Social Competence and Executive Functioning in Adolescents Following a Mild Traumatic Brain Injury

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Abstract

A traumatic brain injury (TBI) is one of the most common injuries sustained by adolescents and a leading cause of death and long-term disability. The vast majority of these cases are mild and yet they can cause a range of difficulties across multiple domains which can negatively impact upon a person's social functioning. The aim of this study was to determine whether adolescents who have sustained a mild TBI would differ from their uninjured peers in regards to social competence. A secondary aim was to investigate whether there was a relationship between an adolescent's level of social competence and their executive functioning abilities.

This investigation involved a population-based sample of 30 young adolescents who had sustained a mild TBI between the age of 12 and 15 years. Parental and/or self-report ratings of behaviour and executive function, as well as a performance-based measure of cognition were explored at 12 months post-injury. These adolescents were then compared to a community recruited, age-matched sample of their TBI-free peers.

A composite scale of social competence based on observable behaviours was formulated. The results showed adolescents with a mild TBI demonstrated greater difficulties with socially competent behaviours compared to their uninjured peers. These difficulties were found to centre around aspect of their behavioural functioning, particularly regarding their regulation and inhibition of behaviour. Higher levels of dysfunction in the mild TBI sample were also found for parental ratings of behaviours associated with executive functions. A relationship between the Social Competence Index and executive function was not found. However, a relationship between the Social Competence Index and composite measures of cognitive functioning was. Suggesting there are more cognitions behind socially competent behaviour than the domain of executive functions alone. These findings highlight the need for post-injury screening for behavioural and social difficulties, with interventions implemented as required, to reduce the risk of on-going social impairment.

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Social Competence and Executive Functioning in Adolescents following a Mild Traumatic Brain Injury

Traumatic brain injuries (TBI) are one of the most commonly diagnosed forms of injury sustained by children and young adults, and a leading cause of death and long-term disability in people under the age of 25 years (Langlois-Orman, Kraus, Zaloshnja, & Miller, 2011; Langlois, Rutland-Brown, & Wald, 2006). This form of injury is defined by the World Health Organization (WHO) as an alteration to brain function or other evidence of brain pathology arising from a mechanical blow to the head from an external force (Borg et al., 2004). The diagnostic criteria for a TBI includes one or more of the following symptoms following a blow to the head: (1) confusion or disorientation; (2) loss of consciousness; (3) post-traumatic amnesia; (4) or other neurological abnormalities; such as, difficulties focusing, seizures, or intracranial lesions. Furthermore, TBI severity can be divided into mild, moderate, or severe sub-groups based upon scores from the Glasgow Coma Scale, and the length of loss of consciousness and/or post-traumatic amnesia. A generally accepted example of this classification is that a person who has sustained a head injury, may be classed as having a mild TBI if they have no more than 30 minutes of loss of consciousness and/or 24 hours of post-traumatic amnesia, and if used, a Glasgow Coma Scale score of between 13-15 points (Borg et al., 2004).

These diagnostic severity ratings are important as they can be used to determine a patient's prognosis and guide the use of diagnostic tests that will help to dictate a management programme that best suits the patient's long-term rehabilitation needs. Not surprisingly, studies have shown that the higher the severity rating the greater the degree of disability (Anderson, Godfrey, Rosenfeld, & Catroppa, 2012; Brener, Harman, Kelleher, & Yeates, 2004; Fay et al., 2009). However, even a mild TBI can result in long-term deficits and the ramifications of these deficits are often underestimated, because many mild TBI survivors do not seek medical attention (Cassidy et al., 2004; Hyder, Wunderlich, Puvanachandra, Gururaj, & Kobusingye, 2007). Furthermore, as many of these cognitive, emotional, social, and behavioural

deficits and difficulties are often not outwardly visible and immediately apparent, TBI has been referred to as the 'Invisible Epidemic' (Rutland-Brown, Langlois, Thomas, & Lily, 2006). However, given the global incidence of this form of injury, it may be argued that TBI is of pandemic proportions.

Epidemiology

The scope of this problem is illustrated in a global review that estimated approximately 10 million people are killed or hospitalised each year as a result of a TBI. Of these cases it was reported that: road traffic accidents were the most common cause (62%), followed by acts of violence (24%), and then falls (8%) (Hyder et al., 2007). Currently, TBI is among the top 15 causes of death in people under the age of 60 years and predictions suggest that it will become the third largest global disease burden by 2020 (Lancet, 2010). Unfortunately, it may be argued that these figures are only a conservative estimate of the true global burden. This is because statistics on the incidences in many low-income countries are unavailable (Gururaj, 2008). Furthermore, high rates of road traffic injuries, sectarian violence, larger numbers of young people in the population, and poor infrastructure all combine to create a high-risk environment for TBI in these countries (Hyder et al., 2007).

International Trends in TBI. Data from individual countries may provide us with a snap shot into this global burden. In the United States (U.S.), an estimated 1.5 million people sustain a TBI each year; including 1.2 million emergency department visits, 290,000 hospitalizations, and 51,000 deaths (Rutland-Brown et al., 2006). This equates to a rate of 576.8 per 100,000 people who will suffer a head injury each year. It has also been estimated that 5.3 million U.S. citizens live with a TBI related disability and that the economic cost of these injuries is approximately 406 billion U.S. dollars (Corso, Finkelstein, Miller, Fiebelkorn, & Zaloshnja, 2006; Langlois-Orman et al., 2011; Langlois et al., 2006).

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In Europe, a German research article reported an annual TBI incidence rate of 350 people per 100,000 and a mortality rate of 11.5 per 100,000. Interestingly, this study also noted that of these deaths approximately 68% died before arriving at hospital and that the leading cause of TBI mortality in Germany was motor vehicle accidents (Firsching & Woischneck, 2001).

Closer to home, a retrospective study in South Australia reported the TBI incidence at 322 per 100,000 people annually. This study also found that young males living in rural areas and working in manual trades showed the highest incidence and were most likely to have sustained their TBI in a motor vehicle accident (Hillier, Hiller, & Metzer, 1997).

Unfortunately, these statistics generally rely solely on hospital admissions, which can seriously underestimate the true extent of TBI, due to the fact that approximately 70-90% of all TBI are classified as mild and only a small proportion of people with mild TBI are admitted to hospital. For this reason the true population-based TBI incidence has been estimated at above 600 per 100,000 people annually (Cassidy et al., 2004).

New Zealand Trends in TBI. Here in New Zealand, a hospital-based study estimated that the total population incidence of TBI ranged between 226.9 per 100,000 people over a full year between 1997 and 1998, and 342 per 100,000 people between 2003 and 2004 (Barker-Collo, Wilde, & Feigin, 2009). These figures suggest that the rate of TBI is on the increase. Furthermore, these rates were not found to be uniform across different populations. Specifically, the annual hospital-based TBI incidence for males and females within the indigenous *Māori* population were 689 per 100,000 and 302.8 per 100,000 people respectively; and for male and female *Pasifika* people living in New Zealand, the rates were 582.6 per 100,000 and 217.6 per 100,000 respectively. These figures were much higher than those found for the remaining population, which had a male/female incidence of 435.4 per 100,000 and 200.9 per 100,000 people per year (Barker-Collo et al., 2009). These authors report that in New Zealand there are an estimated 20,000 to 30,000 new cases of mild TBI and 2,000 to

3,000 new cases of moderate to severe TBI annually, and that this equates to an estimated annual health care cost of between 69 million and 103 million New Zealand dollars.

Further adding to these New Zealand statistics, is a birth cohort study of participants under the age of 25 years. This retrospective study found the average annual rate of TBI to be between 1100 and 2360 per 100,000 young people. They also found that, within their sample approximately 38% of males and 24% of females had experienced at least one TBI (McKinlay et al., 2008).

Recently, a large New Zealand population-based study was conducted to address the limitations of hospital-based studies, which tend to overlook mild TBI cases that are not admitted to hospital. In this world leading study, Feigin et al. (2012) investigated the incidence of TBI across the entire severity spectrum, in all age groups, and in both urban and rural populations. These researchers discovered an annual TBI incidence of 790 per 100,000 people, a rate substantially greater than the other aforementioned international findings. The incidence of mild TBI was also found to be higher than international estimates, at 95% of all cases.

Furthermore, 70% of all these cases were sustained by individuals under the age of 35 years and the most common causes of TBI were falls (38%), mechanical forces (21%), and transport accidents (20%), followed by assaults (17%). Not surprisingly, falls were more often the cause of TBI in children under the age of 14 years, whereas transport accidents and assaults were the predominant causes in young adults aged between 15 and 34 years. Interestingly, the authors report that there was a greater risk of moderate to severe TBI in rural rather than urban populations and they surmise that this may be due to the higher incidence of transport accidents within rural communities. Consistent with previous research was the finding that males sustained a greater proportion of TBI than females and that people of *Māori* ethnicity sustained a TBI more often than people of European descent (Feigin et al., 2012).

Aetiology and Risk Factors

These New Zealand studies confirm international trends in that the risk of sustaining a head injury is highest between 15 and 24 years of age, with smaller incidence peaks for the very young (< 5 years) and the very old (> 75 years) (Rutland-Brown et al., 2006). The most common cause of injury is falls for the very young and the very old, and traffic related injuries, be they motor vehicle, cyclist, or pedestrian, for young adults aged between 15 and 25 years (Falk, 2010; Langlois et al., 2006). Also consistent with international trends was the finding that gender ratios of TBI varied with age. These findings showed that in young children under the age of 5 years, the incidence by gender were fairly similar; however, after this point the TBI incidence tends to increase faster in males, resulting in an incidence ratio of approximately double that found in females by adolescence (1.6 female / 2.8 male) (Barker-Collo et al., 2009; Cassidy et al., 2004). This higher incidence of TBI in young adult males is thought to be partially attributed to their increased rates of risk-taking behaviour, which is reflected in the high rates of motor vehicle accidents involving this sector of the population (Gururaj, 2008).

Costs of TBI

This form of injury can have enormous personal, social, and economic consequences; including, difficulties with initiating and maintaining social relationships, community integration, and vocational opportunities, which can all have a negative impact upon an individual's quality of life (Anderson et al., 2012; Greenham, Spencer-Smith, Anderson, Coleman, & Anderson, 2010; Limond, Dorris, & McMillan, 2009; Petersen, Scherwath, Fink, & Koch, 2008; van Velzen, van Bennekom, Edelaar, Sluiter, & Frings-Dresen, 2009). Furthermore, these repercussions not only affect the survivor but could also have a detrimental effect upon the survivor's family, friends, and their community (Aitken et al., 2009; Brener et al., 2004; Ganesalingam et al., 2008; Yeates et al., 2013). It should also be mentioned that, while most individuals do make a full recovery from a mild TBI, this population is at an increased risk of developing a range of cognitive, emotional, and behavioural problems and difficulties

(Bloom et al., 2001; Gerrard-Morris et al., 2010; Massagli et al., 2004; Vu, Babikian, & Asarnow, 2011). More specifically in children, these TBI related psychosocial and behavioural difficulties are frequently associated with parental stress, family turmoil, disrupted peer relations, and difficulties at school (Aitken et al., 2009; Dooley, Anderson, Hemphill, & Ohan, 2008; Ganesalingam et al., 2008).

These outcomes equate to TBI being a major New Zealand public health concern as well as internationally. These concerns inspired the WHO to commission a task force to review the international trends of this seemingly invisible pandemic and in their conclusions they called for more high quality research that would enable accurate planning for primary healthcare services and positively inform and direct prevention programmes (Cassidy et al., 2004).

This international call has inspired a flurry of valuable research in recent times and as a result the impact of paediatric TBI has been fairly well documented, especially in children with moderate and severe TBI classifications, within the domains of cognition and academic achievement, as well as behavioural and psychiatric sequelae (Chapman et al., 2010; Fulton, Yeates, Taylor, Walz, & Wade, 2012; Gerrard-Morris et al., 2010; Massagli et al., 2004). While these domains have been relatively well examined, much less is known about the consequences of a mild TBI. Particularly, as there has been little investigation into the consequences during adolescence in terms of their psychosocial functioning, the impact that a mild TBI may have on a person's social competence and the short- and long-term implications of poor social functioning on an individual's quality of life.

Social Skills and TBI

Despite this gap in the research, current studies tentatively suggest that the consequences of a childhood TBI may be more detrimental than in adult populations, as this form of injury can negatively impact upon a child's previously acquired skills, inhibiting their learning of new skills, and adversely influencing their attainment of developmental milestones (Karver et al., 2012; Schwartz et al., 2003). What is also

concerning, is the observation that these consequences of a TBI may not become apparent until some years after the injury (Fay et al., 2009). Furthermore, adolescent survivors of a TBI may be especially vulnerable to on-going psychosocial and behavioural difficulties due to the timing of their injury, which may create cognitive and/or neural abnormalities at a time in their development when critical social skills are being learned and honed (Taylor, Barker, Heavey, & McHale, 2012). The acquisition of positive social abilities throughout our development is hugely important to us as a social species. These learned social skills and the social interactions that they drive are fundamental to the way in which we experience our world, and a great deal of our cognitive processes and behavioural activities are dedicated to this domain (Rubin, Schulz-Begle, & McDonald, 2012). Social skills emerge gradually and are honed by the ever changing interplay between an individual and their environment; they dictate a person's ability to develop and maintain lasting relationships, as well as their ability to positively interact and function within their community (Burnett-Heyes, Sebastian, & Cohen-Kadosh, 2012; Taylor et al., 2012). Disruptions to these critical skills can cause psychological distress resulting in social withdrawal and isolation, along with reduced levels of self-esteem and self-worth (Yeates et al., 2007; Yeates et al., 2002). The consequences of these poor social skills can also have a lasting negative impact upon a person's quality of life (Limond et al., 2009; Stancin et al., 2002).

Disruptions to the development of social skills tend to occur through cognitive deficits which can cause behaviours that violate social norms, resulting in stigma, social restrictions, and a scarcity of social opportunities (Taylor et al., 2012). Individuals who have survived a TBI are particularly prone to disruptions to the acquisition of these skills (Levin, Hanten, & Li, 2009; Ross, McMillan, Kelly, Sumpter, & Dorris, 2011). This viewpoint is substantiated by adult TBI research that shows elevated rates of social isolation, poorer psychological adjustment, and a poorer quality of life following a head injury at a younger age (Yeates et al., 2004). These findings suggest that if left untreated psychosocial and behavioural problems acquired as a result of a childhood or adolescent TBI may persist well into later adult life.

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Definition of Social Concepts

Social functioning is a broad term denoting a person's overall performance within their social world and is based upon the social skills that dictate positive interactions (Greenham et al., 2010). Social skills refer to a person's cognitive abilities as well as the verbal and non-verbal communication skills that are necessary to engage in appropriate social behaviour and positive interactions (Yager & Ehmann, 2006). These skills include the ability to correctly interpret relevant and useful information within a social context, to use this information to decide upon socially competent goal-directed behaviours and to engage in verbal and non-verbal behaviours that maximize the likelihood of achieving these goals (Beauchamp & Anderson, 2010).

Social competence is a major contributor to a person's social skills repertoire and an important component of social functioning. This specific competence involves the ability to co-ordinate cognitive and behavioural resources to meet the social expectations of others while achieving one's own social goals (Iarocci, Yager, & Elfers, 2007). Social competence can then be defined as the ability to achieve personal goals within social interactions, while at the same time maintaining a positive relationship with others over time and across situations (Rubin & Krasnor, 1986). This definition captures many of the important components of social competence, and reflects it as a developmentally influenced learnt skill that is dependent upon both the timing of the exchange and the context that surrounds this exchange. It also highlights the complex, reciprocal nature of this goal-driven exchange at both an individual or group level, as well as recognizing the purpose behind the exchange, which is to achieve personal goals while maintaining positive group relations. This definition encompasses the function of most social behaviours; in that, they are mostly goal driven and involve socially acceptable strategies for achieving these goals, also most of these strategies can be observed and judged as being either successful or not. This means that social competence may be considered an observable form of behaviour that is measureable.

Development of Social Competence

Learned skills, such as social competence are culturally bound, emerge gradually throughout the developmental stages of childhood and adolescence, and are critical for developing lasting relationships and for participating within one's social environment (Beauchamp & Anderson, 2010). A child's social learning during their early development is generally limited to their family's social environment. Parents who respond in warm, sensitive, and responsive ways to their young child's needs will foster children who develop secure attachments in the first years of life and consequently go on to develop competent social relationships with others throughout their life course (for more information on attachment theory see Bowlby, 1979).

A child's refinement of socially competent behaviours can be compromised by environmental factors; such as, social disadvantage, environmental deprivation, and parental psychopathology (Rubin et al., 2012). Familial socio-economic status (SES) is one environmental factor that is influential in a child's social development. Low SES has been related to the lower frequency and poorer quality of social interactions and opportunities. These children often live in high density housing environments in high crime neighbourhoods that have limited access to safe play areas and positive role models (Ellaway, Kirk, Macintyre, & Mutrie, 2007). Socially disadvantaged children may be at risk of experiencing an environment that has limited exposure to stimulating social opportunities. Low SES and social disadvantage have consequently been associated with poor school adjustment and problematic peer relations (Ackerman & Brown, 2006).

These influential factors in the development of social competence are inexplicably bound within a cultural context. A person's culture permeates every aspect of their life; it dictates how they behave in particular circumstances, the social norms and rules that govern their lives, even their spiritual beliefs and the ways in which they look upon the world (Saltapidas & Ponsford, 2008). Deviations from the dominant cultural norms are often swiftly reprimanded and this is highlighted in the differing prevalence rates of social problems between the dominant and non-

dominant cultures, illustrating cross cultural influences in the recognition, diagnosis, and reporting of social problems (Rapee & Spence, 2004; Saltapidas & Ponsford, 2008).

This gradual and accumulative socialisation process, whereby a child learns and internalises the cultural rules of socially competent behaviour has been referred to as the socialisation of social competence (Rubin et al., 2012). Internalisation refers to the process of mentally absorbing the messages and rules of socialisation, interpreting and evaluating these rules, before deciding upon whether or not to include them within an existing behavioural repertoire of skills. This process of socialisation is an ever-changing two-way street, as it is both a dynamic and bi-directional process. Not only does the child internalize these cultural rules, but through their behaviours they also influence their social partners and over time, mould the beliefs and behaviours of those partners (Rubin et al., 2012).

As the child matures and enters adolescence, peer relationships outside the family environment become more influential (Rubin et al., 2004). Parents need to allow their child to achieve their own sense of autonomy and explore their newly formed identity while at the same time maintain a bond with their child. Those parents who talk to their adolescent children about peer behaviour, give valuable advice when there are difficulties, and allow a sense of autonomy while at the same time keeping track of where their child is and with whom they are interacting, are more likely to foster a socially competent youth. That youth is more likely to report higher quality peer relations, with less conflict and less engagement in risk-taking behaviours (Allen, Hauser, Eickholt, Bell, & Oconnor, 1994; Rubin et al., 2004).

Adolescence is a developmental stage of particular importance for the acquisition of social competence, as it is a stage marked by significant neuro-structural development, in which the adolescent brain undergoes structural changes to regions that have been associated with social cognition and social problem-solving (De Luca & Leventer, 2008). These changes include a decrease in the amount of grey matter and an increase in the volume of white matter within the frontal and parietal cortices (Casey, Galvan, & Hare, 2005). At the same time, the adolescent is undergoing biological and environmental changes that in typical development results in an

increase in personal independence and peer group activities, with a primary focus on friendships and relationships (Rubin et al., 2004). Adolescence is a time of transition; it is a bridge between childhood and adulthood with a progression out from under the parental wing in an attempt to establish one's own personal identity. The ability to behave in a socially competent manner can ease this transition and contribute towards a person's personal and social identity.

This concept of identity formation and its association with social competence is consistent with Erikson's developmental stages of life model, in that the development of social competence evolves gradually throughout childhood and reaches a point in adolescence when it becomes an important contributor towards an individual's social identity and sense of self. Erikson (1968) contends that from approximately the age of 11 years through to the end of adolescence the main task of a person is to develop a sense of identity. Identity may be defined as the traits that establish just who a person is, where they are going, and where they fit within their societal niche. Identity incorporates a sense of inner peace with the ideas and values of the social group. Failure to negotiate this stage can leave an adolescent without a solid sense of self that may result in confusion about one's place in the world. Erikson called this an identity crises or role confusion, which may present itself in dysfunctional behaviours, such as violence, law breaking, or psychosocial difficulties (Erikson, 1968; Kaplan, Sadock, & Grebb, 1994).

Social competence in childhood incorporates a variety of behaviours that support interpersonal functioning, and are reflected in positive interpersonal exchanges and relationships (Burnett-Heyes et al., 2012). These include emotional and behaviour self-regulation (Ganesalingam, Sanson, Anderson, & Yeates, 2006; Ganesalingam, Yeates, Sanson, & Anderson, 2007); reciprocal perspective taking within interpersonal exchanges (Bornhofen & McDonald, 2008; McLellan & McKinlay, 2013); being assertive rather than aggressive (Dooley et al., 2008); demonstrating pro-social behaviours, such as helpfulness, empathy, and understanding (Scourfield, John, Martin, & McGuffin, 2004); and social skills such as successful group entry, pragmatic communication skills, the ability to work in a dyadic or team environment, social problem solving, and the resolution of conflict (Rubin et al., 2012). When a child

behaves in a socially competent manner, there is an increase in feelings of satisfaction and well-being within themselves and their social partners, and a generation of trust and affection within their social environment (Muscara, Catroppa, & Anderson, 2008b; Rubin et al., 2012)

The cognitive processes involved in the interpretation of social information underpin many of the behavioural skills necessary for interaction in a socially competent manner. This process is referred to as social cognition and has been defined as, "the mental operations underlying social interactions" and is thought to represent a, "specialized domain of cognition developed to solve social, adaptive problems" (Penn, Corrigan, Bentall, Racenstein, & Newman, 1997, p. 115). Social problem-solving abilities can involve an array of cognitive processes, including the interpretation of subtle cues and the generation of alternative solutions. This ability to generate alternative non-aggressive solutions to social problems may be considered an important aspect of social information processing and is therefore a central factor contributing to social competence and social functioning (Crick & Dodge, 1994).

Cognitive difficulties with social information processing such as cognitive inflexibility and difficulties with reasoning or concept formations, can negatively impact upon a person's ability to reason and resolve problems in social situations. This may then impede their ability to interact socially and adapt to new social situations (Muscara et al., 2008b). Consequently, it is not surprising that social cognitive deficits have been associated with the emergence of conduct problems and these cognitive difficulties may negatively impact upon the quality of peer relationships, as well as play a role in the development of inappropriate social behaviour (Oliver, Barker, Mandy, Skuse, & Maughan, 2011). Ganesalingam et al. (2007) found that children with moderate to severe TBI showed poorer social problem-solving skills compared to non-TBI children and they propose that these difficulties may help account for the poor social and behavioural functioning found in many TBI survivors.

Social cognition and problem-solving are influential in a child's ability to self-regulate their behaviours and emotions in social situations and are regarded as important factors in the development of social competence. Self-regulation has been

defined as an individual's ability to manage their thoughts, feelings, and actions in adaptive ways across varying situations (Ganesalingam et al., 2006). This definition highlights self-regulation as a concept that incorporates three dimensions, namely cognitive, emotional, and behavioural. Difficulties within these domains; such as, poor inhibitory control and self-monitoring abilities, temper tantrums, inattention, and hyperactivity, can all have a detrimental impact on a person's social interactions and in turn their social competence (Ganesalingam et al., 2006; Schwartz et al., 2003). For example, children who cannot wait their turn can attract negative peer responses, which may affect later social interactions. Ganesalingam et al. (2006) have found that child TBI survivors show poorer self-regulation abilities and were more likely to demonstrate aggressive and avoidant solutions to social problems when compared to children without a TBI.

Burden of Social Difficulties

The societal burden of social problems is undeniable. Children with poor social competence are at an increased risk of growing into delinquent and/or criminal adolescents and adults (Hamalainen & Pulkkinen, 1996). Poor social functioning has also been linked to aggression and violent behaviours (Dooley et al., 2008; Musher-Eizenman et al., 2004), sexual offenses (Righthand et al., 2005), alcohol and drug use (Henry, Oetting, & Slater, 2009), and bullying (Camodeca & Goossens, 2005). Consequently, this population has been found to be over-represented within our custodial institutions (Slaughter, Fann, & Ehde, 2003). In addition, persistent conduct problems have been linked to social cognition difficulties which can have long-term negative repercussions for the individual (Oliver et al., 2011).

Research suggests that child and adolescent TBI survivors are an 'at risk' population for the development of social difficulties (Anderson et al., 2013; Muscara, Catroppa, Eren, & Anderson, 2009). This point is illustrated in a study by Greenham et al. (2010) who found that children aged 10-16 years with a history of TBI, were at an increased risk of social impairment compared to the general population and that environmental factors; such as, familial dysfunction further increased this risk. Adding

to this risk of social impairment and difficulties with social competence is the finding that parents of TBI children rated their child as being more withdrawn and that they had poorer quality peer relationships compared to ratings of their uninjured peers (Ross et al., 2011).

Research also suggests that childhood TBI survivors are at increased risk of developing psychiatric disorders, which can impact upon their social functioning. For example, Bloom et al. (2001) report that children with TBI (n=46) aged between 6-15 years, had a high rate (48%) of post-injury psychiatric disorders, with ADHD and depression being the most common. Interestingly, it has been reported that even a mild TBI can increase the risk of psychiatric illness, particularly ADHD and it has been theorised that these difficulties are related to behavioural regulations deficits in executive functioning (Max et al., 2004; Max et al., 1998).

A study by Massagli et al. (2004) found that the presence of psychiatric illness in children up to the age of 14 years, who had sustained a mild TBI three years previously and had no pre-injury history of mental illness, was 26% and only 16% in their peers who had not experienced a mild TBI. Of these psychiatric conditions, externalizing behavioural disorders that involve aggression are extremely concerning; as they are often associated with disruptions to peer and familial relationships, peer rejection, and criminal behaviour (Baguley, Cooper, & Felmingham, 2006; Dooley et al., 2008; Pulkkinen, 1996).

Executive Functioning

It is generally accepted that a person's higher order cognitive abilities or executive functions are influential in all aspects of a person's social behaviour (Anderson & Catroppa, 2005; Anderson, Anderson, Northam, Jacobs, & Catroppa, 2001). This neurological executive system may be considered a broad overarching construct that enables a person to successfully engage in deliberate and determined self-serving behaviours, and is particularly relied upon in managing new situations (De Luca & Leventer, 2008). Executive functions are said to include the cognitive processes

involved in formulating goals, planning how to achieve these goals, implementing the plan, and the strategic revision of this plan in response to feedback (Lezak, Howieson, Bigler, & Tranel, 2012). When applied to a social context, these skills are critical for a person to engage in socially competent behaviour.

Evidence suggests that there is a linear sequence for the maturation of the frontal lobes that corresponds to the development of executive functioning skills throughout childhood, adolescence, and into early adulthood. In a meta-analysis, Romine and Reynolds (2005) examined the development of executive functioning abilities in children and young adults aged between 5 and 22 years. Not surprisingly, these researchers found that executive functions develop at different rates, follow different developmental pathways, and reach optimal levels of functioning at different time points in a person's development. This suggests that the developmental trajectory of executive functions may be influenced by both genetic and environmental factors. However, these authors contend that in normal development the abilities of concept formation, rudimentary planning and problem-solving, verbal fluency, and inhibition should all be present between the ages of 5 and 8 years. These skills all steadily increase throughout childhood so that between the ages of 11 and 14 years the ability to inhibit attention to irrelevant stimuli and respond to others in a steadfast and competent manner should be fairly well mastered. Furthermore, between the ages of 17 and 22 years, a person's verbal fluency and planning abilities should have generally peaked and plateaued. In a study of adolescents aged between 11 and 17 years, it was found that older adolescents had a greater attentional capacity, and better planning and problem solving skills which allowed them to complete tasks faster than their younger counterparts (Anderson et al., 2001).

