for Children Second Edition (BASC2) – Parent Form

The Behaviour Assessment System for Children, Second Edition (BASC2) Parent Rating Scale was chosen as a wide ranging measure of the children's behaviour and affect (Reynolds & Kamphaus, 2004). The questionnaire comprises statements about different aspects of behaviour and affect and takes approximately 20 minutes to complete. The parent/guardian completes the form and rates whether the child displays the behaviour "Never", "Sometimes", Often" or "Almost Always" based on the child's recent behaviour. Each item is scored as 0, 1, 2, 3; these scores are then added to form 14 primary scales. The primary scales formed are: hyperactivity, aggression, conduct problems, anxiety, depression, somatisation, atypicality, withdrawal, attention problems, adaptability, social skills, leadership, activities of daily living and functional communication. In addition to the indices the test also has 22 critical items for which a score above zero should be noted. The primary scales also combine to form four composite scales: "Externalising Problems", "Internalising Problems", "Adaptive Skills" and "Behavioral Symptom Index". Table 4 shows the primary scales that are combined to form each of the composite scales.

Table 4

Configuration of BASC2 Composite Scales

Composite Scale	Primary Scale
Externalising Problems Composite	Hyperactivity
	Aggression
	Conduct Problems
Internalising Problems Composite	Anxiety
	Depression
	Somatisation
Behavioural Symptoms Index	Hyperactivity
	Aggression
	Depression
	Atypicality
	Withdrawal
	Attention Problems
Adaptive Skills Composite	Adaptability
	Social Skills
	Leadership
	Activities of Daily Living
	Functional Communication

Internal consistency of the BASC2, as measured by Coefficient Alpha, ranges from .90 to .95 for the combined norms on the composite scales. Internal consistency for the primary scales ranges from .73 to .88. Test-Retest reliability is also found to be generally high being higher than .90 for all the composite scales except for "Internalising Problems" which is .77. The primary scales generally have test-retest reliability between .80 and .89, except for "Anxiety" and "Somatisation" which are .65 and .66 respectively. The BASC2 also incorporates a scale to ensure the form is completed in a valid manner. The F Index measures the rater's tendency to respond in an overly negative manner and to give a falsely negative view of the child. Validity for the scale was obtained though

analysing scale intercorrelations and factor analysis assessing the structure of the composite and scale scores (Reynolds & Kamphaus, 2004).

In the current study children were aged between 6 and 12 years at intake into the study. The BASC2 has slightly different parent rating forms for children aged 6-11 and 12-21 years. The two forms have identical composite and index scores. The only difference is in some of the individual questions that contribute to the overall summary scores. The differences in questions reflect changes in behaviour that are expected with age (see Appendix A).

Children's scores on each of the indices were compared to normative data to give a T-score as documented in Reynolds and Kamphaus (2004). T-scores have a mean of 50 and a standard deviation of 10. In the current study the combined gender normative data was used. The normative data is broken into age groups: 6-7 years, 8-11 years and 12-14 years. The correct age normative data was used for each participant. On the primary scales of "Hyperactivity", "Aggression", "Conduct Problems", "Anxiety", "Depression", "Somatisation", "Atypicality", "Withdrawal", "Attention Problems" and the composite scale "Externalising Problems", "Internalising Problems" and "Behavioural Symptom Index" a higher T-score signifies poorer behavioural functioning. On the primary scales of "Adaptability", "Social Skills", "Leadership", "Activities of Daily Living", "Functional Communication" and the composite scale "Adaptive Skills Composite" a higher score indicates better behavioural functioning.

The standardised administration in Reynolds and Kamphaus (2004) directs the parents to "mark the response that describes how the child has behaved recently (in the last several months)". In the current study the BASC2 was administered in the standardised manner at the baseline, 3-month and 12-month follow-up assessments. However, for the 1-week assessment the parent was asked to rate the child's behaviour over the one week immediately after the TBI. While this is not standard administration of the test it still allowed for assessment of the child's behaviour over that time period. The

1-week follow up test was scored in the standard manner and using the normative data reported in Reynolds and Kamphaus (2004).

2.2.3.2. Qualitative Question

To supplement the standardised assessment an exploratory open ended question about changes in the child's behaviour following the TBI was administered to the participants' parents. This question was included to try detect any subtle changes that may have been noticed by the parent but not detected on the standardised questionnaire. The open ended question was asked before administration of the BASC2 so the items on the BASC2 did not influence the parent's thoughts about the child's behaviour. The open ended question asked was "Since the head injury, in your opinion, has your child's behaviour or mood changed? If so, could you please describe the change(s) you have noticed"? The open ended question was qualitatively scored with a content analysis approach (Krippendorff, 2004). At the completion of the data collection all responses were reviewed and categorised by themes of behaviour or mood change. More than two similar responses across all assessments were required to form a theme. Accordingly these themes were: Fatigue, Withdrawn, Physical Pain (including headaches), Oppositional/Defiant, and Other Changes. The category of Fatigue included responses such as "fatigue" and "tiredness", the category of Withdrawn included responses such as "withdrawn", "quieter" and "not as talkative or physically active". Physical Pain predominantly included reports of "headaches" but also included "sore neck and back". Oppositional/Defiant category included responses such as "answering back" and having a "don't care attitude". Finally, the Other Changes category included all the responses that were more unique and did not fit into a theme across responses. The Other Changes category included responses such as "got mixed up doing morning routine", "staring into space", "dizzy spell", "slight fever", "easily upset" and "loss of appetite".

2.2.4. Measures of Demographic and Background Information

2.2.4.1. Semi-Structured Interview

A semi-structured interview devised by the researchers was administered to the parents. The interview included collection of basic demographic information including

age, school grade and parent's occupation. Developmental information was also obtained including the age at which the child began walking independently and speaking using two word combinations. Parents were also asked about the presence of any pre-existing behavioural or medical conditions including whether the child was taking any medication. A copy of the interview is shown in Appendix B.

2.2.4.2. Australian Socioeconomic Index 2006 (AUSEI06)

Socio-economic status (SES) was measured using the AUSEI06 based on the most recent Australian census data (the 2006 census; McMillan, Beavis & Jones, 2009). This scale uses data from the Australian Bureau of Statistics to determine SES based on an individual's occupation. The scale was devised by analysis of many factors that are thought to reflect SES including income, education and number of hours worked. These are analysed for the different occupational classifications giving each occupation a score between zero and 100 with a higher score indicating higher SES. For example, a general medical practitioner scores 91.9, an accountant scores 57.9 and a truck driver scores 11.8. In the present study the occupation of both the parents were documented with the highest score used to determine the SES of the family. The parent's current occupation was used except for parents who were not working and at home performing domestic duties. In these cases, if their previous profession scored higher on the scale than performing domestic duties, then the score from their previous profession was used.

2.3. Procedure

2.3.1. Referral to Study

The mTBI group was recruited via purposive sampling, whereby parents were informed of their child's eligibility for participation in the study by emergency department clinicians at the Northern Hospital or the general medical centre. Parents were informed about the project only after their child had been medically assessed as not needing active medical treatment or having any major complications. In the event that a parent was still clearly distressed the hospital staff members did not approach the parents with information about the project. If the parent or guardian agreed to receive further information about the study their details were forwarded to the researcher who contacted

the parents by phone. At this point their suitability for the study in terms of age and existence of a recent injury was confirmed and an initial appointment to discuss the details of the study was arranged. It was conveyed to parents in the initial phone conversation that their participation in the study was entirely voluntary and that they were free to withdraw from the study at any time.

All assessment sessions were conducted at the child's home except for one participant who was assessed at the Victoria University Psychology Clinic. When assessment sessions were conducted at home all reasonable efforts were made to ensure that the environment was quiet and distraction free. Each session's duration was 1 hour, approximately. It was the decision of the family which parent would complete the questionnaires at each assessment. Where possible the same parent was used to complete the follow-up questionnaires to ensure consistency across reports. Following the completion of each child's data collection all parents were given the option of receiving verbal feedback on their child's performance on the assessment tasks. This was followed by a written report at the completion of the study.

2.3.2. Twenty Four Hour Assessment

The first assessment occurred within approximately one day of the injury. Prior to the commencement of the assessment the parent or guardian was given detailed information on the study in the form of a written Plain Language Statement (PLS) outlining what the study involved (see Appendix C). A brief statement about the project in developmentally appropriate language was given to or read out to the child (see Appendix D). Any questions or concerns that the child or parent had were addressed at this point. Written consent was then gained from the parent or guardian as well as verbal assent from the child (see Appendix E). Once consent was gained the Westmead PTA scale was administered to the participant and the baseline measure of the BASC2 was administered to the parent or guardian. A semi-structured interview was also completed in which measures of SES and background information, including pre-existing difficulties, were obtained (see Appendix B).

2.3.3. One Week Assessment

A 1 week assessment occurred approximately 7 days after the injury. During this session the BASC2 was re-administered to the parents with regards to the child's behaviour and affect over the past week. An open ended question was also given with regards to the child's behaviour and affect over the previous week. The qualitative question was administered before BASC2 so the parent's response to the question was not biased by the questions in the BASC2. At this time point the child was administered the WASI to obtain an estimate of their FSIQ score.

2.3.4. Three Month Assessment

At the 3-month assessment the BASC2 and the open ended question were re-administered to the parent with regard to the child's behaviour and affect over the previous 3 months. Again the qualitative question was administered prior to the BASC2.

2.3.5. Twelve Month Assessment

A sub group of the original sample were assessed at approximately 12-months post injury. The BASC2 and the open ended question were re-administered to the parent with regard to the child's behaviour and affect over the previous 12 months. Again the qualitative question was administered prior to the BASC2.

2.3.6. Assessment Schedule

Baseline (Within 24 hours of head injury)

- Child:
    - Westmead Post Traumatic Amnesia Scale
- Parent:
    - Semi-Structured Interview
    - BASC2

1 Week

- Child:
    - Short form of Wechsler's Abbreviated Scale of Intelligence (WASI)

- Parent:
    - Open ended question on behavioural and affective change.
    - BASC2

3 Month

- Parent:
    - Open ended question on behavioural and affective change.
    - BASC2

12 Month

- Parent:
    - Open ended question on behavioural and affective change.
    - BASC2

2.3.7. Ethics Approval and Research Collaboration

The study was granted ethics approval by the Victoria University Human Research Ethics Committee and the Northern Hospital Human Research Ethics Committee (see Appendix F).

The data in the current study were collected in collaboration with a complementary study of the effect of mTBI on cognition. This study was being undertaken by Joanne Yacoub Doctor of Psychology (Clinical Neuropsychology) candidate at Victoria University) and titled "Higher Order Cognition in Children after Mild Traumatic Brain Injury". At the 1 week, 3 month and 12 month follow up assessments a neuropsychological assessment battery was conducted with the children as part of that study. The data were collected by both researchers; the author and Joanne Yacoub. All the data on behaviour and affect gathered in the study are reported in this thesis only. The exception to this was the baseline BASC 2 data which were utilised for screening pre-existing problems and are reported in the thesis by Joanne Yacoub. The Full Scale Intelligence Quotient scores for all children are reported in this thesis, as well as the thesis prepared by Joanne Yacoub.

Chapter 3: Results

3.1. Data Analysis

Descriptive, parametric and non-parametric analyses were used to examine the data where appropriate. Each of these approaches are detailed below when they are utilised. The data were analysed using Statistical Package for the Social Science – Windows Version 17.0.

Given the large number of dependent variables in the current research multiple tests were conducted. It is recognised that this leads to an increase risk of type 1 errors and calls for a more conservative error rate to be set. The Bonferroni adjustment can be made to rectify this problem. However, given the number of comparisons this would result in an extremely conservative error rate which would increase the risk of making type 2 errors (Field, 2009). Because of the relationship between type 1 and type 2 errors the type 1 error rate (alpha) was set at $p<.01$. This is a conservative error rate that still allows for the detection of difference where one exists. In addition to reporting p values the magnitude of any significant effect will be reported through the effect size. Given the nature of this study the analyses are intended for heuristic purposes, not to answer definitive hypotheses about change following mTBI.

3.2. Sample Characteristics

3.2.1. Whole Sample

A total of 27 children participated in the study. One child was not included in the group data analysis as it became known during data collection that she had a pre-existing diagnosis of Neurofibromatosis Type 1. This condition is known to potentially involve brain lesions. The interaction between this pre-existing brain pathology and the physical impact of a TBI is unknown and thus, this case was not included in the group analysis. The characteristics of the remaining sample ($n = 26$) are included in Table 5.

Table 5

Whole Sample Characteristics (n=26)

Characteristic		Range
Age at Injury [years; M(SD)]	10.0 (2.2)	6.5-12.9
Grade at School (Median)	4	Preparatory-7
Full Scale Intelligence Quotient [M(SD)]	89.2 (11.9)	69-112
Male:Female (n)	20:6	

3.2.2. Subgroups

The whole sample included children who had pre-existing problems and children who seemed to be developing normally. For some analyses these groups were considered separately. These groups are described below with their characteristics presented in Table 6. The groups are referred to as the no pre-existing problems (NPEP) group and the pre-existing problems (PEP) group.

Table 6

Subgroup Characteristics

	NPEP	PEP
Age at Injury [years; M(SD)]	9.8(2.2)	10.6(2.3)
Grade at School (Median)	4	5
Full Scale Intelligence Quotient [M(SD)]	91.8(11.6)	82.0(10.4)
Male:Female (%)	74% : 26%	86% : 14%
Socio-Economic Status Rating [M(SD)]	47.6(24.2)	50.9(19.5)

3.2.2.1. Pre-Existing Problems Subgroup (PEP Group)

Participants were considered to have a pre-existing problem is they were reported by their parents to have a significant medical, developmental, psychological or psychiatric problem or any other significant illness or injury that may affect the functioning of the central nervous system. Participants were also considered to have a pre-existing problem if there was evidence of overall cognitive difficulties (measured by a Full Scale

Intelligence Quotient of less than 70 on the Wechsler Abbreviated Scale of Intelligence (WASI)). In addition, participants were considered to have a pre-existing problem if there was evidence of clinically significant pre-injury behavioural or affective problems (Measured by T-scores of 70 or more on the Externalising Problems Composite, Internalising Problems Composite or the Behavioural Symptoms Index on the Behaviour Assessment System for Children, 2nd Edition (BASC2)).

Based on these criteria, 8 of the total sample of 27 (29.6%) participants were considered to have a pre-existing problem. Table 7 outlines the types of pre-existing problems and the frequency of each of these.

Table 7

Pre-existing Problems

Problem	Number of participants
Significant medical or psychological problem	3
FSIQ < 70	1
BASC2 problem composite score > 69	4

As described above, the participant with Neurofibromatosis was excluded from the group data analysis. The remaining 7 participants with pre-existing problems were considered separately for some analyses. This group was called the Pre-Existing Problems (PEP) Group.

3.2.2.2. No Pre-Existing Problems Subgroup (NPEP Group)

The remaining 19 participants were considered to be developing normally prior to the mTBI. This subgroup was also considered separately for some analyses and was called the No Pre-Existing Problems (NPEP) Group.

3.2.3. Follow-up Assessment Participation

Of the participants included in the group analyses, 26 completed the baseline assessment. This assessment was completed within approximately 24 hours of the child

sustaining a mTBI for the majority of children. However, a small proportion of participants were assessed much longer than 24 hours after the injury resulting in a significantly positively skewed distribution. Thus, the Median of 26.5 hours (Range = 18.5-167.5 hours) is more reflective of the general time after injury that participants were assessed. Twenty six participants also participated in the 1 week post-injury follow-up assessment (Median = 8 days, Range = 7-34 days). One participant did not complete the 3 month follow up as they were not contactable despite multiple attempts by the researcher. The Median duration after the mTBI of the 3 month follow-up was 3.4 months (Range 2.8-5.4 months). A subgroup of 12 participants also completed the 12 month follow-up. One of these participants was excluded from the data analysis because they had suffered a significant trauma between the 3 and 12 month follow up which may have affected their behavioural or affective functioning. Thus, 11 participants were included in the 12 month follow-up analyses. The reasons for not participating in the 12 month follow-up were: 50% elected not to participate, the vast majority of these were based on the parent's decision; 22% were unable to be contacted; and 28% were outside the cut off date for data collection. The Median duration after injury of the 12 month follow up was 12.3 months (Range = 10.0-14.5 months).

3.2.4. BASC2 Validity Scales

The BASC2 includes a validity scale, the F scale, which is designed to detect overly negative response patterns. The F scale was measured in each form completed with the results being that 100% of forms completed passed the F scale and were thus considered to be valid.

3.3. Aim 1: Changes in Behaviour or Affect Following mTBI

The first aim of the study was to determine whether changes in behaviour or affect were reported by parents over time from baseline to 12 months post injury. If changes were found, the study aimed to characterise these. This aim was examined using two approaches: 1) the BASC2 results were compared across baseline, 1 week and 3 month assessments; 2) at each of the follow up assessments parents were asked qualitatively

whether they had noticed any changes in their child's behaviour or affect since the mTBI. The data from each of these approaches will be reported separately below.

3.3.1. Changes in BASC2 Scores Over Time

3.3.1.1. Scoring the BASC2 Data

To analyse the BASC2 data, raw scores were compared to normative data outlined in the BASC2 manual (Reynolds & Kamphaus, 2004). Children were compared to the combined gender, general (non-clinical), age appropriate normative data yielding T-scores for each of the 14 index and 4 composite scales. On the BASC2 problem scales a T-Score below 60 is considered to be in the 'Normal' range. Between 60 and 69 is considered in the 'At Risk' range and 70 or greater is considered in the 'Clinically Significant' range. On the adaptive functioning scales a T-score above 40 is considered in the 'Normal' range, between 31 and 40 is in the 'At Risk' range and 30 or below is in the 'Clinically Significant' range. Each participant's result on the BASC2 was classified into these 3 categories, producing an ordinal scale. This approached allowed an examination of how many participants were in each of the categories. Because the BASC2 normative data is normally distributed you would expect that in a normal population the majority of children (approximately 84%) would be in the 'Normal' range, approximately 14% in the 'At Risk' range and approximately 2% in the 'Clinically Significant' range. It was felt that this was a more clinically meaningful way of analysing the data than by assessing group T-score means. If some children did score in the 'At Risk' of 'Clinically Significant' range, and these scores were grouped together with other children who scored in the normal range, the resulting mean score may be in the normal range, and the important data about the group who displayed significant problems would be lost.

