

Social Skills and Theory of Mind in Children with Traumatic Brain Injury

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Abstract

This thesis investigated the social competencies of children with traumatic brain injury (TBI) by investigating the predictors of social functioning and developing a measure of affective theory of mind (ToM). Study 1 examined the biopsychosocial predictors of social functioning in 56 children (7 - 16 years) with TBI. Using Beauchamp and Anderson's (2010) socio-cognitive integration of abilities (SOCIAL) model, the study investigated the predictive abilities of family functioning, socio-economic status, children's internal behaviours, executive functions, communication and social-cognitive abilities. A series of hierarchical multiple regression analyses showed that family functioning, internal behaviours, ecological executive functions and ToM made significant unique and collective contributions to the prediction of children's socialisation skills and social behaviours. In light of the importance ToM has on children's social functioning, Study 2 developed a measure of affective ToM and trialled its use on 17 children with TBI and a control group of 59 typically developing children (4 – 6.5 years). A visual and verbal version of a story book was developed to ask children a series of factual and emotional questions which were designed to assess their understanding of others' feelings during social interactions. A series of analyses of variance were run, controlling for children's receptive language skills. Although there was no significant difference between children with TBI and typically developing children on the factual and emotional questions, the results showed that children correctly answered significantly more emotional questions when the story was conveyed verbally as opposed to visually. There was no significant difference between book types on the fact questions. Furthermore, the results showed that affective ToM is a skill that develops with age, particularly during the preschool years. Both Study 1 and 2 have implications for the development of social rehabilitation techniques in children with TBI. In particular, Study 1 highlights the importance of family therapy and rehabilitation that targets children's mood

and understanding of others' beliefs. Study 2 built on the concept of addressing ToM, and the findings have implications for teaching children about emotions and highlight the importance of language.

CHAPTER 1: Traumatic Brain Injury

Traumatic brain injury (TBI) is defined as “an external force to the brain causing transient or permanent neurological dysfunction” (Khan, Bauley, & Cameron, 2003, p. 290). The majority of TBIs are closed head injuries, which are cases where the skull remains intact. This thesis will examine children with closed head TBIs. As described by Crowe (2008), TBI can range from a cerebral concussion, the mildest form of TBI, to more severe forms which often result in coma or death. Traumatic brain injury is the most common cause of brain damage in children and adolescents in the western world (Lezak, Howieson, & Loring, 2004). Such injuries cause a high economic burden with regard to hospital care, medical care, injury-related work loss, disability services and lost income from premature death (Kraus, 1995; Thurman, Alverson, Dunn, Guerrero, & Snizek, 1999), with estimates exceeding one billion US dollars annually (Schneier, Shields, Hostetler, Xiang, & Smith, 2006).

1.1 Types of Brain Trauma

Brain trauma typically results from an external force, which may involve the skull being hit by a moving or stationary object (e.g., hitting concrete during a fall or a moving fist in an assault), or it may involve the effect of acceleration and deceleration forces (e.g., when the head is shaken but does not hit the dash board in a motor vehicle accident) (S. Crowe, 2008). Primary injuries from large impact forces can result in skull fractures, scalp lacerations, epidural haemorrhages and focal contusions. In comparison, injuries involving acceleration-deceleration forces typically result in translational and rotational trauma, which can cause tearing and bruising of blood vessels, contusions and haemorrhages, as well as shearing or straining of axonal fibres (S. Crowe, 2008; Yeates, 2009).

Although focal injuries can occur anywhere in the brain, such damage is predominately found in the frontal and temporal lobes in TBI due to the shape of the anterior

and middle fossa of the skull (Khan et al., 2003; Yeates, 2009). Contusions may also develop at the opposite side of the brain through a process known as contrecoup. For example, when the brain hits the front of the skull in an injury, the effects of inertia result in the brain subsequently colliding with the back of the skull causing a second contusion (S. Crowe, 2008). It is important to note, however, that compared to adults, children are more likely to present with post-traumatic brain swelling, hypoxic-ischemic injuries (reduced oxygen and blood flow to the brain) and diffuse injuries rather than focal damage. It is believed that the biomechanical properties of a child's brain explain this difference. That is, compared to adults, children generally have a larger head to body size ratio, less myelination, and a larger proportion of water content and cerebral blood volume (Kirkwood, Yeates, & Bernstein, 2010; Yeates, 2009). Diffuse axonal injury (DAI) refers to widespread damage which is the result of translational and rotational trauma causing neurons to stretch, swell and separate and thus shear (S. Crowe, 2008). Teasdale (1995) notes that DAI is responsible for the loss of consciousness during the acute phase of a brain injury.

1.2 Epidemiology of TBI

Although the incidence of childhood TBI is high, it is difficult to report exact figures since many mild head injuries often go unreported and epidemiological studies vary widely with regard to injury definition, sources of data and data collection techniques (L. Crowe, Babl, Anderson, & Catroppa, 2009; Kraus, 1995). Recent reports suggest that in the United States alone, more than one million children sustain a TBI annually. Furthermore, approximately 2700 children under the age of 14 years die each year from TBI, 37,000 will be hospitalised and 435,000 will attend an emergency department (Langlois, Rutland-Brown, & Thomas, 2006). Although detailed statistics on Australian epidemiology are needed, a recent incidence report of children from the Australian state of Victoria who presented to the emergency department for a head injury, approximately 90% were classified as mild, 8%

were moderate and 3% were severe. From these data, the authors estimate that approximately 2008 in every 100,000 children will present to an emergency department for a head injury (L. Crowe et al., 2009).

The prevalence of paediatric TBI varies significantly with regard to demographic variables, such as gender and age. In childhood, males are twice as likely as females to sustain a TBI (Kraus, 1995). Although mild injuries are more prevalent than severe injuries, the incidence of severe TBI increases in adolescence, which is thought to be a reflection of a higher likelihood of involvement in a motor vehicle accident (Langlois et al., 2006). A UK based epidemiological study has also shown that children under 5 years of age are most likely to present to an emergency department with a moderate or severe TBI (Yates, Williams, Harris, Round, & Jenkins, 2006). Similar to adult TBI, the aetiology of paediatric TBI varies as a result of inconsistencies across the coding systems of different studies and of different emergency departments. Research demonstrates that the most common causes of TBI in children are motor vehicle accidents and falls, as together they account for approximately 75-80% of all head injuries (Kraus, 1995).

1.3 Severity of TBI

Severity of TBI is classified as mild, moderate and severe, but the definition and tools used to group these classifications are inconsistent in the literature (Carrol, Cassidy, Holm, Kraus, & Coronado, 2004). The most commonly used techniques involve measuring the length of loss of consciousness (LOC) and/or posttraumatic amnesia (PTA). Posttraumatic amnesia refers to the acute recovery phase of brain trauma, and during this time an individual experiences impaired orientation, attention and memory (S. Crowe, 2008). The duration of PTA is often measured by estimation (self or eye-witness reports) or with objective measures. Objective measures include the Galveston Orientation and Amnesia Test (GOAT, H. Levin,

O'Donnell, & Grossman, 1979), or the Children's Orientation and Amnesia Test (COAT, Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990) in children, as well as the Westmead PTA Scale (Shores, Morosszeky, Sandanam, & Batchelor, 1986). The commonly used Westmead PTA scale requires individuals to answer a series of questions about time, date and place, and also requires them to recall a series of pictures previously viewed, thus measuring orientation and new learning.

The most common method of determining injury severity in both clinical and research settings is the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974), a scale based on an individual's level of consciousness, or specifically the duration and level of coma. The assessment is ideally given as soon as practicable and scores are divided into three sections, assessing eye opening, best verbal response and best motor response. The total score is then graded. Scores between 13 and 15 represent mild injuries, scores between 9 and 12 represent moderate injuries and scores ranging from 3-8 are classified as severe (Lezak et al., 2004).

Mild TBI is the most prevalent type of head trauma in children. Although moderate and severe TBI has been shown to result in more significant cognitive and behavioural difficulties, research suggests that mild TBI can also result in similar sequelae (Ponsford, 2012; Ponsford et al., 1999). Following mild TBI, individuals often experience post-concussion symptoms such as headaches, dizziness, fatigue, blurred or double-vision, sensitivity to noise and/or bright lights, tinnitus, restlessness, insomnia, and poor balance. Furthermore, the symptoms extend to cognitive difficulties including reduced speed of thinking, poor concentration and memory problems, as well as psychological problems including depression and anxiety. Although people generally recover within the first three months post injury, in approximately 15-25% of cases these symptoms are ongoing (Ponsford, 2012). These findings also extend to children. Ponsford et al. (1999) assessed 130 children who presented to the emergency department of a hospital with mild TBI on a range

of behavioural and cognitive measures. Compared to healthy controls, children with TBI experienced post-concussion symptomology (namely dizziness, headaches and fatigue) at one week post injury. Although these symptoms resolved at 3 months post injury for most, 17% of the children with a mild TBI exhibited ongoing difficulties, including social and behavioural problems and post-concussion symptoms. These children were more likely to have had a previous head injury, a pre-existing learning difficulty, or neurological, psychiatric or family problems.

1.4 Consequences of TBI

Children with TBI present with a wide range of short- and long-term difficulties that encompass physical disabilities, cognitive decline, behavioural and emotional problems, and social deficits. The consequences of TBI in children are varied and extensive, and research has recently highlighted the integrative nature of various social, cognitive and psychological deficits post-injury (Beauchamp & Anderson, 2010). Significant deficits post TBI can be seen in social functioning and cognitive domains, including attention and executive functions, communicative functions and socio-emotional skills. The remaining chapters of this thesis will discuss these negative consequences as well as changes to behaviour and mood. The current chapter will briefly report on additional consequences such as a decline in intellectual functioning, academic performance, and various neuropsychological skills.

Deficits in intellectual functioning have been shown to occur in paediatric TBI populations, both in studies that compare this clinical group to age-matched healthy controls (V. Anderson, Morse, Catroppa, Haritou, & Rosenfeld, 2004; Catroppa, Anderson, Morse, Haritou, & Rosenfeld, 2007; Goldstrohm & Arffa, 2005) and children with orthopaedic injuries (Goldstrohm & Arffa, 2005; Taylor et al., 1999). Deficits in both verbal (Ewing-Cobbs et al., 1997) and non-verbal (Allen, Thaler, Donohue, & Mayfield, 2010; Tremont,

Mittenberg, & Miller, 1999) domains of intellectual functioning have been shown, but it appears that processing speed, particularly performance on the Coding subtest of the Wechsler Intelligence Scales for Children (WISC), is the factor most affected (Allen et al., 2010; Catroppa et al., 2009).

Research has consistently shown that injury severity is one of the most significant predictors of intellectual ability post injury (V. Anderson et al., 2004; Catroppa & Anderson, 2003; Catroppa et al., 2009; Max et al., 1999). Children with a severe TBI, typically determined by their Glasgow Coma Scale (GCS) score or length of post-traumatic amnesia (PTA), have been shown to have significantly lower IQ scores post-injury than age-matched peers with mild and moderate injuries. Furthermore, such a discrepancy between severity types has been shown to persist for up to six years post injury (Catroppa et al., 2009).

It is established that children with TBI often experience difficulty with academic skills post injury, and it is often this change that first alerts parents that something is wrong (Middleton, 2001). In addition to teacher reports of poor academic performance, deficits have been shown in children's word recognition, mathematical and written language skills (Catroppa et al., 2009; Taylor et al., 1999; Taylor et al., 2002). Problems with children's language functioning have been shown to have cumulative effects on the development of other skills such as general knowledge, social knowledge and working memory (Dennis & Barnes, 1990; Dennis, Purvis, Barnes, Wilkinson, & Winner, 2001). There are several factors known to have an effect on children's academic performance post TBI, including their premorbid academic functioning, post-injury neuropsychological functioning (e.g., poor attention and memory), behavioural adjustment, and family functioning (Kinsella et al., 1997; Yeates, 2009). Catroppa et al. (2009) investigated long-term educational outcomes following paediatric TBI, and showed that injury severity and acute measures of intellectual ability predicted children's educational performance up to seven years later. Taylor et al. (2002) also

showed that children with severe injuries were more likely than those with less severe injuries to have difficulty on academic tests. Despite such impairments, some research suggests that improvements can be seen in children 12 months post injury if they are living in a low-stress environment. These improvements remained true for children with a severe TBI (Taylor et al., 2002). It is also important to note that the school environment can have an impact on children's recovery, particularly in relation to identification of students' needs and implementation of appropriate strategies. Turkstra, Williams, Tonks, and Frampton (2008) discuss the challenges children with TBI face in returning to school, and recognise that many schools are not equipped to deal with the additional needs of these students. In light of such difficulties following TBI and the possibility of improvements, a series of guidelines regarding the child's return to school have been outlined by Savage, Depompei, Tyler and Lash (2005). These guidelines cover factors such as challenges with educational resources, family life, communication and behaviour, but further details are beyond the scope of this thesis.

One possible explanation for children's academic difficulties may be the decline reported in various neuropsychological measures, such as memory and visuospatial skill. Compared to age-matched controls, children with severe TBI have been shown to have significant difficulty completing tasks that require spatial learning (Lehning et al., 2001) and perceptual motor skills (Taylor et al., 1999). Tonks, Yates, Slater, Williams, and Frampton (2009) assessed visuospatial performance on two tasks in 9- to 15-year-olds who sustained an acquired brain injury (ABI) and in 67 healthy controls. Children with an ABI (of whom 78% were TBI patients) were less adept at the visuospatial task than the controls, a deficit that was shown not to result simply from differences in visual discrimination skills. In addition to showing that children with closed head injury have poor visuospatial skills, the results indicated that children with greater visuospatial impairment also rated themselves as having a

greater degree of socio-emotional behaviour disturbance. This suggests a link between children's visuospatial abilities and risk of psychosocial deficits.

Poor memory is a common difficulty reported by, and observed in, children with TBI. Memory impairments have been reported on a range of tasks that assess explicit memory, a deficit which appears to be dependent upon the severity of the injury (Catroppa & Anderson, 2002, 2007; Gerrard-Morris et al., 2010; Lehnung et al., 2001). Deficits in prospective memory have also been observed in children with TBI. Specifically, compared to children with orthopaedic injuries and typically developing children, children and adolescents with moderate to severe TBI have been shown to have significant difficulty remembering to perform an intended action at some time in the future (S. McCauley & Levin, 2004; Ward, Shum, McKinlay, Baker, & Wallace, 2007).

1.5 Summary

Traumatic brain injury in children is an area of long-standing research. This is not surprising given the high incidence of paediatric TBI and the costly and debilitating implications of such an injury. In children, closed head injuries commonly result in DAI, causing neurons to stretch and shear. It is the tearing and stretching that is thought to be responsible for the series of cognitive difficulties children experience post injury. Injury severity is one of the major indicators of the degree of impairment experienced by children, and a range of measures are used in both clinical and research settings to determine injury severity. The most common measures include assessing the duration of PTA and/or level of consciousness.

The developmental, psychological and neurocognitive literature has commented on a series of deficits that occur following paediatric TBI, ranging from social and behavioural disabilities to cognitive, academic and mood difficulties. This chapter summarised deficits

evident in children's intellectual and academic functioning. The remaining chapters will discuss the range of cognitive and social deficits in more detail.

CHAPTER 2: Social Functioning Following Childhood TBI

Social interaction is a key part of human consciousness, and social skills are critical for individuals to be able to engage and interact with others by forming various types of relationships. Social dysfunction is a term used to refer to an individual's capacity, or lack thereof, to operate in a social environment (Yager & Ehmann, 2006). It can often contribute to social isolation, poor quality of life and psychological distress in both adults and children (Beauchamp & Anderson, 2010). In particular, children with poor social skills have been shown to be at higher risk of committing criminal behaviour in adolescence and adulthood (Hawkins, Kosterman, Catalano, Hill, & Abbott, 2005), engaging in aggressive and violent behaviour (Boxer, Goldstein, Musher-Eizenman, Dubow, & Heretick, 2005) and abusing alcohol and drugs (K. Henry & Slater, 2007). In typically developing children, social functioning develops from infancy. During a child's first year of life, social smiling, separation anxiety and social attachment scaffold the development of later social skills, which are aided by the formation of relationships, verbal and non-verbal language and play (Malim & Birch, 1998). Although complex in its development, social functioning occurs naturally in typically developing children. It involves the activation of a distributed neural network and thus as a result, TBI during childhood can significantly alter the development of a child's social functioning.

Given the significance of social functioning, it is not surprising that this is an area of intense investigation within many research domains. Researchers have recently begun to focus on the development of social functioning and determine which cognitive and neuropsychological factors play a role. Although the development of social functioning is often disrupted by neurological, developmental, psychological conditions, and/or environmental factors, there remains a gap in the literature in regard to how this disruption

occurs. Beauchamp and Anderson (2010) argued that the predictors of social functioning are largely unknown and in particular the impact of brain insult and environmental influences are poorly understood. Since social functioning has such a large impact on the daily operations of individuals, the importance of understanding this deficit is paramount. Despite recent attempts to conceptualise this process in theoretical models, where factors such as language and executive functioning have been highlighted, only a few studies have attempted to apply these frameworks to clinical populations.

2.1 Social Dysfunction Following Paediatric TBI

Following a brain injury, children rate social skills as being of primary importance, claiming that they are most concerned about losing friendships (Bohnert, Parker, & Warschausky, 1997). Furthermore, adult survivors of childhood TBI report that social functioning has the greatest impact on their quality of life (V. Anderson, Brown, & Newitt, 2010). Despite this evidence however, social functioning is commonly overlooked by health professionals and parents, who typically prioritise the child's medical and educational problems (Bohnert et al., 1997; Driscoll, Monte, & Grafman, 2011; Warschausky, Cohen, Parker, Levendosky, & Okun, 1997).

Empirical research has used a wide range of measures to assess social functioning. These have included evaluating children's social problem-solving skills, social adjustment, adaptive functioning skills, social competence, and the number and extent of any social problems. F. Muscara and Crowe (2012) discussed a variety of techniques used in the literature to assess social functioning including self-report measures, interviews, rating scales and observational methods. They suggest that rating scales and questionnaires are the most valid and reliable type of measure due to their developmental relevance, ability to identify skills and behaviours, ability to utilise multiple informants, as well as their ecological validity

and psychometric properties. Typically, parents/caregivers act as informants in rating scales and questionnaires as they not only know the child best but are able to provide detailed information about the child when he/she is in their own environment.

Social adaptive behaviour is often measured by the Vineland Adaptive Behaviour Scales (VABS; Sparrow, Balla, & Cicchetti, 1984) or Adaptive Behaviour Assessment System (ABAS; Harrison & Oakland, 2003). The Child Behaviour Checklist (CBCL; Achenbach, 1991) is used to provide a measure of the frequency and extent of social problems exhibited and/or social competence. In order to gain a holistic understanding of a child's social functioning, it is recommended that more than one measure is employed (V. Anderson & Beauchamp, 2012; F. Muscara & Crowe, 2012).

Parental ratings on the VABS indicate that children with TBI have significantly higher reports of maladaptive behaviour (Hawley, 2003; H. Levin, Zhang, et al., 2004; Taylor et al., 1999), as well as poorer socialisation and daily living skills (H. Levin, Zhang, et al., 2004), compared to other children. Maladaptive behaviour has been shown to occur in approximately two-thirds of all paediatric TBI cases (Hawley, 2003) and often does not improve with time (Catroppa et al., 2007). Similar outcomes have been shown in studies using parent ratings on the CBCL, where children with TBI have been shown to exhibit less social competence and more social problems than both children with orthopaedic injuries (Taylor et al., 1999; Yeates et al., 2004) and non-injured populations (Nassau & Drotar, 1997). Social competence, as measured by the ABAS, requires parents to comment on their child's ability to communicate and behave appropriately in social interactions. In a study by Ganesalingham et al. (2011), parents of children with TBI rated their children as less socially competent than did parents of children with an orthopaedic injury, with greater deficits reported for children with a severe TBI. Furthermore, social dysfunction has been shown to occur across various stages of recovery; at six months post injury (Ganesalingam et al., 2011)

and up to five years post injury (Catroppa et al., 2007). This suggests that social dysfunction is a persistent and unrelenting problem in childhood TBI.