Executive functions may be divided into two separate domains. Skills; for example, strategic planning, organizing oneself, goal-setting, behavioural monitoring, problem-solving, inhibition, working memory, and cognitive flexibility have been described as the 'cold' cognitive dimensions of executive functioning (De Luca & Leventer, 2008). Whereas cognitive skills; such as, the ability to empathize with others, theory of mind, emotional regulation, and affective decision-making are all incorporated under the label of 'hot' cognitive dimensions of executive functioning

(Happaney, Zelazo, & Stuss, 2004). Both these cognitive dimensions play an important role in everyday social functioning, as they allow us to reflect upon past experiences and connect us to a range of emotions; including, feelings of joy, guilt, and even despair. They also provide us with a sense of self and of where we fit within our environment. Without these skills we would be reduced to creatures merely responding to environmental stimuli without meaning or purpose (De Luca & Leventer, 2008). Adolescence may be considered a critical period of brain development for affective and social cognitive functions. Evidence suggests that hot executive functions develop at a slower rate and mature later than cold functions, and that an adolescent's ability to interpret affective cues and implement cognitive control in emotionally charged social situations, may be hindered by this late maturation (Prencipe et al., 2011). This may help explain why adolescence is a developmental stage when the likelihood of engaging in risk-taking and/or injurious behaviours increases (Taylor et al., 2012). These behaviours may include reckless or dangerous driving, impulsive and often irresponsible activities, and antagonistic or violent behaviour, all of which have been associated with a greater risk of TBI (Langlois-Orman et al., 2011).

Deficits in executive functioning abilities (executive dysfunction), can produce a host of functional difficulties. These include; an inability to focus or maintain attention which can present itself in impulsive behaviours, an inability to inhibit emotional and behavioural responses, reduced working memory, difficulties overseeing and regulating one's performance on a task, disorganization in planning for future events, poor reasoning skills, difficulties in generating and implementing strategies, problems in changing from one activity to another, and a failure to learn from past experiences. Executive dysfunction may also be associated with behavioural difficulties; including, maladaptive affect, inappropriate energy levels, poor initiative, and inappropriate social behaviours (Anderson, 2008). For example, people who suffer executive functioning difficulties may present themselves as being lazy, unmotivated, slow and unresponsive, or as impulsive and argumentative. They may ask socially inappropriate questions, make hurtful remarks, fail to appreciate humour, or tell socially inappropriate jokes. Consequently, it is not surprising that people who suffer from

executive dysfunction often display poor interpersonal skills and have trouble initiating and maintaining social relationships (Huyder & Nilsen, 2012).

TBI and Executive Dysfunction. Neuro-behavioural problems have been linked to concurrent cognitive functioning difficulties following a TBI (Yeates et al., 2001). Further adding to this pool of literature are studies by Muscara, Catroppa and Anderson (2008a; 2008b), who explored the relationship between TBI severity and executive functioning in 36 Australian participants who had survived a TBI between the age of 8 and 12 years. These participants were followed up 7 to 10 years post injury and the researchers found that TBI severity was correlated with executive dysfunction in a number of cognitive domains; including, cognitive flexibility, abstract reasoning and goal setting. Furthermore, when assessed using the BRIEF Parent Report, the moderate and severe TBI groups were more likely to display maladaptive behaviours consistent with executive dysfunction. These researchers also found that higher levels of executive dysfunction were associated with poorly refined social problem-solving skills and inferior social functioning. Unfortunately, there was no control groups incorporated within these studies so there could be no comparison between mild-TBI and non-TBI groups that would positively link the cause of the executive dysfunction to TBI. However, these findings do indicate that executive functioning difficulties following a childhood TBI persist throughout adolescence and into early adulthood and that a person's problem-solving skills mediate between executive functions and long-term social outcome.

Furthermore, studies have suggested that the majority of cognitive recovery following a TBI occurs within the first year post-injury but that at this 12 month time point there is still a greater degree of cognitive impairment compared to their uninjured peers and that these impairments could impact upon a person's social functioning for long periods of time (Yeates et al., 2004; Yeates et al., 2002). This is illustrated in a follow-up study by Anderson and Catroppa (2005), who found that children who had sustained a severe TBI at a young age, were particularly vulnerable to deficits in their executive functioning and that while these impairments showed

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some improvement over time, long-term difficulties remained that could impact upon their future development. Again, no control group was incorporated within this study's design so that the full impact of a TBI on executive functions was unable to be ascertained.

One of the few studies that have specifically examined the effects of mild TBI on executive functioning was conducted by Maillard-Wermelinger et al. (2009). This study compared children (8-15 years) who had sustained a mild TBI (*n*=186) to children of had suffered mild orthopaedic injuries (*n*=99). These researchers found that when compared to the orthopaedic group, mild TBI children only demonstrated a marginally significant trend towards more executive functioning problems on the BRIEF Parent Metacognition Composite Index. Furthermore, the only BRIEF sub-scale in which the mild TBI group demonstrated significantly more problems was the Organization of Materials sub-scale, suggesting a tendency for mild TBI children to be messier and less organised than their non-TBI peers.

Models of Social Competence

Over the past 20 years several models of social competence have been developed, with Crick and Dodge's (1994) theoretical model of social information processing (SIP) generally being regarded as the gold standard for understanding the cognitive processes behind the management of social information. This SIP model proposes that when faced with a social situation, children draw upon past experiences to guide them through several distinct problem-solving processes before engaging in socially competent behaviours (for more information see Crick & Dodge, 1994; Figure 5 in Appendix A). However, this model does not incorporate influential factors; namely, a person's cultural context, their temperament, or their genetic predisposition, which may be considered important components in the acquisition of social skills and socially competent behaviours (Beauchamp & Anderson, 2010). In order to address these pitfalls, Beauchamp and Anderson (2010) have recently developed an evidence-based framework for social competence.

Socio-Cognitive Integration of Abilities Model (SOCIAL). The SOCIAL model by Beauchamp and Anderson (2010), is an integrative model that recognizes the importance of a child's biological development in the attainment of social skills (see Figure 1). This model takes these biological underpinnings and incorporates them with important socio-cognitive skills which are necessary for a person to function in a socially competent manner. The model also acknowledges personal and environmental factors that can be influential in social functioning.
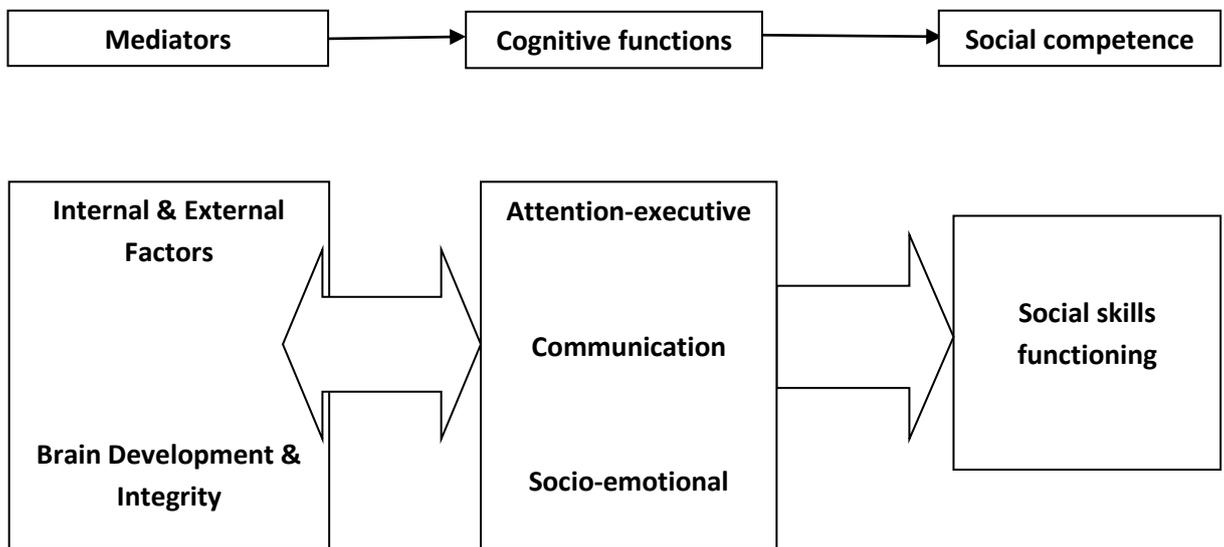
Figure 1. Socio-Cognitive Integration of Abilities Model (SOCIAL) from Beauchamp and Anderson (2010).

This model makes the underlying assumption that all social skills are dependent upon the normal development and maturation of the brain throughout childhood and adolescence and the associated cognitive and behavioural abilities within social environments (Beauchamp & Anderson, 2010). In other words, a person's social competence is dictated by the cognitive abilities of their neural systems and environmental influences. This assumption is represented in the SOCIAL model by the brain development and integrity component.

The other component of the SOCIAL model's first category box represents the mediation of both internal and external factors that shape a person's social functioning. Internal factors refer to personal factors of an individual's self; including, their personality and temperament. External factors refer to environmental contributors that can influence social interactions; such as, a person's family and cultural environment. Beauchamp and Anderson (2010) contend that both these personal and environmental factors interact bi-directionally with the developing brain to influence a person's cognitive functioning and level of social competence.

The second major category box in the SOCIAL model represents cognitive functions that are thought to be essential in everyday social functioning. The first of these factors is called attention-executive, which refers to a broad range of cognitive abilities. These skills include the ability to selectively focus and sustain attention, self-monitoring and self-regulation of one's behaviours and emotions, and the ability to inhibit inappropriate responses. The authors contend that these skills gradually develop in a mostly stepwise fashion throughout childhood and adolescence and that this development is linked to the brain's maturation.

The second factor within the cognitive functions category is communication skills. As people are social creatures, communication skills are crucial in the expression of thoughts, intentions and information, and as such are a key ingredient to the quality of social relationships and social competence (Beauchamp & Anderson, 2010). Being able to follow and understand spoken and unspoken language cues can increase awareness of subtle messages and as a result increase social functioning. People who are unable to decode these messages may not receive the social cues necessary to respond appropriately and may as a result; breach social rules (Peppe, McCann, Gibbon, O'Hare, & Rutherford, 2007).

The third factor within this SOCIAL cognitive group incorporates a person's ability to recognise and process socio-emotional cues. Emotion perception refers to, "the ability to accurately perceive and appreciate affective information from facial expressions, emotional prosody, body posture, and contextual parameters" (Bornhofen & McDonald, 2008, p. 512). Being able to perceive and interpret emotional

information from others is another critical attribute that enables successful social interactions. These skills gradually develop throughout childhood and adolescence as the brain undergoes its maturation processes and childhood deficits in these skills can persist well into adulthood, resulting in socially incompetent behaviour and social isolation (McLellan & McKinlay, 2013).

Closely linked to the perception of emotions, is the construct of attribution, which refers to the way people ascribe lasting personality characteristics to others, or ascribe causes and intent of other's behaviour (Rubin et al., 2012). Attributions are involved in the judgment of a person's truthfulness or deception, and in the ability to interpret meaning from social interactions. Biases in attribution; namely, the tendency to sense hostile intentions from others, have been associated with aggressive and anti-social behaviour, with obvious negative consequences for a person's social functioning and social competence (Dooley et al., 2008).

Beauchamp and Anderson (2010) suggest that these cognitive and affective processes not only dictate a person's ability to function competently in social interactions and environments, but also that deficits in these cognitive abilities can negatively impact upon a person's social environment, their biological development, and even the functioning and structures of their brain. The bi-directional arrow between the mediators of social functioning and the social cognitive functioning boxes in the SOCIAL model represent interaction between these processes.

The SOCIAL model effectively integrates the dynamic relationship between biological, psychological, and environmental contributors to competent social functioning and in doing so illustrates how environmental and biological factors; such as, brain development and injury, can directly impact upon the development and integrity of a person's cognitive and affective abilities. The model provides a broad basis for understanding the biopsychosocial components that contribute to social competence in a child who has not experienced any abnormalities with their brain, their cognitive processes, and who has been raised within a supportive environment. As the focus of this thesis is brain injury, we now look at two models of social

competence that have been specifically designed for children who have experienced a TBI or other interruptions to their brain function or development.

Integrative, Heuristic Model of Social Competence in Children with Brain Disorders. This model of social adjustment developed by Yeates et al. (2007), illustrates the relationships between a child's social adjustment and their peer relations, and incorporates these characteristics with the cognitive and affective components behind social information processing in children with a brain disorder or injury (see Figure 2).

These authors suggest that at a personal level, social information processing is a critical component of social competence. This process is conceived as involving both cognitive and affective components that are mediated by a child's social problem-solving abilities and that these social strategies will vary depending on both the social situation and the nature of the child's relationship with their social partners.

The authors contend that the range and diversity of a child's social behaviours in differing situations and relationships may be considered an important indication of their social competence. In this model the social interactions are divided into three broad behavioural subtypes or tendencies which the authors refer to as: (a) moving towards others or prosocial affiliative behaviours; (b) moving against others or aggressive, competitive behaviours; and (c) moving away from others or socially withdrawn behaviours (Yeates et al., 2007).

The social adjustment component of the model may be evaluated on the basis of one's own perceptions of the situation or from the perceptions of others. This distinction may be important for children with a brain disorder who could lack insight into their deficits and as a result tend to evaluate their own social competence more positively than would others (Yeates et al., 2007).

Insult related risk and resilience factors

Figure 2. Integrative, heuristic model of social competence in children with brain disorders from Yeates et al. (2007).

These components of social information processing, social interactions, and social adjustment all interact bi-directionally with each other in a dynamic fashion and are all influenced by internal neurological factors related to the brain disorder or injury experienced by the child and their environmental risk and resilience factors. In the context of a TBI survivor, it may be hypothesised that the neurological deficits caused by the injury could affect the social information processes causing the child to behave in an aggressive or socially withdrawn manner which would not promote social

affiliation. This could result in peer rejection, fewer friendships, and a label of being socially incompetent or having more social problems than other children their age (Ross et al., 2011; Yeates et al., 2013).

This model links aspects of the brain, cognition, emotions, and behaviours that contribute towards a person's social competence. Furthermore, it does not only apply to children with brain disorders, but may also be applied to people with neuro-developmental abnormalities and healthy individuals of all ages. This makes it an excellent research framework for the comparison of populations who have or have not sustained a brain injury, in an attempt to better understand the intricacies of social behaviour. However, the broad nature of this model does not allow for the isolation of particular deficits that may be contributing to a child's social incompetency.

Child Head Injury Model of Sociability (CHIMS). Drawing upon the two previously mentioned models and a model by Yeates and Taylor (2005: see Figure 6 in Appendix B), a more detailed model was developed that specifically focuses on children and adolescents who have survived a TBI, in an attempt to tease out the many factors that can influence the attainment of social competence within this population (Figure 3).

This model begins with the complicating factors surrounding the actual injury, such as the severity of the TBI and other injuries associated with the accident. The model also highlights pre-injury internal and external characteristics unique to the child that could have an influence on post-injury outcome.

Pre-injury factors include the child's temperament and their personality. For example, an outgoing extraverted personality type and openness to new experiences have been associated with positive social behaviours and skills. Higher levels of self-esteem have also been associated with positive social skills and quality relationships (Wanberg & Kammeyer-Mueller, 2000). Towards the other end of the spectrum, people who are easily embarrassed and shy, often have difficulties with their social interactions, become anxious in social situations, and demonstrate poor social skills

with lower levels of communication and eye-contact (Greco & Morris, 2001). Further down this spectrum at a more clinical level are people who suffer from social withdrawal and social phobia, which can have a debilitating effect on a person's social development (Rubin et al., 2012).
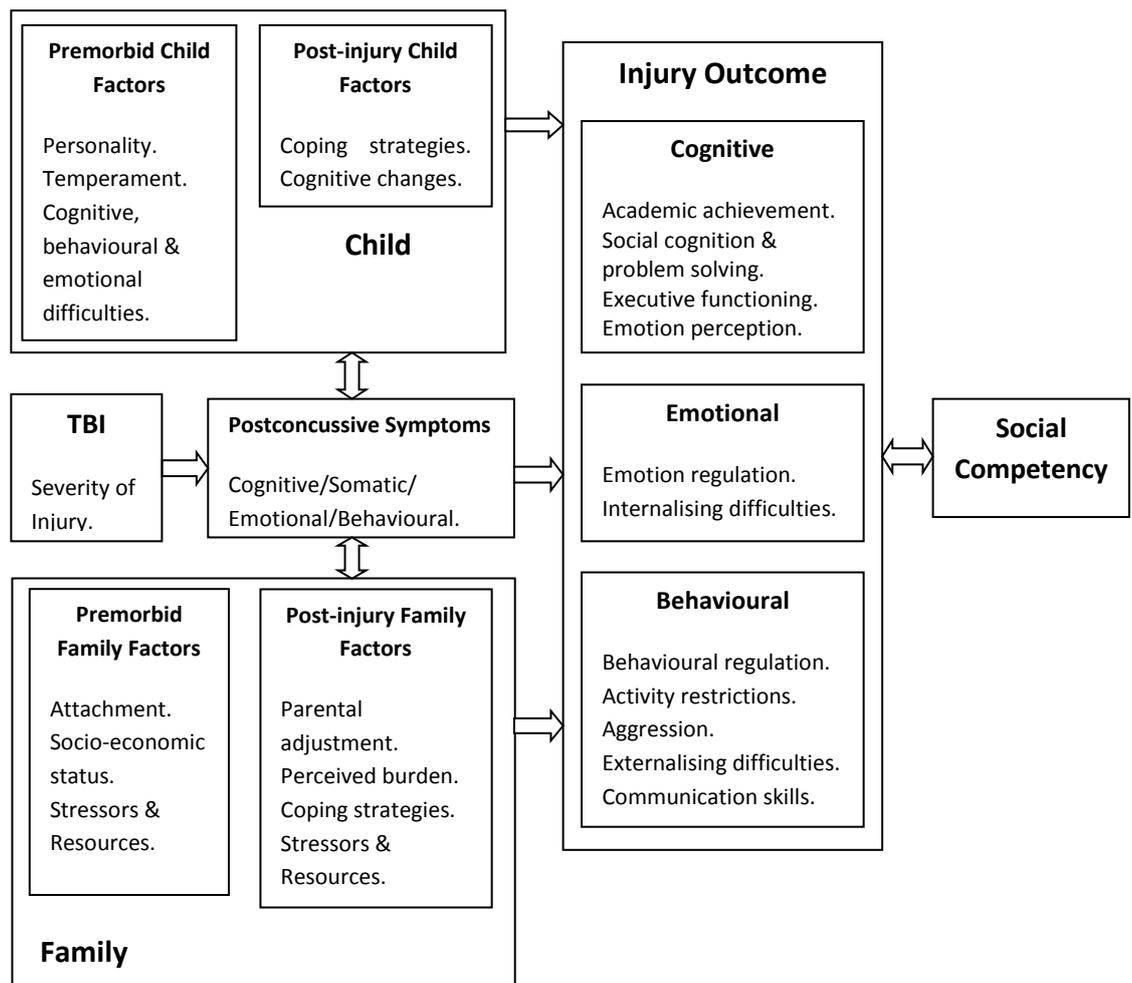
Figure 3. Child Head Injury Model of Sociability (CHIMS).

These pre-injury factors also include the child's developmental status regarding their cognitive abilities, and their behavioural and emotional functioning abilities. These may influence the child's post-injury coping strategies in dealing with the changes brought on by their TBI. Pre-injury environmental factors that could

influence the outcome of a TBI include the quality of relationships and attachments within the family, their socio-economic status, and the resources available to them. These factors may influence a family's sense of burden, their adjustment to the new responsibilities and to the changes brought on by the child's injuries. They may also influence the coping strategies that the family employs for dealing with the stressors associated with their child's injury (Aitken et al., 2009; Kinsella, Ong, Murtagh, Prior, & Sawyer, 1999; Wade et al., 2006; Yeates, Taylor, Walz, Stancin, & Wade, 2010).

Damage to the brain; such as, intracranial lesions or cerebral oedema, can contribute towards post-concussive symptoms which may include somatic symptoms; including, headaches and fatigue; cognitive symptoms such as inattention, forgetfulness, and slowed cognitions; affective symptoms; for example, difficulties with emotion regulation; and behavioural symptoms such as irritability and aggression (Yeates, 2010; Yeates & Taylor, 2012; Yeates et al., 2001). Furthermore, these symptoms may also be influenced by personal and environmental factors unique to the child (Yeates, 2010). While these post-concussive symptoms are generally most pronounced shortly after the injury and tend to resolve over time, it has been reported that some survivors of even a mild TBI can experience persistent symptoms which can have long-term psycho-social consequences (Yeates, 2010; Yeates & Taylor, 2012).

All these aforementioned factors can influence the child's cognitive, emotional, and behavioural outcomes following their injury. The model illustrates that cognitive deficits could include a range of executive functioning difficulties and consequently result in a decrease in academic achievement (Ganesalingam et al., 2011; Levin & Hanten, 2005; Maillard-Wermelinger et al., 2009; Vu et al., 2011); emotional deficits that could include perception and regulation difficulties (Bornhofen & McDonald, 2008; McLellan & McKinlay, 2013; Tlustos et al., 2011); behavioural deficits that may include behavioural regulation difficulties, and problems with impulsivity and aggression (Baguley et al., 2006; Dooley et al., 2008; Ganesalingam et al., 2006). The model then posits that these cognitive, emotional, and behavioural outcomes can interact dynamically with each other to hinder a child's functioning in social circumstances. This reduced level of social competence may lead to behaviours that can further isolate the child socially (Ross et al., 2011), which in turn can increasingly

compound the child's cognitive, emotional, and behavioural difficulties and outcomes (Rubin et al., 2012).

The beauty of this model is in its complexity. It gives a visual depiction of the interplay between multiple factors that can influence a person's social competence following a TBI. This allows for the identification of specific deficits or difficulties that are both internal and external to the child. Once identified, these deficits can then be targeted by specific interventions that have been shown to be effective in treating these particular difficulties. This model also highlights resources that may be beneficial to the child's recovery and the development of their social competency skills, including a strong parental attachment, the resources available to the family; including, community and financial support, medical and rehabilitative procedures available, as well as both the child's and their parent's coping strategies for dealing with the changes in their lives that have been brought about by the TBI (Taylor et al., 2001; Wade et al., 2001; Wade et al., 2006; Yeates et al., 2010).

Research Question

This study proposes to address some of the gaps in the research literature regarding mild TBI and its consequences for adolescent youth. There has been limited research investigating the consequences of a mild TBI on the social development of adolescents and the impact that this form of injury may have on their social functioning. This study endeavours to address this shortfall by asking the important questions, "Are adolescent mild TBI survivors less socially competent than their non-TBI peers and if so, is there a relationship between lower social competency and executive dysfunction in these mild TBI youth?"

Specifically, the main aims of this study are to determine whether adolescents who have sustained a mild TBI are experiencing difficulties with their functioning in a socially competent manner at 12 months post-injury compared to their uninjured

peers and whether there is a relationship between an adolescent's level of social competence and their executive functioning abilities at this time point.

In order to achieve these goals, adolescents who have sustained a mild TBI will be assessed over the first 12 months following their injury to examine whether or not there is any functional change in their behaviour, cognitions, or emotions over this time frame. At 12 months post-injury, mild TBI adolescents functioning will then be compared to a community control sample of their uninjured peers, in order to establish whether there are any differences in social functioning between the groups.

It was hypothesised that due to the nature of their injury, adolescents who have sustained a mild TBI would show poorer functional abilities within the realms of socially competent behaviour compared to their adolescent peers who have not sustained a TBI. It was also hypothesised that factors such as a person's cognitive abilities; in particular their executive functioning abilities; the parent/child relationship, and the adolescent's personality type would be related to socially competent behaviour.

This research is needed to better understand the consequences of a mild TBI at the crucial social developmental crossroads of adolescence. This knowledge is imperative as it has the potential to direct interventions that will improve the social prospects and the ensuing quality of life of this ever widening and diverse population.

Method

Participants

　　TBI Participants. Participants with a mild TBI were recruited from a much larger population-based study (Brain Injury Outcomes New Zealand in the Community: Feigin et al. 2012) . This epidemiological study recruited participants of all ages who had sustained a TBI of any severity between the 1st March 2010 and the 28th February 2011 from a large geographical area in the central North Island of New Zealand. This geographical location included the urban city of Hamilton (129,249 people: 98 km²) and the surrounding rural Waikato District (43,956 people: 31,987 km²). The location was chosen as its population mix approximates New Zealand demographics as a whole (Feigin et al., 2012; Theadom et al., 2012).

　　The Brain Injury Outcomes New Zealand in the Community study (BIONIC) defined a TBI according to the WHO classification criteria and inclusion required one of more of the following symptoms following a blow to the head: (a) loss of consciousness, (b) post-traumatic amnesia, or (c) disorientation or confusion (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004). Mild TBI severity was divided into low risk, medium risk, or high risk according to criteria published by Servadei, Teasdale, and Merry (2001). This classification criteria used a combination of the Glasgow Coma Scale (Teasdale & Jennett, 1974); including, length of post-traumatic amnesia, the presence or absence of clinical symptoms (loss of consciousness, amnesia, vomiting, or headaches), neurological deficits (impaired vision/hearing/speech, difficulties with balance or walking, and general feelings of weakness), and risk factors (coagulopathy, drug and/or alcohol consumption, previous neurosurgical procedures, pre-trauma epilepsy, and age over 60 years).

　　Where possible, participants who consented to taking part in the BIONIC study were followed up at baseline (time of injury), 1 month, 6 months, and 12 months post-injury. Following their 12 month assessment, all BIONIC participants aged under 16 years at the time of their injury and their parents, were invited to take part in the

subsequent COBIC study (COBIC: Consequences of Brain Injury in Children). This study then followed these children up for a further 2 years. The current study focuses on all consenting mild TBI adolescents aged between 12 and 15 years, who had parental and/or self-report data available at 12 months post-injury.