3.3.1.2. Analysis of the BASC2 Data

Because of the ordinal nature of the data, non-parametric statistics were utilised to assess BASC2 scores over time. Repeated-measure analysis included Baseline, 1 Week and 3 Month assessments. The 12 Month assessment was not included in the repeated measure analysis due to the small number of participants in this group. Friedman's ANOVA was used as this test is appropriate for repeated measure analysis with 3

assessment times (baseline, 1 week and 3 month) and ordinal data. Given the small sample size the exact significance level was calculated. If a significant results was found across the 3 assessment times post-hoc analysis was conducted using the Wilcoxon signed-rank test. This test is similar to the Friedman's ANOVA except it only compares 2 conditions. Therefore, if a significant result was found on the Friedman's ANOVA test 3 subsequent Wilcoxon signed-rank tests were run. One Wilcoxon test compared baseline to 1 week, one compared baseline to 3 months, and one compared 1 week to 3 months.

First the BASC2 composite scales were analysed followed by the index scales. The analysis was run using the whole sample. As the whole sample included children with and without pre-existing problems these subgroups were compared to each other to determine whether there were any differences on each of the BASC2 composite and index scales. Where a significant difference was found between the NPEP and PEP group they were analyses separately to determine whether there were changes over time in the subgroup. The Mann-Whitney test was used to compare the subgroups to each other and Friedman's ANOVA and Wicoxon signed-rank test (as described above) were used for analysis over time.

One of the 26 participants in the whole sample did not complete the 3 month assessment and thus they were not included in the repeated measure analysis. Therefore, a total of 25 participants were included in the repeated measure analysis.

3.3.1.3. BASC2 Composite Scales Over Time

The BASC2 has 4 composite scales with each comprising a number of the individual index scales. The composite scales were examined first, before the index scales. Results from the Friedman's ANOVA (χ^2 statistic) over time for the BASC2 composite scales are shown in Table 8.

Table 8

BASC2 Composite Scales Across Baseline, 1 Week and 3 Months (Whole Sample, n=25)

Composite Scale	χ^2	*df*	*p* value
Behavioural Symptoms Index	4.0	2	.333
Externalising Problems Composite	7.5	2	.037
Internalising Problems Composite	0.4	2	1.00
Adaptive Skills Composite	2.8	2	.395

3.3.1.4. BASC2 Index Scales Over Time

Each of the Composite Scales is made up of a number of Index Scales. It is possible to have elevated scores on one of the Index scales but not on the Composite scale to which it contributes. Thus, the Index Scales were also analysed to determine whether any changes occurred over time. The BASC2 has 14 Index scales, the results from the Friedman's ANOVA for these scales are shown in Table 9.

Table 9

BASC2 Index Scales Across Baseline, 1 Week and 3 Months (Whole Sample, n=25)

Index Scale	Chi-Square	*df*	*p* value
Hyperactivity Index	8.82	2	.012
Aggression Index	1.37	2	.626
Conduct Problems Index	7.63	2	.025
Anxiety Index	1.14	2	.712
Depression Index	0.29	2	1.00
Somatisation Index	1.46	2	.506
Atypicality Index	8.40	2	.025
Withdrawn Index	3.00	2	.667
Attention Problems Index	0.29	2	1.00
Adaptability Index	1.33	2	.671
Social Skills Index	4.67	2	.222
Leadership Index	3.50	2	.333
Activities of Daily Living Index	6.00	2	.093
Functional Communication Index	2.33	2	.453

3.3.1.5. BASC2 Composite Scales Subgroup Analysis

No significant differences were found over time on any of the BASC2 composite or index scales for the whole sample. However the whole sample comprised both children with and without pre-existing problems. The PEP and NPEP subgroups were compared on each of the composite scores at each assessment time to determine whether there were any group differences.

The Mann-Whitney test was used as this non-parametric test compares two independent conditions where the data is ordinal. The results (including effect size) are presented in Table 10. The Mann-Whitney test statistic is denoted by the statistic U. Effect size for the Mann-Whitney analysis was calculated and denoted by letter *r* (Field, 2009, p. 550).

Table 10

BASC2 Composite Scale NPEP (n=19) and PEP (n=6) Group Comparison

Composite Scale	Assessment Time	U	*z*	*p* value	Effect Size (*r*)
Behavioural Symptoms Index	Baseline	9.5	-4.33	.001*	-.87
	1 Week	19.0	-3.79	.014	-.76
	3 Months	19.0	-3.79	.014	-.76
Externalising Problems Composite	Baseline	1.0	-4.52	.000*	-.90
	1 Week	9.5	-4.33	.001*	-.87
	3 Months	19.0	-3.79	.014	-.76
Internalising Problems Composite	Baseline	50.0	-.95	.687	-.19
	1 Week	41.0	-1.81	.333	-.36
	3 Months	38.0	-2.57	.243	-.51
Adaptive Skills Composite	Baseline	24.0	-3.02	.036	-.60
	1 Week	26.5	-2.48	.050	-.50
	3 Months	34.5	-2.07	.156	-.41

(* = significant at $p < .01$)

Significant differences were found at some assessment times on the Behavioural Symptoms Index and the Externalising Problems Composite scales. Therefore the subgroups (NPEP and PEP) were analysed separately for each of these scales to determine whether there were changes over time.

3.3.1.5.1. Behavioural Symptoms Index Subgroup Analysis

The NPEP and PEP groups Behavioural Symptom Index results over time are displayed in Figure 1. Results are displayed as the percentage of participants in each of the categories (Normal, At Risk and Clinically Significant) at each assessment time.

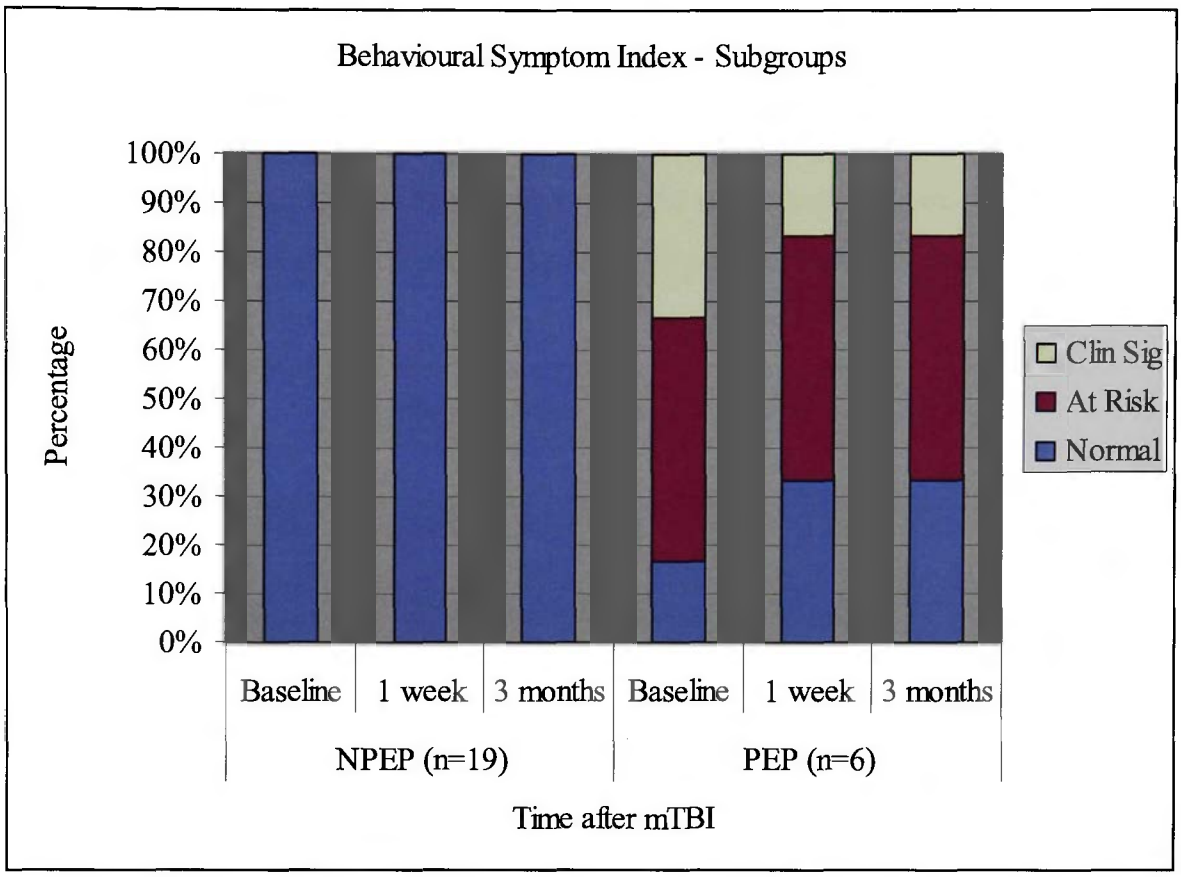

Figure 1. Behavioural Symptom Index - Subgroups

There was a significant difference between the groups at some assessment times on the Behavioural Symptoms Index. Each subgroup was analysed separately to determine whether there were any changes over time.

For the NPEP group all participants were in the Normal range at all assessment times and thus no changes occurred over time.

The PEP group was analysed using Friedman's ANOVA. No significant changes over time from baseline to 3 months post injury were found in this group on the Behavioural Symptoms Index, $\chi^2(2) = 4.0, p > .01$.

3.3.1.5.2. Externalising Problems Composite Subgroup Analysis

The NPEP and PEP groups' Externalising Problems Composite results over time are displayed in Figure 2. Results are displayed as the percentage of participants in each of the categories (Normal, At Risk and Clinically Significant) at each assessment time.

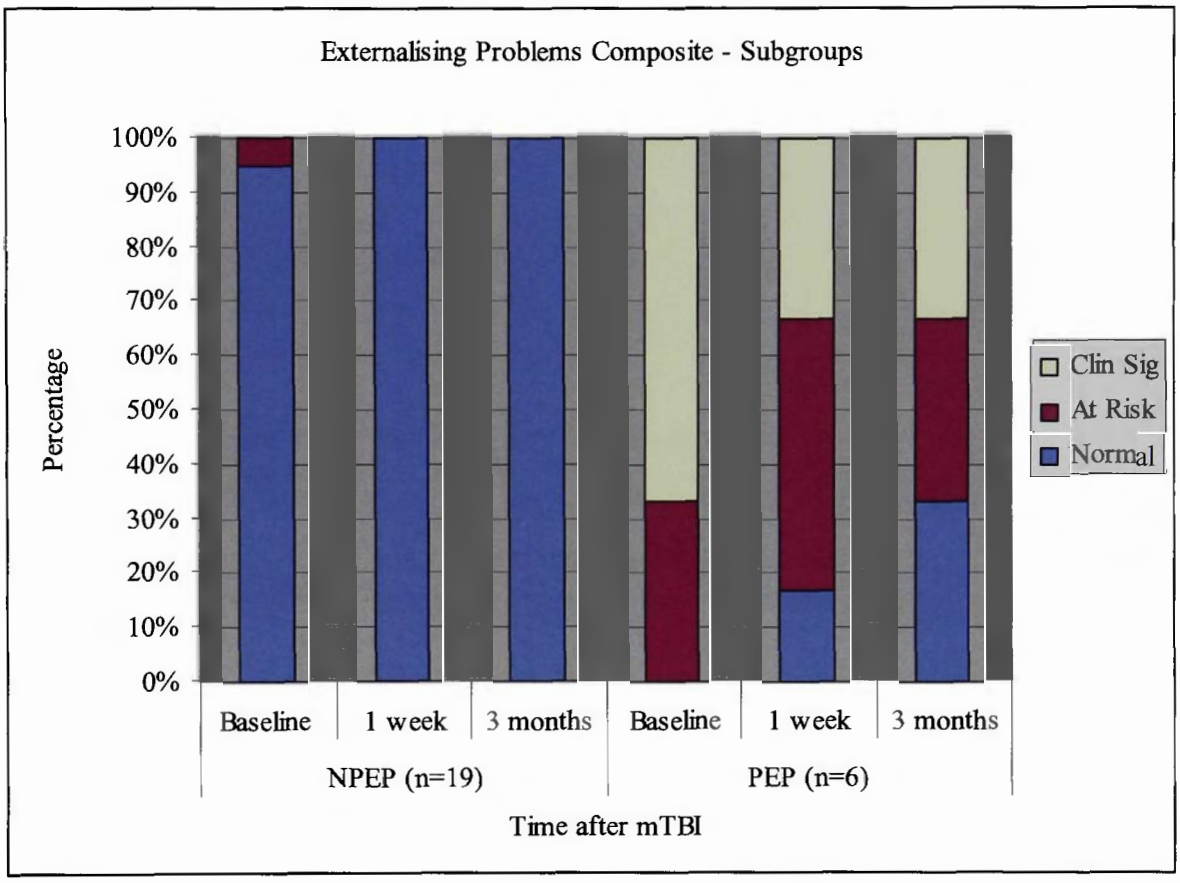

Figure 2. Externalising Problems Composite - Subgroups

There was a significant difference between the groups at some assessment times on the Externalising Problems Composite. Each subgroup was analysed separately to determine whether there were any changes over time.

The NPEP group Externalising Problems Composite did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 2.0, p > .01$.

The PEP group Externalising Problems Composite also did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 5.6, p > .01$.

3.3.1.6. BASC2 Index Scales Subgroup Analysis

As with the composite scales the BASC2 index scale subgroups were compared at each assessment time to determine whether there were any group differences.

The results of the Mann-Whitney test (including effect size) are presented in Table 11.

Table 11

BASC2 Index Scale NPEP (n=19) and PEP (n=6) Group Comparison

Index Scale	Assessment Time	U	*z*	*p* value	Effect Size (*r*)
Hyperactivity	Baseline	2.0	-3.99	.00*	-.80
	1 Week	12.5	-3.59	.00*	-.72
	3 Months	9.5	-4.33	.00*	-.87
Aggression	Baseline	9.5	-4.33	.00*	-.87
	1 Week	19.0	-3.79	.01	-.76
	3 Months	28.5	-3.21	.07	-.64
Conduct Problems	Baseline	1.5	-4.48	.00*	-.90
	1 Week	28.5	-3.21	.07	-.64
	3 Months	28.5	-3.21	.07	-.64
Anxiety	Baseline	44.0	-1.30	.44	-.26
	1 Week	44.0	-1.30	.44	-.26
	3 Months	38.0	-2.57	.25	-.51
Depression	Baseline	38.0	-2.57	.25	-.51
	1 Week	38.0	-2.57	.25	-.51
	3 Months	47.5	-1.78	.56	-.36

Table 11 Continued.

Index Scale	Assessment Time	U	*z*	*p* value	Effect Size (*r*)
Somatisation	Baseline	53.5	-0.40	.83	-.08
	1 Week	56.5	-0.05	.98	-.01
	3 Months	45.5	-1.05	.48	-.21
Atypicality	Baseline	36.5	-1.66	.20	-.33
	1 Week	38.0	-2.57	.25	-.51
	3 Months	40.5	-1.86	.30	-.37
Withdrawal	Baseline	50.5	-0.88	.69	-.18
	1 Week	53.5	-0.40	.83	-.08
	3 Months	54.0	-0.56	.88	-.11
Attention Problems	Baseline	24.0	-2.82	.04	-.56
	1 Week	34.5	-1.92	.16	-.38
	3 Months	24.0	-2.82	.04	-.56
Adaptability	Baseline	41.0	-1.81	.33	-.36
	1 Week	43.0	-1.40	.40	-.28
	3 Months	28.5	-3.22	.07	-.64
Social Skills	Baseline	39.0	-1.54	.27	-.31
	1 Week	43.5	-1.09	.40	-.22
	3 Months	48.0	-0.82	.60	-.16
Leadership	Baseline	54.0	-0.56	.88	-.11
	1 Week	44.0	-1.30	.44	-.26
	3 Months	54.0	-0.56	.88	-.11
Activities of Daily Living	Baseline	35.0	-2.01	.18	-.40
	1 Week	37.5	-1.51	.22	-.30
	3 Months	38.5	-1.50	.25	-.30
Functional Communication	Baseline	28	-2.37	.07	-.47
	1 Week	34.5	-2.07	.16	-.41
	3 Months	31.5	-2.55	.11	-.51

(* = significant at $p < .01$)

Significant differences were found at some assessment times on the Hyperactivity, Aggression and Conduct Problems Index scales. Therefore the subgroups (NPEP and PEP) were analysed separately for each of these scales to determine whether there were changes over time.

3.3.1.6.1. Hyperactivity Index Subgroup Analysis

The NPEP and PEP groups' Hyperactivity Index results over time are displayed in Figure 3. Results are displayed as the percentage of participants in each of the categories (Normal, At Risk and Clinically Significant) at each assessment time.

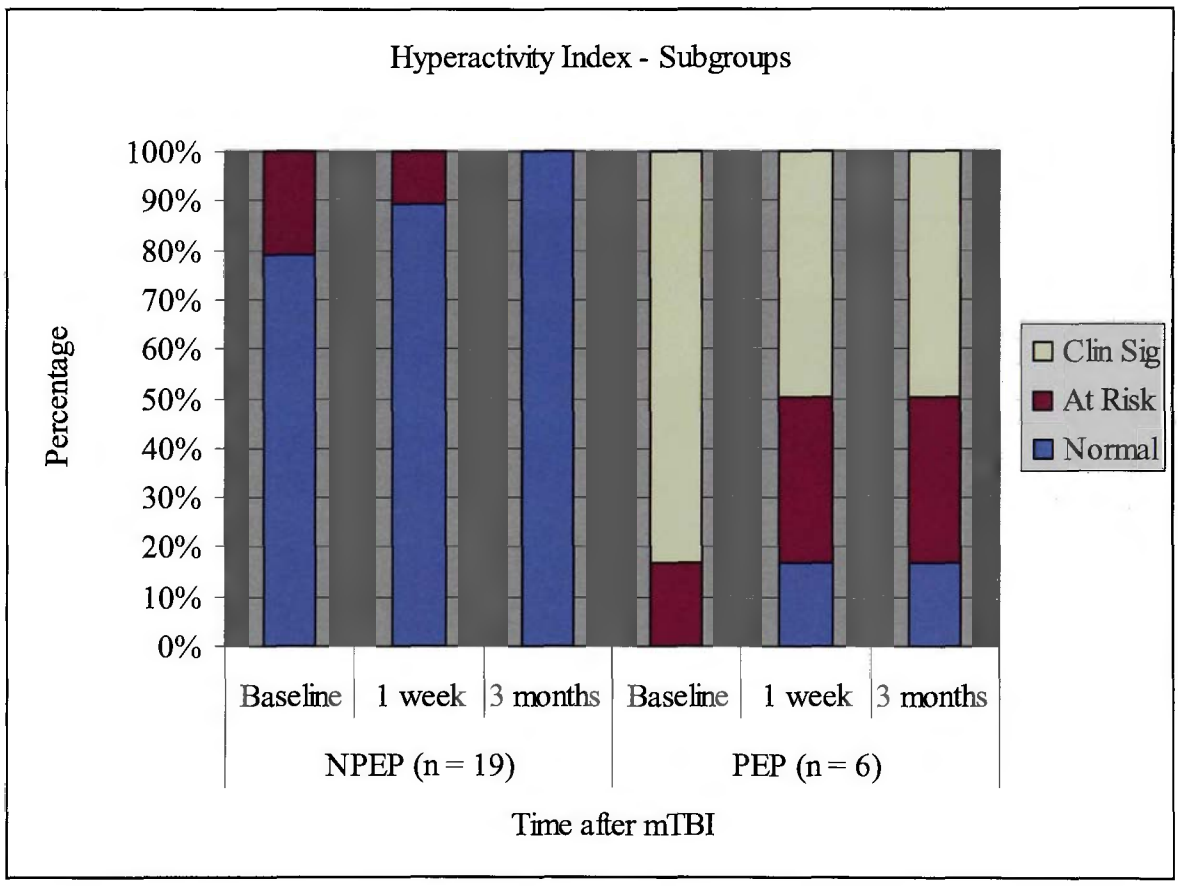

Figure 3. Hyperactivity Index - Subgroups

There was a significant difference between each of the groups at each time point on the Hyperactivity Index. Each subgroup was analysed separately to determine whether there were any changes over time using Friedman's ANOVA.