Research has also shown that TBI can have negative consequences on other aspects of a child's social functioning, such as their ability to solve social problems. Janusz, Kirkwood, Yeates, and Taylor (2002) assessed 75 children with moderate and severe TBI on a task that required them to solve a hypothetical social dilemma. Compared to orthopaedic-injured controls, children with TBI generated lower-level strategies (e.g., strategies that were more egocentric and relied on more physical and impulsive behaviours) to solve the social dilemma and had greater difficulty developing well-reasoned strategies. Furthermore, children with poor social problem-solving skills have been shown to have poorer social skills, fewer peer relationships (Janusz et al., 2002) and less successful social integration (Milders, Ietswaart, Crawford, & Currie, 2008). Importantly, research has replicated this former finding by showing, across multiple samples, that children with TBI have difficulty with social problem-solving (Hanten et al., 2008; Warschausky et al., 1997; Yeates et al., 2004).

It is therefore evident that social dysfunction is a common consequence of paediatric TBI. Although the above research clearly indicates that childhood TBI typically results in social dysfunction, questions remain about the nature of this deficit. Specifically, the prevalence, aetiology, and predictors of social dysfunction are unclear (Noggle & Pierson, 2010; Yeates et al., 2007), as well as the impact of brain insult (V. Anderson & Beauchamp, 2012). Chapter 3 of the current thesis will discuss possible predictors of social dysfunction and the effect of brain insult.

2.2 Conceptual Models of Social Functioning: SOCIAL

Until recently, conceptual models of social functioning had failed to include a neurological component in their explanation of how social functioning develops.

Consideration of the neural bases of social functioning is imperative to understanding social functioning since the behaviours and skills involved in social skills require an efficient connection between a complex series of neural networks. As summarised by Beauchamp and Anderson (2010), the role of neurology has been consistently demonstrated through the use of brain lesion studies and modern brain-imaging techniques. Furthermore, as described by Yeates et al. (2007) and Beauchamp and Anderson (2010), psychological and environmental influences are also an important consideration for the development of social skills. Thus, building upon Crick and Dodge's (1994) social information processing model and the social functioning heuristic proposed by Yeates et al. (2007), Beauchamp and Anderson (2010) developed a conceptual framework. The socio-cognitive integration of abilities (SOCIAL) model expands upon these two models by drawing attention to the vulnerable nature of children's social functioning and highlighting the effect of significant interruptions, such as TBI, within the developmental process. Furthermore, the SOCIAL model builds on previous models by incorporating social and individual factors, such as family environment and personality/temperament, as well as by providing researchers with a more explicit understanding of the cognitive and affective processes involved. Beauchamp and Anderson (2010) intended that these adjustments would allow the model to be operationalised clearly and consistently in future studies.

The SOCIAL model was developed in an attempt to describe how cognitive, socio-emotional, communicative, biological and environmental dimensions interact to predict social functioning within a developmental framework, as well as to understand the effect that brain injury can have on such developmental pathways. It is this model and its various components which form the basis of Study 1 of this thesis. The model, shown in Figure 2.1, is composed of several components and includes classes of mediators, cognitive functions and social functioning. The first class of components, the mediators, includes both internal and external

factors, as well as brain developmental and integrity. ‘Internal factors’ include characteristics such as the child’s temperament or personality, whereas ‘external factors’ refer to environmental features such as SES or family environment. Both factors are included, as both influence the quality and nature of an individual’s social functioning. ‘Brain development and integrity’ is also classed as a mediator, since the structural and neural functions are integral to one’s social functioning. The second class of components refers to the cognitive functions. Although the model emphasises higher-order cognitions, such as attention and executive functions, communication and social cognition skills, Beauchamp and Anderson (2010) also noted that basic functions, such as perceptual processes (e.g., visual, auditory and tactile experiences), are imperative for social functioning. As demonstrated by the bi-directional arrow in Figure 2.1, the mediators and cognitive functions are proposed to be interrelated through both behavioural and neural systems. Together, both components interact dynamically to establish a child’s level of social functioning, as a change in any component within the model can directly or indirectly affect the development of social skills. Beauchamp and Anderson (2010) suggest that the SOCIAL model is applicable to various clinical disorders, including paediatric TBI, and with the availability of appropriate standardised psychological assessments they recommended that the model be operationalised to demonstrate its clinical utility. Despite these recommendations, the validity of this model is yet to be tested in a clinical population.

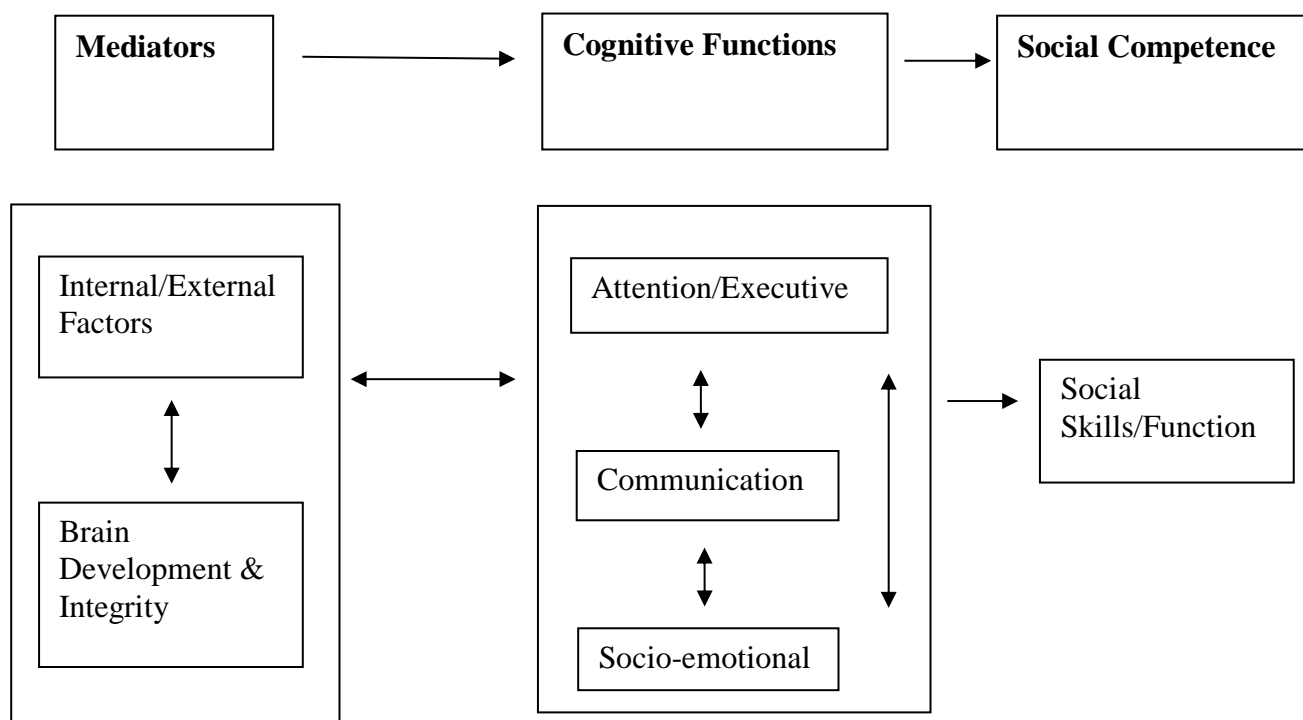


Figure 2.1. The socio-cognitive integration of abilities (SOCIAL) model (Beauchamp & Anderson, 2010)

2.3 Summary

Social functioning is an important part of a person's life and daily environment and therefore social dysfunction can have detrimental consequences for someone's quality of life. In children, social functioning is typically assessed through measures of adaptive functioning, social competence and social problem-solving. Using these measures, research has shown that children with TBI display poor social functioning compared to healthy peers, exhibited by higher ratings of social incompetence, social problems and maladaptive behaviours.

Although it is well established that children have difficulty functioning in a social world following a TBI, the majority of research in this area has lacked a theoretical basis (V. Anderson & Beauchamp, 2012). Thus, Beauchamp and Anderson (2010) developed a new model, SOCIAL, in an attempt to gain a fuller understanding of social functioning in the

context of child development. The SOCIAL model incorporates several aspects of developmental psychology and social neuroscience by involving internal and external factors with brain integrity factors, and cognitive functions (communication, social cognition and attention-executive factors). Beauchamp and Anderson (2010) suggest that the model can be applied to a variety of clinical populations, particularly children with TBI. Despite the model's theoretical relevance, it is yet to be operationalised in a clinical population.

CHAPTER 3: Components of the SOCIAL Model Following Childhood TBI

As described in the previous chapter, the SOCIAL model is comprised of various elements in an attempt to explain social functioning. These elements include cognitive abilities and internal/external factors. This chapter aims to summarise how the model can be operationalised in children with TBI. Specifically, it will discuss how TBI affects each of the model's factors in children, will provide evidence on how each of the factors are related to each other and will also summarise evidence which shows how the factors predict children's social functioning following TBI.

3.1 Internal and External Factors Following Childhood TBI

Components identified by the SOCIAL model as being intrinsic to children's development of social functioning include temperament and personality (Beauchamp & Anderson, 2010), which are often neglected by clinicians and researchers when considering social outcomes of TBI. This is concerning considering the influence such factors can have on the quality of one's relationships, community involvement (Ozer & Benet-Martinez, 2006), level of proactive socialisation (Wanberg & Kammeyer-Mueller, 2000) and emotion-processing skills (Rusting, 1998). Researchers have noted that after TBI, children and adolescents often show mood disturbances, such as anxiety and depression. Increased rates of anxiety are commonly reported in children with mild, moderate and severe TBIs, and these difficulties have been shown to still be present, and in some cases worse, at two years post injury (Hawley, 2003). Anxiety-based disorders typically seen include panic disorder, generalised anxiety disorder, post-traumatic stress disorder and obsessive-compulsive disorder (Noggle & Pierson, 2010). In addition to rates of anxiety in children with TBI being significantly higher than age-matched healthy controls, the incidence of depression is significantly higher (Noggle & Pierson, 2010). Depressive symptoms commonly reported by

parents include ineffectiveness and anhedonia, as well as somatic complaints and depressed mood. Furthermore, research suggests that, similar to anxiety, depressive symptomology often becomes progressively worse (Kirkwood et al., 2000).

Research has shown that following TBI, children can exhibit not only mood-based disorders, but also changes in personality. Using the Neuropsychiatric Rating Schedule, a semi-structured interview, Max et al. (2000) showed that in comparison to healthy controls, children with severe TBI are more likely to meet a diagnosis of Personality Change Disorder, a condition that is characterised by a persistent personality disturbance. According to the Diagnostic and Statistical Manual of Mental Disorders- fourth edition (DSM-IV), the five subtypes of personality change disorder, all of which are seen following TBI, consist of labile, aggressive, disinhibited, apathetic and paranoid. Max et al. (2006) found that approximately 13% of children with TBI meet DSM-IV criteria for personality change disorder between 6 and 12 months post-injury, and 12% of children do so during the second year post-injury. Max et al. also noted that injury severity is a significant predictor for meeting diagnostic criteria for personality change disorder. In light of such changes in personality and low mood, it is not surprising that these children also report poorer health-related quality of life (QoL). Researchers have recently investigated the long-term effect on QoL of childhood TBI in a group of adults and shown that those who sustained a severe injury in childhood had lower ratings of QoL than those with a mild or moderate TBI (V. Anderson, Brown, Newitt, & Hoile, 2009). Low levels of perceived independence, younger age at time of injury, a failure to complete high school and psychological problems were shown to be related to lower ratings of QoL (V. Anderson et al., 2009).

In comparison to internal factors, the SOCIAL model's external factors refer to environmental aspects such as SES and family environment. Evidence about the family's response to a child with a head injury has been accumulating in recent years. Parents can find

it challenging to cope with their child's changed physical, cognitive, and emotional abilities, particularly at a time when they are often dealing with their own feelings of guilt, anger, or blame from the event which caused the injury. Compared to children with orthopaedic injuries, parents of children with TBI report higher caregiver burden, more frequent family disagreements, and higher levels of stress and depression (Goldstrohm & Arffa, 2005; Stancin, Wade, Walz, Yeates, & Taylor, 2008). Although parents of children with more severe head injuries often report greater distress, family functioning post-injury is best predicted by psychosocial and premorbid factors (V. Anderson et al., 2006; V. Anderson, Catroppa, Haritou, et al., 2001). Specifically, family dysfunction post-injury is most often seen in families with a history of parental stress, where the child has functional impairment, or if the family is of a lower SES (V. Anderson, Catroppa, Haritou, Morse, & Rosenfeld, 2005).

3.1.1 The Effect of Internal and External Factors on Social Functioning

According to Beauchamp and Anderson (2010), both internal and external factors are important to an individual's social functioning since they shape how, and with whom, they interact. Despite the above evidence that children and adolescence often show mood disturbances and changes in personality post-TBI, these factors are often neglected in research that examines the predictors of social functioning in clinical populations (Beauchamp & Anderson, 2010). There is currently no published research that directly examines the relationship between children's intrinsic factors and social functioning post TBI. However, past research has shown that factors intrinsic to a typically developing child are important for their ability to engage in a social world. Compared to extraverted and open children, individuals who are more shy and anxious have been shown to have poorer social skills, reduced communication, less eye contact and are more likely to sit further away from others. In particular these children are less likely to initiate and engage in social interactions (Cheek & Buss, 1981; Greco & Morris, 2001). Furthermore, the quality of a person's

relationships and their community involvement has been shown to be related to their personality. In particular, social competence is strongly linked to high levels of agreeableness, extraversion, emotional regulation and low levels of neuroticism (Ozer & Benet-Martinez, 2006).

In addition to internal factors, factors external to the child are important to consider following TBI. Factors extrinsic to the child are important for their social functioning since they relate to the nature of the social environment and the quality of parent-child interactions. In a recent longitudinal study involving 109 children with TBI and 80 orthopaedic-injured controls, Yeates et al. (2004) showed that environmental factors play an important role in children's social functioning. Specifically, negative social outcome was shown to be influenced by lower SES, fewer family resources and poorer pre-morbid family functioning. These findings were supported by Yeates, Taylor, Walz, Stancin and Wade (2010), who demonstrated that parenting style, pre-morbid family functioning and pre-morbid quality of the home were influential factors on a child's social functioning following TBI. Furthermore, lower SES and pre-injury adaptive functioning have been shown to negatively influence long-term social functioning, at seven to ten years post injury (F. Muscara, Catroppa, Eren, & Anderson, 2009).

Finally, 'brain development and integrity' factors are included in the SOCIAL model since structural and neural functions are integral to one's social functioning. Social development can be disrupted by a range of neural mechanisms including genetic disorders, infections, trauma, psychiatric conditions and degenerative disorders. Beauchamp and Anderson (2010) discuss three childhood disorders that illustrate the relationship between the biopsychosocial factors: autism spectrum disorder, schizophrenia and TBI, highlighting the impact that atypical neural development has on children's social functioning. As discussed in Section 1.1, TBI typically results in focal damage to the temporal lobe and frontal lobes; two

areas commonly identified as being involved in the social brain network (Beauchamp & Anderson, 2010).

Characteristics related to the TBI, such as injury severity, age at injury, and time since injury, are also important factors to consider in regard to the child's social functioning. In particular, research has consistently shown that injury severity influences the degree of social impairment, where children with more severe injuries are rated as having poorer social functioning (Catroppa et al., 2007; Ganesalingam et al., 2011; F. Muscara et al., 2009). With regard to age of the child and time since injury, researchers have drawn mixed conclusions. Catroppa et al. (2007) found a significant effect of time since injury on children's adaptive functioning, which suggested that children with TBI did not develop the age-expected adaptive functions during the five years post injury. In comparison, Hanten et al. (2008) found that up to 12 months post TBI, children made age-appropriate gains in social information processing skills. The difference between such findings may be attributed to outcome measures; the former assessing adaptive functioning and the latter assessing social information processing. By examining both adaptive and behavioural aspects of social functioning, Yeates et al. (2004) showed that the age at which children sustained a TBI was a significant predictor of their adaptive functioning, but not of their social functioning or level of social problems. Thus in conclusion, it appears that external factors are also important to consider when assessing children's social functioning post TBI.

3.2 Social Cognition Following Childhood TBI

Social cognition is a higher order cognitive function that allows an individual to carry out appropriate social interactions. The processes involved allow an individual to perceive, understand and interpret a range of social cues and stimuli, as well as to plan appropriate responses within a social environment (R. Adolphs, 2001; Beauchamp & Anderson, 2010).

Functioning in a social world requires an individual to be able to quickly process emotional stimuli, make social inferences and take others' perspectives into account (Snodgrass & Knott, 2006; Tonks, Slater, et al., 2009). For these reasons, it has been hypothesised that deficits in social cognition may contribute to poor social functioning following TBI (C. Bornhofen & McDonald, 2008b; Tonks, Williams, Frampton, Yates, & Slater, 2007c). The social cognition component of the SOCIAL model incorporates a range of functions relevant to this domain. The abilities range from more basic skills such as the perception of faces and emotions, to more complex skills that involve understanding others' mental states. This section will discuss both emotion recognition and theory of mind (ToM) skills. In addition to exploring how social cognition predicts social functioning, the SOCIAL model indicates that factors within the model may influence children's social cognition. Thus, the following sections will discuss how brain integrity factors, internal and external variables, as well as communication and attention-executive functions influence social cognition in children post TBI.

3.2.1 Neural Correlates of Social Cognition in Children

Traumatic brain injury typically results in diffuse axonal injury and focal damage to the frontal and temporal lobes. Interestingly, recent findings on individuals with localised brain damage as well as neuro-imaging studies on healthy individuals have shown that similar neural areas play a role in social cognition. Emotion processing typically involves areas of the frontal cortex, the limbic system, and the somatosensory cortex (C. Bornhofen & McDonald, 2008b; Radice-Neumann, Zupan, Babbage, & Willer, 2007). However, the neural areas involved in emotion recognition and ToM skills vary depending on the valence of the emotion presented (Murphy, Nimmo-Smith, & Lawrence, 2003), how the emotion is presented and the cognitive demands of the task (Herba & Phillips, 2004). Although the details are beyond the scope of this thesis, a heuristic explaining the multifaceted system and

intertwining relationship between each of these neural areas was developed by Tonks et al. (2007c). The heuristic was developed for use with TBI patients, and highlights the interdependent role of the frontal lobes, subcortical structures, and right hemisphere in the processing of emotions.

Although an abundance of research exists exploring the neural correlates of social cognition in adults (e.g., Geraci, Surian, Ferraro, & Cantagallo, 2010; Herba & Phillips, 2004; Phan, Wager, Taylor, & Liberzon, 2002; Stuss & Levine, 2002), only a handful of studies have been conducted with children (Brink et al., 2011). As a child's brain is continually growing and developing, neurological conclusions from adult research are not always easily transferable to children (Tonks et al., 2007c). This is particularly true given the importance of the prefrontal cortex in social cognition in adults (Herba & Phillips, 2004; Stuss & Anderson, 2004), and the fact that the orbitofrontal cortex is the last to mature in ontogeny, often during early adulthood (Barbey, Krueger, & Grafman, 2009). Furthermore, as recognised by Perna (2002), children with a brain injury may have received damage to an area that is not yet fully developed, and thus the full effects of the injury may not always be immediately noticeable. Thus, in addition to severity of injury, the age of the child at the time of the injury is an important factor to consider when assessing social cognition.

Although few studies have explored the neuroanatomical areas involved in social cognition, the existing findings have consistently highlighted the role of the frontal lobes. In a sample of 59 children with TBI, Dennis, Barnes, Wilkinson, and Humphreys (1998) showed that those with frontal lobe contusions were more likely to have difficulty detecting real and deceptive emotions from a short narrative, than those without such a contusion. Couper, Jacobs and Anderson (2002) and Snodgrass and Knott (2006) supported these findings, showing that children's performance on ToM tasks, involving an understanding of moral reasoning and deception, respectively, are negatively affected by frontal lobe lesions. To

investigate this further, Brink et al. (2011) used functional near-infrared spectroscopy (fNIRS) to assess which neural areas were activated during engagement of affective and cognitive based empathic activities in typically developing children aged 4 to 8 years. The results indicated that the medial and bilateral orbitofrontal cortex is used when processing both cognitive and affective empathy. These findings are consistent with those from research on adults, in which the frontal lobes have been shown to be integral to emotion recognition skills (R. Adolphs, Tranel, & Damasio, 2003; Murphy et al., 2003; Phan et al., 2002) and ToM (R. Adolphs, 2001; Channon et al., 2007; Gallagher et al., 2000; Geraci et al., 2010; Stuss & Levine, 2002).