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                    ┌─────────────────────────────┐
                    │   BIONIC study 2010 – 2011  │
                    │   Total Participants (n=744)│        ┌──────────────────────────┐
                    └─────────────────────────────┘        │ BIONIC study participants│
                                 │  ─────────────────────▶  │ outside age range (n=666)│
                                 ▼                          └──────────────────────────┘
                    ┌─────────────────────────────┐
                    │  BIONIC study participants  │
                    │  aged 12-15 years at time   │        ┌──────────────────────────┐
                    │  of injury (n=78)           │        │ BIONIC study participants│
                    └─────────────────────────────┘  ────▶ │ with moderate to severe  │
                                 │                          │ TBI (n=2)                │
                                 ▼                          └──────────────────────────┘
                    ┌─────────────────────────────┐
                    │  BIONIC study participants  │
                    │  aged 12-15 with a mild     │        ┌──────────────────────────┐
                    │  TBI (n=76)                 │        │ Non-consenting BIONIC    │
                    └─────────────────────────────┘  ────▶ │ participants (n=31)      │
                                 │                          └──────────────────────────┘
                                 ▼
                    ┌─────────────────────────────┐
                    │  BIONIC participants who    │        ┌──────────────────────────┐
                    │  consented to future        │        │ Contacted for COBIC study│
                    │  studies (n=45)             │  ────▶ │ but withdrew consent     │
                    └─────────────────────────────┘        │ (n=15)                   │
                                 │                          └──────────────────────────┘
                                 ▼
 ┌──────────────────┐ ┌─────────────────────────────┐ ┌──────────────────────────┐
 │ Non-consenting   │ │ Total COBIC study's mild TBI│ │ TBI participants missed  │
 │ parents of TBI   │◀│ participants aged 12-15     │▶│ to 1yr follow-up (n=7)   │
 │ participants(n=2)│ │ and/or parents (n=30)       │ └──────────────────────────┘
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Figure 4. Flowchart showing the recruitment procedure of adolescent TBI participants.

The TBI sample in this study consisted of 30 adolescent participants (male=23/female=7) aged between 12-15 years at the time of their injury (mean age=13.4/SD=1.07) that had either parental or self-report data available for them. These participants were recruited via a variety of sources, including Waikato Hospital records (n=19/63.3%), Accident and Medical Clinics (n=4/13.3%), the Accident

Compensation Corporation (ACC) database (n=2/6.7%), General Practitioner (GP) referrals (n=1/3.3%), and other sources such as the Brain Injury Association (n=1/3.3%).

These participants sustained their subsequent TBI through a variety of mechanisms; including, injuries sustained by mechanical force (n=14/46.7%: e.g. a pinecone flicked up from a rally car and struck participant in the head), falls (n=6/20%: e.g. fell from flying-fox), and traffic accidents (n=5/16.7%: e.g. motorcycle slid over on a wet road). Of these participants, 17 (56.7%) reported that the TBI was their first, 5 (16.7%) reported that this was their second TBI, 1 participant (3.3%) reported that this was their third TBI, and 3 (10%) reported that they had sustained a TBI on four or more occasions in the past.

Comparison Group. Non-TBI comparison group participants were matched to BIONIC TBI participants by age (6 months either side of their birthday). These participants were recruited from the same geographical catchment area as the BIONIC participants via a variety of routes including: University of Waikato staff e-mails, advertisements placed in school newsletters, flyers sent home by schools to parents of children of the desired age group, requests that existing participants pass on a flyer to friends who they thought might be interested, and flyers distributed to youth groups and services, sports clubs, church groups, and the researcher's personal friends. Table 1 presents the demographic characteristics for TBI and control participants at 12 months post-injury.

As can be seen in this Table, the samples included a larger proportion of males, of NZ European ethnicity, who live in an urban environment, and who do not have a diagnosed health condition. No statistically significant group differences were found for any of the demographic variables. However, a marginally significant difference was found between the TBI and control groups for ethnicity, with larger proportions of TBI participants endorsing *Māori* or *Pasifika* ethnicities.

Table 1.

TBI and control sample characteristics at their 12 months post-injury assessment.

Variable	TBI Group (n=30)	Control Group (n=30)	Statistical Analysis
Gender			$\chi^2(1)$=0.089, *p*= 1.000
Males: n (%)	23 (76.7)	22 (73.3)	
Females: n (%)	7 (23.3)	8 (26.7)	
Endorsed Ethnicity			
NZ European: n (%)	21 (70.0)	25 (83.3)	
NZ Māori: n (%)	6 (20.0)	2 (6.7)	
Pasifika: n (%)	3 (10.0)	0 (0)	
Other Ethnicity: n (%)	0 (0)	3 (10)	
Ethnicity Categorization			*FET*=5.489, *p*= .051
NZ Māori n (%)	6 (20.0)	2 (6.7)	
Pasifika: n (%)	3 (10.0)	0 (0)	
Other: n (%)	21 (70.0)	28 (93.3)	
Residency			$\chi^2(1)$=0.800, *p*= .552
Urban: n (%)	24 (80.0)	21 (70)	
Rural: n (%)	6 (20.0)	9 (30)	
Diagnosed Health Conditions			*FET*=5.645, *p*= .339
No Diagnosed Problems: n (%)	23 (76.7)	18 (60.0)	
Allergies: n (%)	3 (10.0)	6 (20.0)	
Skeletal: n (%)	1 (3.3)	2 (6.7)	
Mental Health: n (%)	0 (0.0)	2 (6.7)	
Gastric Intestinal: n (%)	2 (6.7)	0 (0.0)	
Other: n (%)	1 (3.3)	2 (6.7)	
TBI Injury Severity			
Mild/low risk: n (%)	4 (13.3)	N/A	
Mild/medium risk: n (%)	15 (50.0)	N/A	
Mild/high risk: n (%)	11 (36.7)	N/A	
Age at injury (years): *M (SD)*	13.4 (1.07)	N/A	
Age at assessment (years): *M (SD)*	15.33 (1.19)	15.26 (1.12)	*F*(1,51)=0.055, *p*= .816 ES=0.001
Familial socioeconomic status: *M (SD)*	56.08(27.34)	62.36 (20.98)	*F*(1,54)=0.932, *p*= .339 ES=0.017

χ^2=Chi-squared test for independence, *F*=One-way Between-groups ANOVA, ES=Effect size (Partial Eta squared), *FET=Fisher's Exact Test*.

Adolescents were excluded from the comparison group if they had ever had a TBI. The primary exclusion question for that group was, "has your child ever hit their head so hard that they sought medical attention, were knocked unconscious, or felt dazed and disorientated?" As the TBI group was part of a population-based study, no other exclusion criteria were applied to the comparison group.

Materials

General Information. Parents and participants over the age of 16 years were asked to complete a questionnaire regarding demographic information and their general health and well-being.

Socio-economic status (SES). The participant's familial SES was estimated using the occupation of the main income earner in the family home. Occupations were categorised using the Australia and New Zealand Standard Coding of Occupations (ANZSOC) found on the Australian Bureau of Statistics website (www.abs.gov.au). These codes were then transformed into scores using the Australian Socioeconomic Index 2006 (AUSEI06) (McMillan, Beavis, & Jones, 2009).

The AUSEI06 converts a person's employment classification into occupational status scores and ranks them on a scale from 0-100; with medical practitioners at the top of the scale (100), beauty therapists and prison officers in the middle (49.6), and labourers at the bottom (0). An AUSEI06 score can also be allocated to people who are not in paid employment based on their (Australian) education level (McMillan et al., 2009). This Australian Index was used because there was no New Zealand Socioeconomic Index available at the time that incorporated the ANZSCO codes.

Ethnicity. Participants were asked to indicate their associated ethnic group(s) by choosing as many ethnicities that applied to them from a list which also contained the response option of "other" and an accompanying space for the participant to

specify their associated ethnicity. In keeping with the BIONIC study's methodology, ethnicities were classified according to the following graduated procedure for analysis purposes: (1) any participant who identified "*Māori*" as part of their ethnic mix was classified as *Māori;* (2) following this classification, any participant who indicated one of the Pacific Island ethnicities was classified as *Pasifika;* (3) all remaining participants were classified as Other.

Diagnosed Health Condition. Parents of participants were asked to indicate if their child had a diagnosed health condition or disability and these diagnoses were categorized into the following groupings: No diagnosed Conditions, Allergies (e.g. eczema, asthma, hayfever, and a gluten allergy), Skeletal (e.g. bone cyst, lack of growth, and one leg shorter than the other), Mental Health (e.g. autistic spectrum disorder), Gastric Intestinal (e.g. reflux), and Other (e.g. migraine and haematological imbalances, such as hypoglycaemia and iron deficiency). Of particular note was that two participants in the control group had a diagnosis of autistic spectrum disorder.

Measures

The measures used in this study included two broad measures of social behaviour (BASC-II and SDQ), an ecologically valid measure of executive function (BRIEF), and a computerised performance-based measure of neurocognition (CNS-VS).

Behaviour Assessment System for Children – Second Edition (BASC-II). The BASC-II measure was designed for use with young people aged between 2 and 25 years, "to facilitate the differential diagnosis and educational classification of a variety of emotional and behavioural disorders of children and to aid in the design of treatment plans" (Reynolds & Kamphaus, 2004, p. 1). This measure is multi-dimensional in that it measures both positive (adaptive) and negative (clinical) self-perceptions and observable behaviours, as well as multi-method in that it gathers

information from a variety of sources which may be combined to generate an in-depth evaluation of a person's personality, their perceptions of themselves, and their behavioural and emotional difficulties in different settings (Reynolds & Kamphaus, 2004). The Parent Rating Scale form (PRS) for adolescents (12-21 years), consists of 150 items that are scored using a 4-point Likert response format and the Self-Report of Personality (SRP) for adolescents (12-21 years), consisting of 176 items that incorporate a true/false response format for some items and a 4-point Likert response format for the remaining items. Both the PRS and SRP Likert scales response options consist of; 0 (never), 1 (sometimes), 2 (often), and 3 (almost always).

The BASC-II was chosen for this study as it has been used to successfully analyse social relationships in children and distinguish between psycho-social subtypes in TBI children (Barcons et al., 2012; Ensign, Maricle, Brown, & Mayfield, 2012). Furthermore, the BASC-II adolescent forms have large normative samples (PRS n=1800: SRP n=2606) that are representative of the U.S. population and the clinical sample (PRS n=876: SRP n=950) comprised of young people (12-18 years) receiving mental health or special education services (Reynolds & Kamphaus, 2004).

The BASC-II has good internal consistency (Cronbach's alpha) ranging between 0.70-0.88 for the PRS and 0.67-0.97 for the SRP. This measure also has good test-retest reliability ranging between 0.63-0.97 over an interval of between 9-70 days (PRS n=252: SRP n=240). The PRS inter-rater reliabilities ranged between 0.56-0.90 (n=134) independently scored by two parents or caregivers (Reynolds & Kamphaus, 2004).

The authors of this measure report a moderate to high concurrent validity (r=0.64-0.85) for similar constructs on the Achenbach System of Empirically Based Assessment (ASEBA). Likewise, the Conners' Parent Rating Scale-Revised, and the Conners-Wells Adolescent Self-Report Scale all showed moderate to high correlations with corresponding BASC-II Rating Scales on similar constructs, except for the Anxiety Scales between the parent questionnaires (0.35-0.41).

The BASC-II also includes several validity indexes that measure response sets. For example, all scales have an F-Index that measures the tendency to answer items negatively (faking bad), a Consistency Index that measure differing item responses that

are usually answered consistently, and a Response Pattern Index that shows how often a response differs from the previous response. The SRP has an additional L-Index that measures the tendency to answer items in a positive light (faking good), and a V-Index that measures highly implausible responses.

The BASC-II Questionnaires were scored using the BASC-II ASSIST Plus software package (AGS Publishing, Circle Pines, MN). This software organises item responses into primary scales, content scales, and composite scales and transforms raw scores into T-scores (M = 50/SD = 10). Table 2 lists the PRS primary scales, provides a definition for each scale, the number of items in each scale, provides an example of one of these items, and lists which composite scale the primary scale contributes too. Table 3 has a similar format only it lists the SRP primary scales, their descriptions, the number of items per scale, an example of one of these items, and its corresponding composite scale.

As with the SRP, the PRS primary scales are combined to form content and composite scales. As social competence and executive functioning are the focus of this study, the PRS scales of interest are Hyperactivity, Aggression, Conduct Problems, Externalizing Problems, Internalizing Problems, Withdrawal, Social Skills, Functional Communication, Anger Control, Bullying, Emotional Self-Control, Executive Function, and the Behavioural Symptoms Index. The SRP scales of interest are Social Stress, Inattention/Hyperactivity, Relations with Parents, Interpersonal Relations, and the Emotional Symptoms Index.

Pertaining to the PRS, the Externalizing Problems scale is made up from the scales of Hyperactivity, Aggression and Conduct Problems, and this scale represents disruptive behaviours such as aggression, hyperactivity, and delinquency. Children with high scores on this scale tend to disrupt the activities of peers and adults, are often unresponsive to adult instructions, and they have more problematic relationships with peers. The Internalizing Problems scale is made up from the scales of Anxiety, Depression, and Somatization, and represents an individual's over-control of their behaviour and excessive monitoring of their action. The authors contend that peer relations can be adversely affected by the presence of internalizing symptoms.

Table 2.

BASC-II PRS primary scale definitions, the number of items per scale, item example, and the primary scales corresponding composite scale.

Primary Scale	Definition*	Number of items	Item example	Corresponding Composite Scale
Activities of Daily Living	Skills associated with performing everyday tasks in an acceptable and safe manner	8	Acts in a safe manner?	Adaptive Skills
Adaptability	The ability to adapt readily to changes in the environment	8	Adjusts well to changes in family plans?	Adaptive Skills
Aggression	The tendency to act in a hostile manner that is threatening to others	10	Annoys others on purpose?	Externalizing Problems & BSI
Anxiety	The tendency to be nervous, fearful, of worried about real or imagined problems	11	Worries about things that cannot be changed?	Internalizing Problems & BSI
Attention Problems	The tendency to be easily distracted and unable to concentrate more than momentarily	6	Is easily distracted?	Behavioural Symptoms Index (BSI)
Atypicality	The tendency to behave in ways that are considered 'odd' or commonly associated with psychosis	10	Says things that make no sense?	Behavioural Symptoms Index (BSI)
Conduct Problems	The tendency to engage in anti-social or rule breaking behaviour, including destroying property	14	Lies to get out of trouble?	Externalizing Problems
Depression	Feelings of unhappiness, sadness, and stress that may result in an inability to carry out everyday activities or may bring on thoughts of suicide	13	Says "Nobody likes me."	Internalizing Problems & BSI
Functional Communication	The ability to express ideas and communicate in a way others can easily understand	12	Communicates clearly?	Adaptive Skills
Hyperactivity	The tendency to be overly active, rush through work or activities, and act without thinking	8	Has poor self-control?	Externalizing Problems
Leadership	Skills associated with accomplishing academic, social, or community goals, including the ability to work with others	10	Gives good suggestions for solving problems?	Adaptive Skills
Social Skills	Skills necessary for interacting successfully with peers and adults in home, school, and community settings	8	Encourages others to do their best?	Adaptive Skills
Somatization	The tendency to be overly sensitive to and complain about relatively minor physical problems and discomforts	11	Complains about health?	Internalizing Problems
Withdrawal	The tendency to evade others to avoid social contact	8	Has trouble making new friends?	Behavioural Symptoms Index (BDI)

*Definitions of the Primary Scales quoted from the BASC-II Manual (Reynolds & Kamphaus, 2004).

Table 3.

BASC-II SRP primary scale definitions, the number of items per scale, item example, and the primary scales corresponding composite scale.

Primary Scale	Definition*	Number of items	Item example	Corresponding Composite Scale
Anxiety	Feeling of nervousness, worry, and fear; the tendency to be overwhelmed by problems	13	I worry but I don't know why.	Internalizing Problems & ESI
Attention Problems	The tendency to report being easily distracted and unable to concentrate more than momentarily	9	I have trouble paying attention to what I am doing.	Inattention /hyperactivity
Attitude to School	Feelings of alienation, hostility, and dissatisfaction regarding school	7	School is boring.	School Problems
Attitude to Teachers	Feelings of resentment and dislike to teachers; beliefs that teachers are unfair, uncaring, or overly demanding	9	Teachers make me feel stupid.	School Problems
Atypicality	The tendency towards bizarre thoughts or thoughts and behaviours considered "odd."	9	I hear things that others cannot hear.	Internalizing Problems
Depression	Feelings of unhappiness, sadness, and dejection; a belief that nothing goes right	12	Nothing ever goes right for me.	Internalizing Problems & ESI
Hyperactivity	The tendency to report being overly active, rushing through work or activities, and acting without thinking	7	I have trouble sitting still.	Inattention /hyperactivity
Interpersonal Relations	The perception of having good social relationships and friendships with peers	7	I am liked by others.	Personal Adjustment
Locus of Control	The belief that rewards and punishments are controlled by external events or people	9	I am blamed for things I don't do.	Internalizing Problems
Relations with Parents	A positive regard towards parents and a feeling of being esteemed by them	10	My parents listen to what I say.	Personal Adjustment
Self-esteem	Feelings of self-esteem, self-respect, and self-acceptance	8	I like the way I look.	Personal Adjustment & ESI
Self-reliance	Confidence in one's ability to solve problems; a belief on one's personal dependability and decisiveness	8	I am someone you can rely on.	Personal Adjustment & ESI
Sensation Seeking	The tendency to take risks and to seek excitement	9	I like to dare others to do things.	School Problems
Sense of Inadequacy	Perceptions of being unsuccessful in school, unable to achieve one's goals, and generally feeling inadequate	10	I want to do better but I can't.	Internalizing Problems & ESI
Social Stress	Feelings of stress and tension in personal relationships; a feeling of being excluded from social activities	10	I am lonely.	Internalizing Problems & ESI
Somatization	The tendency to be overly sensitive to, to experience, or to complain about relatively minor physical problems	7	Often I feel sick in my stomach.	Internalizing Problems

Note: *Definitions of the Primary Scales quoted from the BASC-II Manual (Reynolds & Kamphaus, 2004), ESI = Emotional Symptoms Index.

According to the measures authors, the Anger Control content scale measures an individual's tendency to become irritated quickly and an inability to regulate affect and self-control. High scores on this scale are an indication of poor conflict

management skills, an inability to control anger, and general unhappiness. The Bullying Content Scale measures the tendency of an individual to be intrusive, cruel, threatening, or forceful in getting what they want through manipulation or coercion. The authors contend that high scores on this scale reflect a persistent pattern of social maladjustment. The Emotional Self-Control content scale measures an individual's ability to regulate affect and emotions in response to changing environmental situations. High scores on this content scale reflect the influence of a variety of negative emotions; including, sadness, frustration, and anger. The Executive Functioning content scale assesses an individual's ability to control their behaviour by planning, anticipation, inhibiting, or by maintaining goal-directed activities, and by adjusting or changing goal-directed behaviours in response to environmental feedback in an appropriate, purposeful, and meaningful manner. The Behavioural Symptoms Index consists of the Hyperactivity, Aggression, Depression, Attention Problems, Atypicality, and Withdrawal Primary Scales, and reflects the overall level of problem behaviour (Reynolds & Kamphaus, 2004).

Pertaining to the SRP, the Inattention/Hyperactivity scale assesses an individual's inability to maintain attention and the tendency to be easily distracted from tasks. It also assesses difficulties; such as, the inability to stand still, talking while others are talking, and generally behaving in a disruptive manner. The Emotional Symptoms Index incorporates the Primary Scales of Social Stress, Anxiety, Depression, Sense of Inadequacy, Self-Esteem, and Self-Reliance, and is an indicator of serious emotional disturbances that can impact upon an individual's thoughts, feelings, and behaviours, particularly within the realms of internalizing disorders (Reynolds & Kamphaus, 2004). From this point on the BASC-II will simple be referred to as the BASC.

The Strengths and Difficulties Questionnaire (SDQ). The SDQ is a brief one-page screening questionnaire for assessing the psychological adjustment of a child or adolescent, in regards to their behavioural, emotional, and relational strengths and weaknesses (Goodman, 1997). This screening tool employs a multi-method approach

in that it gathers information from a variety of sources, which can be combined to generate an in-depth evaluation of a young person aged between 4-16 years. This study used the parent and youth (11-16 years) extended questionnaire versions (Goodman, 1999).

The SDQ consists of 25 items rated on a 3-point Likert scale response format (1=not true: 2=somewhat true: 3=certainly true). These items contribute towards five sub-scales: Emotional Symptoms (item example: often unhappy, downhearted, or tearful.), Conduct Problems (item example: very angry and often loses temper.), Hyperactivity (item example: restless, cannot stay still for long.), Peer Problems (item example: usually plays on their own.), and Prosocial Behaviour (item example: helpful if someone is hurt, upset, or feeling ill.). The possible scores on each sub-scale range between 0-10.

This measure was chosen because it has been used extensively on young people who have sustained a TBI and those who have not, to evaluate their strengths and weaknesses regarding social functioning (Greenham et al., 2010; Oliver et al., 2011; Petersen et al., 2008). The SDQ has also been recommended as a core measure by McCauley et al. (2012) in an attempt to standardise measures for paediatric TBI research.

The SDQ has a large normative sample (n=10,438) of British children aged between 5-15 years (Goodman, 2001) and normative data is also available from an Australian sample (Mellor, 2005). This screening tool has good internal consistency for the parent's questionnaire (PQ Cronbach's alpha α=0.57-0.82) and the youth self-report questionnaire (SRQ Cronbach's alpha α=0.41-0.80). Test-retest reliabilities were also found to be good over a 4-6 month period, ranging between 0.57-0.72 for the parent questionnaire and 0.51-0.62 for the self-report questionnaire (Goodman, 2001).

Completed questionnaires were scored using syntax for SPSS software according to the SDQ author's website (http://www.sdqinfo.com/cl.html). A Total Difficulties Score is generated by summing the scores from all the sub-scales except for the Prosocial scale and the resulting score may range between 0-40. Goodman (2001) states that scores on the Total Difficulties scale of between 0-15 are within the normal

range, while scores of between 16-19 are within the borderline range, and scores between 20-40 are within the abnormal range. Likewise, higher scores on all sub-scales, except the Prosocial scale, indicate greater problems within that particular domain. Conversely, higher scores on the Prosocial sub-scale indicate better social functioning, with a score of between 6-10 falling within the normal range, a score of 5 is interpreted as being borderline, and a score between 0-4 falling within the abnormal range. As social competence is the focus of this study, all five sub-scales and the Total Difficulties score are of interest (Goodman, 2001).

The Behaviour Rating Inventory of Executive Function (BRIEF). The BRIEF is a set of questionnaires designed to evaluate the self-regulation of cognitive, emotional, and behavioural functioning and their relationship to executive functioning in children aged between 5 and 18 years (Gioia, Isquith, Guy, & Kenworthy, 2000). This measure also employs a multi-method approach to information gathering from different perspectives, so that an all-encompassing picture of the youth's functioning can be ascertained. However, this study focuses on the Parent Form (PF).

The BRIEF PF (86 items) contains items that describe real world scenarios and the participant then indicates on a 3-point Likert scale (1=never: 2=sometimes: 3=often) their level of difficulties with these scenarios over the past 6 months (item example: Does not notice when behaviour causes negative reactions until it is too late).

The BRIEF was chosen for this study as it has been used extensively to evaluate executive functions in children and adolescents who have and have not sustained a TBI (Ganesalingam et al., 2011; Gioia & Isquith, 2004; Maillard-Wermelinger et al., 2009; Muscara et al., 2008a & 2008b; Muscara et al., 2009). This measure has also been recommended by McCauley et al. (2012) for use in paediatric TBI research in an attempt to standardise the use of common psychometric measures for this population. Furthermore, the BRIEF parent form for adolescents has a large normative sample (PF *n*=1,419) that is representative of the U.S. population (Gioia et al., 2000).

The measures author's report that the BRIEF PF has good internal consistency (Cronbach's alpha α=0.72-0.98) for scale and composite scores. This measure also has good test-retest reliability correlations (r=0.80) over a mean interval of two weeks for the normative sample and three weeks for the clinical sample. The authors report moderate to high concurrent validity (*r*=0.30-0.90) for similar constructs on the parent forms of the Child Behaviour Checklist and the BASC-PRS. The BRIEF also includes validity indexes that measure the tendency to answer items negatively and an inconsistency index that measures differing responses that are normally answered consistently (Gioia et al., 2000)).

Completed questionnaires were scored using software provided by the publishers (PAR. Lutz FL). This software generates raw and *T*-scores (*M*=50/*SD*=10) for the PF clinical scales of Inhibit (item example: Interrupts others.), Emotional Control (e.g. Has explosive, angry outbursts.), Initiation (e.g. Is not a self-starter.), Plan/Organize (e.g. Has good ideas but cannot get them on paper.). Clinical scales are combined to form composite scores that the authors call the Behavioural Regulation Index (BRI) and the Meta-cognition Index (MI), which are then combined to form the Global Executive Composite score (GEC). High scores indicate a greater degree of problems and *T*-scores of greater than 65 are considered clinically relevant (Gioia et al. 2000).

Of particular interest to this study are the Global Executive Composite Scale, the Behavioural Regulation Index, and the Meta-Cognition Index. As well as the subscales of Inhibit, Emotional Control, and Plan/Organize. The Global Executive Composite scale is a summary score that incorporates all the clinical scales and is a representation of the child's overall level of executive dysfunction. The Behavioural Regulation Index is a composite scale that incorporates the subscales of Inhibit, Shift, and Emotional Control. This Index represents an individual's ability to mentally shift from one situation, activity, or aspect of a problem to another, and to regulate their emotions and behaviours in an appropriate manner. The authors contend that behavioural regulation supports the cognitive processes behind successful systematic problem solving and appropriate self-regulation. The Meta-Cognition Index is a composite scale that incorporates the subscales of Initiate, Working Memory,

Plan/Organize, Organization of Materials, and Monitor. This Index represents an individual's ability to initiate, plan, organise, and sustain future-oriented problem-solving, and reflects the ability to cognitively self-manage tasks and monitor one's task performance (Gioia et al., 2000).

The Inhibit subscale assesses the ability to inhibit, resist, or not behave in an impulsive manner, and is an important function in behavioural regulation. The Emotional Control subscale assesses an individual's ability to regulate their emotions in a socially conformable manner. Children with difficulties in this domain often have extreme emotional reactions to seemingly minor events or may have temper tantrums with frequency or severity that is not age appropriate. The Plan/Organize subscale measures an individual's ability to manage current and future-oriented tasks. The Plan component represents the ability to anticipate future events, set goals, and mentally construct appropriate strategies ahead of time in order to carry out a task or activity. The Organizing component reflects the ability to bring order to information and involves the recognition and understanding of key points or the main ideas of concepts when learning or communicating information (Gioia et al. 2000).

The CNS Vital Signs (CNS-VS). The CNS-VS is a performance-based computerised neurocognitive test battery that was developed for use as a clinical screening instrument or as a serial assessment tool (Gualtieri & Johnson, 2006). This test battery comprises a standard core battery of seven tests that have been adapted from well-established and valid conventional tests covering a broad range of cognitive domains. In addition to this core test battery, the CNS-VS also offers four additional neurocognitive tests (for more information see Gualtieri & Johnson, 2006).

This study used the core test battery, which comprised of a verbal memory test, a visual memory test, a finger tapping test, a symbol digit-coding test, a stroop test, a shifting attention test, and a continuous performance test. Three additional tests were also used, namely the perception of emotions test, the four part continuous performance test, and the dual task test.

These tests generate clinical domain scores for Verbal Memory, Visual Memory, Composite Memory, Processing Speed, Executive Function, Psychomotor Speed, Reaction Time, Complex Attention, Cognitive Flexibility, Social Acuity, Working Memory, and Sustained Attention. A Neuro-Cognitive Index score is also generated by averaging the domain scores and is an indication of a person's overall neurocognitive status (Gualtieri & Johnson, 2006).

The CNS-VS test battery was chosen because it is appropriate for serial administrations and has been successfully used to identify cognitive profiles in paediatric patients with neurological disorders and to distinguish between these patients and healthy control participants (Brooks & Sherman, 2012). The test battery is administered on a Windows-based PC, takes approximately 45 minutes, and involves a minimal amount of keyboard skills. The CNS-VS was standardised using a large normative sample (n=1,069) aged between 7-90 years and has good internal consistency (Cronbach's alpha α=0.65-0.87) for the clinical domain scales. The CNS-VS also has good test-retest reliability (r=0.31-0.87) for individual tests and domain scores over a period of 1-282 days (Gualtieri & Johnson, 2006).