The NPEP group Hyperactivity Index did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 6.0, p > .01$.

The PEP group Hyperactivity Index also did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 3.8, p > .01$.

3.3.1.6.2. Aggression Index Subgroup Analysis

The NPEP and PEP groups' Aggression Index results over time are displayed in Figure 4. Results are displayed as the percentage of participants in each of the categories (Normal, At Risk and Clinically Significant) at each assessment time.

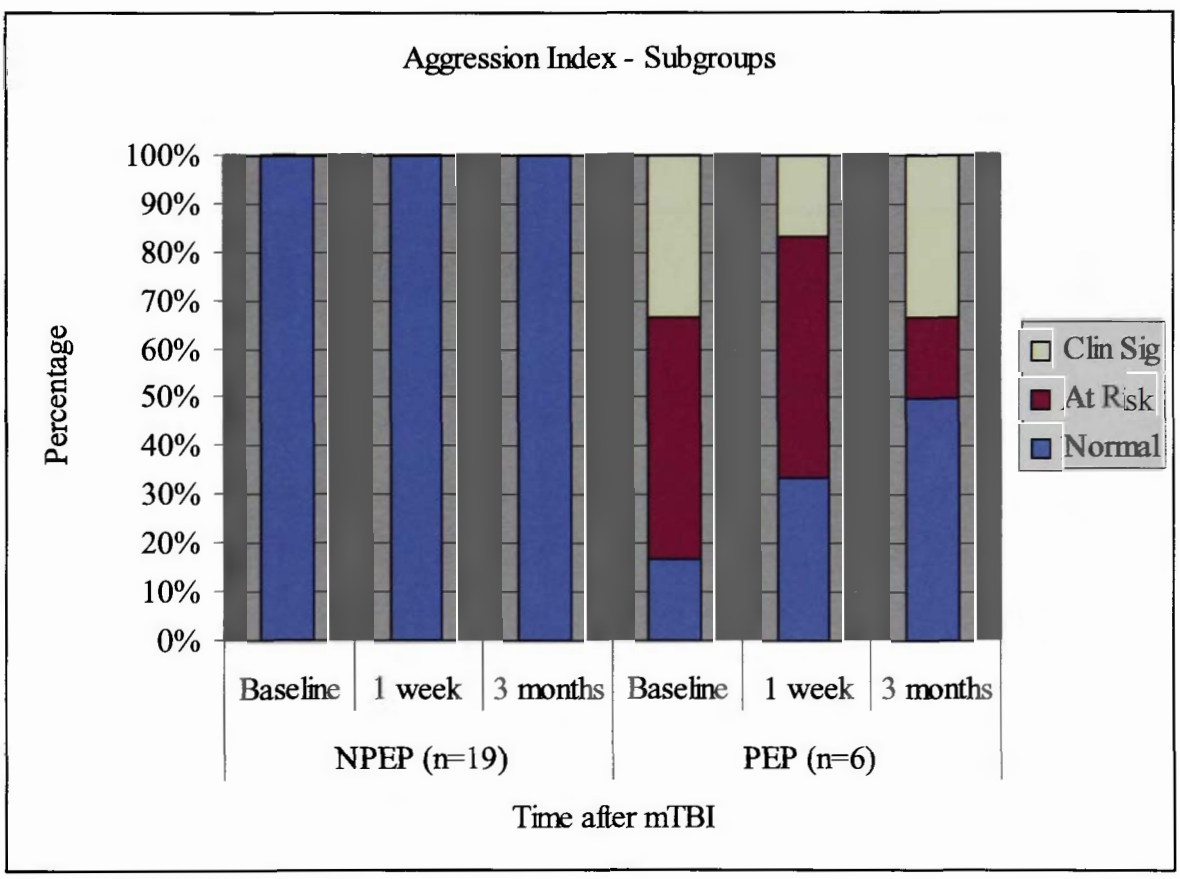

Figure 4. Aggression Index - Subgroups

There was a significant difference between the groups at one assessment times on the Aggression Index. Each subgroup was analysed separately to determine whether there were any changes over time using Friedman's ANOVA.

For the NPEP group all participants were in the Normal range at all assessment times and thus no changes occurred over time.

The PEP group Aggression Index also did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 1.4, p > .01$.

3.3.1.6.3. Conduct Problems Index Analysis

The NPEP and PEP groups' Conduct Problems Index results over time are displayed in Figure 5. Results are displayed as the percentage of participants in each of the categories (Normal, At Risk and Clinically Significant) at each assessment time.

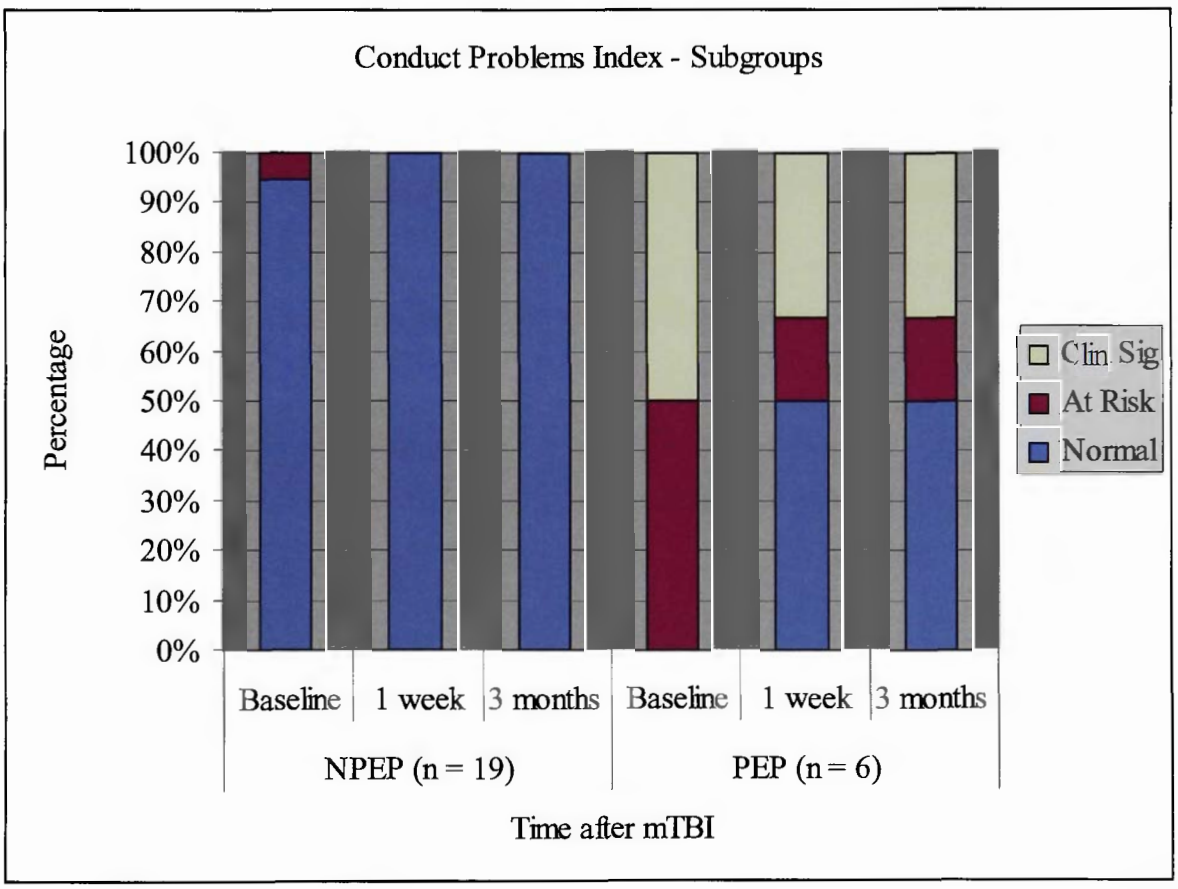

Figure 5. Conduct Problems Index - Subgroups

There was a significant difference between each of the groups at one time point on the Conduct Problems Index. Each subgroup was analysed separately to determine whether there were any changes over time using Friedman's ANOVA.

The NPEP group Conduct Problems Index did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 2.0, p > .01$.

The PEP group Conduct Problems Index also did not significantly change over time from baseline to 3 months post injury, $\chi^2(2) = 5.7, p > .01$.

3.3.2. Changes Reported on Qualitative Question Over Time

Parents were asked to describe whether they had noticed any changes in their child's behaviour or affect at the 1 week, 3 month and 12 month follow-up assessments. The percentage of parents who reported some changes at each of the assessments is shown in the figures below. Figure 6 shows the results for the 'Whole Sample' (ie. NPEP and PEP combined). Figure 7 shows the results for each of the subgroups separately.

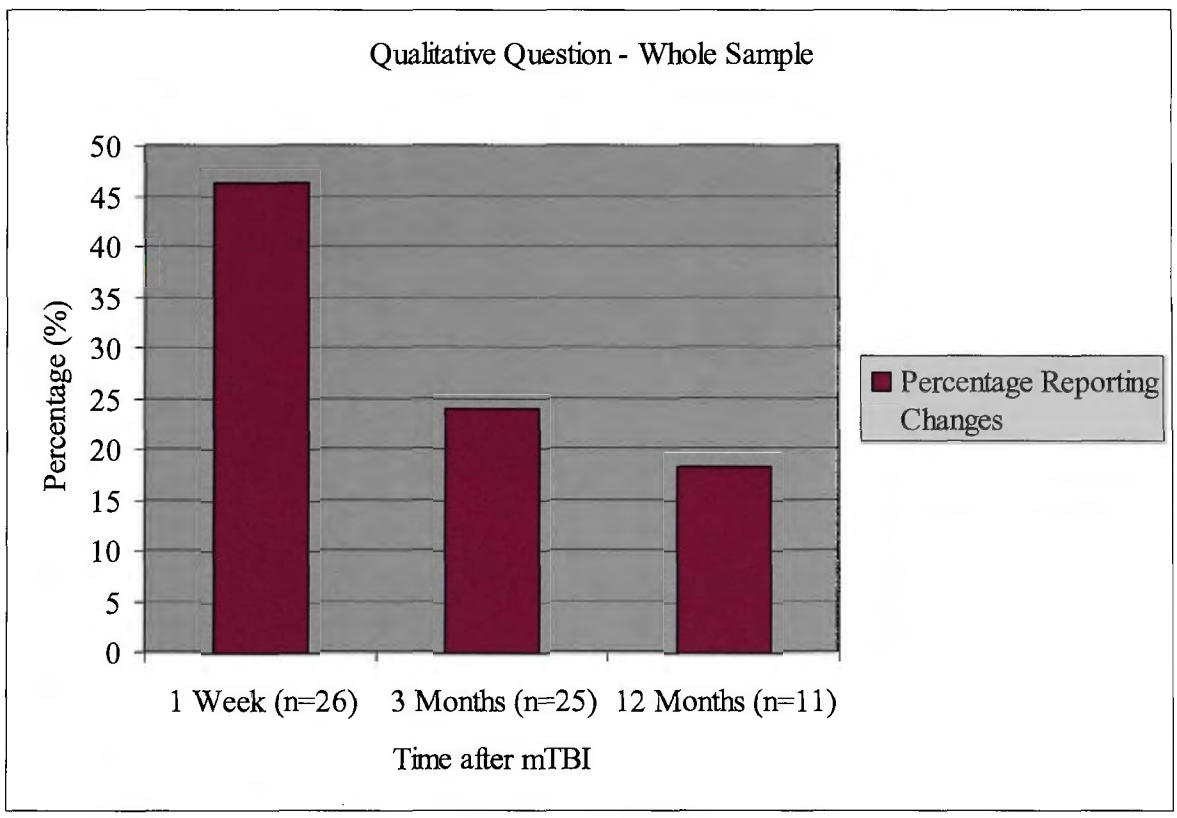

Figure 6. Qualitative Question – Whole Sample

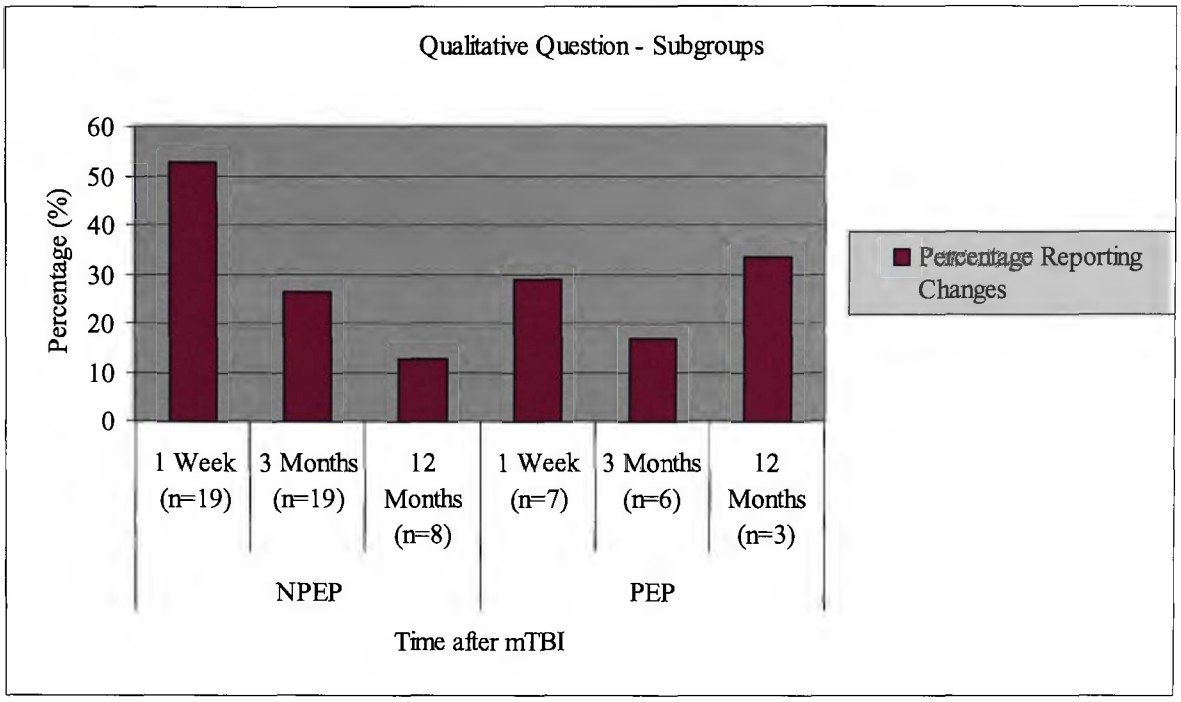

Figure 7. Qualitative Question - Subgroups

The qualitative question was broken down into main themes of responses using a content analysis. The themes were Fatigue, Withdrawn, Physical Pain, Oppositional/Defiant and Other. Each of these themes is graphed separately. For each theme there is a graph of the whole sample and of the subgroups. The results are displayed as the percentage of parents who reported the change at each assessment time.

The percentage of parents at each assessment time who reported that their child was displaying fatigue is shown in Figure 8 (Whole Sample) and Figure 9 (Subgroups).