In addition to confirming the importance of the frontal lobes, adult research has highlighted the role of other neural areas for the processing of emotion-laden stimuli. The limbic system includes a variety of structures, such as the hippocampus and amygdala, which are mainly located subcortically in the medial and ventral regions of the cerebral hemispheres. The amygdala is a group of nuclei situated in the anteromedial temporal lobe and it plays a central role in both emotions and drive (Blumenfeld, 2010; Yip, Leung, Li, & Lee, 2004). The amygdala's role involves linking perceptual representations of emotional-laden stimuli to cognition and behaviour, and in particular it has been recognised as being responsible for detecting threats and processing fear (R. Adolphs, 2001; R. Adolphs et al., 2005). Furthermore, the right hemisphere has been shown to be important for emotion recognition skills (R. Adolphs, 2001; Kucharska-Pietura, Phillips, Gernand, & David, 2003).

3.2.2 Emotion Recognition Skills Following TBI.

Recognition of emotions can occur through a number of different sensory domains. For example, semantic information and prosody are processed through the auditory channel, whereas cues such as body posture and facial expressions are processed through the visual

channel. As such, assessment tools used to assess a child's ability to recognise emotions include identifying, naming, discriminating between, and matching both facial expressions and vocal prosody (Tonks, Williams, Frampton, Yates, & Slater, 2007a). Johnson et al. (2011) found a significant difference between younger (5- to 8- year-olds) and older (8- to 15- year-olds) children's ability to complete facial emotion discrimination tasks, after controlling for task difficulty and general developmental improvements. This evidence supports the idea that there is a change in emotion recognition skills during the pre-teen years. Johnson et al. suggest that unlike their younger counterparts, older children rely on new methods to process expressions, such as interpreting emotional information from a character's eyes. Social cognition in typically developing school-aged children is influenced by various factors. For example, research has shown that sex, SES and verbal ability are important for social adjustment. Specifically, females, children from a higher SES as well as those who have stronger verbal skills are more likely than their counterparts to recognise emotions accurately (Herba & Phillips, 2004; Lepannen & Heitanen, 2001).

Research investigating emotion recognition abilities in individuals with TBI has become increasingly popular during the last decade. However, despite the array of research exploring emotion recognition skills in adults with TBI (Dimoska, McDonald, Pell, Tate, & James, 2010; Ietswaart, Milders, Crawford, Currie, & Scott, 2007; Knox & Douglas, 2009; Milders et al., 2008), only a handful of studies have explored emotion recognition skills in children with TBI. The majority of studies exploring this deficit have conveyed emotions through facial expressions and/or vocal prosody, by comparing performance with that of healthy controls. Pettersen (1991) conducted an exploratory investigation, comparing a paediatric TBI sample with an orthopaedic-injured control group, to study the relationship between children's sensitivity to emotional cues and social functioning. Using three emotion recognition tasks, which involved presentation of visual line drawings, verbal vignettes and

facial expressions, Pettersen showed that the head-injured group was significantly impaired on a global index of emotion interpretation. Furthermore, head-injured children who were impaired at recognising facial expressions were also more likely to be rated by their parents as displaying less socially appropriate behaviour (e.g., not apologising for hurting someone else's feelings).

Tonks et al. (2007b) extended these findings by investigating the effect of prosody, rather than just content in a verbal story, on children's ability to recognise emotion. Eighteen children, aged between 9 and 17 years, with acquired brain injuries (ABI; including patients with TBI, stroke, meningococcal and meningitis) were compared to 67 healthy controls on emotion recognition tasks involving recognition of facial expressions and vocal prosody. Compared to the controls, children with an ABI had significant difficulty reading emotions from both faces and voices. Similar to previous findings in adults (Dimoska et al., 2010), brain-injured children's poor performance on the prosody task was attributed to their reliance on the semantic content rather than the vocal tone. It is also important to note that Milders, Fuch and Crawford (2003) showed that in adults with TBI, a difficulty at recognising emotions in faces and voices is a true reflection of poor emotion recognition skills and not a result of poor performance on face recognition or non-emotional prosody tasks. This finding has since been replicated in children with TBI (Schmidt, Hanten, Xiaoqi, Orsten, & Levin, 2010).

To further explore emotion recognition abilities in a paediatric TBI sample, Tonks et al. (2008) described a case series of seven children with an ABI (six of whom had a moderate or severe TBI) who were identified as being at medium or high risk of developing significant emotional, behavioural or concentration problems. The results were compared to age-matched control data, and indicated that children with an ABI were impaired at selecting and matching facial emotional expressions. Furthermore, when compared to mean scores,

individual ABI cases were shown to be impaired at discriminating and naming facial expressions of emotions. Although no significant group differences were found on the prosody tasks, individual cases of ABI were impaired on the tasks that required children to verbally label an affective prosody, and to identify an emotional tone that was used in a semantically conflicting statement (e.g., “all the puppies are dead” said in a happy tone). It is important to note, however, that this study used a very small sample size and did not consider effects such as time since injury and age at injury. Thus, the authors recommend that the emotion recognition skills of brain-injured children be investigated further.

3.2.2.1 Factors Influencing Impaired Emotion Recognition.

Internal and external factors are important to consider when investigating mediators of poor social cognition. Injury severity and SES have been shown to have a strong influence on an individual’s social cognitive abilities (J. Henry, Phillips, Crawford, Ietswaart, & Summers, 2006; Herba & Phillips, 2004). That is, individuals with a lower SES and more severe TBI are more likely to have difficulty recognising and interpreting another’s emotions than those of a higher SES with a less severe injury (Ietswaart et al., 2007; Tonks et al., 2007b). Schmidt et al. (2010) extended these findings to show that compared to orthopaedic-injured controls, children with TBI make the most improvements in emotion recognition skills during the first 12 months post injury. In particular, children with a higher SES made the quickest recovery over time. In addition, females who sustained their injury at a younger age were more likely than older children and males to make the quickest recovery gains. However, Schmidt et al. note that younger children (6-year-olds) may make the quickest recovery since they are still acquiring the skill, unlike their 17-year-old counterparts. Despite the evidence that exists about external factors, there is a lack of research exploring the relationship between children’s social cognition and intrinsic factors post TBI, and future research needs to explore this relationship.

As summarised in Section 3.3, EF is commonly impaired post TBI (Chevignard, Catroppa, Galvin, & Anderson, 2010; Nadebaum, Anderson, & Catroppa, 2007), and some researchers contend that executive dysfunction mediates poor social cognition post TBI. It has been suggested that this mediation may be due to the overlap of basic skills, such as attention and working memory, and the shared involvement of the frontal lobe (Bibby & McDonald, 2005; C. Bornhofen & McDonald, 2008b; Snodgrass & Knott, 2006). Studies exploring the relationship between emotion recognition and EF post TBI have generally relied upon measures of cognitive flexibility as an indicator of EF. Using the Brixton Spatial Anticipatory Task and the Alternating Fluency Test as measures of cognitive flexibility, Ietswaart et al. (2007) and Milders et al. (2008) showed that EF is positively related to emotion recognition skills in adults with TBI. This relationship was significant for recognising emotions from both faces and prosody, and was present both immediately and 12 months post injury. Furthermore, emotion recognition skills have been shown to be significantly and positively related to measures of attention (Ietswaart et al., 2007) and verbal fluency (J. Henry et al., 2006) in adults with TBI.

A causal relationship between EF, social behaviour and emotional recognition was explored by Tonks et al. (2007b) using a sample of children with an ABI. These authors administered a variety of neuropsychological tests, including measures of verbal fluency, planning, cognitive flexibility, attention, working memory and visuospatial ability. In regard to supporting a predictive relationship, however, the findings were slim, showing significant regressions for only two cognitive measures. Specifically, cognitive flexibility and visuospatial discrimination skills significantly predicted emotion-processing skills. Furthermore, facial affect recognition skills were shown to predict socio-emotional behaviour disturbances. There were non-significant relationships between emotion-processing skills and the remaining neuropsychological measures. It is likely that these minimal results were

limited by a small sample size and a poorly matched control group. As this is the only known study to investigate the predictive relationship between EF and emotion recognition in a paediatric TBI sample, future research needs to further explore the effect cognition has on children's emotional understanding.

3.2.3 Theory of Mind (ToM) Skills Following TBI.

Social cognition refers to functions that enable appropriate social interaction and thus requires a child to be able to interpret other people's feelings and thoughts. Theory of mind (ToM) is a conceptual system that refers to one's ability to think about another person's mental states, such as their thoughts, beliefs, intentions and desires, and to subsequently understand and predict their behaviour (Bibby & McDonald, 2005; Perner & Lang, 2000). A variety of tests have been developed to assess ToM in children, which include use of verbal stories, visual cartoons and combinations of the two. First-order ToM tasks require children to be able to distinguish expectations from reality. For example, in the 'false contents' task, a child is initially shown a Smarties box that contains pencils, not Smarties. The child is then asked what another person would think is in the Smarties box. In typically developing children, first-order ToM tasks are mastered during the pre-school years, as by four and five years of age children are able to demonstrate an understanding of false belief in other people (Baron-Cohen, Leslie, & Frith, 1985, 1986). Second-order ToM tasks are described as being more complex than first-order tasks, since an individual does not only have to infer the thoughts of another person, as in a first-order task, but they also involve reasoning about what one person thinks about another person's thoughts (Baron-Cohen, Jolliffe, Mortimore, & Robertson, 1997). Thus, second-order ToM tasks often assess a child's ability to understand deception, humour, and social faux pas, which are typically mastered by the age of seven years through to adolescence (Walz, Yeates, Taylor, & Stancin, 2010).

Theory of mind is a complex developmental milestone, and competency is achieved across various time points in childhood. The false belief paradigm task is arguably the most widely used task in research (Wellman, Cross, & Watson, 2001), and to master this task children need to demonstrate an understanding that others can have beliefs that differ to their own. It is generally accepted that four- and five-year-olds are competent at this task, whilst three-year-olds are not (Baron-Cohen et al., 1985, 1986). A meta-analysis on typically developing children's understanding of false belief revealed that in the pre-school years, children exhibit genuine conceptual change in their understanding of belief and the mind (Wellman et al., 2001). Between 8 and 12 months, children demonstrate the ability to infer another's intentions by grasping at objects that others look at (Spelke, Phillips, & Woodward, 1995). By 18 months, children are able to imitate the intention behind failed action attempts (Meltzoff, 1995) and also understand differences in food preferences (Repacholi & Gopnik, 1997). After 18 months, children's understanding of the mind significantly improves as they are able to engage in pretence (Leslie, 1987), provide comfort when another is distressed (Bischof-Kohler, 1991) and understand goals they have yet to achieve (Kagan, 1981). At approximately 4 years of age, children demonstrate an understanding that information can be misrepresented and that others can believe something false to be true (Flavell, Flavell, & Green, 1983; Perner, Leekam, & Wimmer, 1987; Wimmer & Perner, 1983). Further developmental changes occur at 11 years of age (Tonks et al., 2007a), when significant improvements are seen in these older children's ability to infer mental states of others. By adulthood, ToM has developed to a point that allows individuals to interpret complex social situations, such as faux pas and deception (Stuss, Gallup, & Alexander, 2001).

In children, ToM is an important skill for social functioning (Tonks et al., 2007b; Walz, Yeates, Taylor, Stancin, & Wade, 2009) and impairments in ToM have been correlated with poor social functioning in a range of childhood clinical groups (see Sprung, 2010),

including autism spectrum disorders (Baron-Cohen, 2000) schizophrenia (Doody, Gotz, Johnstone, Frith, & Cunningham Owens, 1998), attention disorders (Fahie & Symons, 2003) and behaviour disorders (Hughes, Dunn, & White, 1998). In light of the difficulties seen in these cohorts, researchers have recently begun to explore ToM abilities in children with TBI.

Several studies have investigated children's ability to complete first-order ToM tasks following TBI. Turkstra, Dixon, and Baker (2004) and Snodgrass and Knot (2006) found that compared to controls, children with TBI were not impaired at first-order ToM tasks. However, it is important to note that both of these studies included a small sample of children who were assessed at an age when first-order ToM has already been mastered, that is, older than six years. As a result, any potential effects of the head injury on the child's socio-cognitive skills may have not been detected. For this reason, more recent studies have limited the sample of children with TBI to younger cohorts (Walz et al., 2010; Walz et al., 2009). Walz et al. (2009) compared 59 children with TBI to 86 orthopaedic injured controls, aged three to five years, on a series of first-order ToM tasks. The results suggested that the post-acute effects of TBI significantly impacted on children's ability to complete appearance-reality tasks. Furthermore, this deficit was worse for children with a severe TBI than those with a moderate TBI. Walz et al. (2010) extended these findings, showing that young children with severe TBI continue to have difficulty with first-order ToM tasks for 12 months post injury.

In addition to first-order ToM tasks, children with TBI have been shown to have difficulty successfully completing second-order ToM tasks. The production and understanding of deception is relevant to one's understanding of the mind, since it requires the ability to understand that someone else can believe something to be true when it is actually false. In comparison to healthy controls, children with TBI have been shown to be impaired at understanding deception (Dennis et al., 1998; Dennis, Purvis, et al., 2001; H.

Levin & Hanten, 2005). This impairment is true for tasks that require the identification of deceptive emotions (Dennis et al., 1998) as well as of deceptive praise and ironic criticism (Dennis, Purvis, et al., 2001). An understanding of higher-order social communication skills such as sarcasm, deception, irony and humour requires the ability to make inferences and/or attributions about another person's mental state and thus entails the use of ToM skills (Stuss et al., 2001). Similar to findings on adults with TBI (Channon et al., 2007; S. McDonald & Flanagan, 2004; Milders et al., 2008), researchers have shown that children with TBI have difficulty accurately completing tasks that require an understanding of sarcasm and humour (Turkstra et al., 2004; Turkstra, McDonald, & Depompei, 2001), and the production of mature responses to sociomoral dilemmas (Couper et al., 2002; Dooley, Beauchamp, & Anderson, 2010). Furthermore, a test that requires the determination of others' mental states, by looking at their eyes, has been used as a valid measure of ToM (Sprung, 2010). This test requires the participant to be able to put him or herself in the mind of another person and detect how they are feeling. Similar to adults with TBI (Geraci et al., 2010; Havet-Thomassin, Allain, Etcharry-Bouyx, & Le Gall, 2006; J. Henry et al., 2006), children with TBI have difficulty determining another's mental state by looking at their eyes (Tonks et al., 2007b; Tonks et al., 2008). Thus, in summary it appears that children with TBI have significant difficulty understanding others' mental states, desires and beliefs, and this is evident across a range of ToM tasks.

3.2.3.1 Factors Influencing Impaired ToM.

The nature of the TBI has been shown to have a significant effect on children's ability to successfully complete ToM tasks. Children with more severe injuries are less able to detect real and deceptive emotions (Dennis et al., 1998), have a lower understanding of false belief (Walz et al., 2009), and produce less mature responses to socio-moral dilemmas (Dooley et al., 2010). The type of injury incurred has also been shown to influence ToM. Dennis et al.

(1998) showed that children who sustained bilateral frontal contusions performed more poorly than those with hemisphere specific contusions on a task that required them to be able to understand and display particular emotions.

3.2.3.1.1 Language skills and ToM.

Literature on the development of ToM is rife with discussion on the potential effect language has on ToM skills (Milligan, Astington, & Dack, 2007). Significant relations between ToM and language skills have been demonstrated not only in typically developing children (Astington & Jenkins, 1999; Ruffman, Slade, Rowlandson, Rumsey, & Garnham, 2003), but in a variety of clinical populations, including children with autism, specific language impairments and deafness (de Villiers, 2005; Miller, 2001; Tager-Flusberg & Joseph, 2005; Woolfe, Want, & Siegal, 2002). In particular, a relationship between ToM and pragmatic language is suggested since both are social aspects of communication and require the inference of another's thoughts and/or speech (Martin & McDonald, 2003). It is important to note here that Vygotskian theory has provided an important contribution in this regard since ToM and language provide mutual reinforcement to each other (Frawley, 1997). Thus given that TBI effects language acquisition (V. Anderson et al., 1997), it is logical that acquisition of ToM will also be affected. Happe (1993) demonstrated that adolescents and young adults with autism who failed ToM tasks were able to comprehend similes but not metaphors or irony. Although similes can be interpreted literally, Happe contended that understanding metaphors and irony requires people to be able to understand the true meaning of speech and/or the speaker's intentions, and thus involves a pragmatic element. Winner, Brownell, Happe, Blum, and Pincus (1998) assessed individuals with right hemisphere damage and a non-injured control group on both first- and second-order ToM tasks as well as discourse tasks that required an understanding of ironic jokes and lies. Individuals with brain damage performed significantly more poorly than controls on the second-order ToM task,

and furthermore this impairment was predicted by high error scores on the discourse task. Despite the evidence for a significant association between ToM and pragmatic ability in autism and patients with right hemisphere damage, these studies are correlational in nature and therefore the direction of this relationship is unclear (Martin & McDonald, 2003).

With regard to children with TBI, there is a lack of research examining the relationship between pragmatic language and ToM (Martin & McDonald, 2003). Bibby and McDonald (2005) investigated this relationship by assessing children with severe TBI on both verbal and non-verbal ToM tasks. Although children's language skills were not explicitly measured, the authors concluded that the language demands of the questions were significantly related to children's performance on the ToM tasks. That is, children performed better on the false belief question when the ToM questions were asked more explicitly (e.g., 'what was Larry thinking about the can?' when milk, which he does not like, had been put into his Coke can, unbeknown to him) as opposed to a general question that implicitly requires an inference to be made about a character's mental state (e.g., 'what did Larry drink from the can?'). Although this study indicates that language influences ToM, there was no explicit measure of language ability. Therefore, future research on children with TBI should explore this relationship in more detail using valid measures of language ability.

3.2.3.1.2 Executive Functions and ToM.

The relationship between ToM and cognitive ability is a contentious issue in the neuropsychological literature (Dennis, Agostino, Roncadin, & Levin, 2009; Rowe, Bullock, Polkey, & Morris, 2001). Some researchers claim that ToM and executive abilities are independent (Havet-Thomassin et al., 2006; Rowe et al., 2001), while others claim that ToM and EF are related, since the two are developmentally dependent on each other (Perner & Lang, 2000) and share neural connections (Tonks et al., 2007c). Evidence for both sides of

the debate has been explored in not only typically developing children (Wellman et al., 2001), but also in clinical populations such as children with autism (Leslie & Thaiss, 1992). Research investigating the role of EF on ToM in adults with TBI has yielded implications that are similar to studies from other clinical populations; that further evidence is needed to have a solid understanding of the link between ToM and EF (Geraci et al., 2010; Rowe et al., 2001). Although deficits were seen in adults with TBI across both cognitive domains, Milders et al. (2003) and Havet-Thomassin et al. (2006) showed that ToM was not related to measures of cognitive flexibility, planning and inhibition. In contrast, positive correlations between ToM and EF (verbal fluency and cognitive flexibility) were supported by Henry et al. (2006) and Milders et al. (2008). The reason for such differences between studies is often attributed to the inherent difficulty of measuring a broad concept such as EF (Milders et al., 2008) as well as the diffuse nature of TBI (Geraci et al., 2010; J. Henry et al., 2006).

Only a handful of studies of children with TBI have investigated the relationship between EF and ToM. Tonks et al. (2007b) asked children with an ABI, aged between 9 and 17 years, to complete the 'Mind in the Eyes' test, along with a battery of general cognitive tests assessing verbal fluency, processing speed, planning, inhibition, switching, working memory and visuospatial skills. It was found that children with TBI were worse than controls at reading emotions, but a regression analysis revealed that cognitive skill was not a predictor of ToM. The relatively small sample size of 18 head-injured children means that these findings should be interpreted with caution. However, similar findings were reported in a study by Snodgrass and Knot (2006) who also found that there was no link between ToM and cognitive skill in children with frontal lobe damage. Nevertheless, there may be some interaction with other factors, as Bibby and McDonald (2005) found that children with severe TBI who performed poorly on a measure of working memory also had difficulty completing verbal and non-verbal false belief tasks.