Concurrent validity was demonstrated by comparing the CNS-VS to conventional neuropsychological tests (the Rey Auditory Verbal Learning Test: Logical Memory and Facial Recognition from the Wechsler Memory Test: a mechanical finger tapper: the Stroop Test: Trails B and the Verbal Fluency Test) and on another computerised neurocognitive test, namely the NES2 (Finger Tapping, Switching Attention, and the Continuous Performance Test). Moderate correlation coefficients were found with the conventional tests of memory, perceptual motor speed (coding), and executive function. The CNS-VS tests were also moderately correlated with tests of psychomotor speed (finger tapping and coding) and executive function on the NES2 (for further information see Gualieri & Johnson, 2006). The CNS-VS also shows positive correlations with similar traditional tests selected from the Neuropsychological Assessment Battery (NAB) using a mild TBI sample (Lanting, Iverson, & Lange, 2012).

A report is generated by the software package as soon as the test battery is completed and the results are presented in a standardised age and gender appropriate

format (SS: *M*= 100/*SD* = 15). This report presents the Neurocognitive Index and each of the domain scores in five separate categories: Above (SS > 109) indicating high functioning and capacity, Average (SS = 90-109) indicating normal functioning and capacity, Low average (SS = 80-89) indicating a slight deficit and impairment, Low (SS = 70-79) indicating that moderate deficits and impairments are possible, and Very low (SS < 70) indicating that deficits and impairments are likely.

As the focus of this study is executive functioning and social competence, the Neuro-Cognitive Index and the clinical domain scores for Executive Function, Cognitive Flexibility, and Social Acuity are of particular interest. The Neuro-Cognitive Index is calculated by averaging the domain scores for Composite Memory, Psychomotor Speed, Reaction Time, Complex Attention, and Cognitive Flexibility. The Executive Function domain score is based upon the subtraction errors from the correct responses on the shifting attention test. The Cognitive Flexibility domain score is generated from subtracting the shifting attention test errors and the stroop commission errors from the shifting attention test correct responses. The Social Acuity domain score is calculated from subtracting the commission errors from the correct responses on the Perception of Emotions test (for more information on the CNS-VS see the website www.CNS-VS.com).

Procedure

This research study was incorporated within a much larger longitudinal study known as The Consequences of Brain Injury in Childhood Study (COBIC). The COBIC study was jointly conducted and overseen by the University of Waikato and the Auckland University of Technology (AUT), and ethics approval was obtained from both the University of Waikato's School of Psychology Ethics Committee and the Northern Y Regional Ethics Committee.

Potential participants and their families who had expressed interest in the study were sent an information brochure outlining the COBIC study. Approximately seven days after this brochure was sent, a trained researcher conducting the

assessment contacted the potential participant/caregiver to make an appointment at their convenience, in order to explain what the study involved. During this initial meeting, the consent form was read aloud and an opportunity to ask further questions was provided. Following this process, the potential participant and their parent/caregiver (if they agreed to participate) were asked to sign the consent form (information brochure and consent form see Appendix C).

Following the consent process, the participant and their parent/caregiver were asked to complete a general information form (contact details, General Practitioner and school details). The researcher then arranged a convenient time and place for the assessments to be conducted.

For the parent/caregiver the assessment process consisted of the completion of two forms, which take approximately 30-40 minutes to fill out. These forms included the parental versions of the BASC-II, BRIEF, SDQ, and a series of questionnaires that focused on their child's general health and well-being, as well as the parent/caregiver's physical and mental health. Each parent/caregiver was given the option of either filling in the forms themselves and only asking the researcher for advice if they were having difficulties or having the researcher read them the questionnaires and recording the appropriate response for each item.

The participant's assessment was split into two separate sessions, each taking approximately 90-120 minutes to complete. Generally, the first assessment session would entail the participant completing an age appropriate abbreviated IQ test and a test of academic achievement (Wechsler Intelligence Scale for Children – fourth edition and the Woodcock – Johnson Test of Achievement – third edition (data from these assessments are reported elsewhere). Following the completion of these standardised tests, a convenient time and place was arranged for the second assessment session. This assessment session entailed the completion of the CNS-VS, BASC, BRIEF, SDQ, and other questionnaires regarding general information and demographic details, as well as the participant's general health and well-being.

The participant was asked whether they would like the assessment questions read to them aloud by the researcher and the corresponding item responses recorded

or whether they would like to complete the forms themselves, with any items that they did not understand explained to them by the researcher. Once the participant had completed the entire assessment battery, they were presented with a NZ$20 Warehouse voucher as a thank you.

Although the entire assessment battery generated a wealth of valuable information, only data from the parent and self-report versions of the BRIEF, BASC, and SDQ were used. Also included was participant data from the CNS-VS, and information regarding the participant's ethnicity and demographic details, as well as their familial SES.

Results

Statistical Analysis

Data analysis was conducted with IBM SPSS Statistics software Version 20 and the statistical significance level was set at 0.05 (two-tailed). Inferential statistical analysis was carried out using the Pearson's Chi-squared Test for Relatedness or Independence (χ^2) and a Fisher's Exact Test (*FET*) was conducted if the frequency count within the distribution was equal to or less than 5. Exact *p*-values (two-tailed) were reported for χ^2 analyses as the sampling distribution of this test statistic has an approximate distribution (Field, 2009). One-way between-groups ANOVA were used to compare the mean differences between the TBI and control groups and one-way repeated-measures ANOVA were used to compare the TBI sample means at the time points of baseline (time of injury), 1 month and 12 months post-injury. Bonferroni corrected post-hoc tests were conducted if the repeated-measures ANOVA were found to be significant ($p<0.05$) over the 3 time points. Additional analyses were carried out to explore the number of participants who met the clinically significant cut-off ranges and the differences in these proportions. A *p*-value of less than 0.1 was considered to be marginally significant and was reported as such. Partial Eta Squared Effect Sizes were reported for all ANOVA statistics and the conventions are presented in Table 4.

Table 4.

The categorisation and cut-off distributions for Partial Eta Squared Effect Sizes.

Partial Eta Squared Effect Size Categorisation	Conventions
Small Effect Size	< 0.200
Small / Medium Effect Size	0.200 – 0.399
Medium Effect Size	0.400 – 0.599
Medium / Large Effect Size	0.600 – 0.799
Large Effect Size	≥ 0.800

After these analyses, a composite scale of social competence was generated for participants at 12 months post-injury. As social competence may be considered an observable behaviour, parental report scales were chosen to represent the CHIMS Injury Outcome domains of Emotion and Behaviour. This involved generating correlations matrices for each measure. Then scales pertaining to the realms of emotion and behaviour were examined and categorised according to the strength of the correlation between the scale being examined and other scales within their domain, the scales description by the measures authors, and the literature presented within this thesis. A correlations matrix was then generated for the scales hypothesised to represent the CHIMS Injury Outcome domains and scales that did not show a significant correlation to other scales within their domain were substituted. The chosen scales were then factor analysed to assess the scales loadings and scales with a loading of greater than 0.7 were retained.

The chosen scale scores were converted to *Z* scores and summed to provide an overall score of social competence; some scales were inverted so that higher scores always corresponded to greater levels of social competence. A clinical cut-off for clinically relevant difficulties in social competence was set at 2 standard deviations below the control sample mean.

Prior to carrying out any statistical analysis, 10% of the data was randomly selected and checked for data entry errors against the original data spreadsheets. Box plots were generated for each of the measures at 12 months post-injury to identify outliers. Extreme outliers were found in the BASC parent report scales of Hyperactivity (n=1 TBI), Aggression (n=1 control), Internalizing Problems (n=1 TBI, n=1 control), and Withdrawal (n=1 TBI, n=2 control); the BASC self-report scales of Relations with Parents (n=1 control), and Interpersonal Relations (n=3 controls); the BRIEF parent report scale of Emotional Control (n=1 control); the SDQ parent report scale of Emotional Symptoms (n=1 control); the SDQ self-report scale of Peer Problems (n=1 control); and the CNS-VS domain of Cognitive Flexibility (n=1 control). Across all measures there was a higher proportion of outliers within the control group compared to the TBI group (n=12 control / n=3 TBI).

These outlying scores were not due to data entry errors and further examination revealed that the same participants tended to score highly across multiple measures. The validity scales within the BASC parent and self-report forms were checked and no participants fell within the extreme caution range. It was decided to include all outliers in the data analysis as the TBI participants were drawn from a population-based study (BIONIC study) and as such the inclusion criteria for control participants was that they were drawn from the same geographical catchment area as the TBI participants and that the control participants had not sustained a TBI throughout their life course. It should be noted that one of the outliers from the control group had a diagnosis of Autistic Spectrum Disorder and was an extreme outlier on the BASC parent report Withdrawal scale, the BASC self-report Interpersonal Relations scale, the SDQ self-report Peer Problems scale, and the CNS-VS Cognitive Flexibility domain scale.

Shapiro-Wilks tests of normality were carried out for each of the dependent variables and these tests revealed that some of the distributions were not normally distributed. A series of Mann-Whitney U tests and one-way between-groups ANOVA tests were conducted on all variables between the TBI and control groups, these p-values were compared and found to approximate each other on each of the outcome measure dependent variables. For consistency reasons, it was decided to report only the parametric tests.

Sample Characteristics

Table 5 presents the sample characteristics of the TBI group across injury severity ratings. All participants sustained a mild TBI of some description; with the highest proportion of participants sustaining a medium risk mild TBI (50%), followed by a high risk mild TBI (36.7%), and the lowest proportion of participants sustained a low risk mild TBI (13.3%). Other demographic factors were similar across each TBI severity category with a higher proportion of participants being male, of NZ European ethnicity, and living in an urban environment. No significant differences were found across the TBI severity categories.

Table 5.

The sample characteristics of the mild TBI group separated by injury severity ratings.

TBI Sample Characteristics (*n*= 30)	Mild TBI low risk *n*=4, 13.33%	Mild TBI medium risk *n*=15, 50.00%	Mild TBI high risk *n*=11,36.67%	Statistical Analysis
Gender				*FET*=4.149, *p*= .110
Males: *n (%)*	4 (13.33)	13 (43.33)	6 (20.00)	
Females: *n (%)*	0	2 (6.66)	5 (16.66)	
Ethnicity				*FET*=1.653, *p*= .951
Māori: *n (%)*	1 (3.33)	2 (6.66)	3 (10.00)	
Pasifika: *n (%)*	0	2 (6.66)	1 (3.33)	
NZ European: *n (%)*	3 (10.00)	11 (36.66)	7 (23.33)	
Residency				*FET*=1.481, *p*= .462
Urban: *n (%)*	3 (10.00)	11 (36.66)	10 (33.33)	
Rural: *n (%)*	1 (3.33)	4 (13.33)	1 (3.33)	
Diagnosed Health Conditions				*FET*=5.021, *p*= .977
No Conditions: *n (%)*	4 (13.33)	11 (36.66)	8 (26.66)	
Allergies: *n (%)*	0	1 (3.33)	2 (6.66)	
Skeletal: *n (%)*	0	1 (3.33)	0	
Mental Health: *n (%)*	0	0	0	
Gastro Intestinal: *n (%)*	0	1 (3.33)	1 (3.33)	
Other: *n (%)*	0	1 (3.33)	0	
Socioeconomic Status: *M (SD)*	64.37 (44.49)	56.59 (24.71)	53.16 (28.26)	$F_{(2,25)}$=0.191*, p*= .828 *ES*=0.015
Age at Injury (years): *M (SD)*	13.00 (1.41)	13.53 (1.06)	13.36 (1.03)	$F_{(2,27)}$=0.385*, p*= .684 *ES*=0.028

Note: Percentages = percentage of total TBI group, *FET = Fisher's Exact Test, F = One-way Between Groups ANOVA, ES = Effect Size (Partial Eta Squared).*

Functional Changes Following a TBI.

Analysis over time was limited to a subset of the TBI sample who had data available for them at the time points of baseline (time of injury), 1 month and 12 months post-injury (BASC parent *n*=13: BASC self-report *n*=14: CNS-VS *n*=12).

Behavioural Functioning. Behavioural functioning was assessed using the BASC parent report form. Table 6 presents the descriptive and inferential statistics for change over time on the primary scales of Hyperactivity, Aggression, Conduct Problems, Externalizing Problems, Internalizing Problems, Withdrawal, Social Skills, and Functional Communication; the BASC content scales of Anger Control, Bullying, Emotional Self-Control, and Executive Function; and the Behavioural Symptoms Index composite scale.

As can be seen in Table 6, there was a decrease in the mean scores between the baseline and 12 month time points for TBI participants on the scales of Hyperactivity, Aggression, Externalizing Problems, Internalizing Problems, Anger Control, Bullying, Emotional Self-Control, Executive Function, and the Behavioural Symptoms Index. This indicates an improvement in behavioural functioning over time within these domains. However, the scores increased between baseline and 12 months for Conduct Problems and Withdrawal; and decreased for Social Skills and Functional Communication, indicating a worsening in behavioural functioning over time within these domains.

The only statistically significant difference was found for the Aggression subscale and this difference showed a small/medium effect size. A post-hoc test revealed no significant difference between individual time points; due to the Bonferroni correction factor. The greatest decrease in scores was found between the time points of 1 month and 12 months. This indicates a progressive decrease in aggressive behaviour over time in the TBI sample.

Table 6.

A comparison between BASC parent report T scores at baseline, 1 month, and 12 month for TBI participants.

Measure BASC Parent *Tscores* (*n*=13)	Baseline *Mean (SD)*	1 month *Mean (SD)*	12 month *Mean (SD)*	Repeated Measures ANOVA	Effect Size
Hyperactivity	50.54 (8.26)	49.31 (7.33)	49.54 (7.04)	$F(2,24)=0.270, p= .766$	0.022
Aggression	56.00 (11.48)	54.46 (8.07)	50.77 (9.28)	$F(2,24)=3.624, p= .042$	0.232
Conduct Problems	50.23 (7.91)	51.38 (8.68)	51.23 (5.78)	$F(2,24)=0.331, p= .722$	0.027
Externalizing Problems	52.54 (8.93)	51.69 (8.00)	50.62 (7.17)	$F(2,24)=0.795, p= .463$	0.062
Internalizing Problems	51.31 (8.78)	47.54 (6.11)	50.23 (12.94)	$F(1.25,15.01)=0.707, p= .445$	0.056
Withdrawal	46.69 (6.14)	44.77 (5.72)	47.46 (10.45)	$F(1.24,14.88)=0.447, p= .556$	0.036
Social Skills*	51.23 (9.08)	49.38 (11.04)	48.00 (12.05)	$F(1.42, 17.07)=0.558, p= .525$	0.044
Functional Communication*	48.38 (10.52)	50.54 (10.15)	47.00 (8.16)	$F(1.32,15.78)=0.765, p= .430$	0.060
Anger Control	55.00 (6.34)	54.38 (3.80)	54.08 (6.45)	$F(2,24)=0.165, p= .849$	0.014
Bullying	51.54 (9.96)	51.38 (8.83)	49.62 (7.68)	$F(2,24)=1.027, p= .373$	0.079
Emotional Self-Control	52.69 (10.77)	52.15 (8.98)	52.31 (11.44)	$F(1.51,18.17)=0.018, p= .959$	0.001
Executive Function	53.92 (8.91)	51.92 (6.51)	51.77 (4.94)	$F(2,24)=0.634, p= .539$	0.050
Behavioural Symptoms Index	51.85 (9.16)	48.62 (6.53)	49.85 (7.96)	$F(1.53,18.38)=0.727, p= .462$	0.057

Note: *Lower scores on these scales correspond to higher levels of dysfunction, Effect Size = Partial Eta Squared, *SD* = Standard Deviation

Emotional and Interpersonal Functioning. Emotional and interpersonal functioning was assessed using the BASC self-report of personality. Table 7 presents the descriptive and inferential statistics for the primary scales of Social Stress, Inattention/Hyperactivity, Relations with Parents, and Interpersonal Relations; and the Emotional Symptoms Index composite scale (a global measure of emotional functioning).

As can be seen, there was a mean decrease between the baseline and 12 month time points for Inattention/Hyperactivity, and the Emotional Symptoms Index; and an increase for Relations with Parents, indicating an improvement within these domains. However, an increase was found for Social Stress and a decrease for Interpersonal Relations, indicating a worsening in functioning over time for these domains. No statistically significant changes were found for these scales. However, a marginally significant change was found for Relations with Parents (small/medium effect size); however, a post-hoc test revealed no significant difference between the individual time points.

Table 7.

A comparison between the BASC self-report T scores at Baseline, 1 month, and 12 months for TBI participants.

Measure BASC Self-Report *T*scores (*n*=14)	Baseline *Mean (SD)*	1 month *Mean (SD)*	12 months *Mean (SD)*	Repeated Measures ANOVA	Effect Size
Social Stress	43.71 (8.30)	42.64 (6.90)	44.43 (8.02)	$F(2,26)=0.693$, *p*= .509	0.051
Inattention / Hyperactivity	55.29 (9.34)	56.07 (9.76)	52.57 (12.37)	$F(2,26)=1.054$, *p*= .363	0.075
Relations with Parents*	51.79 (8.50)	52.71 (6.86)	55.86 (7.31)	$F(2,26)=3.242$, *p*= .055	0.200
Interpersonal Relations*	55.64 (7.70)	54.71 (4.55)	55.43 (6.54)	$F(1.29,16.78)=0.137$, *p*= .779	0.010
Emotional Symptoms Index	44.07 (5.51)	42.50 (5.13)	43.64 (7.77)	$F(2,26)=0.571$, *p*= .572	0.042

Note: * Lower scores on these scales correspond to higher levels of dysfunction, Effect Size = Partial Eta Squared, *SD* = Standard Deviation.

Cognitive Functioning. Cognitive functioning was assessed using the CNS-VS performance-based computerised test battery. Table 8 presents the descriptive and inferential statistics for the cognitive domains of Executive Function, Cognitive Flexibility, Social Acuity, and the Neuro-Cognitive Index composite score (a summary measure of cognitive functioning) over the three assessment time points.

As can be seen, there were mean increases between the baseline and 12 months on all scales, indicating an improvement in cognitive functioning over time. Statistically significant differences (with small/medium effect sizes) were found for Executive Function and Cognitive Flexibility. Post-hoc tests revealed no significant differences between any specific time points for both these cognitive domains. However, a marginally significant difference was found between the time points of baseline and 1 month, indicating a trend towards an improvement in executive functioning and cognitive flexibility in the month following a TBI.

Table 8.

A comparison between the CNS-VS standard scores at baseline, 1 month, and 12 months for TBI participants.

Measure CNS-VS (*n*=12)	Baseline *Mean (SD)*	1 month *Mean (SD)*	12 months *Mean (SD)*	Repeated Measures ANOVA	Effect Size
Executive Function	98.00 (14.71)	105.79 (7.99)	105.93 (12.91)	$F(2,26)=3.776$, $p= .036$	0.225
Cognitive Flexibility	96.43 (14.10)	105.07 (8.18)	103.21 (13.58)	$F(2,26)=3.619$, $p= .041$	0.218
Social Acuity	86.50 (22.46)	97.71 (22.16)	89.93 (27.11)	$F(2,26)=1.447$, $p= .254$	0.100
Neurocognitive Index	94.42 (14.54)	97.42 (8.37)	97.42 (10.46)	$F(1.23,13.53)=0.635$, $p= .471$	0.055

Note: Effect Size = Partial Eta Squared, *SD* = Standard Deviation.

In summary, the findings show that there were only small changes in functioning over the 12 months following a TBI. Generally, the scores show an improvement in functioning for all scales apart from the BASC parent report scales of Conduct Problems, Withdrawal, Social Skills and Functional Communication; and the BASC self-report scales of Social Stress and Interpersonal Relations; however, none of

this change was statistically significant. The only significant improvements in functioning were found for the BASC parent report scale of Aggression, and the CNS-VS domains of Executive Function and Cognitive Flexibility.

Comparisons between the TBI and Control Groups

It should be noted that, although the samples were matched by age at 12 months post-injury, the sample sizes may vary as a small proportion of participants or their parents either withdrew their consent or decided not to continue with the assessment after partial completion.

Behavioural Functioning. The behavioural functioning of participants was assessed at 12 months post-injury using the BASC parent report, the SDQ parent report, and the SDQ self-report. Table 9 presents the descriptive and inferential statistics for the primary, content, and composite scales of the BASC parent report.

As can be seen in this Table, the mean scores show a higher level of behavioural dysfunction within the TBI group. The only exception to this trend was for the Withdrawal scale. There were significant differences (with small effect sizes) between the groups for Aggression, Conduct Problems, Externalizing Problems, Internalizing Problems, Functional Communication, Bullying, Emotional Self-Control, and Executive Functioning; and a marginally significant difference for Anger Control. All of the mean scores were within the 'normal' range.

Table 9.

A comparison between TBI and control participants on the BASC parent report at 12 months post-injury.

Measure BASC Parent 12month *T*scores	*Mean (SD)*		One-way Between Groups ANOVA	Effect Size
	TBI (*n*=22)	Control (*n*=28)		
Hyperactivity	51.64 (8.42)	47.89 (7.78)	$F(1,48)=2.653, p= .110$	0.052
Aggression	51.86 (10.96)	45.93 (6.29)	$F(1,48)=5.805, p= .020$	0.108
Conduct Problems	52.36 (10.43)	45.00 (5.26)	$F(1,48)=10.572, p= .002$	0.180
Externalizing Problems	52.23 (10.34)	45.93 (5.85)	$F(1,48)=7.406, p= .009$	0.134
Internalizing Problems	50.32 (11.48)	43.32 (9.17)	$F(1,48)=5.748, p= .020$	0.107
Withdrawal	46.91 (8.66)	48.82 (12.73)	$F(1,48)=0.363, p= .549$	0.008
Social Skills*	48.18 (10.72)	49.57 (8.66)	$F(1,48)=0.257, p= .614$	0.005
Functional Communication*	47.14 (8.11)	54.64 (7.33)	$F(1,48)=11.770, p= .001$	0.197
Anger Control	55.68 (8.56)	51.86 (5.86)	$F(1,48)=3.508, p= .067$	0.068
Bullying	51.32 (10.53)	45.43 (5.92)	$F(1,48)=6.266, p= .016$	0.115
Emotional Self-Control	52.50 (11.14)	44.82 (6.93)	$F(1,48)=8.932, p= .004$	0.157
Executive Functioning	53.23 (8.16)	47.86 (8.43)	$F(1,48)=5.144, p= .028$	0.097
Behavioural Symptoms Index	50.41 (8.56)	46.64 (8.03)	$F(1,48)=2.556, p= .116$	0.051

Note: *Lower scores on these scales correspond to higher levels of dysfunction, Effect Size = Partial Eta Squared, *SD* = Standard Deviation.

Table 10 presents the descriptive and inferential statistics for the proportion of participants who scored within the clinically relevant range on the BASC parent report at 12 months post-injury. For all of these BASC scales, there were a larger proportion of TBI participants within the clinically relevant range. The only exception to this trend was on the scale of Withdrawal. No significant differences in the proportions of TBI and control participants meeting clinical cut-offs were found. However, a marginally significant difference was found for Aggressive behaviour.

Table 10.

The proportion of participants within the clinical cut-off range for the BASC parent report at 12 months post-injury.

Measure: BASC Parent TBI *n*=22 Control *n*=28	TBI *n* (%)		Control *n* (%)		Statistics
	Normal	Clinical	Normal	Clinical	*Fisher's Exact Test*
Hyperactivity	21 (95.5)	1 (4.5)	27 (96.4)	1 (3.6)	*FET*=0.030, *p*= 1.000
Aggression	19 (86.4)	3 (13.6)	28 (100.0)	0	*FET*=4.062, *p*= .079
Conduct Problems	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Externalizing Problems	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Internalizing Problems	20 (90.9)	2 (9.1)	27 (96.4)	1 (3.6)	*FET*=0.665, *p*= .576
Withdrawal	21 (95.5)	1 (4.5)	26 (92.9)	2 (7.1)	*FET*=0.147, *p*= 1.000
Social Skills	21 (95.5)	1 (4.5)	28 (100.0)	0	*FET*=1.299, *p*= .440
Functional Communication	21 (95.5)	1 (4.5)	28 (100.0)	0	*FET*=1.299, *p*= .440
Anger Control	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Bullying	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Emotional Self-Control	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Executive Function	20 (90.9)	2 (9.1)	28 (100.0)	0	*FET*=2.652, *p*= .189
Behavioural Symptoms Index	21 (95.5)	1 (4.5)	27 (96.4)	1 (3.6)	*FET*=0.030, *p*= 1.000

Note: Fisher's Exact Test (FET) used when frequency values were ≤ 5.

Table 11 presents the descriptive and inferential statistics for the subscales and Total Difficulties composite scale on the SDQ parent report and SDQ self-report at 12 months post-injury. The TBI sample scores indicate a greater degree of difficulties within this group for all of the SDQ parent report scales except Peer Relations. Statistically significant differences (with small effect sizes) were found for Emotion Symptoms, Conduct Problems, Hyperactivity, and the Total Difficulties scale.

Table 11.

A comparison of the SDQ parent report and the self-report statistical analysis results between control and TBI participants at 12 months post-injury.

Measure: SDQ Parent Report TBI *n=27* / Control *n=28*	*Mean (SD)*		One-way Between Groups ANOVA	Effect Size
	TBI	Control		
Emotion Symptoms	2.07 (2.42)	0.82 (1.25)	$F(1,53)=5.894, p= .019$	0.100
Conduct Problems	2.41 (2.56)	0.68 (0.98)	$F(1,53)=11.074, p= .002$	0.173
Hyperactivity	3.44 (2.67)	1.89 (2.08)	$F(1,53)=5.820, p= .019$	0.099
Peer Relations	1.33 (1.49)	2.11 (2.18)	$F(1,53)=2.337, p= .132$	0.042
Prosocial Behaviour*	7.22 (2.04)	7.61 (1.93)	$F(1,53)=0.516, p= .476$	0.010
Total Difficulties	9.26 (7.64)	5.50 (3.70)	$F(1,53)=5.458, p= .023$	0.093
SDQ Self-Report Report TBI *n=23* / Control *n=29*				
Emotion Symptoms	2.39 (2.29)	2.21 (1.93)	$F(1,50)=0.099, p= .754$	0.002
Conduct Problems	2.57 (2.02)	1.69 (2.02)	$F(1,50)=2.460, p= .123$	0.047
Hyperactivity	4.78 (2.13)	4.07 (2.99)	$F(1,50)=0.934, p= .339$	0.018
Peer Relations	1.22 (0.10)	1.83 (2.21)	$F(1,50)=1.511, p= .225$	0.029
Prosocial Behaviour*	7.26 (1.63)	7.41 (1.74)	$F(1,50)=0.105, p= .748$	0.002
Total Difficulties	10.96 (5.20)	9.79 (6.53)	$F(1,50)=0.486, p= .489$	0.010

Note: *Lower scores on these scales correspond to higher levels of dysfunction, Effect Size = Partial Eta Squared, *SD* = Stand Deviation.

Similarly, the TBI sample obtained higher scores on all of the SDQ self-report scales except for Peer Relations compared to the control group. However, no significant differences were found between the groups for any of these scales.