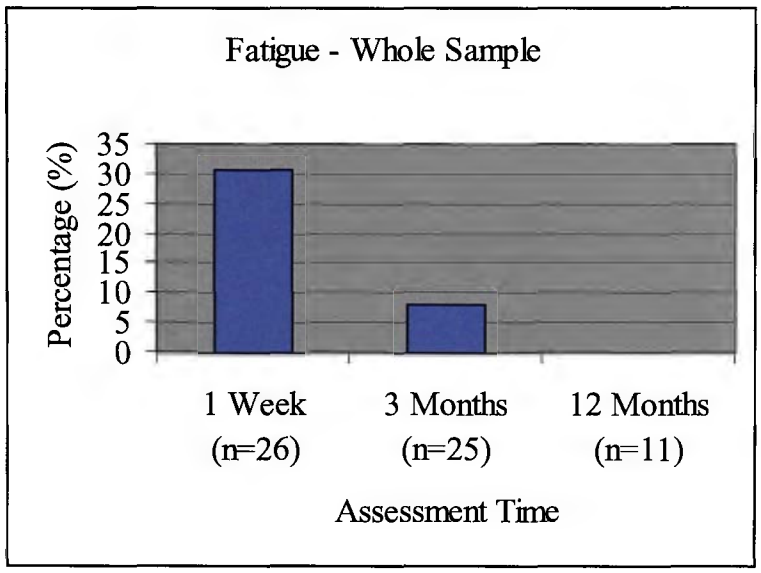

Figure 8. Fatigue – Whole Sample

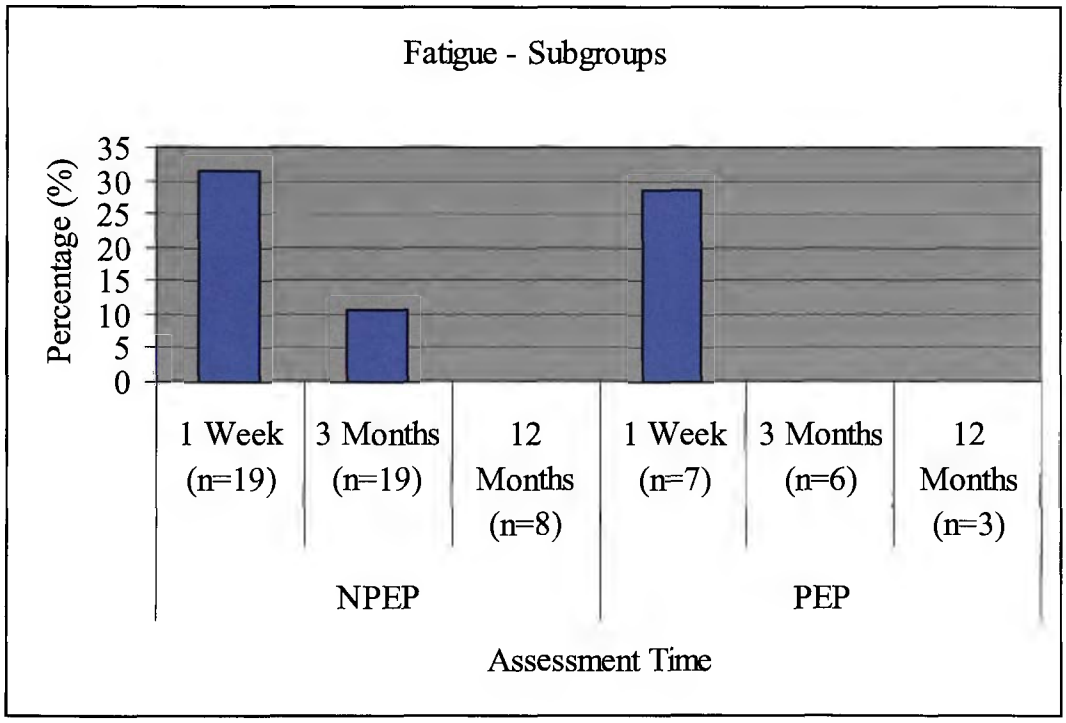

Figure 9. Fatigue – Subgroups

The percentage of parents at each assessment time who reported that their child was withdrawn is displayed in Figure 10 (Whole Sample) and Figure 11 (Subgroups).

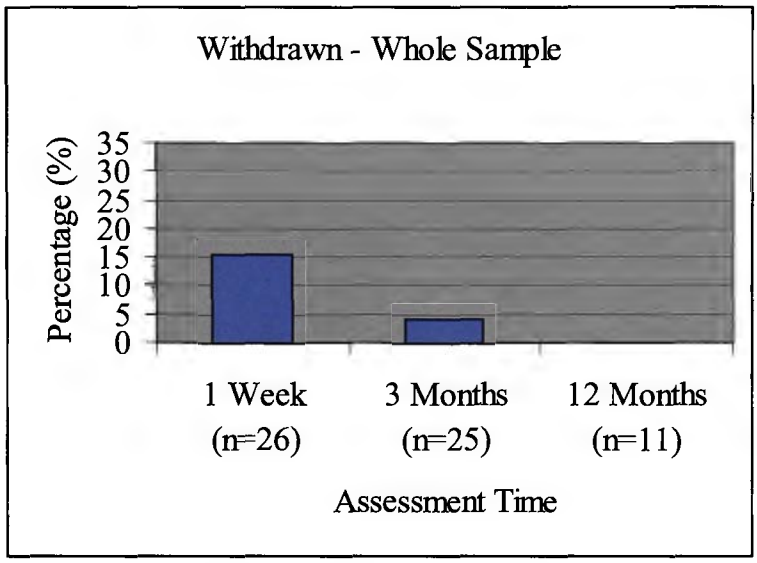

Figure 10. Withdrawn – Whole Sample

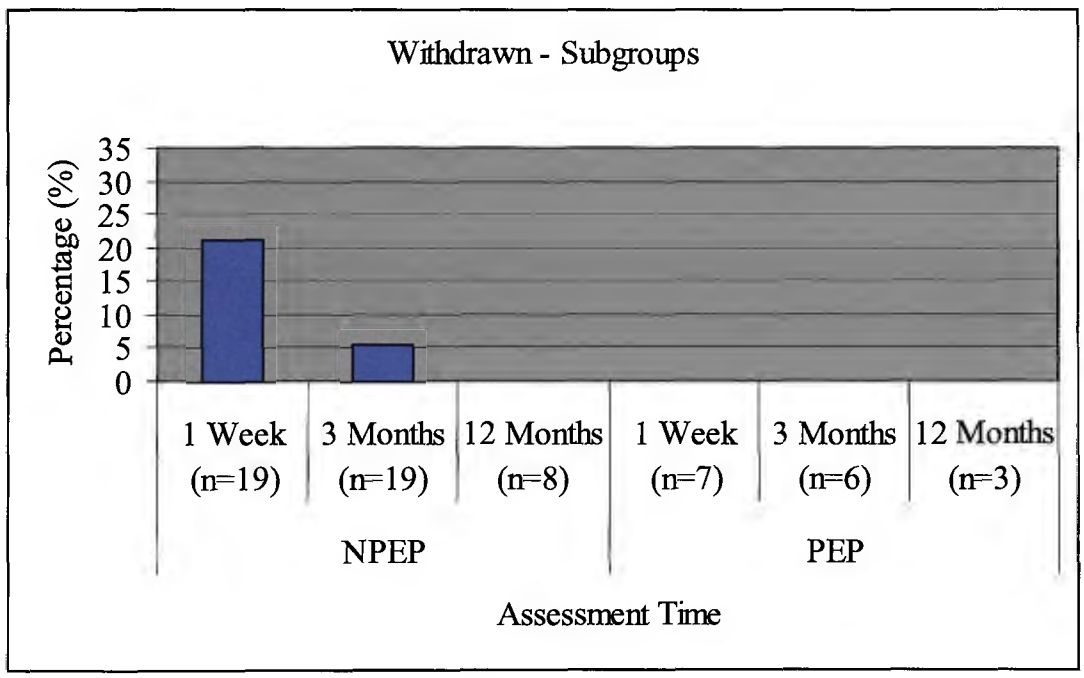

Figure 11. Withdrawn – Subgroups

The percentage of parents at each assessment time who reported that their child was displaying physical pain is shown in Figure 12 (Whole Sample) and Figure 13 (Subgroups).

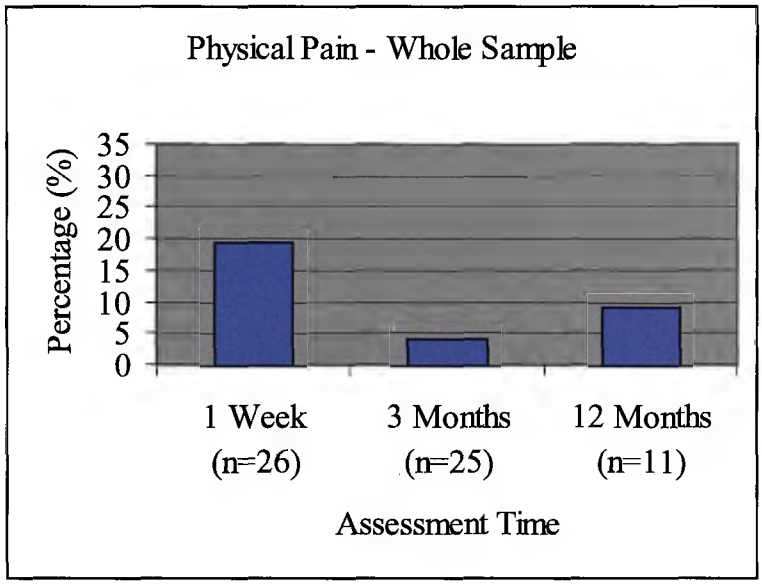

Figure 12. Physical Pain – Whole Sample

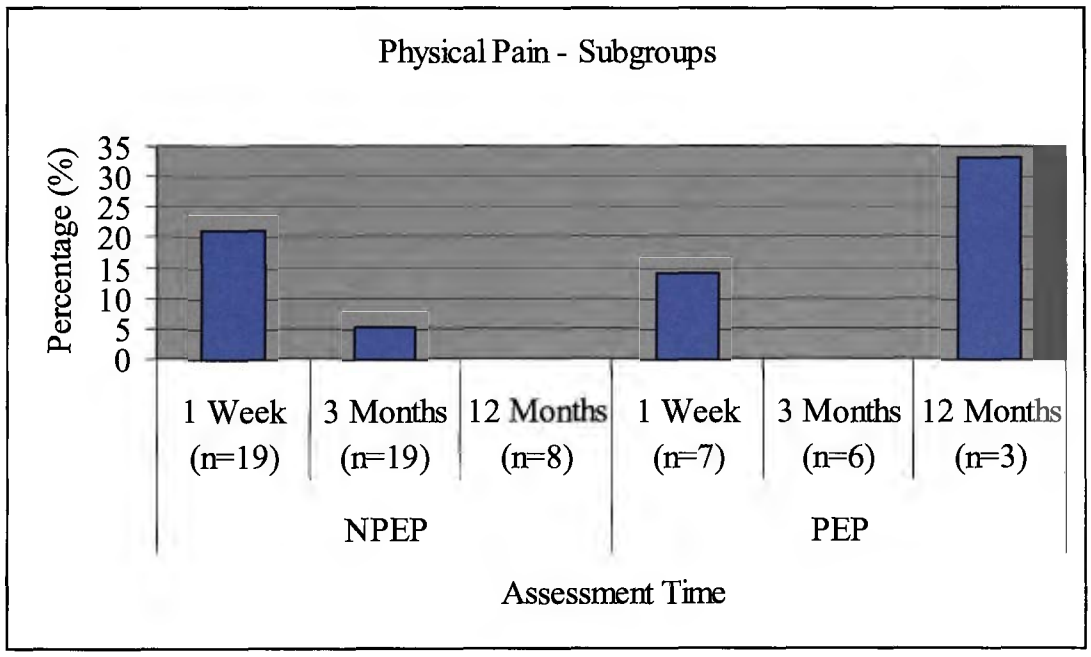

Figure 13. Physical Pain - Subgroups

The percentage of parents at each assessment time who reported that their child was oppositional/defiant is displayed in Figure 14 (Whole Sample) and Figure 15 (Subgroups).

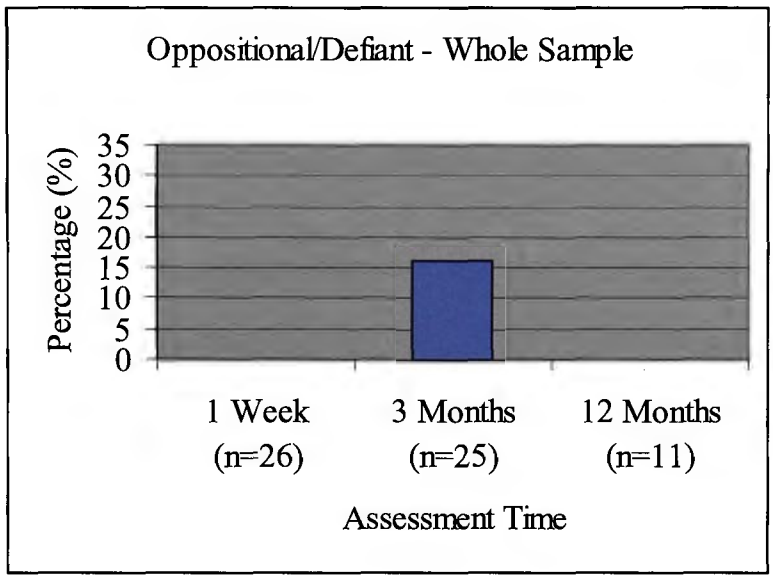

Figure 14. Oppositional/Defiant – Whole Sample

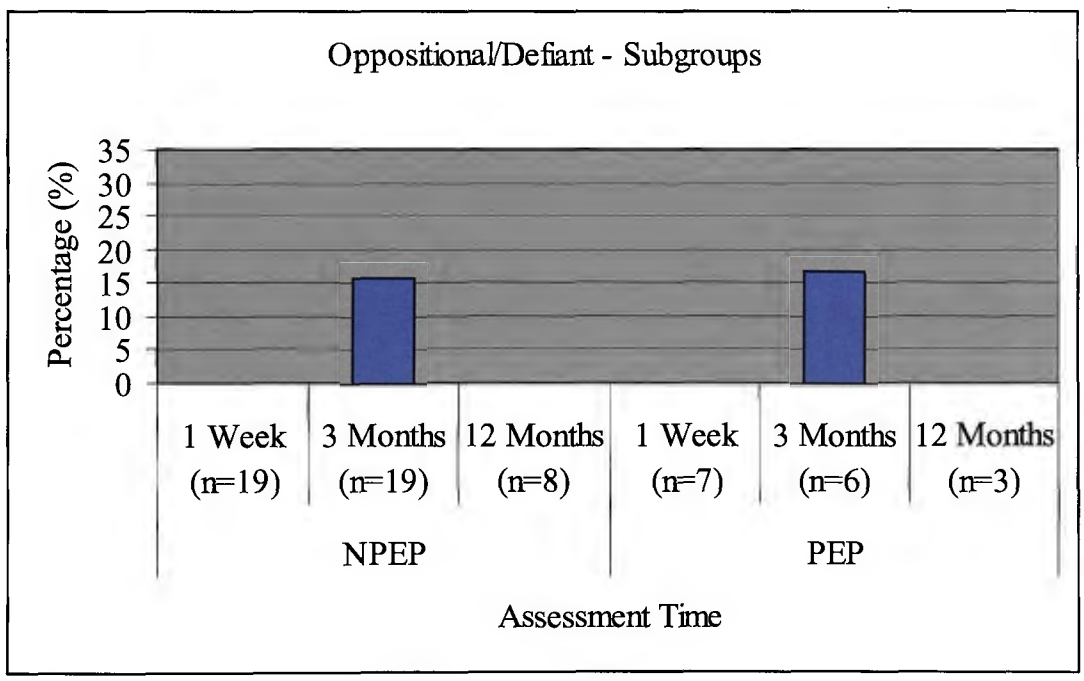

Figure 15. Oppositional/Defiant - Subgroups

The 'Other Changes' category included all qualitative responses that did not fit into consistent themes. Refer back to Method (p. 47) for a more detailed description of what this category included. The percentage of parents at each assessment time who reported that their child was displaying other changes is shown in Figure 16 (Whole Sample) and Figure 17 (Subgroups).

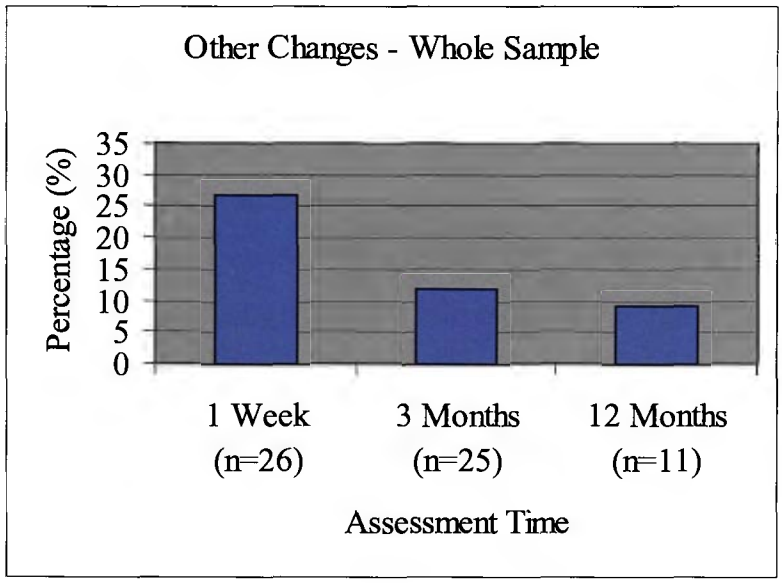

Figure 16. Other Changes – Whole Sample

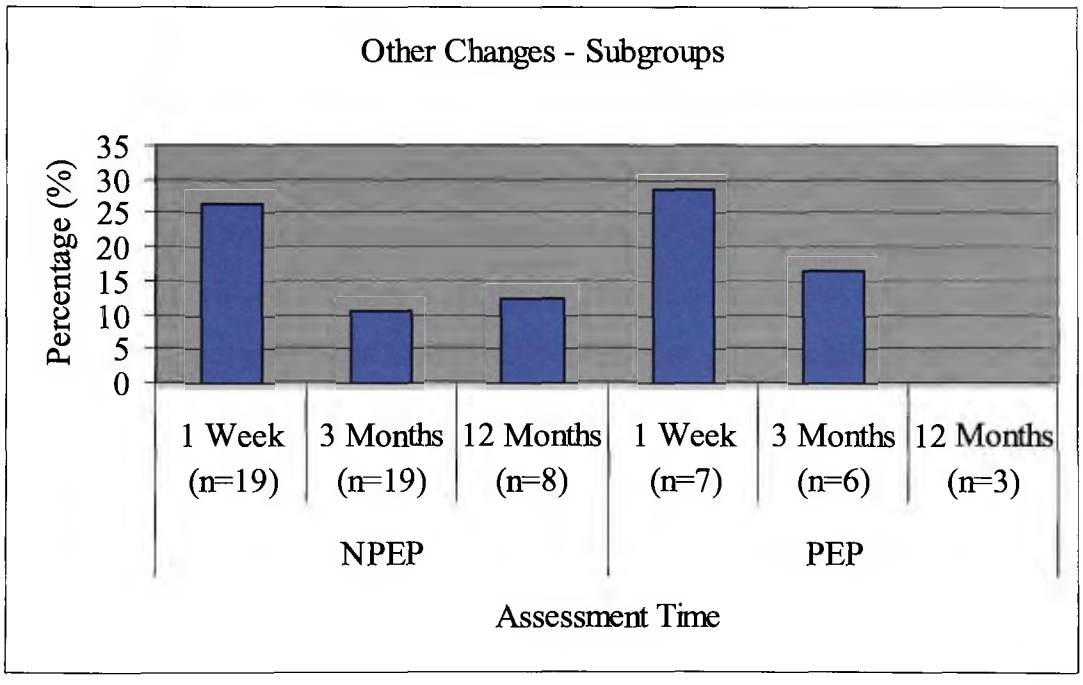

Figure 17. Other Changes - Subgroups

3.4. Aim 2: Subgroup of Children with Behavioural or Affective Changes 3 Months Following a mTBI

Aim 2 was to determine if there was a subgroup of children from the whole sample who displayed behavioural or affective problems 3 months post-injury. This is different to the sub-group of children with pre-existing problems (ie. the PEP and NPEP groups), it was the children who had problems in behaviour or affect at the 3 month follow up assessment, regardless of whether or not they had pre-existing problems. If a sub-group with problems at 3 months was found, it was also the aim of this study to determine whether this group differed in any significant way from the children who did not have problems at 3 months post injury.