The majority of research exploring the relationship between ToM and EF has relied on correlations, and only one study to date has reliably investigated the predictive nature of this relationship in children with TBI. Dennis et al. (2009) assessed 43 school-aged children with TBI on a range of tasks: working memory, inhibition (cognitive and restraint) and ToM. The ToM measure used in this study required children to formulate a speech act which met the needs of a character in a story, who had a false belief. The study's results provided support for the notion that EF is causally related to ToM. Specifically, a path analysis showed that working memory mediates the relationship between cognitive inhibition (which allows an individual to maintain two rules, where one is operative while the other is inhibited) and ToM. Interestingly however, the authors found that restraint inhibition (the type of inhibitory control that involves stopping an action in progress) was not related to children's ToM performance. Thus, the findings of this study support the conclusion of many researchers; that some, but not all, aspects of ToM performance are a result of executive dysfunction (Geraci et al., 2010). Further investigation is clearly needed on the predictive relationship between EF and social cognition in children post-TBI, with a broader range of both EF and ToM measures.

3.2.4 The Effect of Social Cognition on Social Functioning

As described above, social cognition refers to the “mental processes that are used to perceive and process social cues, stimuli and environments” (Beauchamp & Anderson, 2010, p. 40). This definition clearly highlights how social cognition is relevant to social functioning, as the former requires the understanding, interpretation and processing of social interactions. A link between social cognition and social functioning has been empirically supported. Evidence has shown that the information gained from facial expressions significantly relates to personal relationships and social actions in healthy adults (Vuilleumier & Pourtois, 2007), and ToM skills have been shown to predict the social behaviours of

healthy children (Jenkins, Astington, & Wilde, 2000). Furthermore, ToM has been shown to be important for interacting in a social world. Negative social consequences are often seen in individuals who exhibit deficits in ToM, which are typically reported in individuals with autism (U. Frith & Frith, 2003; Hill & Frith, 2003; Sabbagh, 2004) and schizophrenia (Brune, 2005b; Harrington, Siegert, & McClure, 2005). Although research on children with TBI shows similar results, the number of studies demonstrating this is limited. Hanten et al. (2008) assessed 103 children with moderate to severe TBI and showed that children's emotion processing skills, namely emotional prosody recognition, were weakly associated with their social information processing skills. Surprisingly, correlations between recognising emotion in facial expressions and social information processing were non-significant. In addition, Pettersen (1991) showed that children with TBI who have difficulty recognising emotions in faces were also rated by their parents as exhibiting less socially appropriate behaviours. For example, a child might be less likely to respond to an indirect cue or apologise when they hurt someone's feelings. Similar links between social cognition and poor social behaviour have been shown in adult TBI studies, in which correlations between lower ratings of social integration and poor emotion recognition skills are demonstrated (Knox & Douglas, 2009). Importantly, research exploring the relationships between social cognition and social functioning has tended to focus on children's emotion recognition abilities, and there is little work exploring the specific relationship between ToM and social functioning post TBI. Milders et al. (2008) investigated the relationship between adults' performance on both ToM and emotion recognition tasks and their social behaviour. Although patients with TBI exhibited deficits on these measures compared to patients with orthopaedic injury, there was no significant relationship between the measures of social cognition and social behaviour. The authors concluded, that similar to the relationship between EF and social functioning (described below), the relationship between social cognition and social

functioning is ambiguous due to the broad range of measures used to assess different facets of each domain. This is the only known study to investigate the relationship between ToM and social functioning post TBI, and thus more research is clearly needed, particularly in children.

3.3 Attention and Executive Functioning Following Childhood TBI

Executive functioning (EF) is an umbrella term used to describe a range of skills that are required to complete goal-directed behaviour. Executive functions are important for a child's cognitive functioning, behaviour, emotional control and social interaction (P. Anderson, 2002; 2001). A wide range of higher-order skills are classed as EFs, which include, but are not limited to, attention (selective, sustained, focused, and divided), cognitive flexibility, working memory, planning, initiation, inhibition and self-regulation (P. Anderson, 2002). The concept of EF has traditionally been viewed to be controlled by a single construct, the central executive (Baddeley, 1996), but recent alternative conceptualisations of EF have been proposed which offer a multi-model conceptualisation (P. Anderson, 2002). The model proposed by Anderson (2002) has four inter-dependent components: attentional control (the ability to focus one's attention and selectively attend to stimuli), information processing (the speed with which one can process information), cognitive flexibility (includes working memory, the ability to divide one's attention between multiple tasks and shift between response sets) and goal setting (the ability to plan and problem solve). These four components were discussed by Beauchamp and Anderson (2010) to be important for the Attention-Executive component of the SOCIAL model since such skills are fundamental to children's social functioning.

There is now compelling evidence that EF emerges during infancy and continues to develop throughout childhood and early adulthood (V. Anderson, Anderson, et al., 2001; Korkman, Kemp, & Kirk, 2001). Although rapid changes in EF in typically developing

children occur during middle childhood, between the ages of 5 and 8 years (Korkman et al., 2001), it is important to note that each type of EF progresses according to individual developmental trajectories and that EF skills are very heterogeneous (P. Anderson, 2002). As summarised by Catroppa and Anderson (2009), research suggests that attentional-control develops during early and middle childhood. Before the age of 7 years, children's selective attention abilities fully mature and then remain relatively stable. In comparison, shifting attention has been shown to develop rapidly between 7 and 9 years of age, whereas sustained attention skills develop during adolescence (Betts, McKay, Maruff, & Anderson, 2006; McKay, Halperin, Shwartz, & Sharma, 1994). Information processing skills are also beginning to develop early in life, with improvements observed between 3 and 5 years of age (Espy, 1997; Welsh, Pennington, & Groisser, 1991). The speed with which information can be processed continues to mature throughout middle childhood and significant gains are again seen between 9 and 12 years (Kail, 1986). The development of information processing begins to plateau at approximately 15 years of age (Hale, 1990; Kail, 1986). Furthermore, cognitive flexibility has been shown to emerge at approximately 3 to 4 years of age (Espy, 1997), and by 7 to 9 years children are able to switch between multiple dimensions. This skill continues to develop through middle childhood into adolescence (P. Anderson, Anderson, Northam, & Taylor, 2000). Similarly, goal setting and planning skills develop through middle childhood. Children aged 4 years are able to generate new simple concepts (Welsh et al., 1991); however, planning and organisation skills develop later, between 7 and 10 years of age (P. Anderson, Anderson, & Lajoie, 1996; Krikorian & Bartok, 1998) and then development plateaus during adolescence and early adulthood (V. Anderson, Anderson, et al., 2001). In summary, these findings are synonymous with the idea that EF is not controlled by a central executive, but is conceptualised as a multi-modal system containing separate inter-related components.

Although EF has been shown to be an integral part of typical cognitive development, the assessment of EF is problematic in children. The need to assess a child's ability to perform a novel task is difficult when what is novel for one child is not necessarily novel for another, and the fact that in today's modern society novel tasks quickly become common and less original (P. Anderson, 2002). Furthermore, the multifactorial nature of EF poses problems. Specifically, performance-based tests used to assess EF also require lower-order skills such as fine motor skills and visual perception, and thus children's results may be confounded by other deficits. Furthermore, the tests often assess multiple types of EF, such as processing speed and attention making it difficult to determine which EF is truly being evaluated (V. Anderson, Anderson, et al., 2001; Gioia & Isquith, 2004). Subsequently, many researchers have highlighted the need for ecologically valid tasks (Gioia & Isquith, 2004) and thus it is recommended that measures which assess EF skills in everyday life, such as the Behaviour Rating Inventory of Executive Function (BRIEF), are used in conjunction with performance-based measures (Gioia & Isquith, 2004; Vriezen & Pigott, 2002).

3.3.1 Neural Correlates of Executive Functioning in Children

As highlighted in the previous chapters, TBI typically results in diffuse axonal injury and focal damage to the frontal and temporal lobes. Importantly, attention and EF rely on similar neural areas, which is possibly why deficits in these cognitive domains are evident following TBI (B. McDonald, Flashman, & Saykin, 2002). The following section provides a brief summary of the neural areas involved in children's attention and EF.

In general, the frontal lobes are thought to mediate EF. This conclusion is based on studies involving participants with frontal lobe damage who exhibit executive dysfunction (Gratton & Eslinger, 1991) as well as functional neuroimaging studies that show significant activation of the prefrontal cortex when participants engage in various EF tasks (B. Casey,

Giedd, & Thomas, 2000; Rezai et al., 1993). Levin et al. (1994) used the 'Tower of London', a task that measures children's planning and problem-solving skills, to assess the abilities of children who had sustained a closed head injury. The results of the study indicate that the volume of the child's frontal lobe lesion contributed to their performance on the task. Specifically, children who presented with greater orbital, dorsolateral and white matter lesions were more likely to break a greater number of rules and solve fewer problems. In contrast, the size of children's non-frontal lesions was not related to their performance on the task. The involvement of the dorsolateral prefrontal cortex in planning tasks was supported by Cabeza and Nyberg's (2000) empirical review of 275 neuroimaging studies. Involvement of the frontal lobes has been also highlighted for other specific EFs. Specifically, inhibition has been shown to involve the dorsolateral prefrontal cortex and orbitofrontal cortex (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002; B. Casey et al., 1997), while tasks requiring decision making have been shown to activate the orbitofrontal cortex (Rolls, 2004).

Although anterior brain regions are thought to mediate EF, it is important to note that executive deficits are not specific to frontal pathology. That is, executive dysfunction can occur as a result of disruption to numerous neural connections that link the prefrontal cortex with other cerebral regions (Eslinger & Gratton, 1993; Jacobs & Anderson, 2003). A complex bi-directional neural network exists within the brain, connecting the prefrontal cortex with other cortical and subcortical brain regions, including the occipital, temporal and parietal lobes and the limbic region (Denckla & Reiss, 1997; Stuss & Benson, 1986). For example, the cortico-subcortical circuit connects the prefrontal cortex with the basal ganglia and cerebellum via the thalamus, and thus damage to any section of this neural pathway can result in impaired EF (Heyder, Suchan, & Daum, 2004). As a result, Jacobs, Harvey and Anderson (2011) claim that focal lesions to any brain region during development may result in impaired EF. For example, impaired attention has been associated with damage to the superior

temporal cortex, inferior parietal cortex as well as aspects of the corpus striatum (Mirsky, Anthony, Duncan, Ahearn, & Kellam, 1991).

3.3.2 Executive Function Skills Following Paediatric TBI

3.3.2.1 Attention

Complaints of poor attention are common following TBI (Azouvi et al., 2004; Catroppa et al., 2007; Dennis, Guger, Roncadin, Barnes, & Schachar, 2001; Park, Allen, Barney, & Ringdahl, 2009). Since attention is required for many daily skills, it is suggested that deficits in attention may have a negative effect on children's academic, social and psychological functioning (Park et al., 2009). Contemporary models of attention view the concept as containing several interrelated components: sustained attention (the ability to maintain arousal over time and stay focused), selective attention (the ability to attend to target stimuli whilst ignoring irrelevant stimuli), and shifting attention (the ability to divide attention between multiple stimuli as well as alter attention from one stimuli to another) (Catroppa & Anderson, 2005; Catroppa et al., 2007).

Although the literature is rich with information on attention deficits in adults post TBI (Kwok, Lee, Leung, & Poon, 2008; Mateer & Mapou, 1996; Mathias & Wheaton, 2007), research exploring such deficits in children post TBI has only begun to emerge. Fenwick and Anderson (1999) showed that children with a moderate or severe TBI exhibited significant deficits between 8 and 14 years on measures of sustained attention. In comparison, Anderson et al. (2005) found that children who sustained a TBI between the ages of 2 and 7 years did not exhibit deficits in sustained attention, but did on measures of selective attention. Given the array of inconsistent findings, often attributed to the broad range of assessment measures and the varied developmental trajectory for each type of attention, a recent confirmatory factor analysis was conducted. The results of this analysis showed that all areas of attention

(shifting, focused, encoding and sustained) are sensitive to TBI during childhood (Park et al., 2009). Furthermore, the types of attention affected were shown to depend not only on the specific cerebral region impacted during the injury, but also the age of the child at the time of the injury (V. Anderson, Catroppa, Morse, et al., 2005; Catroppa & Anderson, 2005; Catroppa et al., 2007; Fenwick & Anderson, 1999). Not only are attention deficits seen soon after the injury, but evidence suggests that attention deficits are pervasive and unrelenting (Catroppa et al., 2007).

3.3.2.2 Processing Speed

Although processing speed is often linked to attention (Catroppa & Anderson, 2005; Park et al., 2009), Anderson's (2002) model of EF separates the two concepts in light of various factor analytical studies (Alexander & Stuss, 2000; H. Levin et al., 1991). A slowing of information processing has been shown to have a negative effect on social functioning following TBI (Rassovsky et al., 2006) and in adults with schizophrenia (Jabben et al., 2008). Since slowed cognitive processing can have a general negative effect on the ability to engage in social situations (e.g., to be able to follow a rapidly evolving conversation) it has been suggested that a link may also exist between processing speed and social functioning in children with TBI (Beauchamp & Anderson, 2010).

Using a task that required children to respond quickly to a series of letters that flashed on a computer screen, Anderson et al. (2005) showed that pre-schoolers with severe TBI had a slower processing speed than children with a mild or moderate injury. A slow processing speed in children with TBI has also been shown using subtests from the Wechsler Intelligence Scale for Children-Third Edition (Wechsler, 2003) that require children to match coded symbols or search for the presence/absence of target symbols within a small array of mixed symbols (Calhoun & Dickerson-Mayes, 2005). Prigatano, Gray, and Gale (2008)

assessed 65 children with TBI, and showed that, compared to healthy peers and those who experienced trauma, children with TBI were more likely to have difficulty performing well on a processing speed task than on verbal comprehension or visuospatial reasoning tasks. Also, slow processing speed is not only present during the acute stages of TBI recovery, but has been shown to be a long-term deficit (Catroppa et al., 2007).

3.3.2.3 Planning and Problem Solving

Planning and problem-solving are higher order EFs that require the ability not only to plan actions in advance but to also develop new initiatives and concepts (P. Anderson, 2002). Difficulty in setting goals, planning, initiating actions, solving problems and disorganisation is likely to have negative effects on one's friendships and work relationships, and thus subsequently impact on one's social functioning (H. Levin et al., 1997). Levin et al. showed that the planning and concept formation skills of children with closed head injury were significant predictors of adaptive functioning skills, accounting for nearly 19% of the overall variance.

Research measuring children's ability to plan and problem solve has generally relied on the Tower of London task (Shallice, 1982), or variants of it such as the 'Tower' subtest of the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). This task requires children to rearrange beads on vertical rods with the aim of matching a model that was presented by the examiner. A successful solution requires children to plan the sequence of moves without breaking the rules and to evaluate the outcome of each move in regard to achieving the final goal. Compared to controls, children with TBI have significant difficulty completing the Tower tests (Chevignard et al., 2010; H. Levin et al., 1994; H. Levin et al., 1996; H. Levin et al., 1997; Slomine et al., 2002). Furthermore, children's performance on these tasks has been shown to be affected by age at the time of the injury and

the severity of the TBI. Specifically, children who were younger at the time of injury and those with a more severe TBI solved fewer problems, required longer planning time and had greater difficulty monitoring their actions (H. Levin et al., 1994; Slomine et al., 2002). The influence of a child's age at the time of injury has led many researchers to conclude that a head injury sustained during a period of skill development, or when a particular skill is emerging, results in disruption to or a deficit in that particular skill. In comparison, skills that are already attained by children at the time of the head injury are less likely to be affected (V. Anderson et al., 2010). Children with TBI have difficulty not only on the Tower tasks, but also on other tasks that require skills in planning and problem solving such as the Wisconsin Card Sorting Test (WCST; Grant & Berg, 1948) and Twenty Questions Test (TQT; Delis et al., 2001), as well as more ecologically meaningful tasks such as planning an unexpected party (H. Levin et al., 1997; Pentland, Todd, & Anderson, 1998).

3.3.2.4 Inhibition and Cognitive Flexibility

According to Anderson (2002), skills such as inhibition and cognitive flexibility allow individuals to shift between response sets, hold and manipulate items in memory (working memory), learn from mistakes, inhibit automatic responses and process multiple sources of information concurrently. Individuals who have difficulty with these skills often exhibit ritualistic behaviours and continue to break the same rules. As a result these children may have poor social functioning skills, since they have difficulty adapting to changing routines and/or conversations (Beauchamp & Anderson, 2010).

Following TBI, children have been shown to perform more poorly than age-matched controls on a range of tasks assessing inhibition (Ewing-Cobbs, Prasad, Landry, Kramer, & DeLeon, 2004; Konrad, Gauggel, Manz, & Schöll, 2000; H. Levin, Hanten, et al., 2004). Levin et al. (2004) assessed children with severe TBI at least one year post injury on a flanker

task. This task required the child to press a button corresponding to the direction of an arrow, whilst ignoring adjacent stimuli (the flankers), and to withhold a response when an 'x' signal was shown. The results indicated that children with TBI were significantly worse than controls when the flankers were incongruent with the direction of the arrow and when the stimulus signalled a withhold response. As there was no difference between the groups on the congruent or neutral conditions, the results indicate that children with TBI have difficulty inhibiting automatic responses and ignoring irrelevant stimuli.

Similarly, children with TBI have been shown to have reduced working memory capacities compared to controls (Conklin, Salorio, & Slomine, 2008; Ewing-Cobbs et al., 2004; H. Levin, Hanten, et al., 2004; Roncadin, Guger, Archibald, Barnes, & Dennis, 2004). Using an N-back task, where children were asked to press a button if a letter was repeated within a visually presented series of letters, Levin, Hanten, and Chang (2002) found that children with severe TBI had greater difficulty four years post injury compared to healthy controls. Furthermore, children with moderate and severe TBI have been shown to perform significantly more poorly on this task compared to children with mild TBI (H. Levin, Hanten, et al., 2004). Injury severity has also been shown to be an influential factor on children's performance on other tasks assessing working memory following TBI. Although children with severe TBI are impaired on a backward digit span task, no significant differences are seen between children with mild TBI and typically developing children (Conklin et al., 2008; Roncadin et al., 2004).

3.3.2.5 Ecological Measures of Executive Functioning

Concerns exist in the literature as to the ecological validity of performance-based EF tests. These concerns surround the structured and interactive nature of testing situations, namely that children are tested in an environment that enables optimal performance by way

of minimal distractions, prompts, and guidance. For example, children are generally tested in a quiet room and are given cues by the examiner to provide more information, meaning that the child does not need to be as goal-directed or strategic as he/she would potentially be in their natural environment (Gioia & Isquith, 2004). In response to these concerns, researchers have begun to explore EF deficits in children with TBI that are exhibited in everyday activities (Yeates, 2009). The Behaviour Rating Inventory of Executive Function (BRIEF; G. Gioia, P. Isquith, S. Guy, & L. Kenworthy, 2000a) is a commonly utilised parent and teacher report questionnaire used to provide a measure of children's EF in everyday life. The questions target EFs that present as behavioural manifestations, and they are grouped into two domain scores: the behavioural regulation index and the metacognition index. A total score, the global executive composite, is also produced. Importantly, the BRIEF has been shown to be sensitive to the effects of childhood TBI (Gioia & Isquith, 2004; G. Gioia, P. Isquith, S. Guy, & L. Kenworthy, 2000b).

Mangeot, Armstrong, Colvin, Yeates, and Taylor (2002) showed that, compared to children with orthopaedic injuries, children with TBI are rated by their parents as having significantly more dysexecutive behaviours, and children with severe injuries were rated as having the greatest deficits in EF. Furthermore, children's deficits did not vary across the three BRIEF indexes, which suggests that children with TBI exhibit a generalised EF deficit. Ganesalingham et al. (2011) supported these findings, reporting significant differences on the BRIEF between children with severe TBI and age-matched controls. Research exploring the relationship between children's ratings on the BRIEF and their ability on performance-based EF tasks following TBI suggests that the two are poorly related with correlation coefficients ranging between $-.26$ and $.26$ (T. McCauley, Chen, Goos, Schachar, & Crosbie, 2010; Vriezen & Pigott, 2002). This raises questions as to the ecological validity of performance-based tasks and consideration of whether parents over-report their child's symptoms. As a

result, it is now recommended that in order to obtain an accurate understanding of children's EF skills, both performance-based and ecologically valid measures be administered (Gioia & Isquith, 2004; T. McCauley et al., 2010; Vriezen & Pigott, 2002).