Given the level of disagreement in scores between the SDQ parent and self-reports, correlations were conducted between these measures for the subscales of Emotion Symptoms ($r=0.125, p= .399$), Conduct Problems ($r=0.327, p= .023$), Hyperactivity ($r=0.242, p= .097$), Peer Relations ($r=0.541, p= < .001$), Prosocial Behaviour ($r=0.504, p= < .001$), and the Total Difficulties composite scale ($r=0.214, p= .144$). A correlation between the BASC parent and self-reports was unable to be conducted as the subscales differ.

Table 12 presents the proportions of participants who scored within the clinically relevant range on the SDQ parent and self-reports. For all of the SDQ parent report scales there were a higher proportion of clinically relevant difficulties within the TBI sample except Peer Problems and significant differences in these proportions were found for the SDQ parent subscale of Conduct Problems and the Total Difficulties composite scale. The SDQ self-report Emotional Symptoms was the only scale that showed a higher proportion of TBI participants compared to control participants within the clinical range for difficulties. All of the other scales had a higher proportion of control participants within this range. No significant differences in proportions were found for any of the SDQ self-report scales.

Table 12.

The proportion of participants within the clinical cut-off range for the SDQ parent report and Self-report at 12 months post-injury.

Measure:	TBI n (%)		Control n (%)		Statistics
SDQ Parent Report TBI n=27 / Control n=28	Normal	Clinical	Normal	Clinical	*Fisher's Exact Test Chi-Squared (χ^2)*
Emotional Symptoms	23 (85.2)	4 (14.8)	27 (96.4)	1 (3.6)	*FET*=2.103, *p*= .193
Conduct Problems	20 (74.1)	7 (25.9)	28 (100.0)	0	*FET*=8.318, *p*= .004
Hyperactivity	23 (85.2)	4 (14.8)	27 (96.4)	1 (3.6)	*FET*=2.103, *p*= .193
Peer Problems	26 (96.3)	1 (3.7)	24 (85.7)	4 (14.3)	*FET*=1.862, *p*= .352
Prosocial Behaviour	20 (74.1)	7 (25.9)	22 (78.6)	6 (21.4)	$\chi^2(1)$=0.154, *p*= .758
Total Difficulties	21 (77.8)	6 (22.2)	28 (100.0)	0	*FET*=6.984, *p*= .010
SDQ Self-Report TBI n=23 Control n=29					
Emotional Symptoms	17 (73.9)	6 (26.1)	24 (82.8)	5 (17.2)	*FET*=0.602, *p*= .507
Conduct Problems	21 (91.3)	2 (8.7)	25 (86.2)	4 (13.8)	*FET*=0.327, *p*= .682
Hyperactivity	20 (87.0)	3 (13.0)	21 (72.4)	8 (27.6)	*FET*=1.626, *p*= .308
Peer Problems	21 (91.3)	2 (8.7)	22 (75.9)	7 (24.1)	*FET*=2.137, *p*= .268
Prosocial Behaviour	20 (87.0)	3 (13.0)	22 (75.9)	7 (24.1)	*FET*=1.016, *p*= .482
Total Difficulties	22 (95.7)	1 (4.3)	26 (89.7)	3 (10.3)	*FET*=0.650, *p*= .621

Note: Fisher's Exact Test (FET) used if frequency values were ≤ 5. *Chi-squared Test of Independence (χ^2)* used if frequency values were >5.

Emotional and Interpersonal Functioning. As previously mentioned, the emotional and interpersonal functioning of participants was assessed at 12 months post-injury using the BASC self-report of personality. Table 13 presents the descriptive and inferential statistics for the scales of Social Stress, Inattention/Hyperactivity, Relations with Parents, and Interpersonal Relation, and the Emotional Symptoms Index composite scale. As can be seen, control participant scores indicate a greater degree of difficulty on all scales except Inattention/Hyperactivity. No statistically significant differences were found between the scores obtained by each group on any of these scales.

Table 13.

A comparison of the BASC self-report for control and TBI participants at 12 months post-injury.

Measure BASC Self-Report *T* scores TBI *n*=21 / Control *n*=29	Mean (SD)		One-way Between Groups ANOVA	Effect Size
	TBI	Control		
Social Stress	44.62 (11.53)	45.97 (11.53)	$F_{(1,48)}$=0.218, *p*= .642	0.005
Inattention / Hyperactivity	54.14 (11.11)	52.48 (13.35)	$F_{(1,48)}$=0.216, *p*= .644	0.004
Relations with Parents*	53.76 (8.99)	50.52 (8.70)	$F_{(1,48)}$=1.647, *p*= .206	0.033
Interpersonal Relations*	54.76 (6.92)	50.69 (9.92)	$F_{(1,48)}$=2.612, *p*= .113	0.052
Emotional Symptoms Index	44.19 (7.52)	46.24 (10.62)	$F_{(1,48)}$=0.573, *p*= .453	0.012

Note: *Lower scores on these scales correspond to higher levels of dysfunction, Effect Size = Partial Eta Squared, *SD* = Standard Deviation.

Table 14 presents the proportions of participants who scored within the clinically relevant range of functional difficulties on the BASC self-report of personality. Inattention/Hyperactivity was the only scale that showed a higher proportion of clinically relevant dysfunction within the TBI group, all other scales showed a higher proportion of control participants within this range. No statistically significant differences were found for these proportions.

Table 14.

The proportion of participants within the clinical cut-off range for the BASC self-report at 12 months post-injury.

Measure: BASC Self-Report TBI *n*=21 Control *n*=29	TBI *n* (%)		Control *n* (%)		Statistics
	Normal	Clinical	Normal	Clinical	*Fisher's Exact Test*
Social Stress	21 (100.0)	0	28 (96.6)	1 (3.4)	*FET*=0.739, *p*= 1.000
Inattention / Hyperactivity	18 (85.7)	3(14.3)	26 (89.7)	3(10.3)	*FET*=0.179, *p*= .686
Relations with Parent	21 (100.0)	0	28 (96.6)	1(3.40)	*FET*=0.739, *p*= 1.000
Interpersonal Relations	21 (100.0)	0	27 (93.1)	2 (6.9)	*FET*=1.509, *p*= .503
Emotional Symptoms Index	21 (100.0)	0	27 (93.1)	2 (6.9)	*FET*=1.509, *p*= .503

Note: Fisher's Exact Test (FET) used if frequency values were ≤ 5.

Cognitive Functioning. Participants were assessed at 12 months post-injury using the CNS-VS performance-based computerised test battery and the BRIEF parent report. Compared to the control group on the CNS-VS (see Table 15.), the TBI group obtained lower scores indicating poorer cognitive functioning; however, these differences were not statistically significant.

Table 15.

A comparison of the CNS-VS statistical analysis standardized score results between control and TBI participants at 12 months post-injury.

Measure CNS-VS 12months TBI *n*=24 / Control* *n*=30	*Mean (SD)*		One-way Between Groups ANOVA	Effect Size
	TBI	Control		
Executive Function	101.67 (15.90)	102.70 (14.79)	*F(1,52)*=0.061, *p*= .806	0.001
Cognitive Flexibility	98.33 (17.84)	102.63 (14.95)	*F(1,52)*=0.929, *p*= .340	0.018
Social Acuity	89.17 (24.91)	96.93 (16.49)	*F(1,51)*=1.845, *p*= .180	0.035
Neuro-Cognitive Index	95.25 (14.68)	101.48 (12.67)	*F(1,51)*=2.754, *p*= .103	0.051

Note: Control *n*=30 for the scales of Executive Function and Cognitive Flexibility, and *n*=29 for the scales of Social Acuity and the Neurocognitive Index. Effect Size = Partial Eta Squared, *SD* = Standard Deviation.

Table 16 presents the proportions of participants within their CNS-VS functional categories at 12 months post-injury. A higher proportion of TBI participants were within the very low functional category compared to control participants on all of the cognitive domains and the Neuro-Cognitive Index. Of note was the high percentage of TBI participants within the very low category on the Social Acuity scale compared to the proportion within this category for other CNS-VS domains.

Table 16.

The proportion of TBI and control participants within the CNS-VS functional categories at 12 months post-injury.

Measure: CNS-VS	CNS-VS 12 month Functional Categories (TBI *n*=24/Control* *n*=30)									
	TBI Participants *n* (%)					Control Participants *n* (%)				
	Above	Average	Low Average	Low	Very Low	Above	Average	Low Average	Low	Very Low
ss range	ss>109	90-109	80-89	70-79	ss<70	ss>109	90-109	80-89	70-79	ss<70
Executive Function	8(33.3)	12(50.0)	3(12.5)	0	1(4.2)	9(30.0)	17(56.7)	2(6.7)	1(3.3)	1(3.3)
Cognitive Flexibility	6(25.0)	13(54.2)	4(16.7)	0	1(4.2)	10(33.3)	17(56.7)	1(3.3)	1(3.3)	1(3.3)
Social Acuity	4(16.7)	11(45.8)	3(12.5)	1(4.2)	5(20.8)	7(24.1)	15(51.7)	4(13.8)	2(6.9)	1(3.4)
Neuro-Cognitive Index	2(8.3)	16(66.7)	4(16.7)	1(4.2)	1(4.2)	10(34.5)	15(51.7)	2(6.9)	1(3.4)	1(3.4)

Note: 29 control participants for the Social Acuity and Neuro-Cognitive Index, ss = standard score.

Table 17 presents the descriptive and inferential statistics between the groups for the BRIEF parent report scales of Inhibit, Emotional Control, the Behavioural Regulation Index and Meta-Cognition Index composite scales, and Global Executive Composite scale (a global measure of executive function). As can be seen, the TBI group obtained higher scores on all scales compared to the control group, indicating poorer functioning. These differences were statistically significant (with small effect sizes) for Inhibit, Emotional Control, the Behavioural Regulation Index, and the Global Executive Composite.

Table 17.

A comparison of the BRIEF parent report statistical analysis results for control and TBI participants at 12 months post-injury.

Measure BRIEF Parent Report (TBI *n*=27/Control *n*=28)	Mean (SD)		One-way Between Groups ANOVA	Effect Size
	TBI	Control		
Inhibit	56.89 (14.29)	46.54 (7.62)	F(1,53)=11.360, *p*= .001	0.177
Emotional Control	56.15 (12.65)	47.32 (7.40)	F(1,53)=10.061, *p*= .003	0.160
Behavioural Regulation Index	62.25 (14.95)	48.96 (7.82)	F(1,53)=8.576, *p*= .005	0.139
Meta-Cognition Index	54.00 (10.37)	50.39 (8.48)	F(1,53)=2.002, *p*= .163	0.036
Global Executive Composite	55.30 (12.68)	49.07 (8.01)	F(1,53)=4.772, *p*= .033	0.083

Note: Effect Size = Partial Eta Square, *SD* = Standard Deviation.

Table 18 presents the proportion of participants who scored within the clinically relevant range for difficulties on the BRIEF parent report. When compared to the control participants, a higher proportion of TBI participants scored within the clinical range on all scales.

Table 18.

The proportion of participants within the clinical cut-off range for the BRIEF parent report at 12 months post-injury.

Measure BRIEF Parent 12months TBI *n*=27/Control *n*=28	TBI *n* (%)		Control *n* (%)		Statistics
	Normal	Clinical	Normal	Clinical	*Fisher's Exact Test*
Inhibit	17 (63.0)	10 (37.0)	26 (92.9)	2 (7.1)	*FET*=7.201, *p*= .010
Emotional Control	20 (74.1)	7 (25.9)	27 (96.4)	1 (3.6)	*FET*=5.526, *p*= .025
Behavioural Regulation Index	20 (74.1)	7 (25.9)	27 (96.4)	1 (3.6)	*FET*=5.526, *p*= .025
Meta-Cognition Index	24 (88.0)	3 (11.1)	25 (89.3)	3 (10.7)	*FET*=0.002, *p*= 1.000
Global Executive Composite	20 (74.1)	7 (25.9)	26 (92.9)	2 (7.1)	*FET*=3.543, *p*= .078

Note: Fisher's Exact Test (FET) used if frequency values were ≤ 5.

There were statistically significant differences in the proportion of participants who met the clinical cut-offs for Inhibit, Emotional Control, and the Behavioural Regulation Index. A marginally significant difference was found for the Global Executive Composite scale.

In summary, the TBI sample showed a greater degree of behavioural dysfunction and difficulties than the control sample and this was reflected in significantly greater levels of dysfunction as evidence by the BASC parent report scales of Aggression, Conduct Problems, Externalizing Problems, Internalizing Problems, Functional Communication, Bullying, Emotional Self-Control, and Executive Function; the SDQ parent report scales of Emotional Symptoms, Conduct Problems, Hyperactivity, and the Total Difficulties Composite scale. This trend generally equated to a higher proportion of TBI participants within the clinically relevant range for behavioural dysfunction and a significantly higher proportion meeting the clinical cut-off on the SDQ parent report scale of Conduct Problems and the Total Difficulties composite scale. These findings suggest that TBI participants were experiencing a greater range and severity of behavioural problems compared to the control participants. Of interest, was the level of disagreement between parent and self-report scales on the SDQ, with parents of TBI participants perceiving their adolescent's difficulties as greater than the perceptions of the adolescent.

Within the realms of emotional and interpersonal functioning, TBI participants reported greater difficulties with Inattention/Hyperactivity and fewer relationship difficulties. There also appears to be some disagreement between the BASC parental and self-reports of difficulties regarding the inhibition of emotions (r=0.095, p= .540).

In terms of cognitive functioning, TBI participants were found to have higher levels of dysfunction and this equated to greater proportions of TBI participants scoring within the CNS-VS functional category of very low. Similarly, greater cognitive difficulties were found for TBI participants on all of the BRIEF parent report scales and these difficulties were significant for Inhibit, Emotional Control, the Behavioural Regulation Index, and the Global Executive Composite scale. Again, this equated to

higher proportions of TBI participants scoring within the clinically relevant range for functional difficulties and significantly higher proportions of the TBI sample were found for Inhibit, Emotional Control, and the Behavioural Regulation Index.

Social Competence

As social competence may be considered an observable social behaviour, the BRIEF and BASC parent reports were chosen to represent the Emotional and Behavioural Injury Outcome domains on the CHIMS model, as these measures are based on observable child behaviours. As each of these measures are made up of multiple subscales, a correlations matrix was generated for each of these measures (BASC and BRIEF), to assist with selecting the most appropriate scales to include in the composite measure. Only control participant's data was used in this selection process, as this data was considered to be representative of the community at large (normative data) and there could be some underlying deficits or difficulties within the TBI sample that may bias the selection process.

As the ultimate goal was to choose scales that specifically related to the domains of emotion and behaviour; scales that pertained to the domain of cognition were disregarded. This was because the composite index made up of the chosen subscales (Social Competence Index) would later be compared to a performance-based measure of executive function (CNS-VS), in order to examine whether there was a relationship between social competence and executive functioning. Therefore, subscales that made up the BRIEF Meta-Cognitive Index and the BASC scale of Executive Function were not included, as well as global composite scales that incorporated cognitive components (BRIEF Meta-Cognitive Index and the Global Executive Composite scale: BASC scale of Executive Function and the Behavioural Symptom Index. Table 19 presents a correlations matrix for the BRIEF parent report and Table 20 presents a correlations matrix for the BASC parent report.

Table 19.

A correlations matrix for the BRIEF parent report scales at 12 months post-injury.

BRIEF Parent 12month	Inhibit	Emotional Control	Working Memory	Plan / Organize
Emotional Control	r=.428, p= .023			
Working Memory	r=.445, p= .018	r=.044, p= .824		
Plan / Organize	r=.238, p= .222	r=.359, p= .061	r=.686, p=< .001	
BRI	r=.855, p=< .001	r=.748, p= <.001	r=.291, p= .133	r=.327, p= .089

Note: BRI=Behavioural Regulation Index, MCI=Meta-Cognition Index, GEC=Global Executive Composite.

As can be seen in Table 19, a strong and statistically significant relationship was found between the subscales of Inhibit and Emotional Control (*r*=0.428), as well as the Behavioural Regulation Index and both of these scales (*r*=0.855, *r*=0.748 respectively). However, as the Behavioural Regulation Index was strongly related to both Inhibit and Emotional Control, this composite scale was excluded so that individual scales could be match to the separate CHIMS domains of emotion and behaviour. Table 20 shows a strong relationship between the scales of Externalizing Problems and Hyperactivity (*r*=0.804), Aggression (*r*=0.849), Conduct Problems (*r*=0.753), Social Skills (*r*=0.459), Functional Communication (*r*=0.577), Anger Control (*r*=0.797), Bullying (*r*=0.843), and Emotion Self-Control (*r*=0.610); and between Internalizing Problems and Withdrawal (*r*=0.624), and Emotion Self-Control (*r*=0.593). This resulted in all of the above scales being short listed for selection.

Table 20.

A correlations matrix for the BASC parent report scales at 12 months post-injury.

BASC Parent 12month	Hyper…	Aggression	Conduct Problems	Extern… Problems	Intern… Problems	Withd…	Social Skills	Functional Comm…	Anger Control	Bullying
Aggression	r=.475, p=.011									
Conduct Problems	r=.328, p=088	r=.625, p=<.001								
Extern… Problems	r=.804, p=<.001	r=.849, p=<.001	r=.753, p=<.001							
Intern… Problems	r=.297, p=.125	r=.118, p=.550	r=.219, p=.263	r=.279, p=.151						
Withd…	r=.471, p=.011	r=.185, p=.346	r=.016, p=.935	r=.323, p=.094	r=.624, p=<.001					
Social Skills	r=-.374, p=.050	r=-.526, p=.004	r=-.205, p=.296	r=-.459, p=.014	r=-.024, p=.902	r=-.188, p=.339				
Functional Comm…	r=-.609, p=.001	r=-.330, p=.086	r=-.445, p=.018	r=-.577, p=.001	r=-.297, p=.125	r=-.290, p=.134	r=.486, p=.009			
Anger Control	r=.502, p=.006	r=.763, p=<.001	r=.713, p=<.001	r=.797, p=<.001	r=.308, p=.110	r=.263, p=.177	r=-.347, p=.070	r=-.366, p=.055		
Bullying	r=.629, p=<.001	r=.777, p=<.001	r=.657, p=<.001	r=.843, p=<.001	r=.256, p=.188	r=.173, p=.380	r=-.397, p=.037	r=-.452, p=.016	r=.716, p=<.001	
Emotion Self-Control	r=.587, p=.001	r=.586, p=.001	r=.262, p=.178	r=.610, p=.001	r=.593, p=.001	r=.566, p=.002	r=-.374, p=.050	r=-.390, p=.040	r=.586, p=.001	r=.616, p=<.001

Note: Hyper…=Hyperactivity, Extern… Problems=Externalizing Problems, Inter… Problems=Internalizing Problems, Withd…=Withdrawal,

Functional Comm…=Functional Communication,

After conducting the correlations, the author's descriptions of the short listed subscales were read carefully and compared to the literature, in order to assess which scales corresponded to social competence and the domains of emotion and behaviour. Based on this and the correlations: the BASC scales of Emotion Self-Control, Internalizing Problems, and the BRIEF scale of Emotional Control were allocated to the domain of Emotion; and the BASC scales of Hyperactivity, Aggression, Conduct Problems, Externalizing Problems, Social Skills, Functional Communication, Anger Control, Bullying, and the BRIEF scale of Inhibit were allocated to the domain of Behaviour.

A correlation matrix was generated for these selected scales and scales that did not show a strong relationship to the other scales within their domain or were not representative of the components within each domain were excluded and substituted with another scale pertaining to that domain. Scales that correlated with each other for their desired domains were then factor analysed to assess their loadings onto each component and loadings of greater than 0.7 were retained.

Five scales were chosen to represent the CHIMS Injury Outcome domains of Emotion and Behaviour. Within the CHIMS Emotional domain, the BRIEF scale of Emotional Control was chosen to represent Emotion Regulation. The BASC content scale of Internalizing Problems was chosen to represent the domain of Internalizing Disorders and Difficulties, this content scale is made up from the primary scales of Depression, Anxiety, and Somatization. The Internalizing Problems scale was chosen as it is made up of scales that may influence a person's social competence and the Emotional Control scale (BRIEF) was chosen over the Emotion Self-Control scale (BASC) as it showed a greater distinction between the factor analysis loading components.

Within the CHIMS Behavioural domain, the BRIEF scale of Inhibit was chosen to represent Behaviour Regulation. The BASC content scale of Externalizing Problems was chosen to represent the domain of Externalizing Disorders and Difficulties and Aggression. This content scale is made up from the primary scales of Hyperactivity, Aggression, and Conduct Problems. The BASC adaptive scale of Functional Communication was chosen to represent the domain of Communication Skills. The

Inhibit scale was chosen as the authors contend that it is a measure of a person's behavioural regulation which the literature suggests is an important component in social competence, the Externalizing Problems scale was chosen because it incorporates scales of behaviours that the literature suggests would be influential in a person's level of social competence, and Functional Communication was chosen as it is the only scale that measures communication skills. Table 21 presents a correlation matrix for these 5 scales and Table 22 presents the results of the factor analysis's results for each scale and their loadings onto each component.

Table 21.

A correlations matrix for the BRIEF parent report scales of Inhibit and Emotional Control, and the BASC parent report scales of Internalizing Problems, Externalizing Problems, and Functional Communication.

Measure Scales	Inhibit	Emotional Control	Internalizing Problems	Externalizing Problems
Emotional Control	*r=.428 p=.023*			
Internalizing Problems	*r=.333, p=.084*	*r=.811, p=<.001*		
Externalizing Problems	*r=.606, p=.001*	*r=.440, p=.019*	*r=.279, p=.151*	
Functional Communication	*r=-.751, p=<.001*	*r=-.304, p=.115*	*r=-.297, p=.125*	*r=-.577, p=.001*

Table 21 shows a distinction between Externalizing Problems and Internalizing Problems which is consistent with the CHIMS model's separate domains of emotion and behaviour. Functional Communication did not show a strong relationship with Internalizing Problems and Emotional Control; however, this scale was retained because it was the only scale to represent communication skills. All other scales showed a strong relationship and it was postulated that these related scales would all pertain to social competence. Table 22 shows that the scales chosen to represent the CHIMS Behavioural domain all load highly onto one component and the Emotional domain scales load highly onto the second component.

Table 22.

A factor analyses rotated component matrix for the BRIEF parent report scales of Inhibit and Emotional Control, and the BASC parent report scales of Functional Communication, Externalizing Problems, and Internalizing Problems at 12 months post-injury.

BASC and BRIEF scales	Component Loadings	
	Factor 1	Factor 2
Functional Communication	0.892	0.114
Inhibit	0.878	0.218
Externalizing Problems	0.788	0.230
Internalizing Problems	0.147	0.940
Emotional Control	0.260	0.918

Participant's scores for these scales were then converted to *Z* scores and summed to generate a composite scale of social competence for participants at 12 months post-injury, with higher scores pertaining to higher levels of social competence. A comparison of the social competence scores for the TBI (*n*=21) and control participants (*n*=28) revealed that the TBI sample had a lower mean (*M*=-2.262 / *SD*=4.371) compared to the control sample (*M*=2.154 / *SD*=2.860), indicating lower levels of socially competent behavioural functioning. This difference between the groups was found to be statistically significant (*F*(1,47)=18.235, *p*=< .001), with a small/medium effect size (0.280).

The clinical cut-off for social competence impairment was set at two standard deviations below the control participants mean. Within the control group, two participants scored within the clinical range (7.1% of sample) for social competence difficulties; whereas within the TBI group, seven participants scored within the clinical range (33.3% of sample). There was a statistically significant difference for the numbers of participants exceeding the clinical cut-off for the Social Competence Index (*FET*=5.490, *p*= .028).

Social Competence and Personal Functioning. Pearson's correlations between the Social Competence Index scores and the SDQ parental ratings of difficulties were analysed in order to validate the Social Competence Index as a measure (see Table 23). A significant negative correlation was found between all SDQ scales, suggesting an association between poor social competency skills and increased social and personal difficulties.

Correlations were then conducted with the CNS-VS cognitive domains and the BRIEF Meta-Cognitive Index (Meta-Cognitive scales were not included in the Social Competence Index) in order to examine the relationship between social competence and cognitive functioning (see Table 24.). A significant correlation was found between the Social Competence Index and the CNS-VS Neuro-Cognitive Index, as well as the BRIEF parent Meta-Cognitive Index. However, no relationship was found between the Social Competence Index and the CNS-VS domain of Executive Functions. These results suggest that social competent behaviour is associated with a broad range of cognitive functions and that difficulties within these functions are related to lower levels of socially competent behaviour.

Table 23.

Correlations between the Social Competence Index and the SDQ parent report.

Measure	Social Competence (*n*=49)	*n*
SDQ Parent Report		
Emotional Symptoms	*r*= -0.617, *p*= < .001	55
Conduct Problems	*r*= -0.744, *p*= < .001	55
Hyperactivity	*r*= -0.684, *p*= < .001	55
Peer Problems	*r*= -0.363, *p*= .010	55
Total Difficulties	*r*= -0.851, *p*= < .001	55

Note: n = Participant number

Table 24.

Correlations between the social competence index and cognitive functioning.

Measure	Social Competence Index (*n*=49)	*n*
CNS-VS Cognitive Domains		
Executive Function	*r*=0.234, *p*= .122	45
Cognitive Flexibility	*r*=0.239, *p*= .114	45
Social Acuity	*r*=0.123, *p*= .428	44
Neuro-Cognitive Index	*r*=0.377, *p*= .012	44
BRIEF Parent Report		
Meta-Cognition Index	*r*= -0.665, *p*= < .001	49

Note: n = Participant number.

A significant correlation was found between the Social Competence Index and the BASC parent report scale of Withdrawal (*r*=0.402, *p*= .004), suggesting that there is a relationship between higher levels of a shy/withdrawn personality type and lower levels of social competence. No significant correlation was found between the Social Competence Index and the BASC self-report scale of Relations with Parents.

In summary, according to the Social Competence Index the TBI sample showed greater difficulties with functioning in a socially competent manner compared to the control sample and this difference was found to be significant. This equated to a greater proportion of TBI participants scoring within the clinically relevant range for socially competent behavioural difficulties, and again this difference in the proportions of participants meeting the clinical cut-off was found to be significant. Correlations were conducted in order to validate the Social Competence Index and a significant correlation was found between the Social Competence Index and all SDQ parental scales of child difficulties, suggesting a relationship between an adolescent's level of social competence and the personal difficulties they are experiencing. Significant correlations were also found between the Social Competence Index, the CNS-VS Neuro-Cognitive Index and the BRIEF Meta-Cognitive Index, but not for the CNS-VS

domains of Executive Function and Social Acuity, suggesting that there is a broader range of cognitive functions behind socially competent behaviour than just the domain of executive functions alone. Finally, a significant correlation was also found between the Social Competence Index and the BASC scale of Withdrawal, suggesting a relationship between a shy, withdrawn personality type and lower levels of social competency. This all suggests that social competent behaviour is influenced by a broad range of variables and that difficulties with social competence following a TBI are related to difficulties in personal functioning across a variety of domains which can negatively impact upon an adolescent's social functioning.

Discussion

This study investigated the effects of mild traumatic brain injury in young adolescents aged between 12 and 15 years. There were two main aims. The first was to determine whether adolescents who have sustained a mild TBI were experiencing difficulties with social competence at 12 months post-injury compared to their uninjured peers. The second was to investigate whether there was a relationship between their social competence and their executive functioning abilities at 12 months following a TBI. This study also examined whether there was any functional change during the first year post-injury in a subset of the TBI sample for which data was available.