3.4.1. Subgroup at 3 Months Post-Injury

Children were considered to have problems if they were reported by their parents to be displaying a change in behaviour or affect on the qualitative question or if they scored in the clinically significant range (t-scores greater than 69 for problem scales, t-score less than 31 for adaptive scales) on any of the BASC2 composite scales at the 3 month follow-up assessment.

Of the Whole Sample (n=25) 28% were deemed to have behavioural or affective problems at 3 months post-injury based on the above criteria.

3.4.2. Difference of Subgroup with Problems at 3 Months Post-Injury Compared with those Without Problems at 3 Months

As a subgroup of children were found to have behavioural or affective problems 3 months post injury it was investigated whether this group differed from the children who did not have problems at 3 months on a range of characteristics. The characteristics investigated were, gender, age at injury, presence of pre-existing problems, loss of consciousness, socio-economic status, overall cognitive functioning and pre-injury BASC2 index and composite scores. The BASC2 index and composite scored were coded as either being in the normal range or not being in the normal range (ie. in the 'at risk' or 'clinically significant' range).

The variables, age at injury, socio-economic status and overall cognitive functioning were normally distributed and thus parametric analyses were used for these variables. Independent sample t-tests were run analysing whether there were any significant differences between the children who did and those who did not have problems at 3 months post injury. Results are shown in Table 12.

Table 12

Difference Between Children With and Without Problems at 3 Months on the Normally Distributed Variables

Variable	*T*	*Df*	*p* value
Age at injury	-1.48	23	.16
Socio-economic status	-0.22	23	.83
Overall cognitive functioning	-0.31	23	.76

The remaining characteristics, gender, presence of pre-existing problems, loss of consciousness and pre-injury BASC2 scale scores were all dichotomous variables and thus non-parametric analysis were applied.

Fisher's exact test (bi-directional) was used instead of Pearson's chi-square due to the small sample size. Results from each of these analyses for gender, presence of pre-existing problems and loss of consciousness are presented in Table 13. The results for pre-injury BASC2 scores are presented in Table 14.

Table 13

Difference Between Children With and Without Problems at 3 Months on the Dichotomous Variables

Variable	*p* value (Fisher's Exact Test)
Gender	.64
Pre-existing Problems	1.0
Loss of Consciousness	.03

Table 14

Difference Between Children With and Without Problems at 3 Months on the BASC2

Baseline BASC2 Scale	*p* value (Fisher's Exact Test)
Behavioural Symptoms Index	.60
Externalising Problems Composite	1.0
Internalising Problems Composite	1.0
Adaptive Skills Composite	.60
Hyperactivity Index	.66
Aggression Index	1.0
Conduct Problems Index	1.0
Anxiety Index	.29
Depression Index	.49
Somatisation Index	.18
Atypicality Index	1.0
Withdrawal Index	.49
Attention Problems Index	1.0
Adaptability Index	1.0
Social Skills Index	.30
Leadership Index	1.0
Activities of Daily Living Index	.60
Functional Communication Index	1.0

Chapter 4: Discussion

4.1. Aim 1: Changes in Behaviour and Affect Following mTBI

Previous research suggests that children may display changes in behaviour and affect following a mild Traumatic Brain Injury (mTBI). The first aim of the current study was to investigate this notion using the BASC2 and a qualitative question to measure behaviour and affect over baseline, 1 week, 3 months and 12 months post injury.

4.1.1. BASC2

4.1.1.1. Interpretation of Findings

Previous research investigating the impact of mTBI on behaviour and affect has often lacked baseline measurement due to the retrospective design (Catale et al., 2009; Hawley et al., 2004). The current study obtained baseline measurement of behaviour and affect through administering the BASC2 within approximately 24 hours of the injury with regards to the child's pre-injury behaviour and affect. BASC2 scores were interpreted as the percentage of participants in the 'Normal', 'At Risk' or 'Clinically Significant' range based on their T-scores on each of the BASC2 composite and index scales. Results were compared over baseline, 1 week and 3 months post-injury. The 12 month assessment was not included in the BASC2 longitudinal analysis due to the small sample size. Initially the BASC2 composite scales were analysed for changes. Using the whole sample (including children with and without pre-existing problems) no difference was found over time on any of the composite scales. The BASC2 index scales were also analysed separately. Again no significant differences were found over time on any of the index scales.

Given the analysis included both children with and without pre-existing problems, the subgroups (No Pre-Existing Problems (NPEP) and Pre-Existing Problems (PEP)) were compared to determine if there were differences on any of the BASC2 scales at any assessment times. Of the composite scales significant differences were found at baseline on the Behavioural Symptoms Index and at baseline and at 1 week on the Externalising Problems Composite. All the children in the NPEP group were in the 'Normal' range on

the Behavioural Symptom Index at baseline, 1 week and 3 month. In contrast, only 17% of the PEP group were in the 'Normal' range at baseline with 50% of the PEP group being in the 'At Risk' range and 33% in the 'Clinically Significant' range. There was also a trend towards there being a difference between the subgroups at 1 week and 3 months post injury, however, this did not reach significance. A similar pattern of results was seen in the Externalising Problems Composite. Ninety five percent of the NPEP group were in the 'Normal' range at baseline and all NPEP participants were in the 'Normal' range at 1 week and 3 months post-injury. This was in comparison with no participants in the PEP group being in the 'Normal' range at baseline, 33% were in the 'At Risk' range and 67% were in the 'Clinically Significant' range and again the majority of PEP participants were in the 'At Risk' and 'Clinically Significant' range at 1 week. These results suggest that from the outset each of these groups were very difference on these scales and thus it was analysed whether there were changes over time on each of these scales for the subgroups separately. No changes over time were detected for each of the subgroups on the Behaviour Symptom Index and the Externalising Problems Composite.

As well as a significant difference being detected between these groups on these scales, large effect sizes were also found. No significant differences, and small to moderate (at best), effect sizes were found between the groups on the Internalising Problems Composite and the Adaptive Skills Composite.

These findings suggest that while differences were not detected over time on the BASC2 composite scales there was evidence of subgroups within the sample of children recruited to the study that were very different in some aspects of behaviour and affect. The differences seemed to be particularly in externalising, overt behaviour problems.

The BASC2 composite scales are derived from a combination of more specific index scales so to better understand the nature of the differences between the subgroups and determine whether there were specific changes detected over time on the BASC2 the subgroups were also compared on the 14 index scales. Differences were found on the Hyperactive, Aggression and Conduct Problems Indexes. These are the 3 scales that

combine to form the Externalising Problems Composite, explaining why a significant difference was seen on that composite scale. Hyperactivity and Aggression also load on the Behaviour Symptoms Index, however, so do a number of other index scales for which significant differences across subgroups were not found.

On the Hyperactivity Index significant differences were found between the NPEP and PEP subgroups across all assessment times, Baseline, 1 week and 3 months. In the NPEP group the large majority of children were in the 'Normal' range at each assessment time with a small proportion (21% at Baseline and 10% at 1 week) in the 'At Risk' range. In comparison, no PEP children were in the 'Normal' range at baseline with 17% in the 'At Risk' range and 83% in the 'Clinically Significant' range. Similar, or though not quite as extreme, distributions were seen at 1 week and 3 months with 17% in the 'Normal' range, 33% in the 'At Risk' range and 50% in the 'Clinically Significant' range. The subgroups were only significantly different at Baseline on the Aggression and Conduct Problems Index. At baseline all NPEP participants were in the 'Normal' range on the Aggression Index where as only 17% of the PEP group were in the 'Normal' range, 50% were in the 'At Risk' range and 33% were in the 'Clinically Significant' range. Similarly, all except 5% of the children in the NPEP group were in the 'Normal' range on the Conduct Problems Index with the remaining 5% being in the 'At Risk' range. Of the PEP group no children were in the 'Normal' range with 50% being in the 'At Risk' and 50% in the 'Clinically Significant' range at Baseline on the Conduct Problems Index. Where significant differences were found effect sizes were also generally large. In contrast, on the other index scales in the BASC2 where no significant differences were found between groups only small to at most moderate effect sizes were seen.

Despite the significant differences between the subgroups on some of the BASC2 scales, no significant changes over time were found on those scales when the subgroups were analysed separately. Thus, the major finding from the BASC2 was that it was able to detect significant differences between the children in the study who had pre-existing problems and those who did not. These differences were seen particularly at baseline measurement, although were still evident in some of the follow-up assessments. Further,

the differences between the groups were best characterised as externalising problems including hyperactivity, aggression and conduct problems. The importance of the finding that there were subgroups from baseline within the sample and that the subgroups differed significantly on only some aspects of the behavioural and affective measure will be further discussed below.

4.1.1.2. Implications for Clinical Practice and Further Research

No changes were seen over time on any of the BASC2 scales in the whole sample or the subgroups. There are two possible explanations for this finding. Either, no real change in behaviour and affect occurred in the children following the TBI, or, the BASC2 did not detect the changes that did occur. Thus, the BASC2 may not be an appropriate measure to use in research or clinically when trying to detect changes caused by mTBI in children aged between 6 and 12 years. However, the BASC2 was able to detect the existence of pre-existing behavioural and affective problems and was useful in characterising the nature of these. It is clear in the findings from the present study that a substantial proportion of children who were admitted to the study had significant pre-existing problems. This finding is consistent with some of the previous research in the field (Goldstrohm & Arffa, 2005; Ponsford et al., 1999). The group with pre-existing problems displayed significantly different pre-injury BASC2 profiles with significantly higher proportions of problematic externalising behaviours including hyperactivity, aggression and conduct problems than the children without pre-existing problems. Thus, while the BASC2 may not be useful in detecting changes following mTBI, it could have future utility in screening children for pre-existing problems as part of a research protocol. Clinically the BASC2 is commonly used to detect problematic behaviours in children with many different histories and problems which can include mTBI. The findings from this research suggest that if problems are detected on the BASC2 following a child experiencing a mTBI they are more likely to relate to pre-existing or other causes and probably should not be attributed to the mTBI.

4.1.2. Qualitative Question

4.1.2.1. Interpretation of Findings

The qualitative question was intended for exploratory purposes only to investigate whether parents felt there had been behavioural or affective changes in their child following the mTBI. Parents' views can be biased, however, they are generally the ones who spend the most time with their child and thus may be in the best position to notice changes, even if they are quite subtle. Of the whole sample, 46% of parents reported there had been some change in their child's behaviour or affect at 1 week-post injury. This dropped to 24% at 3 months and 18% at 12 months post-injury. These findings appeared to show that there were a proportion of parents who believed there had been changes in their child's behaviour or affect but that these seemed to reduce over a period of 12 months. When the whole sample was split into the PEP and NPEP subgroups some different patterns of perceived changes occurred and thus they will be discussed separately.

The NPEP group continued to display the pattern of changes in behaviour and affect reducing over the period of 12 months after a TBI. 53% reported changes at 1 week, 26% reported changes at 3 months and 13% still at 12 months. The 53% of parents who reported changes at 1 week post-injury is not a surprising finding given the literature on the acute post-concussion syndrome that suggests that the acute symptoms that commonly occur following a mTBI can persist for some days after the injury (Willer & Leddy, 2006). When the kinds of changes parents were reporting was analysed further it was seen that most commonly the parents of the NPEP group were reporting fatigue, withdrawn behaviour and physical pain which included headaches. Similar descriptions of symptoms have been previously documented as common in the acute stage following a mTBI (Willer & Leddy, 2006). The percentage of parents who continued to reported that there were changes in their child's behaviour or mood up to 3 and 12 months post injury is suggestive that there may be some ongoing changes or problems. Previous research with adults and some with children have shown problems continuing beyond the acute period in a proportion (usually around 10-20%) of the sample (Ponsford et al., 1999; Ruff, 2005). These figures are broadly consistent with those found in the present study.

The nature of the changes that parents were reporting at 3 months post injury were 11% reported on-going fatigue issues, 5% reported withdrawn behaviour, 5% reported physical pain symptoms, 16% reported oppositional/defiant behavioural change and 11% reported other changes that did not fit into common themes across responses. This pattern of responding suggests that a small proportion of parents felt that some of the acute symptoms (ie. fatigue, withdrawn, pain) were ongoing with some parents reporting the development of oppositional/defiant behaviour that was thought to be a change since the mTBI and was not reported at 1 week post-injury. Unfortunately only a proportion of the original sample was able to be followed up at 12 months post-injury. Of those in the NPEP group who were assessed at 12 months, no parents reported symptoms of fatigue, withdrawn, physical pain or oppositional/defiant behaviour. Only one parent reported changes at 12 month and this was classified in the 'other' category as it was not part of any of the consistent themes across the parents' reports. From these findings it seems that of the parents who were followed up at 12-months post injury there was really no evidence of consistent changes that persisted at that time. It is unknown whether this would have been the case if all children who were seen at 3 months were able to be assessed again at 12-months post injury.

The PEP group only included a small number of participants making it hard to detect common trends over time. In particular only 3 participants from the PEP group were followed up at 12 months. One of those participant's parent reported ongoing symptoms of physical pain which translates to 33% of the sample. Given the sample was so small it is not felt that anything meaningful can be deduced from that data point. At the 1 week follow up 29% of PEP participants were reported to have behavioural of affective change. This was down to 17% at the 3 month follow-up. The kinds of changes that were reported at 1 week were 29% reporting fatigue, 14% reporting physical pain and 29% reporting other changes. There were no reports of withdrawn or oppositional/defiant behavioural changes at that time. The symptoms at that time could be attributed to those associated with the acute post-concussion syndrome as with the NPEP group. At 3 months no changes in fatigue, withdrawn or physical pain symptoms were reported. Seventeen percent of parents reported an increase in oppositional/defiant behaviour and 17%

reported other changes at 3-months post-injury. The perceived increase in oppositional/defiant behaviour appears consistent with what was reported in the NPEP group at 3 months post injury.

4.1.2.2. Implications for Clinical Practice and Further Research

The qualitative question was included in the study to elicit different information to that that obtained through standardised quantitative measures. It was designed to help inform future directions of research in the area, rather than answer specific hypotheses about change following mTBI. In this context some interesting trends were found which are worthy of further enquiry. In particular quite a large proportion (up to 50%) of parents reported symptoms that are consistent with those known to occur in the acute period following mTBI. These were reported to occur even 1 week after the injury. This has clinically implications as it is thought that often these symptoms resolve within a shorter period than this (Willer & Leddy, 2006). Advice given to parents at medical centres is likely to reflect current literature which may suggest that the child will likely only take a shorter period to 'fully recover'. This information may result in parents keeping their child from school and other activities for only a day or two. However, if in fact a large proportion of children continue to suffer symptoms for up to and possible over one week then this may be important clinical information that parents may benefit from knowing. Some children may benefit from a week or more of reduced activity while the acute symptoms resolve. Further research into the nature and duration of the acute symptoms following mTBI in childhood would be beneficial to inform clinical practice.

From the current results there is some suggestion that a proportion of children may suffer ongoing symptoms for an extended period of 3 or more months. This may be consistent with some of the previous research that has reported changes well beyond the acute period in children following mTBI (Catale et al., 2009; Hawley et al., 2002, 2004; McKinlay et al., 2002; Massagli et al., 2004; Ponsford et al., 1999). Some of the symptoms reported in the current research were the same as those reported in the acute period including fatigue, withdrawn behaviour and physical pain. However, an interesting finding from the current research was a small proportion of parents reporting the

development of oppositional/defiant behaviour at 3 months post injury. This was seen in both children with and without pre-existing problems. This type of behavioural change is not something that has been commonly associated with mTBI but may be worthy of further enquiry. Future research looking at the duration and nature of the symptoms that have typically been thought to be part of the acute syndrome following mTBI would be beneficial. The current research suggests that it would be particularly important to have symptoms of fatigue, withdrawn behaviour and physical pain represented. A useful approach may be to compare these across time over an extended period of over 3 months. It would also be important to compare parents' ratings of these symptoms to a control group as there is some evidence that when asked about specific symptoms such as those of fatigue that a proportion of the population will endorse the symptoms, even if they have not suffered a TBI (Sullivan & Garden, 2009). One of the strengths of the current research was that parents were not asked whether their child was suffering specific symptoms such as fatigue. Rather, they were asked to generate what changes they had noticed, without any suggestion from the researchers as to what might be expected given the injury. That is, they were asked what they thought had changed, not whether they thought their child was suffering symptoms such as fatigue. However, it is acknowledged that the parents may have gained such information from other sources such as medical professionals.

Future research into the possible development of oppositional/defiant behavioural changes following mTBI may also be of interest. To the authors knowledge this is not a finding that has been reported previously. Formal, standardised assessment of these behavioural problems would help understand whether indeed this is an outcome of mTBI. In future research it is important to also understand that these behavioural changes may not be to the extent that the child's behaviour becomes in the clinically significant range. Rather, the changes may be in comparison to their pre-morbid functioning.

This leads to the comparison between the use of the BASC2 and the qualitative question. The BASC2 includes measures of oppositional/defiant behaviour and of withdrawn behaviour. Although these were described as changes by some parents, the

BASC2 failed to show any changes. This suggests that either when specifically asked to rate behaviours there were actually no changes over time and the perceived changes by the parents may be due to them attributing the behaviour to the mTBI where it was actually present all along. Or, the changes in behaviour did actually occur, however, the child's behaviour may still be within the normal limits of what would be expected for their age and thus the changes would not be seen on scales such as the BASC2 that are designed to detect more clinically significant behavioural problems. The difference in findings between the BASC2 and the qualitative question further suggests that measures such as the BASC2 may not be appropriate for detecting changes following mTBI in children.

4.2. Aim 2: Subgroup of Children with Behavioural or Affective Problems 3 Months Following a Mild TBI

4.2.1. Interpretation of Findings

Although changes were not detected over time on the BASC2, there were a group of children at 3 months post-injury who were thought to be displaying changes or behavioural/affective problems. This group included children who were reported on the qualitative question to have ongoing behavioural or affective changes and those who scored in the clinically significant range on any of the BASC2 composite scales at 3 months post-injury. Using these criteria 28% of the sample was found to have behavioural or affective problems 3 months after the mTBI. A similar approach (using different scales to assess the presence of problems) was used by Ponsford et al. (1999). In that study at 3 months post mTBI 17% of the sample of children were found to have behavioural problems. Ponsford et al. (1999) also assessed a control group of children who suffered minor injuries to other parts of the body were at 3 months post-injury. Based on the same criteria as the mTBI group, only 1% of the control group displayed behavioural problems at that time. Although different measures were used and thus conclusive comparisons across studies can not be made, in the current study 28% of children with problems at 3 months post-injury certainly seems worthy of some concern in comparison to the previous research reporting only 1% of control groups displaying problems at that time following a minor injury to other parts of the body. Ponsford et al.