3.3.2.6 Factors Influencing Executive Dysfunction following Paediatric TBI

A range of factors have been shown to influence children's EF following TBI. As described above, injury variables such as the age of the child at the time of the injury and injury severity can influence children's cognitive outcomes. Children with more severe head injuries are more likely to exhibit greater executive dysfunction (H. Levin & Hanten, 2005), demonstrated in poorer performance on tasks assessing cognitive flexibility, working memory and problem-solving (H. Levin et al., 1997; Roncadin et al., 2004; Slomine et al., 2002). Similarly, children who sustain a TBI at a younger age are more likely to have greater executive dysfunction. Anderson et al. (2010) claimed that children who sustain injuries at an age when a skill is still emerging, as opposed to an age when it is fully developed, are more likely to exhibit difficulties with that skill following the TBI.

Executive dysfunction after paediatric TBI has also been associated with family variables. Mangeot et al. (2002) showed that parents of children with TBI, 5 years post injury, rated their children as having more executive dysfunctions than parents of non-head-injured children. Importantly, the authors also showed that parents with greater psychological distress, a greater family burden and poorer family functioning were more likely to have children rated with poorer EF, than families with better scores on the family variables. A significant correlation between family functioning and children's EF following TBI was supported by Nadebaum, Anderson, and Catroppa (2007), who showed that parents' occupations had a significant impact. That is, parents who had more prestigious jobs had children who performed better on goal-setting tasks. Such findings are important since

interventions aimed at improving family functioning may improve the outcome of a child's cognitive abilities and subsequently improve their social functioning (Nadebaum et al., 2007). Although it is needed, there is no research to date exploring the relationship between children's EF abilities and their personality or temperament following TBI.

Executive dysfunction following childhood TBI has been shown to be affected by a child's social cognition, family functioning and pragmatic language skills. As discussed above in Sections 4.2.1 and 4.2.2, EF following TBI has been associated with children's ToM and their emotion recognition skills (Tonks et al., 2007b; Walz et al., 2010). Despite the array of research exploring this relationship, conclusions on the nature of the relationship between social cognition and EF are unclear and more research involving children with TBI is needed (Bibby & McDonald, 2005; Dennis et al., 2009; Snodgrass & Knott, 2006; Tonks et al., 2007b). Specifically, the nature of this unclear relationship was discussed in Section 4.2.2.2.

Finally, children's language skills have also been shown to influence their EF following TBI. Chapman (1995) examined the narrative discourse ability of children aged 9 to 18 years who had sustained a TBI within the previous 12 months. In addition to pragmatic language, Chapman assessed children's verbal EF skills. A composite variable, comprising a measure of verbal and semantic fluency, verbal memory and abstract reasoning, was significantly related to children's performance on a narrative discourse task, which suggests that pragmatic language and EF are related. Brookshire, Chapman, Song, and Levin (2000) assessed children aged 5 to 18 years who had sustained a mild or severe TBI. Children were assessed 3 years post injury on a range of EF and discourse tasks. Participants were required to retell a story narrative and the level of gist and core detail the child provided was assessed. The results indicated a significant positive correlation between discourse production and children's performance on an EF task that required planning and organisation. This finding supports the authors' claim that story generation requires identifying a goal, formulating a

plan, and evaluating the plan's success in light of attainment of the goal. These studies corroborate adult TBI research where significant positive correlations have been shown between inhibition and pragmatic skills (Channon & Watts, 2003) and cognitive flexibility and social communication skills (Struchen et al., 2008).

3.3.3 The Effect of Attention-Executive Functions on Social Functioning

Executive functions are an important factor to consider in terms of social functioning since they allow children to be able to engage in appropriate peer interactions. For example, a child may attract negative peer responses if he or she has difficulty inhibiting verbal or physical aggression, cannot wait for his or her turn in a game, cannot adapt to a changing routine, is disorganised, or is unable to help plan activities (Beauchamp & Anderson, 2010). This will subsequently affect his/her ability to engage in appropriate social interactions. As shown by Galvin and Madalis (2009), executive dysfunction following TBI affects children's abilities across a range of functional domains, including communication, learning, self-care and interpersonal relationships.

Significant associations between children's executive and social functioning skills following TBI have been reported by several researchers. Levin et al. (1997) assessed 151 children with TBI approximately three years post injury, and demonstrated significant and positive moderate correlations between children's performance on three separate measures of EF (specifically assessing problem solving, planning and abstract reasoning) and their adaptive behaviour, as rated by their parents. Furthermore, a regression model revealed that EF accounted for approximately 19% of the variance in children's score on the adaptive behaviour measure. Brookshire, Levin, Song, and Zhang (2004) also showed significant correlations between EF (problem solving and planning) and children's adaptive functioning at 36 months post injury. However, they did not find a significant relationship between the

two variables at three months post injury. This suggests that time since injury may be an important factor to consider when investigating predictors of social dysfunction. The predictors of social functioning were also examined by Yeates et al. (2004), who conducted a series of path analyses on 84 children with moderate and severe TBI. They found that children's performance on a measure of EF (composite score assessing working memory, inhibitory control and cognitive flexibility) made no significant unique contributions to measures of social problems, social competence, social information problem-solving nor social adaptive functioning. It did, however, make a significant joint contribution, with pragmatic language, to the number of social problems children exhibited.

Despite the presence of a significant relationship between children's executive and social functioning following TBI, it is important to note that the majority of the research has been conducted in school-age children or adolescents. Ganesalingham et al. (2011) explored this relationship in pre-school children following TBI and showed that their performance on an inhibition task did not account for their level of social competence. Interestingly, this finding failed to support their second finding that parental ratings of executive abilities, using the BRIEF, significantly predicted parental ratings of the child's social competence. The authors do note, however, that this latter finding may be confounded by the nature of the measures, since both the BRIEF and the measure of social competence are parental questionnaires. Mangeot, Armstrong, Colvin, Yeates, and Taylor (2002) supported Ganesalingham et al.'s (2011) findings of a relationship between the BRIEF and parental ratings of social functioning in children aged 6 to 12 years, at 5 years post injury. In summary, it appears that children's attention and EF are important factors to consider when assessing social functioning after TBI. In particular, there are mixed conclusions on how objective measures of inhibition, problem-solving, planning, abstract reasoning relate to various facets of social functioning. Similar to the need for future research to examine the

relationship between EF and social cognition, further investigation is also warranted to examine the predictive relationship between EF and social functioning in children post TBI. Specifically, a broader range of EF and social functioning measures need to be used.

3.4 Communication Following Childhood TBI

This section will discuss a range of communication and language impairments seen in children following TBI. Communication abilities merge with social cognition and attention-executive function to form the ‘Cognitive Functions’ component of Beauchamp and Anderson’s (2010) SOCIAL model. The current section will discuss the types of communication deficits seen in children with TBI, the effect other SOCIAL variables have on communication as well as the effect communication has on children’s social functioning.

The ability to communicate in a social world requires many different cognitive abilities. Communication relies not only on an intact language system (e.g., phonetics, semantics, syntax), but also requires understanding of the specific communicative context and general knowledge of the world. Thus, communication requires the ability to understand the meaning of speech. Whilst semantics refers to language meaning in a literal context, pragmatics refers to the more complex ability of understanding the meaning of language within a social context (Martin & McDonald, 2003). Thus, pragmatic language involves the relationship between sentences and one’s environment (Dennis & Barnes, 2000; Hoover, Sterling, & Storkel, 2011). Children and adolescents experience a range of communicative impairments following TBI. These include difficulties with the basic components of language, such as phonology, lexical semantics and syntax, as well as the more complex components, such as pragmatics (S. Chapman, Levin, & Lawyer, 1999). As explained by Hoover et al. (2011), there are three different types of pragmatics commonly examined in children: communicative intentions (e.g., requests for objects), discourse (e.g., conveying a

message during conversation) and narration (e.g., using language to relate an experience). Despite researchers' recent interest in pragmatics, there is currently no "gold standard" tool to assess pragmatic language skills in children or adults. Researchers and clinical practitioners therefore generally rely on analysing conversation discourse, narration, or speech acts (Dennis & Barnes, 2000; Hoover et al., 2011).

The development of language and communication skills begins in infancy. Importantly, the maturing of a child's communication abilities is important to the development of his/her social skills. For example, joint attention, which refers to a child's ability to share attention with a social partner (Corkum & Moore, 1995), is an important building block for social interactions as it marks the transition from engaging in dyadic interactions to triadic exchanges (Grossman & Johnson, 2007). Joint attention is also classed as an important milestone in a child's communicative abilities, since it is the foundation skill needed for a child to be able to link words and sentences with the correct objects, properties and/or events (Baldwin, 1995). Furthermore, the amount of time a child spends engaged in joint attention with his/her mother is predictive of the child's early language skills and vocabulary size (Carpenter, Nagell, & Tomasello, 1998). Links between social and communicative development are further supported by a range of empirical research (Bekoff & Allen, 1998; Garvey & Kramer, 1989; Tomasello, 1992). Thus, not only are communicative skills predictive of children's social functioning, it is evident that the two are inter-related from a young age.

Given the relationship between communication and social functioning, the development of a child's pragmatic language skills is important since they allow him or her to understand the meaning of speech, which thus aids social interaction. As summarised by Hoover et al. (2011), pragmatic language skills emerge in infancy when children learn to take turns during interactions (e.g., eye gaze) and by 24 months typically developing children are

able to request information and provide answers to basic questions. By 36 months, children are able to maintain a topic of conversation, and at 4 years they are able to include past and future topics into conversation. Between 7 and 9 years children can understand others' points of view, and by 12 years children have mastered the ability to construct narratives that explain someone's thoughts and feelings about an event or resolution. It is therefore clear that children's pragmatic language skills develop rapidly during childhood, and thus disruption to the progression of these skills may have a detrimental effect on the ability to understand the meaning that is intended beyond what is conveyed in words.

3.4.1 Neural Areas Involved in Communication

As summarised in the previous sections, TBI typically results in diffuse axonal injury and focal damage to the frontal and temporal lobes. Generally, a person's left neural hemisphere is responsible for language abilities; however several neural areas within this hemisphere play an important role in the processing and production of language.

Wernicke's area is located posterior to the central fissure, at the junction between the parietal, temporal and occipital lobes. This area is involved in receiving and interpreting sensory information and thus the comprehension of speech. In comparison, Broca's area, which is located anterior to the central fissure, is responsible for the articulation of sounds and thus speech production (Blumenfeld, 2010). Although speech production and comprehension are important for language, the current thesis focuses on pragmatic language skills. The neural pathology of pragmatic language is not as clear as other language skills due to the paucity of research in this area (Mason & Just, 2006). Researchers are only just beginning to understand the neural properties of discourse processing and have broadly drawn attention to the importance of the right hemisphere (Siegal, Carrington, & Radel, 1996; Winner et al., 1998). Although the involvement of specific neural areas changes with the type

of pragmatic task involved, Mason and Just (2006) highlighted the significance of the inferior frontal gyrus, as well as the superior, middle and inferior temporal gyri. Activation of similar neural areas was shown by Eviatar and Just (2006) in an fMRI study. Participants were asked to read a three-sentence story that ended with either a literal, metaphoric or ironic sentence, on the premise that irony and metaphors require non-literal and social interpretations, extending beyond basic lexical and syntactic processing. The metaphoric sentences were shown to result in higher activation of the left inferior frontal gyrus and the bilateral inferior temporal cortex, whereas the ironic sentences resulted in higher activation of the right superior and middle temporal gyri. These results thus suggest that the frontal and temporal lobes are important for discourse processing. Kuperberg et al. (2000) investigated the neural substrates of language by asking participants to listen to normal spoken sentences as well as to sentences that had either pragmatic, semantic or syntactic violations. Using fMRI to assess participants' neural activity, the authors demonstrated that all three language components activated the left inferior-temporal gyrus, suggesting that this area is involved in constructing a higher-order representation of the meaning of a sentence. Furthermore, when participants listened to the sentence with the pragmatic violation, their left superior temporal gyrus was activated significantly more than during the tasks involving semantics and syntax. This finding suggests that the most anterior gyrus in the temporal lobe is involved in understanding and processing pragmatics. This conclusion is pertinent to the aim of the current thesis given that the anterior temporal lobe is frequently damaged in TBI (S. Crowe, 2008).

3.4.2 Basic Language Deficits in Children with TBI

For the purposes of this thesis, 'basic language skills' refers to language skills that form the building blocks of communication, namely written language, expressive language (e.g., vocabulary production and linguistic ability) and receptive language skills (e.g.,

comprehension of vocabulary and grammar). Following TBI, children can exhibit dysnomia, reduced verbal fluency, difficulty with written language, as well as impaired expressive and receptive language skills (V. Anderson et al., 1997; Chadwick, Rutter, Shaffer, & Shrout, 1981; Ewing-Cobbs et al., 1997; Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987; Hallett, 1997; Morse et al., 1999). In a longitudinal study, Anderson et al. (1997) assessed children on a range of standardised language tests during the acute stages of TBI recovery as well as 12 months post-injury. The results indicated that children with more severe injuries had reduced naming, fluency, story-telling, receptive vocabulary and verbal comprehension compared to children with less severe injuries. Although the results showed no significant improvement over time, there was a trend for children with severe TBI to improve during the initial 12-month recovery period. Injury severity has also been shown to have a significant effect on children's expressive and receptive language skills. Specifically children with severe TBIs perform significantly worse than those with mild or moderate injuries (V. Anderson et al., 2004; Morse et al., 1999).

Despite the findings that suggest that children with TBI exhibit impaired basic language skills, there is contention as to the accuracy of these conclusions. Many researchers claim that traditional language measures underestimate children's true communicative ability (S. Chapman et al., 1997; Ylvisaker, 1993). Many of the tasks used to measure children's vocabulary or receptive language skills also require a rapid response time, verbal fluency and/or the ability to interpret ambiguous sentences. As these higher order executive skills are also impaired following TBI, Chapman et al. (1999) claim that this may influence children's performance scores. That is, the true reason for children performing poorly on measures of basic language ability may not be due to their actual vocabulary or receptive language skills, but to their slowed processing speed, inattention, difficulty making inferences and/or their reduced verbal fluency. Anderson, Catroppa, Morse, Haritou and Rosenfeld (2001) supported

these claims, showing that children with TBI have intact basic language skills. Furthermore, in a review by Ylvisaker (1993) it was concluded that language difficulties only become obvious in children and adolescents with TBI when they are required to communicate in a social situation, rather than them having deficits with specific language skills. Thus, despite intact basic language skills, it appears that children's communication deficits, following TBI, is the result of impairment in more subtle higher-order aspects of language, such as pragmatics.

3.4.3 Higher-order Language Deficits in Children with TBI

Pragmatic language is a complex higher-order skill that is needed to communicate with others in a social context. Pragmatic language requires the ability to understand ambiguous phrases and metaphoric expressions, make inferences between events in social situations and produce speech acts that express the intentions of others (Dennis & Barnes, 1990). For example, poor pragmatic understanding may be reflected in a failure to understand that the remark "Gee, it's hot in here" is actually a polite request to open the window or turn on the air-conditioner. That is, the listener failed to infer the speaker's intentions and to recognise the non-literal meaning of the comment (Martin & McDonald, 2003). Children with TBI have been shown to have difficulty with tasks requiring pragmatic and discourse skills, despite intact vocabulary and word retrieval skills (S. Chapman et al., 1997; Martin & McDonald, 2003). One common measure of pragmatic or discourse ability in children is a narrative task. The task involves children retelling a story that they have just heard, which is then analysed for the amount and type of information reproduced as well as the type of language used (S. Chapman et al., 1997). Both older (9 years and older) and younger (6 to 8 years) children with TBI have been shown to have deficits in producing complex narratives 12 months post-injury, indicating impairments in discourse (S. Chapman, 1995). Chapman, Levin, Wanek, Weyrauch, and Kufera (1998) assessed 23 children with severe TBI on a

narrative task and compared their performance with healthy age-matched peers. The results showed that children with TBI produced significantly fewer propositions (indicating less meaning in their narrative) than the controls. They also had poorer structural completeness and a reduced story gist, indicating that they had significant impairments in discourse ability. In addition, Brookshire, Chapman, Song, and Levin (2000) and Chapman et al. (2001) showed that injury severity affects the type and amount of information retold. That is, children with a mild TBI were shown to have a greater understanding of the story's gist and to produce more content and complex sentences than children with severe TBI.

In addition to discourse that is assessed through children's use of narratives, research has shown that children with TBI exhibit deficits on other pragmatic measures. Dennis and Barnes (1990) found that children with TBI have difficulty understanding ambiguous sentences, interpreting metaphors, drawing inferences from a sequence of events and generating sentences using key words. Specifically, 79% of the children in this study were shown to have difficulty on at least one of the above pragmatic tasks. As a result, Dennis and Barnes (1990) concluded that children with TBI exhibit deficits on a range of pragmatic tasks. The notion that children with TBI exhibit deficits with pragmatic inference and producing speech acts have also been supported by subsequent research (Barnes & Dennis, 2001; Dennis & Barnes, 2000). While the Pragmatic Inference task requires children to infer the meaning of speech, the Speech Acts task requires children to infer the mental state of another person and produce speech from that person's point of view. Dennis and Barnes (2000) assessed 28 children with mild or severe TBI and compared their performance to 28 healthy age-matched controls. Children with severe TBI were less able than controls and children with mild TBI to produce speech acts from another person's point of view. Similarly, children with mild TBI performed significantly more poorly than controls. On the Pragmatic Inference task, children with severe TBI made fewer pragmatic inferences than

controls. Barnes and Dennis (2001) found similar results, and also showed that children with mild TBI are better than children with severe TBI at inferring the true meaning of a story.

Thus, not only does TBI affect children's pragmatic communication skills, but the severity of the injury will often determine the extent of this impairment.

3.4.3.1 Factors Influencing Impaired Communication.

A range of factors have been shown to influence children's language abilities following TBI. As mentioned in the above sections, the nature of the injury is an important variable to consider when assessing cognitive impairments post TBI. Children with more severe head injuries display greater impairment on measures of receptive and expressive language (V. Anderson et al., 2004; Morse et al., 1999) as well as on measures of pragmatics (Barnes & Dennis, 2001; Brookshire et al., 2000; Dennis & Barnes, 2000). As summarised by Chapman et al. (1999), the impact of injury severity on discourse has been shown to persist across a range of ages (from 6 to 18 years), across a range of recovery stages (3 months to 5 years post injury), as well as across a variety of different narrative tasks (S. Chapman et al., 1992; S. Chapman et al., 1998). It is important to note, however, that the severity of the injury is not the only significant factor, with family variables and the child's age at the time of the injury also being influential. Specifically, injuries that are sustained at a younger age result in greater language impairments (S. Chapman, 1995; S. Chapman et al., 1998). Children from a higher SES background have also been shown to retain greater skills in vocabulary, as well as in receptive and expressive language skills after a head injury (V. Anderson et al., 2004; Catroppa & Anderson, 2004). Furthermore, since basic language skills form the foundation of children's pragmatic language skills, it is not surprising that research has found a significant relationship between the two. In both typically developing children and children with TBI, discourse skills have been shown to be significantly and positively

correlated with their word fluency (Dennis & Barnes, 1990) and vocabulary skills (Brookshire et al., 2000; S. Chapman et al., 1998; Dennis & Barnes, 1990).

As discussed in previous sections, a relationship between children's pragmatic language skills and other cognitive abilities has been suggested following TBI. In particular, Martin and McDonald (2003) discussed three possible theories that may explain the reason for poor pragmatics in particular clinical populations. The Social Inference Theory highlights the relationship between pragmatic language and theory of mind. Happe (1993) showed that in people with autism, the understanding of pragmatic language was dependent upon ToM ability. Similarly, a significant positive relationship between ToM and pragmatic language has been shown in individuals with right hemisphere brain damage (Siegal et al., 1996; Winner et al., 1998). However, few studies have examined this relationship in children with TBI (Martin & McDonald, 2003). Given that patients with right hemisphere damage and autism, like children with TBI, exhibit pragmatic difficulties and poor social cognition, it is likely that these abilities are also related in children with TBI. Thus, there is clearly a need for future research to explore the relationship between children's pragmatic language skills and social cognitive ability following TBI.