It was hypothesised that due to the nature of their injury, adolescents who have sustained a mild TBI would show poorer functional abilities within the realms of socially competent behaviour compared to their peers who have not sustained a TBI. It was also hypothesised that factors such as executive functioning, the parent/child relationship, and personality type would be related to socially competent behaviour. Specifically, it was predicted that difficulties in executive function (characterised by lower scores on the CNS-VS domain of Executive Functions), a poorer quality parent/child relationship, (characterised by lower ratings of the BASC self-report scale of Relations with Parents), and a shy/withdrawn personality type (characterised by higher ratings from the BASC parent report scale of Withdrawal) would be associated with lower levels of socially competent behaviours.

In order to investigate these issues, a detailed model of social competence was formulated (Child Head Injury Model of Sociability; CHIMS; see Appendix B) that drew upon previous broad models of social competence and the literature reviewed. The CHIMS model presents the three outcome domains of cognition, behaviour, and emotion following a TBI and posits that these domains dynamically interact and contribute towards a person's level of social competence. As social competence may be considered an observable social behaviour, parent rating scales from the BASC and

the BRIEF were matched to the CHIMS Injury Outcome domains of Behaviour and Emotion, in order to produce a composite measure of social competence.

It should be made quite clear that a myriad of unseen variables dynamically interact and contribute towards a person's level of social competence. That is; a person is constantly assessing social cues and information, re-evaluating and reformulating their strategies according to these cues in order to achieve their social goals in a fashion that allows them to maintain a positive relationship with their social partner or partners over time (Rubin & Krasnor, 1986). This is depicted in the CHIMS model by incorporating the behavioural, emotional, and cognitive categories within the injury outcomes box and the bi-directional arrows between component boxes. The Social Competence Index only focused on a small observable portion of the model (emotion and behaviour), because these domains may be considered observable and the literature suggests that they are key contributors towards a person's social competence. Consequently, the Social Competence Index cannot be regarded as an all-inclusive measure of social competence.

Social Competence

As predicted, scores on the Social Competence Index revealed that at 12 months post-injury, adolescents who had sustained a mild TBI showed lower levels of socially competent behaviours compared to their uninjured peers. Furthermore, a greater proportion of mild TBI adolescents (33.3%) compared to the community control sample (7.1%) scored over two standard deviations below the mean score of the control group. At an individual level, this equates to the odds of a mild TBI adolescent experiencing difficulties in social competence being over 4.5 times higher than an uninjured peer. These findings confirm the hypothesis that adolescents who have sustain a mild TBI would have poorer functional abilities with regards to socially competent behaviours.

This is consistent with Anderson et al. (2013) who found that when compared to healthy controls, TBI children and young adolescents (5-16 years) were at risk of

social impairment within the first 6 months post-injury. However, as the current study's comparisons were conducted at 12 months post-injury, the findings suggest that these difficulties may persist for a longer period of time following their injury. Likewise, Greenham et al. (2010) found that young adolescents (10-16 years), who had sustained a TBI at least 12 months prior to assessment, were at increased risk of social impairment compared to normative expectations. Furthermore, Muscara, Catroppa, Eren and Anderson (2009) found that children (8-12 years) who had suffered a TBI were at risk of social difficulties 7-10 years following their injury and that injury severity predicted long-term social outcomes. Specifically, children who suffered a mild TBI tended to function at a higher level socially compared to their moderate and severe injury peers. These findings stress the importance of long-term clinical follow-up for TBI sufferers, and where necessary social reintegration therapy throughout adolescence and into adulthood following their injury in early adolescence (Muscara et al., 2009).

At first, this all sounds negative for the future of adolescents' who have sustained a mild TBI; however, the findings need to be interpreted as a whole. Alternatively, the current study may be viewed as showing that two thirds of the TBI sample are functioning within the normal realms of socially competent behaviour and that only a third of the adolescent mild TBI population are 'at risk' of developing difficulties with respect to social competence. Consequently, these results may be interpreted as a positive outcome for this population.

In order to investigate the validity of the Social Competence Index, the findings were compared to outcomes from the SDQ parent report and significant relationships were found for all SDQ scales; suggesting a relationship between lower levels of socially competent behaviour and greater personal difficulties. Furthermore, a statistical association was found between the Social Competence Index and the BASC parent report scale of Withdrawal, suggesting that there is a relationship between higher levels of a shy/withdrawn personality type and lower levels of social competence. This confirms the hypothesis that an adolescent's level of functioning in a socially competent manner is related to their personality type. However, data from the current study cannot be used to imply causation, as we do not know the pre-morbid

functioning of the mild TBI adolescents. Nonetheless, these findings may imply that personal difficulties with social competence create psychological stress in social situations, resulting in the presentation of avoidant/withdrawn behaviours, which may in turn further hamper peer relationships and social functioning (Romine & Reynolds, 2005; Ross et al., 2011).

This is in line with Ross et al. (2011) who found that parents of TBI children rated their child as being more withdrawn and having poorer quality peer relationships in contrast to the ratings of parents of non-TBI children. This relationship between a shy/withdrawn personality type and social competence in TBI survivors is concerning, particularly as Yeates et al. (2013) found that children (8-13 years) without a mutual friend were rated lower than those with a mutual friend on sociability, popularity, and pro-social behaviour; as well as, having higher ratings of rejection and victimization. These negative perceptions can have detrimental social consequences for a person who is already having difficulties with social functioning and social competence. This relationship between a person's personality type and social competence is represented in the CHIMS model Child Characteristics domain.

In order to more closely examine which aspects of functioning were hindering the portion of the TBI sample who were experiencing lower levels of social competence, outcomes were investigated across the functional domains of behaviour, cognition, and emotion.

Behavioural Functioning. In regards to the behavioural functioning of the mild TBI sample, very little change in parental ratings of their adolescent's behaviour were found in the first year following their injury. Generally, the results showed that most of the sample scored within the normal range of functioning and that there was a very small functional improvement over this time period; however, most of this change was so marginal that it needs to be tentatively interpreted. No change in behavioural functioning is what one would expect to see in the normal population, as the BASC is standardised by age and gender. Interestingly, this improvement in behavioural functioning was not global and was not found for Conduct Problems, Withdrawal,

Social Skills, and Functional Communication. These scales all show a small decline in functioning within the first year post-injury. This finding is concerning, as these behavioural domains are all considered important contributors towards a person's social functioning (Crick & Dodge, 1994; Oliver et al., 2011; Ross et al., 2011; Yeates et al., 2007; Yeates et al., 2004). However, the deterioration in functioning for these scales was not found to be statistically significant but they could help to explain the difference between the TBI and control samples in social competence at 12 months post-injury.

All in all, these findings may be considered a positive outcome as it shows that the behavioural functioning for the TBI sample did not significantly deteriorate over this time frame as a result of the injury. Furthermore, a significant improvement in parental ratings was found for aggression. This finding shows that aggressive behaviour within the family environment had decreased, which is another positive result as it may help reduce the burden, distress, and worry experienced by parents following their adolescent's injury (Aitken et al., 2009; Ganesalingam et al., 2008; Wade et al., 2006). This is important as higher levels of perceived parental burden and stress resulting from their adolescent's TBI has been associated with poorer injury outcomes and caregiver wellbeing (Aitken et al., 2009).

Despite this improvement, the TBI sample showed significantly poorer parental ratings of behaviour across a broad range of functional categories (including aggression) when compared to their uninjured peers at 12 months post-injury. This level of behavioural difficulties equated to a larger proportion of the TBI sample scoring within the clinically relevant range for behavioural problems showing that not only is the range of behavioural difficulties greater within the TBI sample but that the severity of these difficulties is also greater. These findings suggest that their uninjured peers had a greater repertoire of socially appropriate behaviours available to them for achieving their social goal than the behavioural repertoire within the TBI sample, which appeared to be restricted. This was reflected in the amount of difficulty adolescents in the TBI sample were experiencing. It should be mentioned however, that we do not know whether these difficulties predated their injury or if they were the result of their injury, we just know that the TBI sample were experiencing a greater

degree of difficulty across a range of behavioural domains at 12 months post-injury compared to their uninjured peers.

These findings are consistent with current literature reviews on behavioural difficulties following a TBI (Prigatano, Fulton, & Wether, 2010; Yeates & Taylor, 2005) and helps to place the behavioural outcomes of mild TBI on the same continuum as their moderate and severe TBI counterparts (Schwartz et al., 2003; Taylor et al., 2002; Yeates et al., 2001). However, the literature suggests mild TBI outcomes are on the less severe end of this continuum (Fay et al., 2009; Muscara et al., 2008a; Muscara et al., 2009).

These significant group differences, which highlight poorer behavioural functioning within the TBI sample, were found to be particularly prominent on scales associated with externalising difficulties, such as Aggression, Conduct Problems, Bullying, and Emotional Self-Control. These group differences in externalising difficulties are consistent with Max et al. (1998) who found that mild TBI adolescents were particularly prone to developing disruptive behaviours and behavioural disorders, such as Attention Deficit Hyperactivity Disorder, Oppositional Defiant Disorder, and Conduct Disorder. Furthermore, in a three year follow-up study, Massagli et al. (2004) found that mild TBI children (<14 years) with no pre-injury history of mental illness were at increased risk of diagnosed psychiatric disorders (26%) compared to their uninjured peers (16%), particularly hyperactivity associated illnesses.

Of these externalising difficulties associated with TBI, Dooley et al. (2008) suggest that aggression is most concerning, as it has been associated with negative peer and family relations, peer rejection, and delinquent and criminal activities, which can all have long-term negative social implications. Furthermore, Oliver et al. (2011) have linked persistent conduct problems to difficulties in social cognition, all with far-reaching negative implications for these individuals. This link between persistent conduct problems and difficulties in social cognition are substantiated in the present study by the significant difference between the sample groups, with poorer TBI sample functioning found for the BASC parental ratings of Executive Functioning. When these conduct problems and high levels of aggression are combined with bullying behaviours

and poor emotional control, it may be considered a recipe for impaired social functioning.

Also concerning was the significant group difference that shows a greater degree of difficulties within the TBI sample for internalising problems. This could suggest that the TBI sample's limited behavioural repertoire may be restricting their ability to obtain their desired social goals and this in turn is causing psychological stress, resulting in feelings of anxiety and depression. Research has shown that in the first year post-injury children and young adolescents (6-15 years) who have sustain a TBI (over all severity categories) are an at risk population for the development of internalising difficulties and disorders (Bloom et al., 2001).

Of interest was the finding that, despite there being a small decline in functioning for BASC parental ratings in social skills within the first year following a mild TBI, very little difference was found between the samples for this scale at 12 months post-injury. This is surprising given the TBI sample demonstrated poorer functioning across a number of behavioural domains and the links between the poor self-regulation of behaviour and reduced social functioning established by previous research, have shown to have a detrimental impact upon peer relations (Ganesalingam et al., 2007; Levin et al., 2009). However, it is tentatively suggested that this finding could be due to a lack of parental knowledge regarding social skills difficulties that their adolescent is experiencing within their peer group outside of the home environment.

Higher scores within the TBI sample and significant group differences for parental ratings of their adolescent's difficulties were also found for the SDQ and again these differences were largest for scales associated with externalizing problems, such as Emotion Symptoms, Conduct Problems, Hyperactivity, and the Total Difficulties composite scale. However, no significant group differences were found for any of the scales on the SDQ self-report.

This discrepancy between parental and self reports for the SDQ is interesting, as the tests author reports inter-rater correlations between these two versions of the SDQ to be 0.37 for Emotional Symptoms (current study r=0.13), 0.44 for Conduct

Problems (current study *r*=0.33), 0.41 for Hyperactivity (current study *r*=0.24), 0.40 for Peer Relations (current study *r*=0.54), 0.30 for Prosocial behaviour (current study *r*=0.50), and 0.48 for the Total Difficulties composite scale (current study *r*=0.21) in a community sample (*n*=3,893) (Goodman, 2001).

This suggests that there may be something contributing to these inter-rater discrepancies for the externalising scales (Emotional Symptoms, Conduct Problems and Hyperactivity) and the Total Difficulties scale, rather than just the normal variance found between parental and self reports. These findings indicate that the parent's perceptions of their adolescent's functioning differed from the perceptions of the adolescent and it is suggested that this difference in reported difficulties could centre around their adolescent's injuries, given the TBI sample generally showed higher scores and greater variance compared to their uninjured peers. Therefore it could tentatively be suggested that following a mild head injury adolescents may lack some degree of insight or awareness into the extent of their functional problems and difficulties. These findings highlight the importance of multi-informant ratings when assessing the outcome of a TBI.

The suggestion that there could be some level of impaired awareness regarding functional difficulties following a mild TBI was unexpected and was not incorporated in the current study's literature review. However, this type of rater disagreement is consistent with Sherer et al. (1998) who found that TBI patients across all severity ratings (mean age=28.8/*SD*=9.8 years) tended to overestimate their level of functioning compared to family member ratings (mean post-injury interval=13 months) and that there was a greater agreement between family and clinician ratings of functioning. Furthermore, Green et al. (2012) found that parents and adolescents (15-18 years) who had sustained a childhood TBI (*n*=17; all TBI severity categories included in this study) were fairly consistent in their ratings of psychosocial functioning. These findings may shed some light on why the current study found discrepancies between parent/adolescent SDQ ratings of behavioural and emotional difficulties but not social difficulties.

Cognitive Functioning. In keeping with the behavioural findings at 12 months post-injury, adolescent's with a mild TBI showed significantly poorer parental ratings than their uninjured peers for the BRIEF, particularly in regards to the behavioural regulation aspects of executive function; such as, emotional control and the ability to inhibit behaviours, as well as on the Global Executive Composite scale. The BRIEF is described as being an ecologically valid measure of executive functioning that provides a measure of executive skills displayed in everyday activities and behaviours (Gioia et al., 2000). These findings equated to significant differences in the proportion of participants reaching the clinically relevant range of executive dysfunction for Inhibit, Emotional Control and Behavioural Regulation. Again, the data indicates that the TBI sample was experiencing a broader range of executive functioning difficulties and that these difficulties were of a greater severity.

These findings are in partial agreement with Maillard-Wermelinger et al. (2009) who found, according to the BRIEF parent report at 12 months post-injury, there was a trend towards there being more problems within their mild TBI sample (8-15 Years) compared to an orthopaedic injuries sample. However, this study only found a marginally significant group difference indicating more problems for their mild TBI sample on the Meta-Cognition Index.

These higher levels of executive dysfunction with regards to behavioural regulation in the current TBI sample are consistent with the behavioural difficulties found within this population for the BASC parental ratings. They are also in line with Yeates et al. (2001) who found that neuro-behavioural symptoms were predicted by concurrent cognitive functioning following a TBI. Furthermore, Muscara, Catroppa and Anderson (2008b) found persistent difficulties in executive functioning according to the BRIEF parent report following a TBI, and these difficulties appeared to persist throughout adolescence and into adulthood. These researchers suggest that higher levels of executive dysfunction are associated with less sophisticated social problem-solving skills and poorer social outcomes in young adults (16-22 years) who sustained a TBI in early adolescence (8-12 years: all TBI severity categories included in this study). The current results provide support for the notion that executive dysfunction following a mild TBI contributes to difficulties in social functioning and social competence.

Despite these group differences, which show poorer functioning in the TBI sample for the behavioural regulation aspects of executive function in parental ratings for the BRIEF, no significant differences were found for the performance-based CNS-VS cognitive domains of Executive Function, Cognitive Flexibility, Social Acuity and the Neuro-Cognitive Index at 12 months post-injury. The difference between these two measures may reflect differences between a purely performance-based measure of an individual's cognitive functions (CNS-VS) and parental ratings of behaviours associated with executive functioning (BRIEF), which suggests they may be assessing quite different aspects of cognitive functioning.

These inconsistencies between measures means that the hypothesis that social competence would be related to a person's executive functioning abilities was not supported, as the correlation between the Social Competence Index and the CNS-VS cognitive domain of Executive Function (r=0.234, p= .122) was not significant. However, a significant relationship was found between the Social Competence Index and the CNS-VS Neuro-Cognitive Index (r=0.377, p= .012), and between the Social Competence Index and the BRIEF parent Meta-Cognition Index (r=0.352, p= .013). These findings suggest (unsurprisingly) that there are a wide range of cognitive functions underlying socially competent behaviour rather than the domain of executive function alone and this is reflected in multiple contributors towards social competence within the CHIMS Cognition Outcome Domain box (page 25). Unfortunately, a relationship between the Social Competence Index and the BRIEF parent report Global Executive Composite Index (a global measure of executive function) was unable to be made as the Behavioural Regulation Index scale of Inhibit was used to generate the Social Competence Index and the Behavioural Regulation Index contributes towards the Global Executive Composite Index.

Data from the CNS-VS showed an improvement in cognitive functioning for the TBI sample in the first month following injury and this improvement was found to be significant for the domains of Executive Function and Cognitive Flexibility. However by 12 months post-injury, the improvement had either dissipated or reached a plateau. This was another positive finding, as it is exactly what one would expect to find due to

the age related standardisation of this measure and it indicates that the maturation of cognitive functions are developing appropriately following a mild TBI.

Research suggests that the basic neural structures associated with executive functions may be present in early childhood development. However, important differences appear to exist with respect to their maturation. Neuro-imaging research shows ongoing myelination of neural fibers and maturation of frontal lobe structures (associated with executive functioning) throughout childhood and adolescence (Anderson et al., 2001). This implies that children and adolescents gradually acquire the capacity for more efficient and faster processing throughout their youth because the transmission of neural impulses has been found to become more rapid with increased myelination and the ongoing development of the frontal lobes would allow for greater age related efficiency in complex executive tasks (Anderson et al., 2001; Levin & Hanten, 2005; Romine & Reynolds, 2005). This would explain the improvement in executive functioning seen in the sample for the first month following a mild TBI; however, this improvement would be expected to plateau due to the measures standardisation.

This suggests that by adolescence cognitive pathways may have already been laid down and that during adolescent years these pathways are being strengthened and reinforced by a person's behavioural repertoire. This implies that adolescence is a time for exploring and rehearsing this behavioural repertoire in a manner that fits with societal norms and the formation of their desired social identity. According to the current study's findings, this behavioural repertoire may be restricted in the mild TBI sample by their difficulties with behavioural regulation and the reduced capacity to inhibit behavioural responses. This restriction may then reduce their ability to function in a socially competent manner.

Taken as a whole, these findings are in line with Yeates et al. (2002) who found that the majority of cognitive recovery following a TBI occurred within the first 12 months post-injury. However, at this 12 month time point TBI survivors still showed greater cognitive difficulties compared to their peers who had sustained orthopaedic injuries. Unfortunately, Yeates et al. (2004) also found no observable signs of recovery

in social functioning after 12 months post-injury. This suggests a link between neuro-cognition and social functioning, and that any difficulties present at 12 months post-injury are likely to persist over time. Due to the lack of research in this area for adolescent who have sustained a mild TBI, these findings highlight the need for longitudinal studies to examine whether there is any change in social functioning and competence as mild TBI adolescents transition in adulthood.

Emotional Functioning. The BASC self-report of personality scores also showed little change in TBI participant's functioning during the year following their injury. These findings are consistent with Anderson, Brown, Newitt, and Hoile (2011), who found no evidence of dysfunctional personality change in adolescent and young adult survivors of a childhood mild TBI.

When the mild TBI sample was compared to their uninjured peers at 12 months post-injury, both groups mean scores were within the normal range and no significant differences between the groups were found. Although, the control sample were found to have marginally higher scores in emotional functioning and interpersonal relations, indicating poorer functioning. When these finding are considered in conjunction with the SDQ parent and self report discrepancies, it may be interpreted that the control sample were more aware of functional difficulties within the realms of their social and emotional functioning.

The only exception to these higher scores within the control sample was found for Inattention/Hyperactivity and this higher rate of self-reported difficulties within the TBI sample is consistent with research that suggests a link between TBI and the post-injury development of Attention Deficit Hyperactivity Disorder (ADHD) in adolescents (Max et al., 2004; Max et al., 1998). Furthermore, theorists have postulated that these difficulties are related to behavioural regulation deficits in executive functioning, particularly the inability to inhibit emotional and behavioural responses, which is considered by some to be a central component to this disorder (Levin & Hanten, 2005; Max et al., 2004; Ylvisaker & DeBonis, 2000).

In relation to interpersonal functioning and the Social Competence Index, the hypothesis that there would be a relationship between higher levels of social competence and higher quality parent/adolescent relations was not confirmed, as there was no significant correlation between the Social Competence Index and the BASC self-report scale of Relations with Parents (r=0.041, p= .791). This finding is surprising given that the quality of the parent/child relationship has been shown to predict social adjustment and competence in children and young adolescents (Rubin et al., 2004; Yeates et al., 2010). The previously suggested diminished insight into one's functional difficulties found within the TBI sample may help explain why a significant correlation was not found; however, further research is needed within this area to fully explain this anomaly. We now turn to the current studies methodological strengths and limitations.

Limitations

The current study's findings need to be considered in light of its strengths and limitations. This study was cross-sectional in design and as such, does not take into account the pre-morbid functioning of adolescents who have sustained a mild TBI. As a result, the study was limited in its capacity to distinguish whether group differences were the result of a TBI or whether the differences preceded the injury. The sample size in this study was comparable to other TBI studies. Nonetheless, the small size did limit the statistical analyses, particularly the ability to carry out regression analysis to examine predictors of TBI related social outcome.

Another potential limitation was the use of a control group that had not sustained any form of injury. Opinion appears to be divided over the use of an injured verses uninjured control group, as some have suggested that individuals who have sustained a TBI would be better compared to individuals who have experienced other forms of traumatic injuries (Yeates & Taylor, 2012). Consequently, a control group which has sustained orthopaedic injuries is considered by some to be more representative of factors that have been associated with a head injury, such as trauma, hospitalisation, and subsequent medical treatments (Mathias, Dennington, Bowden, &

Bigler, 2013). However in the current study, all of the TBI participants sustained a mild TBI and the majority did not require hospitalisation. In mild TBI studies such as this, McKinlay (2010) posits that the use of an orthopaedic control group may confound the results, as this group may have experienced a greater proportion of trauma, stress, and pain associated with their injury. Furthermore, Mathias et al. (2013) claim that an orthopaedic injury control group does not show any clear advantages over a carefully recruited community control group.

While the sample groups were matched on age, no significant group differences were found for other demographic variables. However, a marginally significant difference was found for the demographic variable of ethnicity, with a larger proportion of the TBI sample associating with *Māori* or *Pasifika* ethnicity. This difference is representative of the TBI population within New Zealand, as studies have shown that people of these ethnicities are disproportionately over-represented within the TBI population (Barker-Collo et al., 2009; Feigin et al., 2012). It should also be acknowledged that not all TBI participants from the BIONIC study consented to follow-up in the present study, which may have biased the sample to some degree.

There were a number of strengths associated with the methodology used in the current study. The adolescents included were restricted to a small, specific age band (12-15 years). This restriction may be considered a strength, as the research literature on adolescents of this age who have sustained a mild TBI is extremely limited. This restricted age range meant that participants were able to be assessed using the same versions of individual tests, allowing for simpler and more accurate comparison of scores, and greater consideration of the important developmental aspects associated with young adolescents of this age when interpreting the findings (McKinlay, 2010).

This study's greatest strength was that it was a population-based study and endeavoured to capture every instance of TBI across the geographical catchment area of interest. Considerable effort was made to capture TBI participants from a variety of sources other than just hospital admissions or databases, which often fail to capture the experiences of individuals who have sustained a milder form of TBI and are not admitted to hospital or who do not seek medical attention. Unlike the vast majority of

TBI research, no individuals were excluded based on pre-morbid developmental or behavioural functioning deficits or difficulties. While this made cross comparisons of other studies more difficult, it also meant that the results are more generalizable to the population at large.

Future Research

The current study has established that socially competent behaviour can be observed and measured. It used the Social Competence Index as a broad measure of social functioning across the domains of behaviour, emotion, and cognition; with less attention being paid to specific aspects of social functioning within each domain. However, the Social Competence Index also allows for a breakdown and analysis of the individual scales that make up the index, so that key problem areas may be identified and addressed. Future in-depth research is needed to externally validate the Social Competence Index, as well as tease out and highlight any subtle differences within specific aspects of social functioning that may be missed when focusing on overall levels of functioning. This would provide a better understanding of the characteristics and consequences of a mild head injury.

This study failed to provide a conclusive link between social competence and executive functions and the findings suggest there may be a broader range of cognitive functions involved in socially competent behaviour other than executive functioning alone. Further research is needed to examine the range and breadth of the cognitive functions behind social functioning. That research would help provide a greater knowledge and understanding of the neuro-behavioural pathways that may become compromised following a mild TBI and help inform the best target for treatment.

This study also unearthed discrepancies between parental perceptions and self perceptions of functional difficulties and it was suggested that following a mild TBI adolescents may lack some degree of insight or awareness into the extent of their difficulties and the difficulties their behaviour may cause to others. Further research is

needed in order establish the rigour of these discrepancies and the robustness of self-report measures within the TBI population.

Longitudinal TBI research studies that follow young adolescents through the transition into adulthood and beyond are rare and desperately needed. This data would provide valuable information on any changes in functioning or the emergence of any additional difficulties over time. This knowledge would allow us to better understand and identify factors that may contribute towards the social outcome of people who have sustained a TBI, particularly those who are experiencing clinically relevant difficulties.

Considering the numbers of mild TBI adolescents who exceeded the clinical cut-offs in the present study, future researchers may consider incorporating a clinical interview and direct behavioural observations within their study design, in order to gain an in-depth understanding of the clinically relevant difficulties that are being experienced by these individuals.

Further research that investigates individual environmental variables is also needed to better understand and identify factors that may place a person at risk of a poorer social outcome and also factors that may help contribute towards a person's recovery following a head injury.

Conclusion

In conclusion, in this study adolescents who have sustained a mild TBI were found to have greater difficulties with their functioning in a socially competent manner compared to their uninjured peers at 12 months post-injury. This equated to a larger proportion of the TBI sample experiencing clinically significant difficulties in their social functioning. Furthermore, these difficulties were found to be particularly pronounced for externalising behaviours.

The results also suggest that these behavioural problems may stem from cognitive difficulties behind the self-regulation side of executive functioning that are

associated with externalising behaviours. A relationship was found between the Social Competence Index and the CNS-VS Neuro-Cognitive Index (composite scale), as well as the BRIEF parent Meta-Cognition Index, indicating that there could be a broader range of cognitive abilities behind social competence rather than just the domain of executive functions alone. More research is needed within this area to identify the neuro-behavioural pathways associated with social competent behaviours.

A relationship between a shy/withdrawn personality type and social competence was also found, with higher levels of withdrawal being associated with lower levels of social competence. Unexpectedly, the prediction that social competence would be related to the parental relationship was not confirmed in self-report ratings on the BASC. This unexpected finding may be partially explained by a lack of awareness in the mild TBI sample into the extent of their behavioural problems and the difficulties these problems may be causing others, as illustrated be the lack of agreement between parent and self reports. This was an unexpected finding and further research is needed to explain these discrepancies fully.