(1999) went on to show that the group of children who had problems at 3 months post-injury were significantly different from the children who did not have problems on a number of pre-morbid factors. The most significant differences were in whether the child had a previous TBI and the presence of pre-morbid stressors. In a similar manner the current study aimed to determine whether the group of children who had problems at 3 months post-injury differed from those who did not have problems. The variables investigated were: age at injury, socio-economic status, overall cognitive functioning, gender, presence of pre-existing problems, loss of consciousness, and BASC2 baseline index and composite scale scores. No significant differences were found on any of these variables between the group of children with and those without problems at 3 months post-injury. Thus, findings similar to Ponsford et al. (1999) were not found.

4.2.2. Implications for Clinical Practice and Further Research

As with the research conducted by Ponsford et al. (1999) a subgroup of children was found at 3 months post-injury that displayed a range of problems. Although no control group was included in the present research, previous research suggests that in a group of children who have suffered a minor injury to other parts of the body only a very small minority would be expected to show problems at 3 months post-injury (Ponsford et al., 1999). Thus, the current finding of 28% of children displaying some problems at 3 months post injury is a clinical concern. This finding is also consistent with the previous research suggesting that children can display problems this long after a mTBI (Catale et al., 2009; Hawley et al., 2002, 2004; McKinlay et al., 2002; Massagli et al., 2004; Ponsford et al., 1999). However, it is still not clear whether these problems represent a change in behaviour or affect or are consistent with problems that were present prior to the mTBI. Ponsford et al. (1999) demonstrated that the group of children with problems at 3 months post-injury was different at baseline compared to the group who did not have problems 3 months post-injury. This finding was not replicated in the present research. However, the current study had a much smaller sample size, as such, it was only a small group of children who comprised the group with problems at 3 months-post injury making the detection of a difference, if one exists, difficult. Thus, the current research is unable to support or refute the notion that the children who have ongoing problems

following a mTBI, in fact were different prior to the injury. This will be an important issue to clarify in trying to understand the possible short and long term consequences of mTBI in childhood. If it is the case that the presence of pre-morbid problems is predictive of outcome following mTBI this has important clinical implications. It suggests the need to fully investigate a child's pre-morbid functioning to be able to better treat and inform the child, family, school, etc. regarding the expected outcome and risks following mTBI. Further research will be important to better understand this issue. In particular it is important for research to gather sound baseline measurements of functioning and to have a large enough sample of children with mTBI to be able to form subgroups within the sample.

4.3. Sample Characteristics

Despite a large amount of background information being obtained from the participants, very few exclusion criteria were applied. This allowed for a sample of children who were as close as possible to representative of the population of children who present to medical centres having suffered a mTBI. There were some characteristics of the sample that were different to what would be expected in the general population and may represent something different about the group of children who are more likely to suffer a mTBI, or more likely to participate in research following such an injury where it is available.

4.3.1. Gender

There was a marked difference in the male to female ratio of children involved in the study in comparison to the general population. Seventy four percent of the sample recruited to the study were male. This is consistent with previous research. Ponsford et al. (1999) reported 75% of their sample of children who suffered a mTBI and volunteered to participate in the research were male. In a large study of computerised records Massagli et al. (2004) reported 67% of the children between the age of 5 and 14 years of age who suffered mTBI were male. In comparison, of the children aged between 0 and 4 years when they suffered a mTBI only 50% were male. Hawley et al. (2004) also reported 70% of children in their large sample of children who suffered a mTBI between the ages of 5

and 15 years were male. This difference may reflect gender differences in the types of activities that children undertake with a bias towards male children being involved in more activities with a higher risk of suffering a TBI than female children. Regardless of the aetiology of this pattern it is important to consider this when analysing the characteristics of the group. It is also important to note that the current sample is consistent with what has been found in many previous studies (including large studies) and is thus reflective of the group of children who suffer mTBI and present to medical centres, not reflective of a unique sampling bias in the current study.

4.3.2. Pre-Existing Problems

In the present study children were considered to have pre-existing problems if they were reported by their parents to suffer a significant medical or psychological illness. Or if their estimated Full Scale Intelligence Quotient was below the second percentile, that is they performed worse than 98% of children in the normative group of the same age on an abbreviated test of overall cognitive functioning. Or children were also considered to have pre-existing problems if they were found to be above the 98th percentile on any of the problem behaviour composite measures on the BASC2 parent rating scale. These criteria were designed to detect children with significant pre-existing problems. In the general population these criteria would be unlikely to apply to the vast majority of children. The cognitive and behavioural disturbances would generally only apply to 2% of the population. The significant pre-existing medical or psychological illnesses included diagnoses of neurofibromatosis 1 and oppositional defiant disorder, both of which have low base rates in the general population. In this context, the finding that 30% of the children recruited to the study had a significant pre-existing problem is quite substantial. However, this is not inconsistent with previous literature. Ponsford et al. (1999) reported that 27% of their large sample of children who suffered mTBI had pre-existing neurological or psychiatric problems. Other studies have excluded children with pre-existing problems (Catale et al., 2009). It could be argued that it is important to remove children with pre-existing problems from the sample as the pre-existing problems may confound the results. However, the evidence from the current study suggests that as a group, children who suffer mTBIs and present to medical centres actually have a much

higher proportion of pre-existing problems than the general population. Thus, by excluding these children you are actually changing the group of children who have mTBI and thus only assessing a sub group of these children. It is felt that the approach taken by the present study to include these children, but analyse them as a separate subgroup helps over come some of these issues. However, this finding has implications for sample sizes in future research. If in fact there are two quite distinct subgroups of children who suffer mTBI then future research needs to aim to have larger sample sizes to allow for there to be enough power in each of the subgroups to be able to detected changes, where they do exist.

In the current study the children with pre-existing problems were analysed separately for some analyses and referred to as the Pre-existing Problems (PEP) group. The baseline behavioural and affective profile of the PEP group were compared to the No Pre-existing Problems (NPEP) group using the BASC2. Significant differences were seen on some, but not all, of the BASC2 scales. The scales on which significant differences were found at baseline were those that loaded on the Externalising Problems Composite. The Hyperactivity, Aggression and Conduct Problems scales were all found to differ significantly, with large effect sizes, between the PEP and NPEP group. The PEP group had significantly more children with significant behavioural disturbances on these scales than the NPEP group. The BASC2 manual describes the externalising behavioural problems as those that are overt and disruptive in nature (Reynolds & Kamphaus, 2004). Each of the sub-scales that comprise to make the Externalising Problems scales were also found to be significantly different between the PEP and NPEP group. The Hyperactivity scale is designed to detected hyperactive and impulsive behaviours such as those seen in Attention Deficit Hyperactive Disorder. Examples of such behaviours include being over-active, having poor self-control and acting without thinking (Reynolds & Kamphaus, 2004). Reynolds and Kamphaus (2004) described the Aggression scale as representing behaviour that causes harm to others or property. This includes both verbal and physical threats and aggressive behaviour. The Conduct Problem scale also includes overtly disruptive anti-social and rule breaking behaviours including cheating, lying, stealing and running away from home (Reynolds & Kamphaus, 2004). These scales that were found to

be significantly different between the groups are in contrast to the scales where no differences were found. No differences were found between groups on the internalising scales including symptoms of anxiety, depression and somatisation. No differences were found on any of the adaptive behaviour scales which included adaptability, social skills, leadership, activities of daily living and functional communication. Further, no difference was found on the atypicality, withdrawal or attention problem scale. The difference on the hyperactivity scale but not the attention problem scale is an interesting finding. The attention problem scale is reported to represent behaviours associated with inattention such as difficulty maintaining attention, the tendency to be easily distracted. While these behaviours are also thought to be present in disorders such as Attention Deficit Hyperactive Disorder they are thought to be distinct from the more externalising behaviours detected on the Hyperactivity scale (Reynolds & Kamphaus, 2004).

The reason why in the present study and some previous research there is a large percentage of children who present with significant pre-existing problems has not been thoroughly explored or explained in the previous literature. There are a number of possible explanations for the finding. It is possible that parents with children with pre-existing problems are more likely to take their child to a hospital or medical centre. Or the parents of children with pre-existing problems may be more amenable to participation in research than those without problems. This may be because they can see personal gain from having an assessment which may assist with their child. Or parents who have children with problems may feel that they are contributing to the general body of knowledge that may help them directly or others in a similar situation by participating in research and thus also have a greater incentive to participate than parents of children with no problems.

The nature of behavioural differences detected between the PEP and NPEP group may also give credence to another theory that has been proposed for this finding. That is, it is possible that children with particular behavioural problems are at greater risk of suffering a mTBI due to behaviours that they display that make them more likely to suffer an injury. In a cohort study Brehaut et al. (2003) reported that children were more

likely to suffer an injury if they suffered a behavioural disorder than those who did not suffer such a disorder. The presence of a disorder was determined by the prescription of methylphenidate, a medication commonly used in children with disorders such as Attention Deficit Hyperactive Disorder. This finding and others like it suggest that it may be characteristics of the children rather than sampling biases that account for the increase risk of injury, including mTBI. In the present study the children with pre-existing problems were found to have significantly more externalising behavioural problems than those without pre-existing problems. The externalising behaviours include those overt behaviours that may conceivably contribute to the risk of suffering an injury. The hyperactivity scale is designed to reflect children who are over active, have poor self control and act without thinking. These behavioural traits may put a child at more risk of injury. For example, a child with these behavioural problems may be more likely to run onto a road to chase a ball without thinking about the potential risks and thus putting themselves at greater risk of being involved in an accident. The finding that the PEP children had greater levels of externalising behavioural problems but not other behavioural or affective disturbances lends weight to the notion that it is this kind of behavioural problem that increases risk of suffering a TBI. Thus, it is possibly these kinds of behavioural problems that lead to the increased proportion of children with pre-existing problems who suffer mTBI. In the current study the BASC2 appeared to be useful in detecting and characterising the nature of pre-existing behavioural problems. Thus, even though the BASC2 did not seem to be sensitive to detecting changes over time, it is likely to be a useful tool in future research for detecting and understanding pre-existing behavioural problems in this population. It will also be important in the future to understand whether there is any interaction between having pre-existing problems and suffering a mTBI and whether the outcomes for these children differ from those children who do not have problems prior to the injury. This has begun to be addressed in the literature, however, as many studies exclude children with pre-existing problems the research into this group is in its early stages.

4.4. Limitations of the Present Study

4.4.1. Control Group

The present study did not include a control group which limited some of the interpretations that could be drawn from the data. The BASC2 data were able to be compared to a normative sample, however, this is unlikely to be as appropriate as a matched control group from the same location and community and matched for important factors such as age and socio-economic status. It also would have been useful to have a control group to use the qualitative question with. This would have allowed an evaluation of whether parents tend to report changes in their child's behaviour regardless of whether they had suffered a TBI. To answer this question a study would probably need two control groups; one who had not suffered any injury or incident and the parents were just reporting whether there had been general changes over time; the other group would need to be a non-head injury group. The latter group would be useful to determine whether parents may perceive a change in their child's behaviour which may be related to an emotional reaction to their child suffering an injury. Unfortunately in practice recruiting a control group, particularly in a longitudinal study is highly problematic. There is often little incentive for parents or children to participate in research if they cannot relate to the particular area being studied. While you may be able to get a group of children to participate out of the parents' interest of knowing the results of their child's assessment, it is very difficult to recruit participants to have multiple assessments over time. While control groups are important in this area of research, it is acknowledge that there are significant limitations in the practice of recruiting and retaining children for this purpose.

4.4.2. BASC2

The BASC2 is a standardised instrument for which the research on its reliability, validity and its normative data are all based on its standardised administration. In the present research the BASC2 was administered in the standardised manner at the baseline, 3 month and 12 month follow-up assessments. However, it was not used in the standardised manner at the 1 week follow-up assessment. In the standardised administration parents are asked to rate their child's behaviour over the past few months. However, at the 1 week follow-up in the current study parents were asked to rate their

child's behaviour over the past 1 week. It is possible that parents would have underrated all the behaviours on the BASC2 as they occurred less frequently in the space of 1 week than over a few months. However, when compared to normative data it did not appear that this was the case. Rather, the results from the 1 week follow-up were broadly consistent with all the other assessment times. A control group would have been useful to compare this non-standardised administration to. However, for the reasons outlined above this was unable to be achieved in the current research.

4.4.3. Sample Size

Based on recommendations from previous research, and power calculations of the sample size required to detect a moderate effect size, the current study aimed to recruit a sample of close to 30 participants (Satz et al., 1997). This was able to be achieved, however, due to the presence of subgroups within the overall sample the number of children recruited to the study did not reflect the number of children included in much of the data analysis. The number of children, particularly in the PEP group was very small making analysis difficult. If there were changes in this group they would have been very difficult to detect with so few participants. The presence of the PEP group was valuable in understanding the kinds of children who suffer mTBI and agree to participate in such research. However, if future research was to take the approach of analysing the subgroups of children with and without pre-existing problems separately they would benefit from having much larger sample sizes. Sample size is also important in a longitudinal study. In the present study there was a large attrition of participants between the 3 and 12 month follow-up. To overcome this future studies may need to aim to have a much larger sample at intake to still have a reasonable number of participants at the longer follow-up times.

4.4.4. Longitudinal Design

The loss of a large number of participants (approximately 50% of the sample) between the 3 and 12-month follow up made interpretation of the 12 month follow-up data difficult. This was particularly unfortunate in the current research as there was some indication from the parents' reports at 3 months that a proportion of parents felt there were still changes in their child's behaviour and affect following the mTBI. Given the

small number of participants at the 12 month follow-up it was hard to ascertain whether these parents felt that the problems had resolved or whether they were still persisting at 12-months post-injury. In particular, when the 12 month follow-up was split into the subgroups the numbers in the groups became extremely small and did not allow any meaningful analysis.

4.4.5. Data Analysis

In the current research there were a number of different research questions using the same data and multiple dependent variables. As a result a large number of different comparisons were made in the data analysis. It is widely acknowledged that making multiple comparisons increases the risk of finding a statistically significant difference where one does not exist (Type 1 errors; Field, 2009). To account for this problem the Type 1 error rate was set at a more conservative level ($\alpha = .01$). It could be argued that this should have been made even more conservative if the Bonferroni adjustment had been made. However, this would have increased the risk of making Type 2 errors. Similar problems with the Bonferroni adjustment have been previously described (Nakagawa, 2004). While the multiple comparisons and adjusted error level may have been a limitation of the present study it is felt that the approach taken to counter this problem was appropriate as some significant results were still found in the data analysis. Further, where these results were found the effect sizes were calculated and found to generally be large suggesting they were real and meaningful results.

4.4.6. Qualitative Question

The qualitative questions that were included in the present research were a strength of the research but also had some limitations. For exploratory purposes the qualitative question generated a lot of interesting information which has clinical and future research implications. However, there were also some limitations to this approach that need to be acknowledged. By asking parents to describe changes in their child behaviour and mood generally rather than rating set behaviours the questions are biased by each parent's interpretation. While this is also a strength of the approach, the problem may be that one parent thinks of different examples to another parent and they are thus not comparing the

same thing. In contrast, if you ask parents to specifically think about set behaviours then the parents would at least be comparing the same specific behaviours. The other limitation of this approach is that some changes in children's behaviour and affect occur normally with age and development. In longitudinal study of children this is important to consider. While a control group was not available in the present study this may have helped separate out any changes that parents may report in children of this age over the follow-up periods of 1 week, 3 months and 12 months post injury. By the relatively slow nature of development, changes perceived at the 1 week follow-up assessment would be less likely to be reflective of developmental changes than those reported at the 12 month follow-up.

4.4.7. Severity of Injury Measurement

Measurement of injury severity has traditionally been difficult and quite variable in mTBI research. There has not been a general consensus in the literature as to what the best approach may be. Generally there needs to be some indication that an injury has occurred. That is, there needs to be some evidence of changes in brain functioning such as physiological changes including for example, loss of consciousness, nausea, headache or photophobia. There also needs to be some indication that the injury is not more severe and better treated as a moderate to severe TBI. Extended durations of loss of consciousness and reduced score on physiological measures such as the Glasgow Coma Scale (GCS) are common and easily measured in more severe injuries. However, in mild TBI loss of consciousness may be brief or not even occur making it hard to measure and little change may be detected on commonly used scales such as the GCS. Post Traumatic Amnesia (PTA) extends for periods longer than loss of consciousness and reduced GCS score, even in mTBI (Symonds, 1928). Thus, this is an easier entity to measure to formally evaluate severity in more mild TBIs. However, standardised measures of duration of PTA such as the Westmead PTA scale have been designed to assess more severe injuries in which PTA extends of days or weeks. Thus, the practice of administering the test daily for at least 3 days is inappropriate in a group where the PTA would be expected to cease within the first 24 hours. Modified versions of the Westmead PTA scale have been used in the literature assessing children hourly after the injury to

determine duration of PTA. This approach has been reported to be effective for this purpose. In the current research a modified version of the PTA scale was administered hourly at approximately 24 hours post injury until one perfect score was obtained. Using this method all children except one reached a perfect score with one trial. This was thought to reflect that the children in the study were no longer in PTA at 24 hours post-injury, and thus classified as having a mTBI. However, the approach did not allow for separating out how long the PTA duration lasted for and whether there were differences in the group of some children suffering more 'severe' mTBIs than others. That is, the children would have had the same result on the current assessment if they were no longer in PTA at one hour post injury as if PTA had not resolved until 23 hours post injury. It would have been interesting to compare whether there were outcome differences based on the relative level of severity of the mTBI. Admittedly this would be a difficult design to undertake as it would require the scale to begin being administered as soon as possible following the mTBI. However, this would be a future research question worth some enquiry given the need for a efficacious method for measuring injury severity in mTBI.

4.4.8. Behavioural Observations from Single Source

The current study only included observational data from a single source. When measuring behaviour it has been suggested that the use of multiple observers is beneficial to obtaining accurate and reliable information (Reynolds & Kamphaus, 2004). The children in the present study were predominantly of primary school age. At this age teacher rating of behaviour can also be beneficial as they often spend significant amounts of time with the children. This data would be able to be compared to the parent rating to determine whether the child is consistently thought to be displaying behaviours over a range of environments. Unfortunately, due to teachers' limited availability such data can be very difficult to obtain.