In addition to the influence of social cognition, the relationship between EF and pragmatic language abilities is important. The relationship between these two factors, following TBI, is summarised in Section 3.3.2.1. Although this section concludes that there is a paucity of research examining the relationship between these two factors in children with TBI, one study to date has specifically investigated the effect of EF on pragmatic language skills in this population. Chapman (1995) assessed a group of adolescents 12 months post TBI on a range of cognitive and linguistic tasks. A composite cognitive variable, assessing aspects of EF (fluency and abstract reasoning ability) as well as verbal memory, was shown to significantly predict children's performance on a discourse task. This finding not only

shows the direction of the effect and supports a significant relationship between EF and pragmatics in children with TBI, but also suggests that memory ability may be a significant factor.

3.4.4 The Effect of Communication on Social Functioning

All aspects of communication are important for social functioning. As described by Beauchamp and Anderson (2010), expressive and receptive language skills directly affect an individual's ability to engage in conversation and thus have an impact on one's social interactions. Higher-order language aspects, such as pragmatics, are also influential. If a child is unable to detect the true meaning of a message or interpret metaphors and gist within speech, then he/she may respond inappropriately during social interactions (Beauchamp & Anderson, 2010). Despite this logic, very few studies to date have explored the relationship between language and social functioning in children with TBI. Hanten et al. (2008) conducted a longitudinal study on 103 children who had sustained either a moderate or severe TBI to investigate this. Using passage comprehension and word identification tasks as a measure of language, Hanten et al. (2008) showed that children's ability to solve hypothetical social conflicts was significantly and positively correlated with children's language ability. Furthermore, Yeates et al. (2004) conducted path analyses to determine the effect of children's pragmatic language skills on their social information processing skills and social functioning after controlling for age, race, SES and IQ. Their study showed that children's performance on measures of social problem-solving, pragmatic language and EF made both significant independent and collective contributions to the prediction of social functioning. Specifically, pragmatic language skills provided significant unique contributions to children's social information processing. With EF measures controlled, pragmatic language provided significant collective contributions to social problems and social adaptive functioning, but not to measures of social competence. In regard to unique contributions,

pragmatic language significantly influenced social adaptive functioning only. This is the only known study to explore multiple predictors of social functioning in children with TBI, and thus the conclusions drawn need verification by future research.

3.5 Summary

The SOCIAL model is an integrative biopsychosocial framework that defines the core features of social functioning. Beauchamp and Anderson (2010) contend that paediatric TBI is a clinical disorder that clearly illustrates the SOCIAL model since children commonly experience deficits in each of the core areas discussed within the model. In regard to the internal components, researchers have noted that children and adolescents often show mood disturbances, such as anxiety and depression after TBI (Kirkwood et al., 2010{Noggle, 2010 #102}) as well as personality changes (Max et al., 2000). Furthermore, external components are recognised with parents of children with TBI reporting high levels of caregiver burden and stress as well as frequent family disagreements (Goldstrohm & Arffa, 2005; Stancin et al., 2008). In addition to the model's mediators, the three key cognitive components of the SOCIAL model were discussed as an outcome of paediatric TBI and the interactive nature of these three components was also discussed.

Social cognition is a complex ability that is typically mastered during childhood and adolescence. It refers to a range of skills including the ability to recognise and interpret other people's emotions, adopt other's perspectives and understand others' thoughts, desires and beliefs. Children with TBI have difficulty recognising other people's emotions, regardless of whether the emotion is presented visually or orally. Children with TBI also have difficulty performing a range of ToM tasks. Specifically, they have difficulty inferring another's thoughts and beliefs, as well as understanding complex processes such as deception, irony and sarcasm.

Following TBI, children commonly experience a range of executive dysfunctions. Impairments are often seen in attention, processing speed, inhibition, cognitive flexibility, planning, and problem-solving. Furthermore, parents of children with TBI typically report EF deficits to be evident in various aspects of the child's everyday life. As deficits are evident in performance-based and ecologically-valid measures of EF, researchers recommend that both types of measures be utilised when assessing the EF of children with TBI (Gioia & Isquith, 2004; T. McCauley et al., 2010; Vriezen & Pigott, 2002).

Children with TBI are reported to have difficulty communicating with others, a deficit that has been highlighted in their poor performance on measures of written, receptive and expressive language. Despite these difficulties, many researchers claim that children's performance on these tasks, post-TBI, is a reflection of their executive dysfunction and poor pragmatic language skills, not their actual skills in basic language (S. Chapman et al., 1997; Martin & McDonald, 2003; Ylvisaker, 1993). Higher-order language skills, such as pragmatics and discourse abilities, have been shown to be impaired following paediatric TBI. Specifically, children with TBI have difficulty understanding ambiguous phrases and metaphoric expressions, making inferences between events in social situations, and producing speech acts that express the intentions of others.

CHAPTER 4: Study 1

Paediatric TBI commonly results in difficulties and deficits in many areas of a child's life. As summarised in Chapter 2, social dysfunction is reported to be one of the most debilitating consequences following TBI (Driscoll et al., 2011). Brain impairment places a large burden on interpersonal relationships and has a significant and detrimental impact on a person's ability to function in a social world. Beauchamp and Anderson (2010) introduced the SOCIAL model in an attempt to define social functioning using a set of biopsychosocial factors. By discussing the developmental and interactive nature of these factors, the model highlights the importance of integrating multiple perspectives whilst also considering a novel facet, brain insult. A recent escalation in social neuroscience research has demonstrated the importance of neural circuits and networks in regard to the execution of complex behaviours that enable successful social functioning. As highlighted in Chapter 2, the model's components include brain integrity factors, internal (e.g., child's temperament) and external factors (e.g., family environment), as well as communication, attention-executive and social cognitive functions. These components were discussed in Chapter 3 in regard to children with TBI. Specifically, the inter-twining relationship they share and the effect they have on a child's social functioning was discussed.

Social functioning often requires an individual to be able to interpret the meaning of another's speech, to inhibit inappropriate social responses, and to attend to changing information. Thus, many claim that social functioning may be influenced by a range of cognitive factors (e.g., Ganesalingam et al., 2011; Yeates et al., 2004). This is particularly likely, since in addition to social dysfunction following TBI, children also exhibit deficits in pragmatic language (Dennis & Barnes, 2000; J. Sullivan & Riccio, 2010), EF (Chevignard et al., 2010; Nadebaum et al., 2007) and social cognition (Tonks, Slater, et al., 2009; Walz et al.,

2010). Evidence for a link between social functioning and each of these cognitive functions was discussed in Chapter 3.

4.1 Aims and Hypotheses

The present study aimed to investigate the predictors of children's social functioning following TBI. Although the SOCIAL model, proposed by Beauchamp and Anderson (2010), highlights several important biopsychosocial features, relationships within this model need further empirical attention in a childhood TBI sample. As discussed above, the conclusions drawn from past research on the predictors of children's social functioning are unclear. One aim of the current study was to clarify some of the links within the SOCIAL model. Specifically, the current study aimed to provide insight on the relationship between (i) social cognition and social functioning, and (ii) between pragmatic language and social cognition. To date, no published research has explored this relationship in children with TBI. Furthermore, the current study aimed to provide additional evidence on the links between (iii) pragmatic language, EF and social functioning, (iv) between EF and social cognition, and (v) between EF and pragmatic language. In order to add to the current literature of this latter aim, the study applied a broader range of cognitive and social measures than has been used in past research. Specifically, measures of social functioning incorporated adaptive functioning and social problems, and measures of EF included an ecological measure and several performance based measures. Therefore, the overall aim of the current study was to operationalise the SOCIAL model in a paediatric TBI sample. In accordance with the SOCIAL model, it was hypothesised that:

1. Familial variables (as measured by SES and family functioning) and intrinsic childhood variables (as measured by internal behaviours) would jointly account for a

significant amount of variance in children's social functioning following TBI, as measured by their socialisation skills and social problems.

Furthermore, after controlling for familial and intrinsic childhood variables, it was also hypothesised that:

2. Measures of EF would account for a significant amount of variance in children's social functioning following TBI, as measured by their socialisation skills and social problems. Although the concept of EF was hypothesised to predict children's social functioning, the identification of which specific EF measures would be involved in this predictive relationship was exploratory in nature.
3. Measures of pragmatic language would account for a significant amount of variance in children's social functioning following TBI, as measured by their socialisation skills and social problems.
4. Measures of social cognition would account for a significant amount of variance in children's social functioning following TBI, as measured by their socialisation skills and social problems. Although the concept of social cognition was hypothesised to predict children's social functioning, the identification of which specific social cognitive measure would be involved in this predictive relationship was exploratory in nature.
5. Measures of EF, pragmatic language and social cognition would jointly account for a significant amount of variance in children's social functioning following TBI, as measured by their socialisation skills and social problems.

4.2 Method

4.2.1 Participants

Participants were 56 children aged between 7 and 16 years, who presented to the department of emergency medicine at the Royal Hobart Hospital (RHH) between January 2009 and September 2011. Due to ethical considerations, families were initially contacted by a RHH staff member to determine if they were interested in hearing more about the study from the researchers. The RHH staff member then passed on the details of 170 families. Of those who agreed to be contacted, 56 participated in the study. The parents of the remaining 114 children either could not be contacted ($n = 35$), chose not to participate ($n = 71$) or were excluded based on the following criteria: (i) the child's first language was not English ($n = 0$) (ii) the child had a history of a neurological and/or neurodevelopmental condition (e.g., autism, epilepsy) ($n = 0$), or (iii) the child had experienced more than one severe TBI ($n = 8$). The final group of head-injured children had a mean age of 13 years ($SD = 2.9$ years).

Children's families were contacted to participate in the research as soon as practical. Children were therefore assessed at various times post injury; ranging between three and 33 months ($M = 16.46$ months, $SD = 9.05$). Injury severity was classified as mild, moderate or severe according to the child's Glasgow Coma Scale (GCS) scores and/or post-traumatic amnesia (PTA) scores from their RHH file according to the criteria detailed in Section 1.3. There were 51 (91%) mild injuries, three (5%) moderate injuries and two (4%) severe injuries. This sample of children consisted of 43 males (77%) and 13 females (23%). Both of these statistics are consistent with previous research which indicates that males are more likely than females to sustain a TBI, and mild injuries are more prevalent than moderate or severe injuries (L. Crowe et al., 2009; Kraus, 1995).

4.2.2 Materials

4.2.2.1 *Social Functioning (outcome variable)*

Similar to the method used by Yeates et al. (2004), social functioning was assessed using two standardised parental questionnaires: The ‘socialization domain’ of the Vineland Adaptive Behaviour Scale- second edition (VABS-II; Sparrow, Cicchetti, & Balla, 2005) and the ‘social problems’ subscale of the Child Behaviour Checklist (CBCL; Achenbach, 1991). Both standardised instruments have been widely used within paediatric TBI populations (Hanten et al., 2008; F. Muscara et al., 2009; Taylor et al., 1999; Yeates et al., 2004). As summarised in Chapter 2, F. Muscara and Crowe (2012) discussed the importance of assessing more than one facet of social functioning. Thus by including a measure of children’s socialisation skills and social problems, it was intended that a broad understanding of social functioning would be obtained.

The VABS-II is a parent/caregiver rating scale that is used to provide a measure of adaptive functioning. The ‘socialization domain’ was used in the current study, which measures the quality of children’s interpersonal relationships, their participation in play and leisure activities, and their coping skills. This domain has been shown to have satisfactory test-retest reliability, with coefficients ranging between .88 and .94 (Sparrow et al., 2005). Raw scores were converted to standardised domain scores based on the child’s age. Standardised scores were then converted to percentile rank scores, which were used as the outcome measure, where higher scores reflect better socialisation skills.

The CBCL is also a parent/caregiver rating scale. The ‘social problems’ subscale of the CBCL assesses a variety of difficulties a child may experience in interpersonal relationships, exhibited through behaviours such as clinginess, preferring to play with younger children, not getting along with peers, and clumsiness. This subscale has been shown

to have satisfactory, with a mean test-retest reliability coefficient of .90 (Achenbach, 1991). Raw scores were converted to T-scores based on the child's age and gender. Percentile scores were obtained and used as the outcome measure, where a higher score reflects a greater number of social problems.

4.2.2.2 Internal Factors (predictor variable)

Children's internal behaviours were measured using the internalizing subscale score from the parent-rated CBCL (Achenbach, 1991). As described above, the CBCL has been used widely on parents of children who have experienced a TBI. The test-retest reliability coefficient for the internalizing subscale is 0.91 (Berube & Achenbach, 2003). The internalizing behaviour scale is comprised of the anxious/depressed, withdrawn/depressed and somatic complaints subscales, which require parents to score various behaviours as either: (i) not true, (ii) somewhat or sometimes true or (iii) very true or often true. Behaviours classified as internalizing included crying a lot, being fearful, preferring to be alone, being sad, arguing a lot, demanding attention, destroying things and having a bad temper. Raw scores were converted to T-scores, based on the child's age and gender. All T-scores were transformed to percentile rank scores, where a higher score represents more problematic behaviour.

4.2.2.3 External Factors (predictor variable)

The external factor was comprised of measures of SES and family functioning. Socioeconomic status was determined by parental occupation status using the Australian Socioeconomic Index 2006 (AUSEI06). This measure has been widely used in various research fields, and has also been specifically utilised in Australian-based research on children with TBI (e.g., Dooley et al., 2010). Parents' occupations were firstly ranked according to the Australian and New Zealand Standard Classification of Occupations

(ANZSCO) and scores were then converted to an AUSEI06 value according to the criteria set by McMillan, Beavis, and Jones (2009). The AUSEI06 scores range from 0 to 100, where higher scores reflect greater occupational prestige, and thus higher SES. Although data on both parents' occupations was obtained, only the parent with the highest AUSEI06 score was recorded. If parents were unemployed/housewife/student, then as recommended by McMillan, Beavis and Jones (2009), the AUSEI06 score was based on the parent's occupational potential which was determined by his/her highest level of education.

Family functioning was measured using the Intimacy, Conflict and Parenting- Family Functioning Scales (ICPS-FFS; Noller, Seth-Smith, Bouma, & Schweitzer, 1992). The ICPS-FFS has sound psychometric properties (Noller et al., 1992) and has been reliably used in Australian-based research on children with TBI (e.g., Catroppa et al., 2009). It is a 30-item parent-report questionnaire designed to measure family interaction style. All items are rated on a six-point Likert scale, ranging from one (totally agree) to six (totally disagree). Raw scores are totalled to provide three scores, representing the family's intimacy, conflict and parenting style, where higher scores reflect greater amounts of the relevant category.

4.2.2.4 Attention-Executive Function (predictor variable)

Beauchamp and Anderson (2010) discussed a broad array of abilities that come under the heading of attention-EF. Following Anderson's (2002) model of EF, four components were included in the current study: attentional control, processing speed, cognitive flexibility/inhibition and planning.

Attentional control was measured using the 'Digit Span' subtest of the Wechsler Intelligence Scale for Children-fourth edition (WISC-IV; Wechsler, 2003). The WISC-IV is widely used, and the average test-retest reliability coefficient for the digit span subtest equals .87 (Wechsler, 2003). This test requires children to verbally recall an increasing span of

numbers, both forwards and backwards. Raw scores were converted to scaled scores based on the child's age. Scaled scores were then converted to percentile ranks, where a higher score reflects better attentional control.

Processing speed was assessed using the 'Symbol Search' subtest of the WISC-IV (Wechsler, 2003). The average test-retest reliability coefficient for 'Symbol Search' is .79. In this task, children were asked to indicate, on paper, whether one of two target symbols were present in a row of symbols. As per instructions, children were asked to complete as many items as possible within a two-minute time frame. Scaled scores were derived based on the child's age and then converted to percentile ranks, where a higher score reflects faster processing speed.

Cognitive flexibility and inhibition were assessed using the 'Inhibition' subtest of the NEPSY-II (Korkman, Kirk, & Kemp, 2007). The NEPSY-II has been shown to have sound psychometric properties, with test-retest coefficients ranging between .33 and .93, and during its development, the NEPSY-II was trialled on various clinical populations, including children with TBI (Brooks, Sherman, & Strauss, 2010). In the 'Inhibition' subtest, children are shown a series of circles/squares and arrows (pointing up and down), and are asked to name the shape/direction of the stimuli as quickly and accurately as possible. During the inhibition section, children were asked to provide the opposite response (i.e., say 'circle' when they saw a square, or say 'up' when the arrow was pointing down). In the switching section, children were asked to say the correct shape/direction when the stimulus was black, but say the opposite when the stimulus was white. Scaled scores were calculated based on the child's age, the speed with which they could complete the series and the number of errors (including self-corrected errors) made. Scaled scores were converted to percentile rank scores, which were used as the outcome measure. A higher score reflected greater inhibition/flexibility skills.

Planning was assessed using the Delis-Kaplan Executive Function System's (D-KEFS; Delis et al., 2001) 'Tower' test. The D-KEFS 'Tower' test has been shown to have satisfactory reliability, with test-retest correlation coefficients equalling .51 (Delis, Kramer, Kaplan, & Holdnack, 2004), and has also been widely applied to the paediatric TBI population (V. Anderson et al., 2010; Chevignard et al., 2010; Tonks et al., 2007b). Children are given a peg board, with 3 vertical rods, and 5 discs of varying size. Following a series of rules, children are required to move the discs between the pegs to achieve a goal position. The child is asked to do this as quickly as possible and in as few moves as possible, whilst breaking as few rules as possible. The standardised total achievement score is based on the child's age, total number of moves, number of rule violations, and item completion time. This score was converted to a percentile rank score, which was used as the outcome measure. A higher score reflects greater planning skills.

The Behavioural Rating Inventory of Executive Functioning (BRIEF; Gioia et al., 2000a) is a parent-rated questionnaire that provides a measure of children's everyday EF. As discussed in Section 3.3.2.5, it is recommended that when assessing EF, both performance-based and ecologically valid measures be administered (Gioia & Isquith, 2004; T. McCauley et al., 2010; Vriezen & Pigott, 2002). The BRIEF has been shown to have adequate reliability, with test-retest coefficients ranging between .76 and .85 (Gioia et al., 2000b). In addition, the BRIEF has been used with many clinical populations including paediatric TBI (V. Anderson, Anderson, Northam, Jacobs, & Mikiewicz, 2002; Gioia et al., 2000b; Mangeot et al., 2002). The global executive composite (GEC) T-score is calculated in light of the child's age and sex, and provides an overall indication of their performance on a range of areas including emotional control, inhibition, shifting, initiation, and working memory. The composite score was converted to a percentile rank score, which was used as the outcome measure. A higher percentile rank score reflects greater executive dysfunction.

4.2.2.5 Communication (predictor variable)

Pragmatic language skills were assessed using the screening composite of the Test of Language Competence- Expanded edition (TLC-E; Wiig & Wayne, 1988). The TLC-E is a norm-referenced, standardised test that has been shown to be sensitive to the effects of paediatric TBI, and test-retest correlation coefficients for composite scores exceed .90 (Dennis & Barnes, 1990). The screening composite includes the ‘Oral Expression: Recreating Speech Acts’ and ‘Figurative Language’ subtests. In the ‘Oral Expression: Recreating Speech Acts’ subtest children are shown a picture of a particular setting and are required to produce a contextually appropriate utterance using two or three key words. The ‘Figurative Language’ subtest measures children’s ability to interpret idioms and metaphors both orally and by selecting the correct meaning from four alternative answers. Children’s standardised composite scores were converted to percentile rank scores, which were used as the outcome measure. A higher percentile rank score reflects greater pragmatic language skills.

4.2.2.6 Social Cognition (predictor variable)

The NEPSY-II (Korkman et al., 2007) includes a social perception domain which contains two subtests; the ‘Affect Recognition’ (AR) and ‘Theory of Mind’ (ToM) subtests. The AR subtest involves four sub-domains which required children to be able to identify and match characters’ emotions from photos of children’s faces. Test-retest reliability coefficients are satisfactory, ranging between .50 and .61 (Korkman et al., 2007). Scaled scores were calculated, based on the child’s age, and converted to percentile rank scores, where a higher score reflects better affect recognition skills.