This study has helped to bring knowledge of the consequences of a mild TBI in line with that of their moderate and severe TBI counterparts by emphasising that young adolescents who sustain a mild TBI are at increased risk of experiencing difficulties within their social environment, at a time in their development when peer relationships are becoming hugely important to them. These difficulties in competently achieving their desired social goals that fits with social norms and expectations may hinder the formation of an adolescent's intended social identity and consequently, have long-term negative repercussions for their social outcome and their quality of life. This study has highlighted the need for on-going post-injury screening for behavioural and social deficits within the mild TBI population and further research is recommended (longitudinal) to examine the long-term repercussions of these difficulties and the social outcomes of a mild TBI.

References

Ackerman, B. P., & Brown, E. D. (2006). Income poverty, poverty co-factors, and the adjustment of children in elementary school. In R. V. Kail (Ed.), *Advances in Child Development and Behavior, Vol 34* (Vol. 34, pp. 91-129). San Diego: Elsevier Academic Press Inc. 10.1016/s0065-2407(06)80005-4

Aitken, M. E., McCarthy, M. L., Slomine, B. S., Ding, R., Durbin, D. R., Jaffe, K. M., et al. (2009). Family Burden After Traumatic Brain Injury in Children. *Pediatrics, 123*(1), 199-206. 10.1542/peds.2008-0607

Allen, J. P., Hauser, S. T., Eickholt, C., Bell, K. L., & Oconnor, T. G. (1994). Autonomy and relatedness in family interactions as predictors of expressions of negative adolescent affect. *Journal of Research on Adolescence, 4*(4), 535-552. 10.1207/s15327795jra0404_6

Anderson, P. (2008). Towards a developmental model of executive function. In V. Anderson, R. Jacobs & P. Anderson (Eds.), *Executive functions and the frontal lobes: A lifespan perspective* (pp. 3-22). New York: Taylor and Francis Group

Anderson, V., Beauchamp, M. H., Yeates, K. O., Crossley, L., Hearps, S. J. C., & Catroppa, C. (2013). Social competence at 6 months following childhood traumatic brain injury. *Journal of the International Neuropsychological Society, 19*, 539-550. 10.1017/S1355617712001543

Anderson, V., Brown, S., Newitt, H., & Hoile, H. (2011). Long-term outcome from childhood traumatic brain injury: Intellectual ability, personality, and quality of life. *Neuropsychology, 25*(2), 176-184. 10.1037/a0021217

Anderson, V., & Catroppa, C. (2005). Recovery of executive skills following paediatric traumatic brain injury (TBI): A 2 year follow-up. *Brain Injury, 19*(6), 459-470. 10.1080/02699050400004823

Anderson, V., Godfrey, C., Rosenfeld, J. V., & Catroppa, C. (2012). 10 years outcome from childhood traumatic brain injury. *International Journal of Developmental Neuroscience, 30*(3), 217-224. 10.1016/j.ijdevneu.2011.09.008

Anderson, V. A., Anderson, P., Northam, E., Jacobs, R., & Catroppa, C. (2001). Development of executive functions through late childhood and adolescence in an Australian sample. *Developmental Neuropsychology, 20*(1), 385-406. 10.1207/s15326942dn2001_5

Baguley, I. J., Cooper, J., & Felmingham, K. (2006). Aggressive behavior following traumatic brain injury - How common is common? *Journal of Head Trauma Rehabilitation, 21*(1), 45-56.

Barcons, N., Abrines, N., Brun, C., Sartini, C., Fumado, V., & Marre, D. (2012). Social relationships in children from intercountry adoption. *Children and Youth Services Review, 34*, 955-961. 10.1016/j.childyouth.2012.01.028

Barker-Collo, S. L., Wilde, N. J., & Feigin, V. L. (2009). Trends in head Injury incidence in New Zealand: A hospital-based study from 1997/1998 to 2003/2004. *Neuroepidemiology, 32*(1), 32-39. 10.1159/000170090

Beauchamp, M. H., & Anderson, V. (2010). SOCIAL: An integrative framework for the development of social skills. *Psychological Bulletin, 136*(1), 39-64. 10.1037/a0017768

Bloom, D. R., Levin, H. S., Ewing-Cobbs, L., Saunders, A. E., Song, J., Fletcher, J. M., et al. (2001). Lifetime and novel psychiatric disorders after pediatric traumatic brain injury. *American Academy of Child and Adolescent Psychiatry, 40*(5), 1-11. 10.1097/00004583-200105000-00017

Borg, J., Holm, L., Cassidy, J. D., Peloso, P. M., Carroll, L. J., von Holst, H., et al. (2004). Diagnostic procedures in mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 36*, 61-75. 10.1080/16501960410023822

Bornhofen, C., & McDonald, S. (2008). Emotion perception deficits following traumatic brain injury: A review of the evidence and rationale for intervention. *Journal of the International Neuropsychological Society, 14*(4), 511-525. 10.1017/s1355617708080703

Bowlby, J. (1979). The Bowlby-Ainsworth attachment theory. *Behavioral and Brain Sciences, 2*(4), 637-638.

Brener, I., Harman, J. S., Kelleher, K. J., & Yeates, K. O. (2004). Medical costs of mild to moderate traumatic brain injury in children. *Journal of Head Trauma Rehabilitation, 19*(5), 405-412. 10.1097/00001199-200409000-00005

Brooks, B., & Sherman, M. (2012). Computerized neuropsychological testing to rapidly evaluate cognition in pediatric patients with neurologic disorders *Journal of Child Neurology, 27*, 982-991. 10.1177/0883073811430863

Burnett-Heyes, S., Sebastian, C. L., & Cohen-Kadosh, K. (2012). Brain development and the emergence of social function. In V. Anderson & M. H. Beauchamp (Eds.), *Developmental social neuroscience and childhood brain insult: Theory and practice* (pp. 45-65). New York, N.J.: The Guilford Press

Camodeca, M., & Goossens, F. A. (2005). Aggression, social cognitions, anger and sadness in bullies and victims. *Journal of Child Psychology and Psychiatry, 46*(2), 186-197. 10.1111/j.1469-7610.2004.00347.x

Carroll, L. J., Cassidy, J. D., Holm, L., Kraus, J., & Coronado, V. G. (2004). Methological issues and research recommendations for mild traumatic brain injury: The WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 36*(43), 113-125. 10.1080/16501960410023877

Casey, B. J., Galvan, A., & Hare, T. A. (2005). Changes in cerebral functional organization during cognitive development. *Current Opinion in Neurobiology, 15*(2), 239-244. 10.1016/j.conb.2005.03.012

Cassidy, J. D., Carroll, L. J., Peloso, P. M., Borg, J., von Holst, H., Holm, L., et al. (2004). Incidence, risk factors and prevention of mild traumatic brain injury: Results of the

WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of Rehabilitation Medicine, 36*, 28-60. 10.1080/16501960410023732

Chapman, L. A., Wade, S. L., Walz, N. C., Taylor, H. G., Stancin, T., & Yeates, K. O. (2010). Clinically significant behavior problems during the initial 18 months following early childhood traumatic brain injury. *Rehabilitation Psychology, 55*(1), 48-57. 10.1037/a0018418

Corso, P., Finkelstein, E., Miller, T., Fiebelkorn, I., & Zaloshnja, E. (2006). Incidence and lifetime costs of injuries in the United States. *Injury Prevention, 12*(4), 212-218. 10.1136/ip.2005.010983

Crick, N. R., & Dodge, K. A. (1994). A review and reformulation of social information-processing mechanisms in childrens social-adjustment. *Psychological Bulletin, 115*(1), 74-101. 10.1037/0033-2909.115.1.74

De Luca, C. R., & Leventer, R. J. (2008). Developmental trajectories of executive functions across the lifespan. In V. Anderson, R. Jacobs & P. Anderson (Eds.), *Executive functions and the frontal lobes* (pp. 23-56). New York: Taylor and Francis Group

Dooley, J. J., Anderson, V., Hemphill, S. A., & Ohan, J. (2008). Aggression after paediatric traumatic brain injury: A theoretical approach. *Brain Injury, 22*(11), 836-846. 10.1080/02699050802425444

Ellaway, A., Kirk, A., Macintyre, S., & Mutrie, N. (2007). Nowhere to play? The relationship between the location of outdoor play areas and deprivation in Glasgow. *Health & Place, 13*(2), 557-561. 10.1016/j.healthplace.2006.03.005

Ensign, J., Maricle, D. E., Brown, C., & Mayfield, J. W. (2012). Psychosocial subtypes on the Behavior Assessment System for Children, second edition following pediatric traumatic brain injury. *Archives of Clinical Neuropsychology, 27*(3), 277-292. 10.1093/arclin/acs030

Erikson, E. H. (1968). *Identity, youth and crisis*. New York, N.J.: W.W. Norton & Co.

Falk, A. C. (2010). Age differences in brain injury characteristics. *Developmental Neurorehabilitation, 13*(5), 315-321. 10.3109/17518423.2010.496766

Fay, T. B., Yeates, K. O., Wade, S. L., Drotar, D., Stancin, T., & Taylor, H. G. (2009). Predicting longitudinal patterns of functional deficits in children with traumatic brain injury. *Neuropsychology, 23*(3), 271-282. 10.1037/a0014936

Feigin, V. L., Theadom, A., Barker-Collo, S., Starkey, N. J., McPherson, K., Kahan, M., et al. (2012). Incidence of traumatic brain injury in New Zealand: A population-based study. *The Lancet Neurology*, 1-12. http://dx.doi.org/10.1016/S1474-4422(12)70262-4

Field, A. (2009). *Discovering statistics using SPSS* (3rd ed.). Thousand Oaks, CA: SAGE Publications Ltd.

Firsching, R., & Woischneck, D. (2001). Present status of neurosurgical trauma in Germany. *World Journal of Surgery, 25*(9), 1221-1223. 10.1007/s00268-001-0085-5

Fulton, J. B., Yeates, K. O., Taylor, H. G., Walz, N. C., & Wade, S. L. (2012). Cognitive predictors of academic achievement in young children 1 year after traumatic brain injury. *Neuropsychology, 26*(3), 314-322. 10.1037/a0027973

Ganesalingam, K., Sanson, A., Anderson, V., & Yeates, K. O. (2006). Self-regulation and social and behavioral functioning following childhood traumatic brain injury. *Journal of the International Neuropsychological Society, 12*(5), 609-621. 10.1017/s1355617706060796

Ganesalingam, K., Yeates, K. O., Ginn, M. S., Taylor, H. G., Dietrich, A., Nuss, K., et al. (2008). Family burden and parental distress following mild traumatic brain injury in children and its relationship to post-concussive symptoms. *Journal of Pediatric Psychology, 33*(6), 621-629. 10.1093/jpepsy/jsm133

Ganesalingam, K., Yeates, K. O., Sanson, A., & Anderson, V. (2007). Social problem-solving skills following childhood traumatic brain injury and its association with self-regulation and social and behavioural functioning. *Journal of Neuropsychology, 1*, 149-170. 10.1348/174866407x185300

Ganesalingam, K., Yeates, K. O., Taylor, H. G., Walz, N. C., Stancin, T., & Wade, S. (2011). Executive functions and social competence in young children 6 months following traumatic brain injury. *Neuropsychology, 25*(4), 466-476. 10.1037/a0022768

Gerrard-Morris, A., Taylor, H. G., Yeates, K. O., Walz, N. C., Stancin, T., Minich, N., et al. (2010). Cognitive development after traumatic brain injury in young children. *Journal of the International Neuropsychological Society, 16*(1), 157-168. 10.1017/s1355617709991135

Gioia, G. A., & Isquith, P. K. (2004). Ecological assessment of executive functioning in traumatic brain injury. *Developmental Neuropsychology, 25*(1-2), 135-158. 10.1207/s15326942dn2501&2_8

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). *Behavior Rating Inventory of Executive Function: Professional manual*. Odessa, FL: Psychological Assessment Resources.

Goodman, R. (1997). The Strengths and Difficulties Questionnaire: A research note. . *Journal of Child Psychology and Psychiatry, 38*(5), 581-586. 10.1111/j.1469-7610.1997.tb01545.x

Goodman, R. (1999). The extended version of the Strengths and Difficulties Questionnaire as a guide to child psychiatric caseness and consequent burden. *Journal of Child Psychology and Psychiatry, 40*(5), 791-799. 10.1111/1469-7610.00494

Goodman, R. (2001). Psychometric properties of the Strengths and Difficulties Questionnaire. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*(11), 1337-1345. 10.1097/00004583-200111000-00015

Greco, L. A., & Morris, T. L. (2001). Treating childhood shyness and related behavior: Empirically evaluated approaches to promote positive social interactions. *Clinical Child and Family Psychology Review, 4*(4), 299-318. 10.1023/a:1013543320648

Green, L., Godfrey, C., Soo, C., Anderson, V., & Catroppa, C. (2012). Agreement between parent-adolescent ratings on psychosocial outcome and quality-of-life following

childhood traumatic brain injury. *Developmental Neurorehabilitation, 15*(2), 105-113. 10.3109/17518423.2011.638331

Greenham, M., Spencer-Smith, M. M., Anderson, P. J., Coleman, L., & Anderson, V. A. (2010). Social functioning in children with brain insult. *Frontiers in Human Neuroscience, 4*, 10. 10.3389/fnhum.2010.00022

Gualtieri, C. T., & Johnson, L. G. (2006). Reliability and validity of a computerized neurocognitive test battery, CNS Vital Signs. *Archives of Clinical Neuropsychology, 21*, 623-643. 10.1016/j.acn.2006.05.007

Gururaj, G. (2008). Road traffic deaths, injuries and disabilities in India: Current scenario. *National Medical Journal of India, 21*(1), 14-20.

Hamalainen, M., & Pulkkinen, L. (1996). Problem behavior as a precursor of male criminality. *Development and Psychopathology, 8*(2), 443-455.

Happaney, K., Zelazo, P. D., & Stuss, D. T. (2004). Development of orbitofrontal function: Current themes and future directions. *Brain and Cognition, 55*(1), 1-10. 10.1016/j.bandc.2004.01.001

Henry, K. L., Oetting, E. R., & Slater, M. D. (2009). The role of attachment to family, school, and peers in adolescents' use of alcohol: A longitudinal study of within-person and between-persons effects. *Journal of Counseling Psychology, 56*(4), 564-572. 10.1037/a0017041

Hillier, S. L., Hiller, J. E., & Metzer, J. (1997). Epidemiology of traumatic brain injury in South Australia. *Brain Injury, 11*(9), 649-659.

Huyder, V., & Nilsen, E. S. (2012). A dyadic data analysis of executive functioning and children's socially competent behaviours. *Journal of Applied Developmental Psychology, 33*(4), 197-208. 10.1016/j.appdev.2012.05.002

Hyder, A. A., Wunderlich, C. A., Puvanachandra, P., Gururaj, G., & Kobusingye, O. C. (2007). The impact of traumatic brain injuries: A global perspective. *Neurorehabilitation, 22*(5), 341-353.

Iarocci, G., Yager, J., & Elfers, T. (2007). What gene-environment interactions can tell us about social competence in typical and atypical populations. *Brain and Cognition, 65*(1), 112-127. 10.1016/j.bandc.2007.01.008

Kaplan, H. I., Sadock, B. J., & Grebb, J. A. (1994). *Kaplan and Sadock's synopsis of psychiatry: Behavioural sciences, clinical psychiatry* (7ed.). Baltimore, MD: Williams and Wilkins.

Karver, C. L., Wade, S. L., Cassedy, A., Taylor, H. G., Stancin, T., Yeates, K. O., et al. (2012). Age at injury and long-term behavior problems after traumatic brain injury in young children. *Rehabilitation Psychology, 57*(3), 256-265. 10.1037/a0029522

Kinsella, G., Ong, B., Murtagh, D., Prior, M., & Sawyer, M. (1999). The role of the family for behavioral outcome in children and adolescents following traumatic brain injury. *Journal of Consulting and Clinical Psychology, 67*(1), 116-123. 10.1037//0022-006x.67.1.116

Lancet. (2010). Traumatic brain injury: time to end the silence. *Lancet Neurology, 9*(4), 331-331.

Langlois-Orman, J. A., Kraus, J. F., Zaloshnja, E., & Miller, T. (2011). Epidemiology. In J. M. Silver, T. W. McAllister & S. C. Yudofsky (Eds.), *Textbook of traumatic brain injury* (2 ed., pp. 3-22). Arlington, VA: American Psychiatric Publishing, Inc

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury - A brief overview. *Journal of Head Trauma Rehabilitation, 21*(5), 375-378.

Lanting, S. C., Iverson, G. L., & Lange, R. T. (2012, October). *Concurrent validity of CNS Vital Signs in patients with mild traumatic brain injury*. Paper presented at the American Congress of Rehabilitation Medicine Conference, Vancouver, BC, Canada.

Levin, H. S., & Hanten, G. (2005). Executive functions after traumatic brain injury in children. *Pediatric Neurology, 33*(2), 79-93. 10.1016/j.pediatneurol.2005.02.002

Levin, H. S., Hanten, G., & Li, X. Q. (2009). The relation of cognitive control to social outcome after paediatric TBI: Implications for intervention. *Developmental Neurorehabilitation, 12*(5), 320-329. 10.1080/17518420903087673

Lezak, M. D., Howieson, D. B., Bigler, E. D., & Tranel, D. (2012). *Neuropsychological assessment* (5ed.). New York: Oxford University Press, Inc.

Limond, J., Dorris, L., & McMillan, T. M. (2009). Quality of life in children with acquired brain injury: Parent perspectives 1-5 years after injury. *Brain Injury, 23*(7-8), 617-622. 10.1080/02699050902997870

Maillard-Wermelinger, A., Yeates, K. O., Taylor, H. G., Rusin, J., Bangert, B., Dietrich, A., et al. (2009). Mild traumatic brain injury and executive functions in school-aged children. *Developmental Neurorehabilitation, 12*(5), 330-341. 10.1080/17518420903087251

Massagli, T. L., Fann, J. R., Burington, B. E., Jaffe, K. M., Katon, W. J., & Thompson, R. S. (2004). Psychiatric illness after mild traumatic brain injury in children. *Archives of Physical Medicine and Rehabilitation, 85*(9), 1428-1434. 10.1016/j.apmr.2003.12.036

Mathias, J. L., Dennington, V., Bowden, S. C., & Bigler, E. D. (2013). Community versus orthopaedic controls in traumatic brain injury research: How comparable are they? *Brain Injury, 27*(7-8), 887-895. 10.3109/02699052.2013.793398

Max, J. E., Lansing, A. E., Koele, S. L., Castillo, C. S., Bokura, H., Schachar, R., et al. (2004). Attention deficit hyperactivity disorder in children and adolescents following traumatic brain injury. *Developmental Neuropsychology, 25*(1-2), 159-177. 10.1207/s15326942dn2501&2_9

Max, J. E., Lindgren, S. D., Knutson, C., Pearson, C. S., Ihrig, D., & Welborn, A. (1998). Child and adolescent traumatic brain injury: correlates of disruptive behaviour disorders. *Brain Injury, 12*(1), 41-52.

McCauley, S. R., Wilde, E. A., Anderson, V. A., Bedell, G., Beers, S. R., Campbell, T. F., et al. (2012). Recommendations for the use of common outcome measures in pediatric

traumatic brain injury research. *Journal of Neurotrauma, 29*(4), 678-705. 10.1089/neu.2011.1838

McKinlay, A. (2010). Controversies and outcomes associated with mild traumatic brain injury in childhood and adolescence. *Child: Care, Health and Development, 36*(1), 3-21. 10.1111/j.1365-2214.2009.01006.x

McKinlay, A., Grace, R. C., Horwood, L. J., Fergusson, D. M., Ridder, E. M., & Macfarlane, M. R. (2008). Prevalence of traumatic brain injury among children, adolescents and young adults: Prospective evidence from a birth cohort. *Brain Injury, 22*(2), 175-181. 10.1080/02699050801888824

McLellan, T., & McKinlay, A. (2013). Sensitivity to emotion, empathy and theory of mind: Adult performance following childhood TBI. *Brain Injury, 27*(9), 1032-1037. 10.3109/02699052.2013.794965

McMillan, J., Beavis, A., & Jones, F. L. (2009). The AUSEI06: A new socioeconomic index for Australia. *Journal of Sociology, 45*(2), 123-149. 10.1177/1440783309103342

Mellor, D. (2005). Normative data for the Strengths and Difficulties Questionnaire in Australia. *Australian Psychologist, 40*(3), 215-222. 10.1080/00050060500243475

Muscara, F., Catroppa, C., & Anderson, V. (2008a). The impact of injury severity on executive function 7-10 years following pediatric traumatic brain injury. *Developmental Neuropsychology, 33*(5), 623-636. 10.1080/87565640802171162

Muscara, F., Catroppa, C., & Anderson, V. (2008b). Social problem-solving skills as a mediator between executive function and long-term social outcome following paediatric traumatic brain injury. *Journal of Neuropsychology, 2*, 445-461. 10.1348/174866407x250820

Muscara, F., Catroppa, C., Eren, S., & Anderson, V. (2009). The impact of injury severity on long-term social outcome following paediatric traumatic brain injury. *Neuropsychological Rehabilitation, 19*(4), 541-561. 10.1080/09602010802365223

Musher-Eizenman, D. R., Boxer, P., Danner, S., Dubow, E. F., Goldstein, S. E., & Heretick, D. M. L. (2004). Social-cognitive mediators of the relation of environmental and emotion regulation factors to children's aggression. *Aggressive Behavior, 30*(5), 389-408. 10.1002/ab.20078

Oliver, B. R., Barker, E. D., Mandy, W. P. L., Skuse, D. H., & Maughan, B. (2011). Social cognition and conduct problems: A developmental approach. *Journal of the American Academy of Child and Adolescent Psychiatry, 50*(4), 385-394. 10.1016/j.jaac.2011.01.006

Penn, D. L., Corrigan, P. W., Bentall, R. P., Racenstein, J. M., & Newman, L. (1997). Social cognition in schizophrenia. *Psychological Bulletin, 121*(1), 114-132. 10.1037/0033-2909.121.1.114

Peppe, S., McCann, J., Gibbon, F., O'Hare, A., & Rutherford, M. (2007). Receptive and expressive prosodic ability in children with high-functioning autism. *Journal of Speech Language and Hearing Research, 50*(4), 1015-1028. 10.1044/1092-4388(2007/071)

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*(3), 215-221. 10.1080/02699050801935245

Prencipe, A., Kesek, A., Cohen, J., Lamm, C., Lewis, M. D., & Zelazo, P. D. (2011). Development of hot and cool executive function during the transition to adolescence. *Journal of Experimental Child Psychology, 108*(3), 621-637. 10.1016/j.jecp.2010.09.008

Prigatano, G. P., Fulton, J., & Wether, J. (2010). Behavioral consequences of pediatric traumatic brain injury. *Pediatric Health, 4*(4), 447-455. 10.2217/PHE.10.43

Pulkkinen, L. (1996). Proactive and reactive aggression in early adolescence as precursors to anti- and prosocial behavior in young adults. *Aggressive Behavior, 22*(4), 241-257. 10.1002/(sici)1098-2337(1996)22:4<241::aid-ab1>3.0.co;2-o

Rapee, R. M., & Spence, S. H. (2004). The etiology of social phobia: Empirical evidence and an initial model. *Clinical Psychology Review, 24*(7), 737-767. 10.1016/j.cpr.2004.06.004

Reynolds, C. R., & Kamphaus, R. W. (2004). *BASC-2: Behaviour assessment system for children, second edition, manual*. Circle Pines, MN: AGS Publishing.

Righthand, S., Prentky, R., Knight, R., Carpenter, E. C., Hecker, J. E., & Naugle, D. (2005). Factor structure and validation of the juvenile sex offender assessment protocol (J-SOAP). *Sexual Abuse-a Journal of Research and Treatment, 17*(1), 13-30. 10.1007/s11194-005-1207-7

Romine, C. B., & Reynolds, C. R. (2005). Model of the development of frontal lobe functioning: Findings from a meta-analysis. *Applied Neuropsychology, 12*(4), 190-201. 10.1207/s15324826an1204_2

Ross, K. A., McMillan, T., Kelly, T., Sumpter, R., & Dorris, L. (2011). Friendship, loneliness and psychosocial functioning in children with traumatic brain injury. *Brain Injury, 25*(12), 1206-1211. 10.3109/02699052.2011.609519

Rubin, K. H., Dwyer, K. M., Booth-LaForce, C., Kim, A. H., Burgess, K. B., & Rose-Krasnor, L. (2004). Attachment, friendship, and psychosocial functioning in early adolescence. *Journal of Early Adolescence, 24*(4), 326-356. 10.1177/0272431604268530

Rubin, K. H., & Krasnor, L. R. (1986). Social-cognitive and social behavioural-perspectives on problem-solving. *Minnesota Symposia on Child Psychology, 18*, 1-68.

Rubin, K. H., Schulz-Begle, A., & McDonald, K. L. (2012). Peer relations and social competence in childhood. In V. Anderson & M. H. Beauchamp (Eds.), *Developmental social neuroscience and childhood brain insult: Theory and practice* (pp. 23-45). New York, N.J.: The Guilford Press

Rutland-Brown, W., Langlois, J. A., Thomas, K. E., & Lily, Y. L. (2006). Incidence of traumatic brain injury in the United States, 2003. *Journal of Head Trauma Rehabilitation, 21*(6), 544-548. 10.1097/00001199-200611000-00009

Saltapidas, H., & Ponsford, J. (2008). The influence of cultural background on experiences and beliefs about traumatic brain injury and their associaton with outcome. *Brain Impairment, 9*(1), 1-13.

Schwartz, L., Taylor, H. G., Drotar, D., Yeates, K. O., Wade, S. L., & Stancin, T. (2003). Long-term behavior problems following pediatric traumatic brain injury: Prevalence, predictors, and correlates. *Journal of Pediatric Psychology, 28*(4), 251-263. 10.1093/jpepsy/jsg013

Scourfield, J., John, B., Martin, N., & McGuffin, P. (2004). The development of prosocial behaviour in children and adolescents: a twin study. *Journal of Child Psychology and Psychiatry, 45*(5), 927-935. 10.1111/j.1469-7610.2004.t01-1-00286.x

Servadei, F., Teasdale, G., & Merry, G. (2001). Defining acute mild head injury in adults: A proposal based on prognostic factors, diagnosis and management. *Journal of Neurotrauma, 18*(7), 657-664. 10.1089/089771501750357609

Sherer, M., Boake, C., Levin, E., Silver, B., Ringholz, G., & High, W. (1998). Characteristics of impaired awareness after traumatic brain injury. *Journal of the International Neuropsychological Society, 4*, 380-387.