4.5. Future Research

The current research was designed to be exploratory in nature and thus, causal inferences were unable to be drawn from the results. However, the findings from the

present study do highlight a number of issues that would be worthy of further investigation.

There is suggestion in the current findings that children with pre-existing problems, particularly externalising behavioural problems, may be over-represented in the population of children who suffer mTBI. This is not the first finding of this nature and further research into the aetiology of this pattern of findings will be important for both the clinical and research domain. Given the clinical nature of the majority of research in this area it has traditionally been difficult to gather sound baseline measurement. There is also the risk of sampling biases due to possible differences in those who chose to participate in the research and those who do not. Despite the difficulty of such a study, cohort based investigation into those who suffer mTBI versus the remainder of the cohort who did not suffer mTBI would be useful in addressing this question.

The current research also suggests that longitudinal research in the area is important. The results indicate that some children may suffer on-going consequences of mTBI over 3 months after the injury. Thus, future research with longer follow-up periods will be important to understand the trajectory of any changes that may occur following mTBI in children.

The qualitative component of the current research indicated that changes in behaviour and affect were specifically reported by parents to be in the areas of fatigue, withdrawn behaviour, physical pain and oppositional/defiant behaviour. Future research using standardised measures which are sensitive to detecting subtle changes in these areas and control groups for comparison will help understand whether these are genuine changes that occur or just a product of parents' perceptions.

Future research also needs to consider the likely subgroups that are present in the population of children who suffer mTBI. Large sample sizes would be beneficial to be able to assess changes over time in both children with pre-existing problems and those who are considered to be developing normally. Larger sample sizes would also be

important for further investigate factors that are predictive of children have on-going behavioural changes versus those who are thought to make a full recovery following a mTBI.

The current study did not support the use of the BASC2 in detecting changes over time following mTBI. However, it did find that it was a useful tool in determining which children had pre-existing problems and the nature of those problems at baseline. Thus, they current research would support future research using the BASC2 for that purpose.

The Westmead PTA scale was modified in the current research as the standard daily administration is inappropriate for use with mTBI where PTA generally resolves within hours. Ponsford et al. (1999) used a similar modification reportedly successfully. This scale has a number of advantages over other scales when measuring PTA, however, further research into its use in mTBI is needed. In particular it would be beneficial to use it hourly as soon as possible after mTBI and determine whether it is able to detect at what point PTA ended in people who have suffered a mTBI. In the current research it was used approximately 24 hours after the injury. While the scale was able to show that participants were no longer in PTA, it did not give information on when exactly the child stopped being in PTA. Research of this nature may be most effectively conducted in a hospital setting. Currently in Australia it is widespread clinically practice to administer the Glasgow Coma Scale to determine severity of injury. However, a measure such as the Westmead PTA scale may be found to be more sensitive to the effects of milder TBIs.

4.6. Overall Implications and Conclusions

A number of conclusions were drawn from the current research. In summary, the BASC2 was not found to detect changes over time following a mTBI in childhood. However, it was found to be effective in differentiating between children who did and those who did not have pre-existing problems prior to the injury. In particular the BASC2 showed that children who had pre-existing problems had significantly higher levels of problematic externalising behaviours such as hyperactive, aggressive and conduct disordered behaviours than those without pre-existing problems. Children with pre-

existing problems were over-represented in the current sample in comparison to what would be expected in the general population. This finding replicates that of previous research. However, there is not yet a definitive explanation for this pattern of participation in such studies. The differences found on the behavioural rating measure at baseline were proposed to support one possible explanation. That is, the pattern of problematic externalising behaviours in the group of children with pre-existing problems may suggest that children with these problems are more likely to suffer a mTBI as these behavioural problems may make them more likely to be involved in a situation that results in a mTBI. At this stage this notion is theoretical with further research required.

While no changes over time were detected on the BASC2 there was some suggestion from the qualitative component of the research that at least some children displayed behavioural or affective changes well beyond the acute period following mTBI. There have been variable results in the previous research as to whether this is in fact the case. Reports from parents in the current study suggest that approximately half the children showed behavioural changes at 1 week post-injury and this dropped to approximately one quarter of the sample at 3 months post-injury. Due to the large decrease in sample size at the 12 month follow-up assessment the findings were harder to interpret and compare to the previous follow-up assessments. Either way, the suggestions by parents that some children were felt to display behavioural or affective changes at 3 months post-injury is notable and worthy of further investigation in a more standardised manner. The nature of the changes described by parents in the qualitative question may help inform what standardised measures may be appropriate to help answer these questions. Further, the current study highlights the distinction between 'clinically significant' behavioural problems (such as those measured by the BASC2) and 'parentally' significant behavioural changes as noticed by the parents or other carers who know the child well. The latter may not involve behavioural problems that are in the significant range on scales such as the BASC2. The behaviours may be in the 'normal' range but still represent a subtle but significant difference from pre-morbid functioning. It is an on-going challenge in this area of research to find a measure that is sensitive at detecting such subtle changes, if they do in fact occur.

While a subgroup of children were thought to be displaying problems at 3 months post-injury, the current study was unable to distinguish any factors that would predict inclusion in this group. Given the size of the sample in the current study when it was split into subgroups the number of participants in some groups was very small leading to little power to detect differences where they may have existed. Thus, conclusions were unable to be drawn as to the reason why some children were thought to have problems or changes at 3 months and not others.

Overall the present research aimed to explore behavioural and affective changes following mTBI in children. It is felt this aim was achieved with suggestion of specific characteristics of children who are more likely to suffer mTBI and possible behavioural and affective changes which can inform future research and clinical practice in the area.

References

Achenbach, T.M. (1991). *Manual for the child behavior checklist/4-18 and 1991 profile.* Burlington, VT: University of Vermont Department of Psychiatry.

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for ASEBA school-age forms & profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth & Families.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders.* (4th ed. TR). Washington, DC: American Psychiatric Association.

Anderson, V.A., Catroppa, C., Rosenfeld, J., Haritou, F., & Morse, S.A. (2000). Recovery of memory function following traumatic brain injury in pre-school children. *Brain Injury, 14,* 679-692.

Anderson, V., Catroppa, C., Morse, S., Haritou, F., & Rosenfeld, J. (2001). Outcome from mild head injury in young children: A prospective study. *Journal of Clinical and Experimental Neuropsychology, 23,* 705-717.

Anderson, V., Catroppa, C., Morse, S., Haritou, F., & Rosenfeld, J. (2005). Functional plasticity or vulnerability after early brain injury. *Pediatrics, 116,* 1374-1382.

Anderson, V., & Pentland, L. (1998). Residual attention deficits following childhood head injury: Implications for ongoing development. *Neuropsychological Rehabilitation, 8,* 283-300.

Aram, D., & Enkleman, B. (1986). Cognitive profiles of children with early onset unilateral lesions. *Developmental Neuropsychology, 2,* 255-262.

Beg, M.E., Casey, J.E., & Saunders, C.D. (2007). A typology of behavior problems in preschool children. *Assessment, 14,* 111-128.

Bigler, E.D. (2007). Anterior and middle cranial fossa in traumatic brain injury: relevant neuroanatomy and neuropathology in the study of neuropsychological outcome. *Neuropsychology, 21,* 515-531.

Boake, C., McCauley, S.R., Levin, H.S., Pedroza, C., Contant, C.F., Song, J.X., Brown, S.A., Goodman, H., Brundage, S.I., & Diaz-Marchan, P.J. (2005). Diagnostic criteria for postconcussional syndrome after mild to moderate traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neuroscience, 17,* 350-356.

Brehaut, J.C., Miller, A., Raina, P., & McGrail, K.M. (2003). Childhood behavior disorders and injuries among children and youths: a population-based study. *Pediatrics, 111,* 262-269.

Brosseau-Lachaine, O., Gagnon, I., Forget, R., & Faubert, J. (2008). Mild traumatic brain injury induces prolonged visual processing deficits in children. *Brain Injury, 22,* 657-668.

Busch, C.R., & Alpern, H.P. (1998). Depression after mild traumatic brain injury: A review of current research. *Neuropsychology Review, 8,* 95-108.

Catale, C., Marique, P., Closset, A., & Meulemans, T. (2009). Attentional and executive functioning following mild traumatic brain injury in children using the test for attentional performance (TAP) battery. *Journal of Clinical and Experimental Neuropsycholgy, 31,* 331-338.

Coetzer, B.R., Hayes, N.M., & Du Toit, P.L. (2002). Long-term employment outcomes in a rural area following traumatic brain injury. *Australian Journal of Rural Health, 10,* 229-232.

Colantonio, A., Ratcliff, G., Chase, S., Kelsey, S., Escobar, M., & Vernich, L. (2004). Long term outcomes after moderate to severe traumatic brain injury. *Disability and Rehabilitation, 26,* 253-261.

Conners, C.K. (1997). *Conners' rating scales-revised: technical manual.* North Tonawanda, NY: Multi-Health Systems.

Crouchman, M., Rossiter, L., Colaco, T., & Forsyth, R. (2001). A practical outcome scale for paediatric head injury. *Archives of Disease in Childhood, 84,* 120-124.

Donders, J., & Ballard, E. (1996). Psychological adjustment characteristics of children before and after moderate to severe traumatic brain injury. *Journal of Head Trauma Rehabilitation, 11,* 67-73.

Doyle, A., Ostrander, R., Skare, S., Crosby, R.D., & August, G.J. (1997). Convergent and criterion-related validity of the behavior assessment system for children-parent rating scale. *Journal of Clinical Child Psychology, 26,* 276-284.

Ewing-Cobbs, L., Levin, H.S., Fletcher, J.M., Miner, M.E., & Eisenberg, H.M. (1990). The children's orientation and amnesia test: relationship to severity of acute head injury and to recovery of memory. *Neurosurgery, 27,* 683-691.

Ewing-Cobbs, L., Prasad, M.R., Landry, S.H., Kramer, L., & DeLeon, R. (2004). Executive functions following traumatic brain injury in young children: a preliminary analysis. *Developmental Neuropsychology, 26,* 487-512.

Fann, J.E., Burington, B., Leonetti, A., Jaffe, K., Katon, W.J., & Thompson, R.S. (2004). Psychiatric illness following traumatic brain injury in an adult health maintenance organization population. *Archives of General Psychiatry, 61,* 53-63.

Farmer, M.Y., Singer, H.S., Mellits, E.D., Hall, D., & Charney, E. (1987). Neurobehavioral sequelae of minor head injuries in children. *Pediatric Neuroscience, 13,* 304-308.

Feinstein, A., Hershkop, S., Ouchtlerlony, D., Jardine, A., & McCullagh, S. (2002). Posttraumatic amnesia and recall of a traumatic event following traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neurosciences, 14,* 25-30.

Field, A. (2009). *Discovering statistics using SPSS.* (3rd ed.). London: SAGE.

Flanagan, R. (1995). A review of the behaviour assessment system for children (BASC): assessment consistent with the requirements of the individuals with disabilities education act (IDEA). *Journal of School Psychology, 33,* 177-186.

Fletcher, J.M., Ewing-Cobbs, L., Miner, M.E., Levin, H.S., & Eisenberg, H.M. (1990) Behavioral changes after closed head injury in children. *Journal of Consulting and Clinical Psychology, 58,* 93-98.

Fortune N., & Wen, X. (1999). *The definition, incidence and prevalence of acquired brain injury in Australia.* Canberra: Australian Institute of Health and Welfare.

Gioia, G.A., Isquith, P.K., Guy, S.C., & Kenworthy, L. (2000). *Behavior rating inventory of executive functioning: professional manual.* Lutz, FL: Psychological Assessment.

Gladman, M., & Lancaster, S. (2003). A review of the behaviour assessment system for children. *School Psychology International, 24,* 276-291.

Goldstrohm, S.L., & Arffa, S. (2005). Preschool children with mild to moderate traumatic brain injury: an exploration of immediate and post-acute morbidity. *Archives of Clinical Neuropsychology, 20,* 675-695.

Graziano, P.A., Reavis, R.D., Keane, S.P., & Calkins, S.D. (2007). The role of emotion regulation in children's early academic success. *Journal of School Psychology, 45,* 3-19.

Hauser, R.M. (1994). Measuring socioeconomic status in studies of child development. *Child Development, 65,* 1541-1545.

Hawley, C.A., Ward, A.B., Magnay, A.R., & Long, J. (2002). Children's brain injury: a postal follow-up of 525 children from one health region in the UK. *Brain Injury, 16,* 969-985.

Hawley, C.A., Ward, A.B., Magnay, A.R., & Long, J. (2004). Outcomes following childhood head injury: a population study. *Journal of Neurology, Neurosurgery and Psychiatry, 78,* 737-742.

Hess, D.W., Marwitz, J.H., & Kreutzer, J.S. (2003). Neuropsychological impairments after spinal cord injury: a comparative study with mild traumatic brain injury. *Rehabilitation Psychology, 48,* 151-156.

Jarratt, K.P., Riccio, C.A., & Siekierski, B.M. (2005). Assessment of attention deficit hyperactive disorder (ADHD) using the BASC and BRIEF. *Applied Neuropsychology, 12,* 83-93.

Jennett, B. (2002). The Glasgow coma scale: history and current practices. *Trauma, 4,* 91-103.

Jennett, B., & Bond, M. (1975). Assessment of Outcome after severe brain damage. *Lancet, 1,* 480-484.

Kaufmann, P.M., Fletcher, J.M., Levin, H.S., Miner, M.E., & Ewing-Cobbs, L. (1993). Attentional Disturbance after pediatric closed head injury. *Journal of Child Neurology, 8,* 348-353.

Kennedy, J.E., Jaffee, M.S., Leskin, G.A., Stokes, J.W., Leal, F.O., & Fitzpatrick, P.J. (2007). Posttraumatic stress disorder and posttraumatic stress disorder-like symptoms and mild traumatic brain injury. *Journal of Rehabilitation Research and Development, 44,* 895-920.

Kirkwood, M., Janusz, J., Yeates, O.K., Taylor, G.H., Wade, S.L., Stancin, T., & Drotar, D. (2000). Prevalence and correlates of depressive symptoms following traumatic brain injuries in children. *Child Neuropsychology, 6,* 195-208.

Klein, E., Caspi, Y., & Gil, S. (2003). The relation between memory of the traumatic event and PTSD: evidence from studies of traumatic brain injury. *Canadian Journal of Psychiatry, 48,* 28-33.

Krippendorff, K. (2004). *Content analysis: an introduction to its methodology.* (2nd ed.). California: Sage Publications.

Lalloo, R., Sheiham, A., & Nazroo, J.Y. (2003). Behavioural characteristics and accidents: findings from the health survey for England, 1997. *Accident Analysis and Prevention, 35,* 661-667.

Levin, H.S., & Hanten, G. (2005). Executive functions after traumatic brain injury in children. *Pediatric Neurology, 33,* 79-93.

Levin, H.S., Hanten, G., Zhang, L., Swank, P.R., Ewing-Cobbs, L., Dennis, M., Barnes, M.A., Max, J., Schachar, R., Chapman, S.B., & Hunter, J.V. (2004). Changes in working memory after traumatic brain injury in children. *Neuropsychology, 18,* 240-247.

Levin, H.S., O'Donnell, V.M., & Grossman, R.G. (1979). The Galveston orientation and amnesia test: a practical scale to assess cognition after head injury. *The Journal of Nervous and Mental Disease, 167,* 675-684.

Luis, C.A., & Mittenberg, W. (2002). Mood and anxiety disorders following pediatric traumatic brain injury: a prospective study. *Journal of Clinical and Experimental Neuropsychology, 24,* 270-279.

McCauley, S.R., & Levin, H.S. (2004). Prospective memory in pediatric traumatic brain injury: a preliminary study. *Developmental Neuropsychology, 25,* 5-20.

McGlamery, M.E., Ball, S.E., Henly, T.B., &, Besozzi, M. (2007). Theory of mind, attention, and executive function in kindergarten boys. *Emotional and Behavioural Difficulties, 12,* 29-47.

McKinlay, A., Dalrymple-Alford, J.C., Horwood, L.J., & Fergusson, D.M. (2002). Long term psychosocial outcomes after mild head injury in early childhood. *Journal of Neurology, Neurosurgery, and Psychiatry, 73,* 281-288.

McMillan, J., Beavis, A., & Jones, F.L. (2009). The AUSEI06: A new socioeconomic index for Australia. *Journal of Sociology, 45,* 123-149.

Marosszeky, N.E.V., Ryan, L., Shores, E.A., Batchelor, J., & Marosszeky, J.E. (1998). *The PTA protocol: guidelines for using the Westmead post-traumatic amnesia (PTA) scale.* Sydney: Wild & Wooley.

Massagli, T., Fann, J., Burington, B., Jaffe, K., Katon, W., & Thompson, R. (2004). Psychiatric illness after mild traumatic brain injury in children. *Archives of Physical Medicine and Rehabilitation, 85,* 1428-1434.

Mather, F.J., Tate R.L., & Hannan, T.J. (2003). Post-traumatic stress disorder in children following road traffic accidents: a comparison of those with and without mild traumatic brain injury. *Brain Injury, 17,* 1077-1087.

Mathias, J.L., Beall, J.A., & Bigler, E.D. (2004). Neuropsychological and information processing deficits following mild traumatic brain injury. *Journal of the International Neuropsychological Society, 10,* 286-297.

Mathias J.L., & Wheaton, P. (2007). Changes in attention and information-processing speed following severe traumatic brain injury: a meta-analytic review. *Neuropsychology, 21,* 212-223.

Max, J.E., Levin, H.S., Landis, J., Schachar, R., Saunders, A., Ewing-Cobbs, L., Chapman, S.B., & Dennis, M. (2005). Predictors of personality change due to traumatic brain injury in children and adolescents in the first six months after injury. *Journal of the American Academy of Child and Adolescent Psychiatry, 44,* 434-442.

Max, J.E., Levin, H.S., Schachar, R.J., Landis, J., Saunders, A.E., Ewing-Cobbs, L., Chapman, S.B., & Dennis, M. (2006). Predictors of personality change due to traumatic brain injury in children and adolescents six to twenty-four months after injury. *Journal of Neuropsychiatry and Clinical Neuroscience, 18,* 21-32.

Nakagawa, S. (2004). A farewell to Bonferroni: the problems of low statistical power and publication bias. *Behavioral Ecology, 15,* 1044-1045.

O'Connor, P. (2002). *Hospitalisation due to traumatic brain injury (TBI), Australia 1997-98. Injury research and statistics series.* Adelaide: Australian Institute of Health and Welfare.