The ToM subtest requires children to comprehend others’ perspectives, experiences and beliefs, and is broken into two sub-domains. Test-retest reliability coefficients are satisfactory, ranging between .70 and .77 (Korkman et al., 2007). The first involved the child

listening to scenarios and taking on another person's perspective. In the second sub-domain children were shown a pictured situation (e.g., a girl who has just fallen off her bike) and were asked to identify, from four faces, which face illustrates the emotion felt by the character. This sub-test provides a percentile rank range score as the outcome measure. From this range, the median percentile rank score was calculated and used as the outcome measure for the study. Higher percentile rank scores reflect greater ToM.

4.2.3 Procedure

Ethics approval was obtained from the Tasmanian Human Research Ethics Network (approval number: H11378). Informed consent was obtained from parents of all children, as well as from children who were aged 12 years and above. Each child was assessed individually by one of three trained researchers in a quiet room at the University. Parents were asked to remain in a waiting area outside the room to complete the set of parental questionnaires. Children were offered a break part way through the battery of tests in an attempt to reduce fatigue. The individual tests were administered in accordance with standardised instructions outlined in the manual. Tests were administered in the following order: WISC-IV Digit Span, D-KEFS Tower, TLC-E Oral Expression: Recreating Speech Acts, NEPSY-II Theory of Mind, NEPSY-II Inhibition, NEPSY-II Affect Recognition, TLC-E Figurative Language, and WISC-IV Symbol Search. The parental questionnaires were given in the following order: AUSEI06, BRIEF, CBCL, VABS-II Socialization Scale, and the ICPS-FFS. As some parents requested feedback on their child's assessment, the researcher phoned these parents once the assessments were scored to provide them with a brief summary of their child's cognitive abilities.

4.3 Design and Analyses

As discussed above, percentile rank scores were used as the outcome measure when possible. This allowed all variables to be measured on the same scale, and unlike standard scores or T-scores, percentile ranks are unique in that they provide insight into how common or uncommon a score is relative to the normative population (Crawford, 2012).

Results were analysed using SPSS statistical package (IBM SPSS statistics package 20.0, 2011). Prior to all analyses, the data were screened for missing values and the assumptions of a multivariate analysis. A missing values analysis showed that 4.62% of all values were incomplete. Specifically, scores for attention, planning, communication, ToM and affect recognition were missing one value (1.8%), scores for ecological EF, family functioning and social problems were missing three values (5.4%) and adaptive functioning was missing 19 values (33.9%). Scores for inhibition, cognitive flexibility and processing speed were not missing any values. To determine if there was any pattern to the missing data, Little's Missing Completely at Random (MCAR) test was conducted (Little, 1988; Tabachnick & Fidell, 2001). However, as the null hypothesis was rejected, $X^2(117) = 150.91$, $p = .02$, the data were deemed to be not missing at random. Therefore, the multiple imputation method (MI) was chosen to replace all missing scores (Tabachnick & Fidell, 2001). The minimum and maximum values for each variable were set, and as recommended by IBM (2011), all variables acted as both a predictor and had values imputed when required. As recommended by Shafer (1999), all variables were imputed following the $m = 5$ imputations method. Therefore, all subsequent analyses were conducted by calculating the average parameter estimates of the five imputations (Tabachnick & Fidell, 2001).

All scores were converted to z -scores and no significant univariate outliers were identified (scores with absolute values greater than 3.29 for $p < .001$, (Field, 2005). There

were also no multivariate outliers identified, as no Mahalanobis distance values exceeded the critical values (16.27, 18.47, or 20.52 for analyses using 3, 4 or 5 independent variables, respectively; Tabachnick & Fidell, 2001). Due to the multiple imputations and small n , the assumption of normality was assessed by examining skewness and kurtosis values (Tabachnick & Fidell). To determine the significance of these scores, Fisher's coefficients were obtained by dividing each value by its standard error. The final value was then compared with zero on the Z distribution. The assumption of normality was deemed to be violated if the Fisher coefficients of skewness and/or kurtosis were significant at a level of $p = .01$ (Tabachnick & Fidell). Following this procedure, two variables were shown to violate the assumption of normality; the intimacy subscale of family functioning and planning (Table A1, Appendix A). These variables were transformed to satisfy the assumption of normality using reflected square root transformations.

Inspection of scatterplots revealed that the assumptions of linearity and homoscedasticity were met. The assumption of multicollinearity was considered robust through inspection of tolerance values ($r > .7$) and inter-correlations between requisite independent variables ($r < .90$) (Tabachnick & Fidell, 2001). Finally, the Durbin-Watson statistic was used to assess for independence of residuals. As all values approximated 2.0, the residuals were deemed uncorrelated (Field, 2005).

Pearson correlations and a principal components analysis were run on the family functioning variables. Independent t-tests were run to determine the effect sex and injury severity has on each of the dependant variables. Pearson correlations were also run to investigate the relationship between each of the variables within the SOCIAL model. Finally, a series of hierarchical multiple regressions were run to investigate the predictors of social functioning. Variables that correlated highly with the dependent variables were entered into the hierarchical regression. An alpha level of .05 was selected for all statistical analyses and

effect size was measured by Partial Eta Squared (η^2) with .01 a small effect, .25 a medium effect and .40 a large effect (Tabachnick & Fidell, 2001). All raw data can be found on the attached DVD under Study 1.

4.4 Results

4.4.1 Descriptive Statistics

Descriptive statistics for each of the cognitive and internal/external variables are presented in Table 4.1. Children's mean scores for attention-EF, social cognition and communication indicate performance within the average range. Families who participated in the study were, on average, from a middle SES. With regard to social functioning, parents rated their children's social problems to be within the normal range ($< 93^{\text{rd}}$ percentile), and to have an 'adequate' level of adaptive behaviour (18^{th} - 83^{rd} percentiles).

Table 4.1.

Descriptive statistics for children's (n = 56) performance on each of the cognitive variables and internal/external variables, expressed as a percentile.

SOCIAL component	Variable	<i>M</i>	<i>SD</i>
Social Functioning	Social Problems	66.00	16.42
	Socialisation	48.18	35.70
Internal	Internal Behaviour	56.92	33.28
External	Family Functioning: Intimacy	63.69	8.16
	Family Functioning: Parenting Style	40.39	5.18
	Family Functioning: Conflict	25.71	8.85
	SES	57.81	20.27
Attention-EF	Attention	41.56	25.92
	Planning	57.23	25.48
	Processing Speed	45.82	26.15
	Inhibition	44.41	30.04
	Switching	49.84	29.28
	Ecological EF	61.05	32.33
Social Cognition	Affect Recognition	45.76	21.82

	Theory of Mind	35.84	37.39
Communication	Pragmatic Language	32.53	24.22

4.4.2 The Composite Variable: Family Functioning

Similar to Nadebaum et al. (2007), a family functioning composite score was derived from the three ICPS-FFS subscores; intimacy, conflict, and parenting style. Since the assumption of normality is not essential for summarising the relationship between variables when creating a composite variable (Tabachnick & Fidell, 2001), the untransformed data for intimacy were used to aid interpretability. As recommended by Tabachnick and Fidell (2001), Principal Components Analysis (PCA) was used to reduce the three family functioning scores down to one component. Use of PCA was further justified since it is intended that the outcome component will be used in subsequent analyses (Tabachnick & Fidell).

As previously described, the ICPS-FFS is composed of three subscores: intimacy, conflict and parenting style. Pearson correlations were run to determine the relationship between each of these three subscores. The intimacy scores correlated significantly with conflict ($r = -.57, p < .001$) and parenting style ($r = .68, p < .001$) and a significant correlation was also present between conflict and parenting style ($r = -.48, p < .001$).

Prior to performing the PCA, the data were assessed to determine their suitability for factor analysis. All three variables were highly correlated (between .4 and .9), and the Kaiser-Meyer-Olkin value equalled .68 (exceeding the recommended value of .6; Tabachnick & Fidell, 2001). Furthermore, Bartlett's Test of Sphericity reached statistical significance, $\chi^2(3) = 55.22, p < .001$, supporting the factorability of the correlation matrix. Thus, the data were deemed appropriate for a PCA. Factor scores were derived using the regression method,

as recommended by Field (2005). Only one factor was extracted where eigenvalues exceeded one. This factor explained 71.94% of the total variance. Similar to Nadebaum et al. (2007), intimacy and parenting style scores loaded positively on the final composite (.89 and .85, respectively), and conflict scores loaded negatively (-.80). Thus, high scores on the family functioning composite score reflect greater amounts of family intimacy, a more democratic parenting style, and fewer family conflicts.

4.4.3 Effect of Demographic and Brain Integrity Variables

Due to the low number of participants with a moderate or severe TBI, these two groups were collapsed into one. Thus, the ensuing analysis investigated the difference between children with a mild TBI ($n = 51$) and children with a moderate or severe TBI ($n = 5$). Table 4.2 reports the descriptive data for children's socialisation and social problem scores according to their sex and injury severity. It is evident from these data that there was a trend for males and children with more severe injuries to have greater social problems and poorer socialisation skills, however caution is warranted when interpreting this result due to the small sample size.

Table 4.2.

Mean percentiles (and standard deviation), socialisation (VABS) and social problems (CBCL), by sex and severity.

Category		Socialisation	Social Problems
Sex	Male	46.94 (34.53)	66.14 (16.24)
	Female	52.26 (39.90)	65.54 (17.64)
Injury Severity	Mild	50.40 (35.03)	65.22 (15.81)
	Moderate/Severe	25.44 (37.04)	74.04 (21.83)

A series of independent *t*-tests were conducted to determine if there was any effect of sex or injury severity on each of the social functioning measures. For each of the analyses, equal variance was assumed given that Levene's tests were not significant ($p > .05$). No significant differences between males and females were found in children's social problems, $t(54) = .11$, $p = .88$, $\eta^2 < .001$ and socialisation skills, $t(54) = -.49$, $p = .58$, $\eta^2 = .004$. Similarly, there was no significant difference between children who sustained mild TBI and those who sustained a moderate/severe TBI in their level of social problems, $t(54) = 1.15$, $p = .31$, $\eta^2 = .02$ and socialisation skills, $t(54) = -1.52$, $p = .18$, $\eta^2 = .04$. Pearson correlation coefficients were calculated to investigate the relationship between time since injury and the two measures of social functioning. There was no significant relationship between the length of time post injury and children's social problems ranking, $r = .18$, $p = .21$, and children's socialisation skills, $r = -.19$, $p = .21$. Therefore, time since injury, injury severity and sex were not included in subsequent analyses.

4.4.4 Inter-Correlations

4.4.4.1 *Correlations within Components of SOCIAL*

Pearson correlation coefficients were calculated between the SOCIAL model's first class of mediators, namely between the two external factors (family environment and SES) and the one internal factor. There was no significant correlation between internal behaviour and family functioning ($r = -.24, p = .08$), internal behaviour and SES ($r = -.17, p = .24$), nor between SES and family functioning ($r = -.11, p = .44$).

Pearson correlation coefficients were also calculated between the SOCIAL model's second class of mediators, namely between each of the attention-EFs, both of the social cognitive measures, and pragmatic language (see Table 4.3). Of the nine significant correlations found, two are likely to be significant by chance ($36 \text{ correlations} \times .05 = 1.8$). Thus the nine significant correlations found were greater than that expected by chance. Specifically, the results show that children with greater attentional control were more likely to have faster processing speed and greater cognitive switching abilities. Children who could process information quickly were able to inhibit automatic responses more accurately, switch between two tasks more accurately and understand the meaning behind spoken language more accurately. In addition, children who were able to inhibit automatic responses more accurately were also able to switch between two tasks more accurately and were rated by their parents as having less executive dysfunction. Finally, the better a child's pragmatic language skills, the greater their cognitive switching abilities, the better their theory of mind skills, and the greater their affect recognition skills.

Table 4.3.

Pearson correlation coefficients between each of the attention-EF, social cognitive and communication variables.

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1.Attention								
2. Planning	-.06							
3. Processing Speed	.33*	-.01						
4. Inhibition	.05	.17	.29*					
5. Switching	.27*	.13	.43**	.50**				
6. Ecological EF	-.19	-.01	-.23	-.30*	-.10			
7. Affect Recognition	-.02	-.13	.17	.14	.15	-.11		
8. Theory of Mind	-.16	-.18	.20	-.01	.04	.19	.34*	
9. Pragmatic Language	.26	.08	.45**	.26	.52**	-.23	-.04	.12
* $p < .05$, ** $p < .01$								

Finally, a Pearson correlation coefficient was calculated between the two measures of social functioning. There was no significant correlation between children's ratings of social problems and their socialisation skills ($r = -.13$, $p = .50$).

4.4.4.2 Correlations between Components of SOCIAL

Pearson correlation coefficients were calculated between the three internal/external variables and the two social functioning variables. Of the two significant correlations in Table 4.4, less than one is likely to be significant by chance ($6 \text{ correlations} \times .05 = 0.3$), suggesting that the two significant correlations found exceeded that expected by chance. The results indicate that children with higher levels of problematic internal behaviours were more likely to have a greater number and frequency of social problems. Furthermore, children from families who reported a more dynamic parenting style, greater intimacy, and less conflict, were more likely to be rated by their parents as having greater socialisation skills.

Table 4.4.

Pearson correlation coefficients between the three internal/external variables and two measures of social functioning (social problems and adaptive behaviour)

Internal/External Variables	Social Problems	Socialisation
Internal behaviour	.57**	-.26
Family functioning	-.05	.31*
SES	-.20	.01
* $p < .05$, ** $p < .01$		

To determine if any of the other internal/external variables were contributing to the correlations reported in Table 4.4, a series of partial correlations were also run. By controlling for the remaining two internal/external variables and the other social functioning variable, a series of 6 partial correlations were run (see Appendix A, Table A2). As there was

very little difference between the partial correlations and zero order correlations, the zero order correlations are reported here.

Pearson correlation coefficients were also calculated between the nine cognitive variables and the two social functioning variables (Table 4.5). Of the two significant correlations shown in Table 4.5, one is likely to be significant by chance ($18 \text{ correlations} \times .05 = 0.9$), suggesting that the number of significant correlations found exceed that expected by chance. The results indicate that children who are rated as having a greater number of problematic internal behaviours are more likely to have a greater number of, and more frequent, social problems ($r = .53, p < .01$). Furthermore, children with greater ToM skills are more likely to be rated by their parents as having greater socialisation skills ($r = .32, p < .01$). A series of partial correlations were also run to determine if any of the other cognitive variables were contributing to the correlations reported in Table 4.5. By controlling for the remaining eight cognitive variables and the other social functioning variable, a series of 18 partial correlations were conducted (see Appendix A, Table A3). As there was very little difference between the partial correlations and zero order correlations, the zero order correlations are reported here.

Table 4.5.

Pearson correlation coefficients between the nine cognitive variables and two measures of social functioning (social problems and socialisation skills)

Cognitive Variables	Social Problems	Socialisation Skills
Attention	-.19	.17
Planning	.09	-.02
Processing Speed	-.01	.33
Inhibition	-.21	.06
Switching	-.03	.16
Ecological EF	.53**	-.32
Affect Recognition	-.02	.26
Theory of Mind	.08	.32*
Pragmatic Language	.05	.23
* $p < .05$, ** $p < .01$		

4.4.5 Hierarchical Multiple Regressions: Predicting Social Functioning

A series of hierarchical multiple regressions were conducted to investigate the predictors of children's social problems and socialisation skills. The predictor variables were comprised of the variables shown to be significantly correlated with either of the two social functioning variables (shown above). Thus, internal behaviours, family functioning, ToM and ecological EF were used as the dependent variables. Based on the SOCIAL model, internal

behaviours and family functioning were entered into the regression at step one, and the two cognitive variables were entered at step two (see Table 4.6).

In combination, all four variables significantly accounted for 47% of the variance in children's social behaviours ($R^2 = .47$, $F(4, 51) = 7.81$, $p < .001$). The internal/external variables alone significantly accounted for 33% of the total variance ($R^2 = .33$, $F(2, 53) = 13.09$, $p < .001$). After the addition of theory of mind and EF, an additional 14% of variance in children's social problems was explained ($\Delta R^2 = .14$, $F_{\Delta}(2, 51) = 6.68$, $p < .01$). This indicates that social cognition and EF are able to explain variance in children's social problems, over and above the effects of family functioning and children's internal behaviours. Furthermore, the standardised beta values indicate that children's internal behaviours and EF provide a significant amount of unique variance to children's social problems. Specifically, internal behaviours ($\beta = .46$, $p < .001$) accounted for a larger portion of variance than EF ($\beta = .39$, $p < .01$).

Together, internal behaviours, family functioning, ToM and EF accounted for 30% of the variance in children's socialisation skills ($R^2 = .30$, $F(4, 51) = 5.43$, $p < .001$). The internal/external variables alone significantly accounted for 14% of the total variance ($R^2 = .14$, $F(2, 53) = 4.37$, $p < .05$). After the addition of theory of mind and EF, an additional 16% of variance in children's socialisation skills was explained ($\Delta R^2 = .16$, $F_{\Delta}(2, 51) = 5.76$, $p < .01$). This indicates that social cognition and EF are able to explain variance in children's socialisation skills, over and above the effects of family functioning and children's internal behaviours. Furthermore, the standardised beta values indicate that children's ToM and EF provide a significant amount of unique variance to their socialisation skills. Specifically, ToM ($\beta = .35$, $p < .01$) accounted for a larger portion of variance than EF ($\beta = -.32$, $p < .05$).

Table 4.6.

Summary of Hierarchical multiple regression analyses predicting children's social problems and socialisation skills

	Social Problems			Socialisation Skills		
	<i>B</i>	<i>SE B</i>	β	<i>B</i>	<i>SE B</i>	β
Step 1						
Internal behaviours	0.29	0.06	.59***	-0.21	0.19	-.20
Family functioning	1.64	1.98	.10	9.32	5.55	.32
Step 2						
Internal behaviours	0.23	0.06	.46***	-0.06	0.17	-.06
Family functioning	2.87	1.88	.18	6.23	5.25	.18
Theory of mind	0.02	0.07	.04	0.46	0.19	.35**
Ecological EF	0.20	0.06	.39**	-0.35	0.17	-.32*
* $p < .05$, ** $p < .01$, *** $p < .001$						

As both cognitive measures significantly accounted for unique variance in children's socialisation skills, additional hierarchical multiple regressions were run. Firstly, children's socialisation skills were predicted by controlling internal behaviours, family functioning and ToM (Table 4.7) and secondly, by controlling internal behaviours, family functioning and ecological EF (Table 4.8).

Table 4.7.

Hierarchical multiple regression analysis predicting children's socialisation skills from ecological EF, whilst controlling internal behaviours, family functioning and ToM

	Socialisation Skills		
	<i>B</i>	<i>SE B</i>	β
Step 1			
Internal behaviours	-0.21	0.19	-.20
Family functioning	9.32	5.55	.32
Step 2			
Internal behaviours	-0.18	0.18	-.17
Family functioning	8.63	5.31	.24
Theory of mind	0.36	0.19	.28
Step 3			
Internal behaviours	-0.06	0.17	-.06
Family functioning	6.23	5.25	.18
Theory of Mind	0.46	0.19	.35**
Ecological EF	-0.35	0.17	-.32*
* $p < .05$, ** $p < .01$,			

Table 4.8.

Hierarchical multiple regression analysis predicting children's socialisation skills from ToM, whilst controlling internal behaviours, family functioning and ecological EF

	Socialisation Skills		
	<i>B</i>	<i>SE B</i>	β
Step 1			
Internal behaviours	-0.21	0.19	-.20
Family functioning	9.32	5.55	.32
Step 2			
Internal behaviours	-0.14	0.18	-.13
Family functioning	7.90	5.66	.22
Ecological EF	-0.23	0.19	-.21
Step 3			
Internal behaviours	-0.06	0.17	-.06
Family functioning	6.23	5.25	.18
Ecological EF	-0.35	0.17	-.32*
Theory of Mind	0.46	0.19	.35**
* $p < .05$, ** $p < .01$			

Both Tables 4.7 and 4.8 show that together internal behaviours and family functioning significantly accounted for 14% of the variance in children's socialisation skills ($R^2 = .14$, $F(2, 53) = 4.37$, $p < .05$). However, neither variable provided significant amounts of unique variance. As shown in step two of Table 4.7, ToM did not significantly predict any variance in children's socialisation skills after accounting for internal behaviours and family functioning, $\Delta R^2 = .08$, $F_{\Delta}(1, 52) = 5.24$, $p = .06$. However, by adding ecological EF at step three, an additional 8% of variance was significantly explained, $\Delta R^2 = .08$, $F_{\Delta}(1, 51) = 5.83$, $p < .05$.