Slaughter, B., Fann, J. R., & Ehde, D. (2003). Traumatic brain injury in a county jail population: prevalence, neuropsychological functioning and psychiatric disorders. *Brain Injury, 17*(9), 731-741. 10.1080/0269905031000088649

Stancin, T., Drotar, D., Taylor, H. G., Yeates, K. O., Wade, S. L., & Minich, N. M. (2002). Health-related quality of life of children and adolescents after traumatic brain injury. *Pediatrics, 109*(2), 8. 10.1542/peds.109.2.e34

Taylor, H. G., Yeates, K. O., Wade, S. L., Drotar, D., Stancin, T., & Burant, C. (2001). Bidirectional child-family influences on outcomes of traumatic brain injury in children. *Journal of the International Neuropsychological Society, 7*(6), 755-767. 10.1017/s1355617701766118

Taylor, H. G., Yeates, K. O., Wade, S. L., Drotar, D., Stancin, T., & Minich, N. (2002). A prospective study of short- and long-term outcomes after traumatic brain injury in children: Behavior and achievement. *Neuropsychology, 16*(1), 15-27. 10.1037//0894-4105.16.1.15

Taylor, S. J., Barker, L. A., Heavey, L., & McHale, S. (2012). The typical developmental trajectory of social and executive functions in late adolescence and early adulthood. *Developmental psychology, Advance online publication* 10.1037/a0029871

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

Theadom, A., Barker-Collo, S., Feigin, V. L., Starkey, N. J., Jones, K., Jones, A., et al. (2012). The spectrum captured: A methodological approach to studying incidence and outcomes of traumatic brain injury on a population level. *Neuroepidemiology, 38*(1), 18-29. 10.1159/000334746

Tlustos, S. J., Chiu, C. Y. P., Walz, N. C., Taylor, H. G., Yeates, K. O., & Wade, S. L. (2011). Emotion labeling and socio-emotional outcomes 18 months after early childhood traumatic brain injury. *Journal of the International Neuropsychological Society, 17*(6), 1132-1142. 10.1017/s1355617711001202

van Velzen, J. M., van Bennekom, C. A. M., Edelaar, M. J. A., Sluiter, J. K., & Frings-Dresen, M. H. W. (2009). How many people return to work after acquired brain injury?: A systematic review. *Brain Injury, 23*(6), 473-488. 10.1080/02699050902970737

Vu, J. A., Babikian, T., & Asarnow, R. F. (2011). Academic and language outcomes in children after traumatic brain injury: A Meta-Analysis. *Exceptional Children, 77*(3), 263-281.

Wade, S. L., Borawski, E. A., Taylor, H. G., Drotar, D., Yeates, K. O., & Stancin, T. (2001). The relationship of caregiver coping to family outcomes during the initial year following pediatric traumatic injury. *Journal of Consulting and Clinical Psychology, 69*(3), 406-415. 10.1037//0022-006x.69.3.406

Wade, S. L., Gerry Taylor, H., Yeates, K. O., Drotar, D., Stancin, T., Minich, N. M., et al. (2006). Long-term parental and family adaptation following pediatric brain injury. *Journal of Pediatric Psychology, 31*(10), 1072-1083. 10.1093/jpepsy/jsj077

Wanberg, C. R., & Kammeyer-Mueller, J. D. (2000). Predictors and outcomes of proactivity in the socialization process. *Journal of Applied Psychology, 85*(3), 373-385. 10.1037//0021-9010.85.3.373

Yager, J. A., & Ehmann, T. S. (2006). Untangling social function and social cognition: A review of concepts and measurement. *Psychiatry-Interpersonal and Biological Processes, 69*(1), 47-68. 10.1521/psyc.2006.69.1.47

Yeates, K. O. (2010). Mild traumatic brain injury and postconcussive symptoms in children and adolescents. *Journal of the International Neuropsychological Society, 16*(6), 953-960. 10.1017/s1355617710000986

Yeates, K. O., Bigler, E. D., Dennis, M., Gerhardt, C. A., Rubin, K. H., Stancin, T., et al. (2007). Social outcomes in childhood brain disorder: A heuristic integration of social neuroscience and developmental psychology. *Psychological Bulletin, 133*(3), 535-556. 10.1037/0033-2909.133.1535

Yeates, K. O., Gerhardt, C. A., Bigler, E. D., Abildskov, T., Dennis, M., Rubin, K. H., et al. (2013). Peer relationships of children with traumatic brain injury. *Journal of the International Neuropsychological Society, 19*(5), 518-527. 10.1017/s1355617712001531

Yeates, K. O., Swift, E., Taylor, H. G., Wade, S. L., Drotar, D., Stancin, T., et al. (2004). Short- and long-term social outcomes following pediatric traumatic brain injury. *Journal of the International Neuropsychological Society, 10*(3), 412-426. 10.1017/s1355617704103093

Yeates, K. O., & Taylor, H. G. (2005). Neurobehavioural outcomes of mild bead injury in children and adolescents. *Pediatric Rehabilitation, 8*(1), 5-16. 10.1080/13638490400011199

Yeates, K. O., & Taylor, H. G. (2012). Neurobehavioural outcomes. In M. W. Kirkwood & K. O. Yeates (Eds.), *Mild traumatic brain injury in children and adolescents: From basic science to clinical management* (pp. 124-144). New York, N.J.: The Guilford Press

Yeates, K. O., Taylor, H. G., Barry, C. T., Drotar, D., Wade, S. L., & Stancin, T. (2001). Neurobehavioral symptoms in childhood closed-head injuries: Changes in prevalence and correlates during the first year postinjury. *Journal of Pediatric Psychology, 26*(2), 79-91. 10.1093/jpepsy/26.2.79

Yeates, K. O., Taylor, H. G., Wade, S. L., Drotar, D., Stancin, T., & Minich, N. (2002). A prospective study of short- and long-term neuropsychological outcomes after

traumatic brain injury in children. *Neuropsychology, 16*(4), 514-523. 10.1037//0894-4105.16.4.514

Yeates, K. O., Taylor, H. G., Walz, N. C., Stancin, T., & Wade, S. L. (2010). The family environment as a moderator of psychosocial outcomes following traumatic brain injury in young children. *Neuropsychology, 24*(3), 345-356. 10.1037/a0018387

Ylvisaker, M., & DeBonis, D. (2000). Executive function impairment in adolescence: TBI and ADHD. *Topics in Language Disorders, 20*(2), 29-57. ISSN: 02718294

Appendices

Appendix A

The social information-processing model of children's adjustment (SIP: Crick & Dodge, 1994)
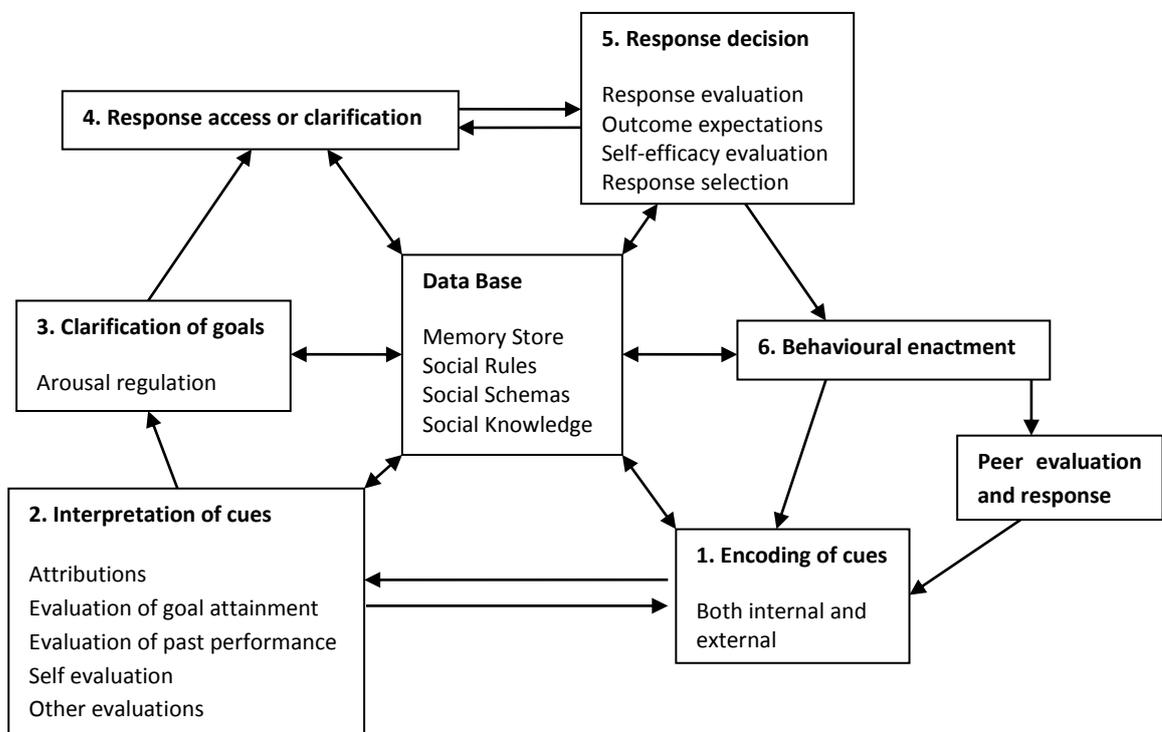
Figure 5. Social Information-processing Model of Children's Social Adjustment from Crick and Dodge (1994).

According to Crick and Dodge (1994) the interpretation of social information involves a number of processes, including (a) retrieval of memories with similar situational cues; (b) an analysis of past events; (c) interpretations regarding the goals of others; (d) memories of goals in similar situations; (e) evaluation of expected outcomes and self-efficacy; and (f) interpretations of meaning within the exchange for

both the self and the peer. All these interpretive processes are guided by previous memories. The author's call this the data base of information which is depicted in the centre of the model.

During step 3, a desired outcome is selected. The authors contend that this goal represents a focused arousal state that we are working towards. This goal may also be repeatedly revised or even reconstructed in response to social cues.

In step 4, the authors theorize that the child then accesses from memory possible responses, or in novel situations the child may construct new responses to these cues.

In step 5, all responses are evaluated and one is chosen. A number of factors may be involved in this response selection process; including, the expected outcome from each proposed response, confidence in their ability to engage in each response, and their evaluation of the social appropriateness of each response.

Finally in step 6, the chosen behavioural response is enacted. However, the mental processing of social interactions does not stop, as these processes are continually cycling. This means that a person may be constantly encoding and interpreting dynamic situational cues while simultaneously evaluating and re-evaluating possible responses in accordance with these changing cues. This is represented by the feedback loops between steps 1 and 2, and steps 4 and 5.

The advantages of breaking down these social information processes into basic steps are numerous. Firstly, it may lead to a better understanding of how children learn about themselves and others socially, and the ways in which children make links between behaviours and their consequences. Secondly, the models focus on the mental processes that may be influenced by the way others respond to a child's behaviour. This could shed light on how a child's self-perceptions develop. These self-perceptions can then influence the way a child behaves towards others in the future. Finally, a basic understanding of the processes involved in social interactions may help to better predict a child's future behaviours and levels of social competence.

Furthermore, when social problems arise, this model provides the structure to isolate deficits so that they can be targeted in interventions (Crick & Dodge, 1994).

Appendix B.

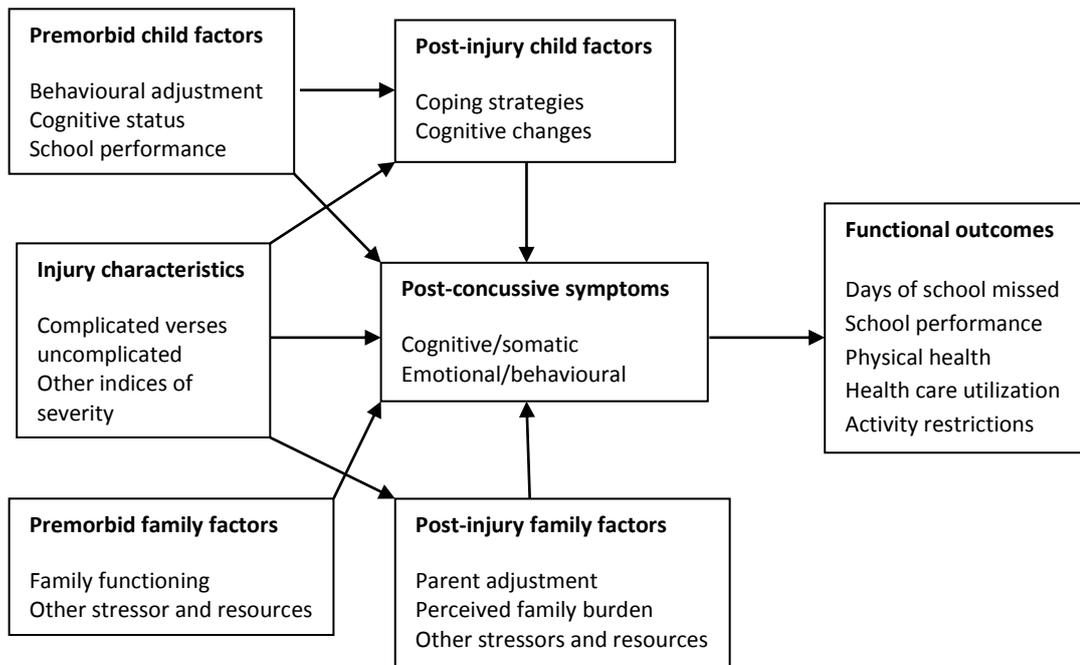The evolution of the CHIMS model of social competence.

Figure 6. Evidence-based model of functional outcomes in children with mild closed-head injuries from Yeates and Taylor (2005).
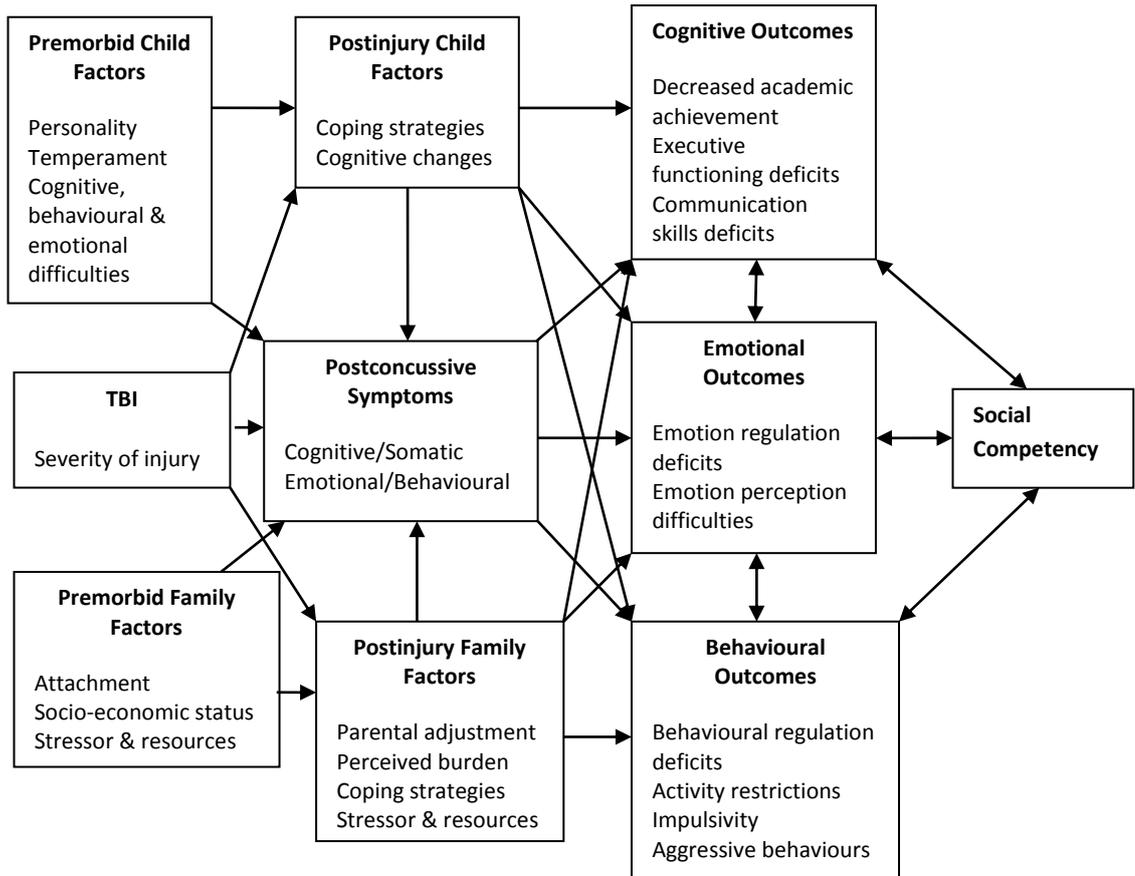
Figure 7. Influential factors to social competency in children and adolescents with a TBI.
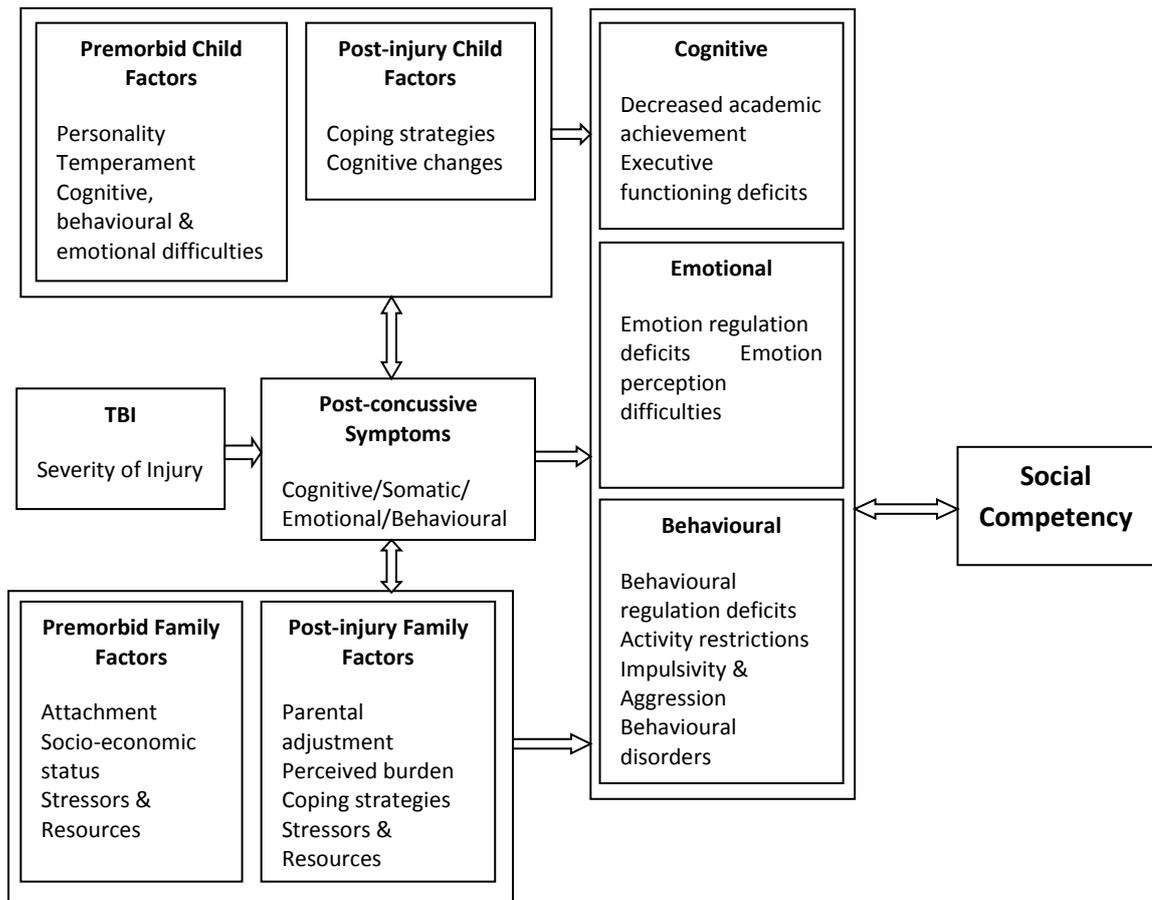
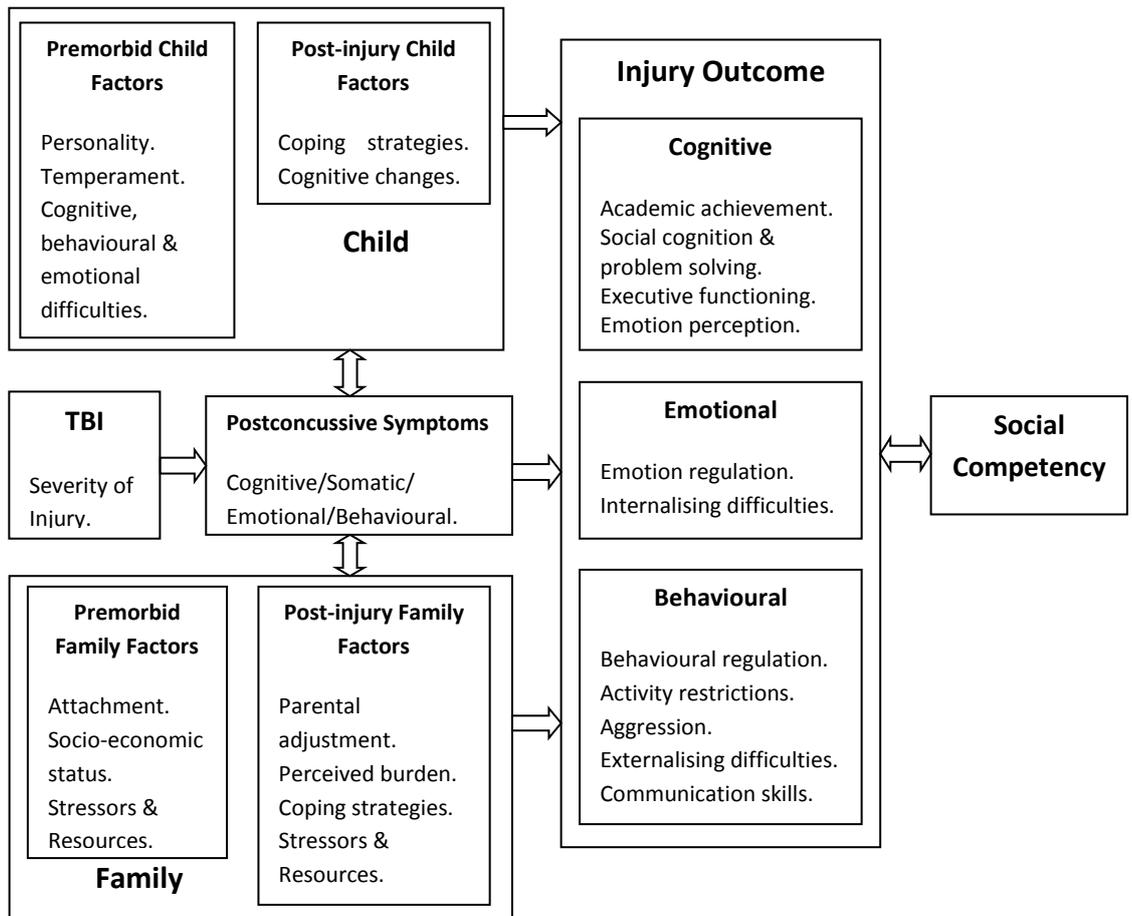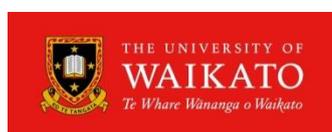*Figure 8.* First draft of the Child head injury model of sociability (CHIMS).

Figure 9. Final draft of the Child Head Injury Model of Sociability (CHIMS).

A copy of the COBIC study's child and adolescent participant information sheet and consent form.

The Consequences of Brain Injury In Childhood (COBIC)

Child and Adolescent Participant Information Sheet (under 16)

Who are we?

We are a team of people who work in universities and health care services in New Zealand. We would like to help people who have had a head injury and to find out information that will make treatment better.

What is the study about?

To help us to do this we would like to ask people who have had a head injury about any problems they have (such as finding it difficult to remember things) and to see how quickly they get better. We also want to talk to people who haven't had a head injury so we can find out more about how a head injury affects people.

We are asking every child who had a head injury and took part in the BIONIC study to take part in this study as well. We also want children who are under 16 years of age and have not had a head injury to take part. You do not have to be involved in the study and you can stop taking part any

time you want to. You can ask us any questions you like before you say that you would like to take part.

What will happen if I want to take part?

We would like to ask your parent or a person who looks after you some questions and if you have had another head injury we would like to look through what the doctors have written about your injury. If you would like us to stop talking to your parent or person who looks after you at any point, that's okay, please just tell us you want us to stop talking to them.

Having a head injury can sometimes effect how well people can remember things, how they think and how they behave. We would like to compare people who have had a head injury and people who haven't had a head injury to find out more about how a head injury effects how people remember, how they think and also how they get on at school. So if it's ok with you and your parents we would also like to talk to your school teacher to find out about how you are getting on at school.

A researcher will come to visit you (where you live, or somewhere easy for you) and bring some activities that will help us to look how you remember things and how you think. We hope that you find these activities enjoyable. The activities last for about 4 hours, but we will split these activities up so that you can do them on at least two different days. We will also ask you some questions about things you like doing and how you are feeling. This is not a test so we don't usually tell you how you did.

To help us to see how quickly people get better, we will ask you to answer the same questions and to do the same activities now, and in 1 year and 2 years time. At each time point we will come to see you twice, for about 90 minutes each time. In total this will take about 1.5 days of your time over 2 years.

Do I have to take part?

No, it is up to you. If you would like to help us with the study, a researcher will ask you to sign a form to say that you are happy to take part.

You are free to stop your part the study at any time and you do not have to give us a reason. If you have had a head

injury and you are still receiving treatment, this will not change whether you take part in this study or not. If you have any worries or questions about the study you can come and talk to us.

We will keep everything private but if we think that you might not be safe we might have to tell some other adults who can help us to keep you safe.

How many people will be in the study?

We think there will be about 690 children and young people from New Zealand taking part in this study. Around half of them will have had a head injury.

How long does the study go on for?

We will be starting the study in April 2011 and will continue until the end of October 2014.

What will happen afterwards?

When we look at what everyone has told us, we will write about what we have found. We won't write your name anywhere, so people won't know that what you have said was from you.

After the study has finished we will keep all your information locked in a cupboard at the University. Only the people working on this study will be able to look at this information.

We will keep everything private but if we think that you might not be safe we might have to tell some other adults who can help us to keep you safe.

How will the study affect me?

We cannot promise that the study will help you, but the information that we find out will help us to treat people better in the future.

To say thank you, we will give you a gift or voucher ($20) after you have finished the activities now, and when you do the activities in 1 and 2 years time 3 gifts or $60 vouchers in total).

Has this study been approved by anybody?

Before any research goes ahead it has to be checked by a Research Ethics Committee. They make sure that the

research is fair. This study has been checked and approved by the Northern Region Y Ethics Committee (Ref NTY/11/02/016).

What if I have any questions?

If you would like to contact someone about the study or if you have any worries, you can talk to any member of the team or you can phone;

Nicola Starkey who runs the study;

Telephone: 07 8384466 ext 6472

**Thank you for reading about this study
You can keep this information.**

The Consequences of Brain Injury In Childhood (COBIC)

Child Participant Consent Form

I know that;

I have read the information about the study (version 3 dated 31/5/2011) and/or had the information about the study explained to me

I have had the opportunity to ask questions about the study and I am happy with the answers I have been given.

I understand that it is my choice to take part in the study and I do not have to take part if I do not want to.

I understand that I can pull out of the project if I want to at any time.

If I have an injury I am happy for the team to look at what the doctors have written about my injury.

I am happy for the team to contact my school teacher

I understand that when the team write about the study they will not use my name.

I understand that if the researchers are worried that I might not be safe, they may contact other adults who can help me.

If I have any worries I can talk to the study manager or any member of the team.

I understand that my GP may be told that I am taking part in this study.

I agree to take part in this research study.

I _____ (Name of child)

agree to take part in this study.

Signature   of

child_____

Date: _____

Project explained by .... Project role

……………………………………

Signature .... Date
………………………………………

Note: A copy of the consent form to be retained by participant and a copy to be placed in the case record file.

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