Olsson, K.A., Le Brocque, R.M., Kenardy, J.A., Anderson, V., & Spence, S.H. (2008). The influence of pre-injury behaviour on children's type of accident, type of injury and severity of injury. *Brain Injury, 22,* 595-602.

Ommaya, A.K., & Gennarelli, T.A. (1974). Cerebral concussion and traumatic unconsciousness. *Brain, 97,* 633-654.

Ong, L.C., Chandran, V., Zasmani S., & Lye, M.S., (1998). Outcome of closed head injury in Malaysian children: Neurocognitive and behavioural sequelae. *Journal of Paediatrics and Child Health, 34,* 363-368.

Ostrander, R., Weinfurt, K.P., Yarnold, P.R., & August, G.J. (1998). Diagnosing attention deficit disorders with the behavioral assessment system for children and the child behavior checklist: test and construct validity analyses using optimal discriminant classification trees. *Journal of Consulting and Clinical Psychology, 66,* 660-672.

Pentland, L., Todd, J.A., & Anderson, V. (1998). The impact of head injury severity on planning ability in adolescence: A functional analysis. *Neuropsychological Rehabilitation, 8,* 301-317.

Petersen, C., Scherwath, A., Fink, J., & Koch, U. (2008). Health-related quality of life and psychosocial consequences after mild traumatic brain injury in children and adolescents. *Brain Injury, 22,* 215-221.

Ponsford, J., Facem, P.C., Willmott, C., Rothwell, A., Kelly, A., Nelms, R., & Ng, K. (2004). Use of the Westmead PTA scale to monitor recovery of memory function after mild head injury. *Brain Injury, 18,* 603-614.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Ayton, G., Nelms, R., Curran, C., & Ng, K.T. (1999). Cognitive and behavioural outcome following mild traumatic head injury in children. *Journal of Head Trauma Rehabilitation, 14,* 360-372.

Ponsford, J., Willmott, C., Rothwell, A., Cameron, P., Ayton, G., Nelms, R., Curran, C., & Ng, K. (2001). Impact of early intervention on outcome after mild traumatic brain injury in children. *Pediatrics, 108,* 1297-1303.

Prior, M., Kinsella, G., Sawyer, M., Bryan, D., & Anderson, V. (1994). Cognitive and psychosocial outcomes after head injury in children. *Australian Psychologist, 29,* 116-123.

Raskin S.A., & Rearick, E. (1996). Verbal fluency in individuals with mild traumatic brain injury. *Neuropsychology, 10,* 416-422.

Reynolds, C.R., & Kamphaus, R.W. (2004). *Behavior assessment system for children – second edition manual.* Circle Pines, MN: American Guidance Service Publishing.

Rowe, R., Maughan, B., & Goodman, R. (2004). Childhood psychiatric disorder and unintentional injury: findings from a national cohort study. *Journal of Pediatric Psychology, 29,* 119-130.

Ruff, R. (2005). Two decades of advances in understanding of mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 20,* 5-19.

Rush, B.K., Malec, J.F., Brown A.W., & Moessner A.M. (2006). Personality and functional outcome following traumatic brain injury. *Rehabilitation Psychology, 51,* 257-264.

Sandoval, J., & Echandia, A. (1994). Behavior assessment system for children. *Journal of School Psychology, 32,* 419-425.

Satz, P. (2001). Mild head injury in children and adolescents. *Current Directions in Psychological Science, 10,* 106-109.

Satz, P., Zaucha, K., McCleary, C., Light, R., & Asarnow, R. (1997). Mild head injury in children and adolescents: a review of studies (1970-1995). *Psychological Bulletin, 122,* 107-131.

Schwebel, D.C., Speltz, M.L., Jones, K., & Bardina, P. (2002). Unintentional injury in preschool boys with and without early onset of disruptive behaviour. *Journal of Pediatric Psychology, 27,* 727-737.

Seidman, L.J. (2006). Neuropsychological functioning in people with ADHD across the lifespan. *Clinical Psychology Review, 26,* 466-485.

Shores, A.E., Marosszeky, J.E., Sandanam, J., & Batchelor, J. (1986). Preliminary validation of a clinical scale for measuring the duration of post-traumatic amnesia. *The Medical Journal of Australia, 144,* 569-572.

Silver, J.M., McAllister, T.W., & Yudofsky, S.C. (2005). *Textbook of traumatic brain injury.* Virginia: American Psychiatric Publishing, Inc.

Skoglund, T.S., & Nellgard, B. (2005). Long-term outcome after transient transtentorial herniation in patients with traumatic brain injury. *Acta Anaesthesiologica Scandinavica, 49,* 337-340.

Sparrow, S.S., Balla, D.A., & Cicchetti, D.V. (1984). *Vineland adaptive behaviour scales.* Circle Pines, MN: American Guidance Service.

Steele, R.G., Richards, M.M., Benson, E.R., Corbin, S.R., & Cushing, C.C. (2008). Repressive adaption in a nonclinical sample: consistent and inconsistent reports of child psychosocial functioning across informants. *Journal of Personality Assessment, 90,* 286-291.

Strauss, E., Sherman, E.M.S., & Spreen, O. (2006). *A compendium of neuropsychological tests: administration, norms and commentary.* New York: Oxford University Press.

Sullivan, K.A., & Garden, N. (2009, October). *Base rates of post-concussion symptoms in an Australian sample.* Paper presented at the 15th Annual College of Clinical Neuropsychologists Conference, Melbourne, Victoria.

Symonds, C.P. (1928). Differential diagnosis and treatment of cerebral states consequent upon head injuries. *British Medical Journal, 2,* 829-832.

Taylor H.G., & Alden, J. (1997). Age-related differences in outcomes following childhood brain insults: an introduction and overview. *Journal of the International Neuropsychological Society, 3,* 555-567.

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. A practical scale. *Lancet, 2,* 81-84.

Vakil, E. (2005). The effect of moderate to severe traumatic brain injury (TBI) on different aspects of memory: a selective review. *Journal of Clinical and Experimental Neuropsychology, 27,* 977-1021.

Veiel, H.O.F. (1997). A preliminary profile of neuropsychological deficits associated with major depression. *Journal of Clinical and Experimental Neuropsychology, 19,* 587-603.

Wechsler, D. (1999). *Wechsler abbreviated scale of intelligence (WASI).* San Antonio, TX: Harcourt Assessment.

Willer, B., & Leddy, J.L. (2006). Management of concussion and post-concussion syndrome. *Current Treatment Options in Neurology, 8,* 415-426.

Willmott, C., Anderson, V., & Anderson, P. (2000). Attention following pediatric head injury: a developmental perspective. *Developmental Neuropsychology, 17,* 361-379.

World Health Organisation. (1992). *The ICD-10 classification of mental and behavioural disorders: clinical description and diagnostic guidelines.* Geneva: World Health Organisation.

Yeates, K.O., Swift, E., Taylor, G., Wade, S.L., Drotar, D., Stancin, T., & Minich, N. (2004). Short- and long-term social outcomes following pediatric traumatic brain injury. *Journal of the International Neuropsychological Society, 10,* 412-426.

Appendix A:

Behavioural Assessment System for Children, 2nd Edition (BASC2), Parent Rating Form (6-11 and 12-21 Years Old): Illustrative Example Statements

BASC2 Example Questions

Due to copyright concerns the full BASC2 form was not included as an appendix. Example statements from each of the index scales for each of the forms used in the current research are in included below.

Parent Rating Scale – Child Aged 6-11 years:

Hyperactivity: "Is overly active"
Aggression: "Hits other children"
Conduct Problems: "Breaks the rules"
Anxiety: "Worries about things that cannot be changed"
Depression: "Is sad"
Somatization: "Complains of pain"
Atypicality: "Acts as if other children are not there"
Withdrawal: "Avoids competing with other children"
Attention Problems: "Is easily distracted"
Adaptability: "Adjusts well to new teachers"
Social Skills: "Offers help to other children"
Leadership: "Will speak up if the situation calls for it"
Activities of Daily Living: "Needs to be reminded to brush teeth"
Functional Communication: "Answers telephone properly"

Parent Rating Scale – Adolescent Aged 12-21 years:

Hyperactivity: "Disrupts other adolescents' activities"
Aggression: "Hits other adolescents"
Conduct Problems: "Breaks the rules"
Anxiety: "Is nervous"
Depression: "Is sad"

Somatization: "Complains about health"

Atypicality: "Acts strangely"

Withdrawal: "Avoids other adolescents"

Attention Problems: "Is easily distracted"

Adaptability: "Adjusts well to changes in plans"

Social Skills: "Offers help to other adolescents"

Leadership: "Is good at getting people to work together"

Activities of Daily Living: "Picks out clothes that match the weather"

Functional Communication: "Answers telephone properly"

Appendix B:

Parent Background History Interview

Interview with Parents

Childs Name: _____

Gender: F M Telephone No: _____

Grade: _____ School: _____

Age: _____ DOB: _____

Parents Names: _____

Developmental milestones: when did your child start: -

Walking: _____

Speaking two word combinations:

_____
_____

Does your child have a history of any significant medical condition(s)?

YES NO

If yes, please specify?

_____
_____
_____
_____

Is your child on any medication (s)?

_____
_____
_____
_____

Parents Occupation

_____
_____
_____
_____
_____

Discuss any pre-existing behavioural or attentional problems present before the injury. (Present at home or at school)

Appendix C:

Plain Language Statement – Parent

VICTORIA UNIVERSITY | A NEW SCHOOL OF THOUGHT

St Albans Campus (Building 3)
Mc Kechnie Street
ST ALBANS
MELBOURNE VIC 8001

THE NORTHERN HOSPITAL

185 Cooper Street, Epping Vic. 3076
Telephone 03 8405 8000
Facsimile 03 8405 8524
www.nh.org.au

Victoria University
Invitation to Participate in a Research Study – mTBI Parent Form
Cognitive, behavioural and affective outcomes following head injuries study

We would like to invite you and your child to be part of a study on the impact of a mild head injury on how children think, feel and behave. There is not much research in to how, if at all, children are affected by a mild head injury. It is important to understand whether a head injury impacts on children's future in order to determine whether extra support and interventions may be beneficial.

Participants in this study will be asked to complete a few tests of their memory, ability to process information and complex thinking abilities. The tests will involve the participant responding to both verbal and visual information that is presented by a researcher. Examples of such tests include asking a person to remember one thing while at the same time asking them to think about something else. Another example would be to ask children to think of as many things in a category as they can within 60 seconds, and then asking them to order the items according to their size and in alphabetical order. These tests are widely used in research and are appropriate for different age groups. These tests are not normally considered stressful. The parent/guardian of the child will be asked to answer some questions about the child's behaviour and feelings. Most of the questions will be rated on a scale of 4 choices and some questions may request a more detailed response.

Initial testing will take place soon after the injury has occurred; at this point the severity of the injury will be assessed and you will be asked to complete a questionnaire about your child's behaviour, mood and basic background information. A second session will occur approximately 1 week following the injury. This session will involve the child participating in a number of tests and yourself completing another questionnaire about your child's behaviour since the injury. Further sessions of the same nature will occur 3 months and 12 months following the injury.

The above-mentioned tests offer an additional evaluation of cognitive functioning (i.e. information processing) to the standard evaluation performed by the emergency physician. These tests results may appear to be different from the information received at the time of the injury, however they reflect the assessment of information processing rather then sensory and motor function.

Testing will be conducted in either the Victoria University Psychology Clinic which is located at the Victoria University campus in McKechnie Street, St Albans, or at your

daughter/sons School (if the school is agreeable and a suitable space is available), in a quiet room of your home, or at the Northern Hospital. Actual testing will take approximately 30 minutes for the first session and up to 1 hour for the subsequent sessions, and short breaks can be included within the testing process if needed. We recognise that you as parents may have a very busy schedule and that this may make extra demands on your time. Therefore, the location and time of testing will be discussed with you.

Feedback on your child at the time of each assessment as well as group outcomes of the study at the end of the study will be provided to parents. Feedback on your child at the time of the 3 month follow-up as well as group outcomes of the study at the end of the study will be provided to any parent (s) upon request. If any significant problems were detected earlier you would be informed of these as soon as possible and offered a referral for a full neuropsychological assessment or to a suitable medical practitioner.. All test results obtained from this study will be kept completely confidential. Your child's participation in this study is voluntary, and you may withdraw your child from the study at any given time without any loss or penalty. If a child becomes clearly anxious during testing or otherwise indicates a desire to stop then testing would be discontinued immediately and the child would be debriefed. You will be informed of the incident and offered the opportunity for referral to a suitable agency for example the Victoria University Psychology Clinic; telephone Dr Alan Tucker 9919-2266.

Parents who are willing to let their child participate in the current study need to complete the consent form attached and return it in the reply paid envelope provided. If you have any questions regarding the study, please do not hesitate to contact Dr Alan Tucker, Miss Joanne Yacoub or Miss Ann Sloan on 9919 2266

Thank-you for taking the time to read this information. We look forward to hearing from parents who agree to let their child participate.

Yours sincerely,

Joanne Yacoub, and Ann Sloan and Alan Tucker (supervisor, principal investigator)

Any queries about your participation in this project may be directed to the research supervisor (Dr. Alan Tucker, ph. 9919 2266). If you have any queries or complaints about the way your daughter/son has been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University, PO Box 14428 MCMC, Melbourne, 8001 (telephone no: 03-9688 4710

Appendix D:

Plain Language Statement – Children

Victoria University
School of Psychology

Invitation for Children Who Have Had a Head Injury to Take Part in a Research Study

Higher Order Cognition, Behaviour and Affect in Children Following Mild Traumatic Brain Injury

We would like to invite you to be part of a project that looks at how well young people can think, behave and remember things after hurting their head in an accident. There are a number of different areas of thinking, behaviour and memory we can look at, and a number of different ways we can test these areas. For example, one way is to ask you to remember one thing while at the same time asking you to think about something else. Another way is to ask your parents how you act at home and school.

For our project we would like to ask you to do some short tests, but these tests are not like school tests. You would be asked to do these tests a few times. Some of the tests we'll be asking you to do might be too easy for someone your age, and it is important to know that in some tests it may be hard for someone your age to get all of the items correct. All we want you to do is try your best on each of these tests.

If you agree to take part in this research study and then decide that you don't want to anymore (for whatever reason) you can tell either me or your parents. Also if you become worried during testing or don't want to finish the tests, we will stop the testing straight away. If you are still worried after testing you can talk to your parents or me about contacting the Victoria University Psychology Clinic by calling Dr Alan Tucker 9919-2266.

Thank-you for your time, if you have any questions about our project please ask me

If you agree to take part in my project talk to your parents about it first and they will let me know

Thank-You

Joanne Yacoub and Ann Sloan

Any queries about your participation in this project may be directed to the research supervisor (Dr. Alan Tucker, ph. 9919 2266). If you have any queries or complaints about the way your daughter/son has been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University, PO Box 14428 MCMC, Melbourne, 8001 (telephone no: 03-9688 4710

Appendix E:

Consent Form

Victoria University

Consent Form for Parents

RESEARCH STUDY

Higher Order Cognition, Behaviour and Affect in Children Following Mild Traumatic Brain Injury

I .....as

Parent/Guardian of .....give my

permission for my child to participate in the research study.

I have read and understood the information provided by the researcher and I believe that I have been fully informed about this research study. I also understand that I am free to withdraw my child from the research study at any time and that this withdrawal will not jeopardise him/her in any way

I have been informed that any information provided by me or my child will be kept confidential

Signed:.....Date:.....

Witness:.....

Please provide a telephone number where you can be reached so that a time can be arranged for testing to take place:.....

Any queries about your participation in this project may be directed to the research supervisor (Dr. Alan Tucker, ph. 9919 2266). If you have any queries or complaints about the way your daughter/son has been treated, you may contact the Secretary, University Human Research Ethics Committee, Victoria University, PO Box 14428 MCMC, Melbourne, 8001 (telephone no: 03-9688 4710).

Appendix F:

Ethics Approval

VICTORIA UNIVERSITY | A NEW SCHOOL OF THOUGHT

MEMO

TO Dr. Alan Tucker
School of Psychology
St. Albans Campus

DATE 02/04/2007

FROM Professor Michael Polonsky
Chair
Victoria University Human Research Ethics Committee

SUBJECT Ethics Application - HRETH06/157

Dear Dr. Alan Tucker,

Thank you for attending the February VUHREC meeting and re-submitting this application for ethical approval of the project:

HRETH 06/157 Higher Order Cognition, Behaviour and Affect in Children Following Mild Traumatic Brain Injury

The proposed research project has been accepted by the Chair, Victoria University Human Research Ethics Committee and approval for this application has been granted from 2 April 2007 to 2 April 2009.

Please note that the Human Research Ethics Committee must be informed of the following: any changes to the approved research protocol, project timelines, any serious or unexpected adverse effects on participants, and unforeseen events that may effect continued ethical acceptability of the project. In these unlikely events, researchers must immediately cease all data collection until the Committee has approved the changes.

Continued approval of this research project by the Victoria University Human Research Ethics Committee (VUHREC) is conditional upon the provision of a report within 12 months of the above approval date (by **2 April 2008**) or upon the completion of the project (if earlier). A report proforma may be downloaded from the VUHREC web site at: http://research.vu.edu.au/hrec.php

If you have any queries, please do not hesitate to contact me on 9919 4625.

On behalf of the Committee, I wish you all the best for the conduct of the project.

Professor Michael Polonsky
Chair
Victoria University Human Research Ethics Committee

THE NORTHERN HOSPITAL

Northern Health

November 29, 2006

Dr Alan Tucker
Senior Lecturer
School of Psychology
Victoria University
P.O. Box 14428
MELBOURNE CITY MC 8001

Dear Dr Tucker,

RE : 19/06 "Higher Order Cognition, Behaviour and Affect in Children Following Mild Traumatic Brain Injury"

Thank you for your letter dated November 2, 2006 in which you clarified The Northern Hospital HREC's queries relating to the subject Study.

The Northern Hospital HREC at its meeting on November 28, 2006 has now ratified the subject study until April 2008.

To enable the Committee to fulfil its obligations in relation to monitoring the program, you are asked to provide a report within 12 months or on completion of your project whichever is earlier.

You must also inform The Northern Hospital Human Research and Ethics Committee immediately of any matter, which arises that, may affect the nature of the approved program. Should you require any further assistance please do not hesitate to contact Cheryle Williams, Secretary HREC on 8405 8018.

Yours sincerely,

Robert Burnham
EXECUTIVE DIRECTOR OF CLINICAL OPERATIONS/
CHIEF NURSING OFFICER
NORTHERN HEALTH