Furthermore, as shown in Table 4.8, ecological EF, alone, did not significantly predict any variance over and above the effects of children's internal behaviours and family functioning, $\Delta R^2 = .04$, $F_{\Delta}(1, 52) = 2.66$, $p = .20$. However, by adding ToM at step three, an additional 12% of variance was significantly explained, $\Delta R^2 = .12$, $F_{\Delta}(1, 51) = 8.52$, $p < .05$. Thus, the results from Tables 4.7 and 4.8 corroborate the findings in Table 4.6, to show that children's ToM skills account for more variance in their socialisation skills than their ecological EF. The two additional regression analyses add to findings in Table 4.6 by showing exactly how much unique variance each cognitive variable explains. In addition, that after controlling for internal behaviours, family functioning and the alternative cognitive variable, ToM explains an additional 4% of variance over and above ecological EF.

4.5 Discussion

The results of the current study offer partial support for the hypotheses. One was refuted, two were partially supported and two were fully supported. The first hypothesis, which was that familial (as measured by SES and family functioning) and intrinsic (as measured by internal behaviours) childhood variables would jointly account for significant variance in children's social functioning following TBI was partially supported. The current

study suggested that internal childhood behaviours and family functioning are important for social functioning. Specifically, higher levels of dysfunctional internal behaviour were shown to be significantly related to higher levels of social problems, and better family functioning was shown to be significantly related to better socialisation skills. In regard to the predictive nature of this relationship, the regression analyses showed that together, family functioning and internal behaviours significantly accounted for 33% of the variance in children's social problems and 14% of the total variance in children's socialisation skills. In addition, children's internal behaviours accounted for a significant amount of unique variance of children's social behaviours.

This is the first study to investigate the effects of internal factors on children's social functioning following TBI. The results however do support previous research on healthy children which show that internal factors, such as personality, are related to measures of social competence (e.g., Cheek & Buss, 1981; Greco & Morris, 2001). Family functioning has been shown to be an important contributor to children's social outcome following TBI and thus the current study corroborates these previous studies (Yeates et al, 2010; Yeates et al 2004).

However, in contrast to the first hypothesis, SES was not significantly related to either measure of social functioning. This result is dissimilar to previous studies that have shown that lower SES has a negative influence on children's social functioning, both in the short and long term after a TBI (F. Muscara et al., 2009; Yeates et al., 2004; Yeates et al., 2010). One possible explanation for this may be that the current study used a different tool to assess SES. Previous studies (e.g., Yeates et al., 2004) that have shown that SES has a significant effect on children's social functioning post-TBI have relied on a broader measure of SES. Specifically these broader measures not only assess occupational status, but also annual family income and years of maternal education. Past research has also highlighted the

influence of injury characteristics on children's social functioning. The current study suggests that social functioning was not affected by injury severity or time since injury. Although this is different to previous research, which has shown that children with more severe injuries have poorer functioning (Catroppa et al., 2007; Ganesalingam et al., 2011; F. Muscara et al., 2009) and that the child's age at the time of the injury is an important variable for social outcomes (Yeates et al., 2004), it is important to note, however, that the sample of children who participated in the current study differed from those in previous research. The specific nature and potential effect of these differences are discussed below in Section 4.9.4:

Limitations. In summary, the findings from the current study reflect the first component of the SOCIAL model, and seem to suggest that factors intrinsic and extrinsic to the child are important in shaping the emergence of social functioning.

The second hypothesis was that after controlling for familial and intrinsic childhood variables, measures of EF would account for significant variance in children's social functioning following TBI. This hypothesis was supported by the current study, as children's ecological EF skills were shown to provide significant unique and collective contributions to their socialisation skills and social behaviours. Furthermore, ecological EF accounted for a significant 8% of the variance in children's socialisation skills after controlling for internal behaviours, family functioning and children's ToM skills. These findings are akin to the findings of previous research which have shown that children's EF is significantly related to their social functioning following TBI (H. Levin et al., 1997; Mangeot et al., 2002), and also predicts their social functioning (Brookshire et al., 2004; Ganesalingam et al., 2011). The current study adds to the existing literature in this area by addressing this relationship in children with TBI who are aged 7 to 16 years, by including children with mild TBI, and by also using socialisation skills and social behaviours as a measure of social functioning. As explained in Section 3.3, EF is an umbrella term for a range of higher order cognitive

processes. The current study suggests that ecological EF, a concept that measures children's EF in everyday life through the frequency of behavioural manifestations, seems to be important for children's socialisation skills and social behaviours. Specifically, it is likely that this result is a reflection of the fact that children with poor inhibition, emotional control, planning skills and initiation are also likely to have fewer friendships and coping skills and poorer adaptive behaviours. For example, it is thought that a child who cannot inhibit and monitor inappropriate responses or regulate social overtures will have difficulty maintaining interpersonal relations.

Although the concept of EF was hypothesised to predict children's social functioning, the hypothesis about which specific EF measure would be involved in the predictive relationship was exploratory in nature. Thus, the current study aimed to investigate the relationship between all six measures of EF (ecological EF, attentional control, processing speed, cognitive inhibition, cognitive switching and planning) and the two measures of social functioning (socialisation skills and social behaviours). In the current study, ecological EF was the only EF measure to form a significant relationship with either of the two social functioning measures. Specifically, greater ecological executive dysfunction was significantly associated with poorer social behaviours, and performance-based measures of EF were not related to either social functioning measure. This result is akin to those made by Ganesalingam et al. (2011), who found significant associations between parental ratings of both EF and social functioning, but not between performance-based EF measures and parent reports of social functioning. Ganesalingam et al. (2011) pointed out that the relationship may be confounded by the nature of the tools used to measure these constructs. That is, significant relationships were only found between concepts that were assessed by parental report. If children's EF abilities are truly a predictor of social functioning, one would expect to also find significant relationships between the performance-based EF and parent-rated

social functioning measures. However, Ganesalingam et al. (2011) claim that performance-based EF measures differ to behavioural ratings of EF since the former lack ecological validity. That is, the highly structured environment where such tests are administered differs to everyday social contexts where children exhibit difficulties with such skills, and thus performance-based tests may not be an accurate reflection of a child's true ability. Thus it is possible that the current result reflects the type of assessments used to measure the constructs. Alternatively, it is possible that social functioning is only truly predicted by aspects of EF that reflect everyday life, such as those demonstrated in the BRIEF, and not by purer neuropsychological EF abilities. In summary, as EF is a broad concept measured by a range of skills and abilities, it appears that only certain facets of EF play a role in children's social functioning following TBI and this is possibly why the literature is rife with inconsistency.

Another possible explanation relates to the possibility of a mediating role of social problem-solving skills. F. Muscara, Catroppa, and Anderson (2008) showed in a paediatric TBI sample that greater executive dysfunction was associated with poorer social functioning; a relationship mediated by a more immature level of social problem solving skill. Thus, it is possible that the non-significant relationships found in the current study between the performance-based EF measures and social functioning was a reflection of a third mediating variable such as the child's social problem-solving skills. In summary, the current study has shown that a rating of children's ability to use EF in everyday life, following a TBI, may be important in determining their social behaviour, the quality of their interpersonal relationships and coping skills, as well as their participation in play and leisure activities.

The current study did not support hypothesis three, which was that after controlling for familial and intrinsic childhood variables, measures of pragmatic language would account for significant variance in children's social functioning following TBI. Children's pragmatic language skills did not significantly correlate with either of the two social functioning

measures, and it was therefore not included in the subsequent regression analyses. This finding does not corroborate previous research, which has shown significant relations between children's language and social skills post TBI (Hanten et al., 2008; Yeates et al., 2004). Similar to the current study, Yeates et al. (2004) used the screening composite score from the Test of Language Competence-Expanded edition (TLC-E; Wiig & Wayne, 1988) as a measure of pragmatic language, to show that it is a significant predictor of children's social information processing, levels of social problems and social adaptive functioning, as rated by the child's parents. It is therefore surprising that the current study's results do not corroborate the findings of Yeates et al. (2004). One possible explanation may be that unlike the current study, Yeates et al. (2004) investigated the effects solely in children with moderate and severe TBIs. This possible limitation is further discussed in Section 4.9.5. Alternatively, as only a handful of studies have investigated this relationship in a sample of children with TBI, it is possible that the current study is accurate and the findings of past research have been confounded by extraneous variables. For example, although Yeates et al. (2004) controlled for group membership, age, race, SES and IQ, their study did not account for family functioning or children's internal behaviours, two factors shown to have a significant effect on children's social functioning. Thus, it is possible that the significant relationship shown in past research is a reflection of the effect that internal and external factors have on social functioning. In summary, the current study suggests that children's pragmatic language skills are not important for their social functioning skills, once the effects of internal behaviours and family functioning have been controlled.

The current study supported the fourth hypothesis, which was that after controlling for familial and intrinsic childhood variables, measures of social cognition would account for significant variance in children's social functioning following TBI. The results indicate that ToM, but not affect recognition, played a significant role in children's socialisation skills and

social behaviour. Specifically, after controlling for intrinsic and extrinsic factors, ToM and EF jointly and significantly accounted for 14% of the variance in children's social problems. Theory of mind was not a unique predictor of social problems. With regard to children's socialisation skills, ToM and EF jointly and significantly accounted for 16% of the variance. Theory of mind was shown to be a unique predictor, and was also shown to account for a significant 12% of the variance in children's socialisation skills after the effects of internal behaviours, family functioning and ecological EF were removed. These results are similar to past research which has shown that ToM predicts social behaviours in typically developing children (Jenkins et al., 2000), children with autism (U. Frith & Frith, 2003; Hill & Frith, 2003; Sabbagh, 2004) and children with schizophrenia (Brune, 2005b; Harrington et al., 2005). Although the current study is the first to examine the relationship between ToM and social functioning in children with TBI, Milders et al. (2008) investigated this relationship in adults with TBI. Their findings did not support a significant relationship between the two, and highlighted the broad nature of the two concepts. Unlike Milders et al. (2008) the current study used the NEPSY-II as a measure of ToM, a test that assesses children's understanding of others' perspectives, intentions and beliefs, and includes both a contextual and verbal section, as well as measures of both socialisation and social behaviours as a measure of social functioning. Thus, it is possible that the current study did not concur with the findings of Milders et al. (2008) due to the nature of the assessment measures employed. It may also be the case that the relationship between ToM and social functioning differs between children and adult populations, particularly given the developmental trajectory of ToM.

In summary, this is the first study to investigate the relationship between ToM and social functioning in children with TBI, and the current findings therefore add to the body of literature on socio-cognitive outcome following paediatric TBI. The result indicates that being able to understand another person's thoughts, intentions and desires may be an

important skill to master to be able to function appropriately in a social world. Appropriate social functioning entails effective social interaction which requires a range of skills including the ability to recognise how others are feeling and understand that people's beliefs and intentions may not match their verbal output (e.g., sarcasm, false belief).

Although hypothesis four predicted that children's social cognition would significantly influence their social functioning, it also stipulated that the specifics of which type of socio-cognitive measure would be a significant predictor was exploratory in nature. The results of the current study showed that ToM was an important predictor, but affect recognition was not. This latter finding supports previous research which has explored the relationship between affect recognition and social behaviour, showing non-significant relationships in children with TBI (Hanten et al., 2008) and adults with TBI (Milders et al., 2008). Although it is plausible that affect recognition is an important skill to master in order to function well in a social world, it appears that higher-order social cognitive skills, such as ToM, are more important. It may be that recognising another's emotions from their facial expressions is an easy task to master in a neuropsychological test environment and is not an accurate reflection of the socio-cognitive skills required in daily social life.

The fifth hypothesis was that after controlling for familial and intrinsic childhood variables, measures of EF, pragmatic language and social cognition would jointly account for a significant amount of variance in children's social functioning following TBI. This hypothesis was partially supported. Measures of EF and social-cognition made significant unique and joint contributions to children's social functioning. However, measures of pragmatic language were shown to play no significant role in their social functioning.

The current study suggested that children's social problems are significantly predicted by a range of factors. As a whole, children's internal behaviours, family functioning, ToM

skills and their ecological EF significantly accounted for 47% of the variance in social problems. Specifically, children's internal behaviours and ecological EF made significant unique predictions. When controlling for the effects of internal behaviours and family environment, it was found that the two cognitive variables significantly accounted for 13% of the variance in the rating of children's social problems. In regard to children's socialisation skills, the results showed that in combination, children's internal behaviours, family functioning, ToM skills and ecological EF significantly accounted for 14% of the variance. Specifically, the two cognitive factors made a significant unique contribution. Whilst controlling for the effects of the remaining three variables, the results showed that children's ToM skills significantly accounted for 12% of the variance in children's socialisation skills, and ecological EF significantly accounted for 8%. Therefore, the results of the current study offer partial support for the SOCIAL model, and suggest that the emergence of social skills may be dependent upon a set of biopsychosocial factors, including the child's environment, behaviour and cognitive abilities. This study is the first to operationalise the SOCIAL model in its entirety and thus additional research is needed to confirm the findings.

In addition to investigating the predictors of social functioning, the SOCIAL model proposes a series of bidirectional inter-relationships between each of the variables within the model, at both a behavioural and neural level. These relationships are discussed in the following subsections. No specific hypotheses were made in regard to these relationships since they are not directly involved in the prediction of social functioning; however, they are included in the current thesis since they are involved in the operationalization of the SOCIAL model.

4.5.1 Social Cognition

The current study used two measures of social cognition, affect recognition and ToM. Neither of these two variables significantly correlated with any of the attention-EF or communication measures. With regard to affect recognition, this non-significant result contrasts with the findings by Ietswaart et al. (2007) and Milders et al. (2008) who found significant correlations between emotion recognition and EF in adults with TBI. However, only one study to date (Tonks et al., 2007b) has investigated this relationship in children with an ABI. They found variability of results, since of the seven neuropsychological measures used in the assessment battery, only two (cognitive flexibility and visuospatial discrimination) were significantly related to children's ability to recognise angry and neutral faces. One possible explanation as to why the current study did not confirm these findings may be related to the nature of the assessments. That is, in the current study facial recognition skills were measured as a broad construct, and not in relation to specific facial expressions. Furthermore, the current study focused on EF, rather than on a broad range of neuropsychological skills such as visuospatial discrimination. Thus, overall the current study has added to the body of literature in this area by suggesting that EF and pragmatic language are not strongly correlated to children's affect recognition following TBI.

With regard to ToM, the current findings are inconsistent with previous research, which has shown significant relations between ToM and language skills in typically developing children as well as in children with autism, specific language impairments, deafness and right hemisphere brain damage (Astington & Jenkins, 1999; de Villiers, 2005; Miller, 2001; Ruffman et al., 2003; Tager-Flusberg & Joseph, 2005; Winner et al., 1998; Woolfe et al., 2002). It is important to note however, that these studies measured general language skills rather than pragmatic language. Although Bibby and McDonald (2005) suggested a significant relationship between language and ToM in children with TBI, their

study failed to explicitly measure children's language skills. Therefore, the current study is the first to measure the relationship between children's ToM and pragmatic language skills following TBI. The result suggests that the two concepts are not significantly related. In a similar vein, the current study also found that children's ToM and EF skills were not significantly related. As discussed in Section 4.2.2.2, this relationship is a contentious issue in the neuropsychological literature and the current study supports the findings of Havet-Thomassin et al. (2006) and Rowe et al. (2001) by showing that ToM and EF are independent. Similar findings in paediatric ABI cohorts were reported by Tonks et al. (2007b) and Snodgrass and Knot (2006). In summary, the diffuse nature of TBI and the inherent difficulty of measuring a broad concept such as EF and ToM are attributed to the literature's inconsistent findings (Geraci et al., 2010; J. Henry et al., 2006; Milders et al., 2008).

4.5.2 Communication

The current study used a measure of pragmatic language to assess children's communication abilities following TBI. Children's pragmatic language skills were significantly and positively related to two cognition domains, processing speed and cognitive switching. This indicates that children with TBI who had a better understanding of the meaning of speech also had faster processing speed and greater cognitive switching abilities. Although past research has not shown these two specific EF skills to be correlated with pragmatic language following paediatric TBI, research has shown significant correlations with other facets of EF. In particular pragmatic language has been shown to be significantly related to measures of children's verbal fluency and abstract reasoning (S. Chapman, 1995), and their planning and organisation skills (Brookshire et al., 2000). Thus, the current study adds to the body of literature in paediatric TBI by showing that pragmatic language is perhaps related to a range of EF skills. Specifically, the results indicate that children's ability

to understand the gist and meaning behind a conversation is related to the child's ability to process the dialogue of conversation quickly (i.e., processing speed) and to be able to switch between topics in a conversation (i.e., cognitive flexibility).

4.5.3 Attention-EF

The current study included six measures of attention-EF. These included measures of attention, processing speed, planning, inhibition/flexibility and ecological EF. Children with greater attentional control were shown to also have faster processing speed and cognitive switching abilities, and children with faster processing speed were shown to have greater cognitive inhibition and cognitive switching. Finally, children with greater cognitive inhibition were also shown to have greater cognitive switching abilities and fewer ecological executive dysfunctions. These results highlight the integrated nature of EF and support Anderson's (2002) claims in regard to the inter-dependent nature of the EF components. The correlational results between EF and the measures of communication and social cognition are discussed above in Sections 4.5.1 and 4.5.2.

4.5.4 Limitations and Suggestions for Future Research

Despite the promising results in the current study, there are several methodological considerations that need to be discussed. Foremost, the study's participants included 91% of children with a mild TBI. Although this statistic reflects the proportion of mild paediatric TBIs presented to emergency departments in Australia (L. Crowe et al., 2009), it should be noted that social, cognitive and behavioural deficits are more likely to occur following a moderate or severe TBI (V. Anderson et al., 2006; V. Anderson et al., 2004). This limitation was raised in Section 4.5, in regard to the first and third hypotheses, but is applicable to all of the findings. The high proportion of mild injuries may also explain why participants in the current study did not display significantly low scores on all of the measures, but rather were

performing within the average ranges. Although this suggests that future research should attempt to operationalise the SOCIAL model using children with moderate and severe TBIs, it is also important to note that the theoretical underpinnings behind the SOCIAL model should also apply to the development of social functioning in typically developing children and therefore the severity of the children's injuries should not influence the predictive relationships observed. The current sample was also limited in size and thus statistical methods were restricted. To operationalise the SOCIAL model, it would be ideal to implement a structural equation model (SEM) where causal relations between latent constructs could be measured. Therefore, future research should attempt to operationalise the model with a larger sample, which includes more children with moderate and severe TBI, in order to confirm the existence of the inter-twining relationships within the SOCIAL model. In addition to children with TBI, it would also be beneficial to operationalise the model in other clinical groups, such as children with autism or schizophrenia.

Secondly, the current study did not take children's pre-morbid abilities into account. Although this factor is not included within the SOCIAL model, past research has shown that children's pre-injury adaptive abilities are a significant and important factor in determining their functioning post injury (V. Anderson et al., 2006). Specifically, pre-injury behavioural characteristics and adaptive functioning have been shown to be important in predicting post injury behaviours, family functioning and adaptive functioning in children with TBI (Anderson et al., 2001, Anderson et al., 2005, Yeates et al. 2005). As pre-injury status was not examined in the current study, it is impossible to know whether it affected the relationships that were measured, and if so how. Future research should therefore consider including this variable when operationalizing the SOCIAL model.

4.5.5 Implications

The current study investigated the predictive ability of a range of social, cognitive, family and behavioural variables, and showed that four variables significantly predict children's social functioning post TBI. It is interesting to note that of the four significant variables, three were parent ratings and only one was measured by the child's performance. This may have implications for future research, as it suggests that parent ratings are perhaps more reliable than children's performance measures when investigating the predictors of social functioning in TBI samples. This is important to note given that parent questionnaires are easier and less time consuming to administer in comparison to child-based performance tasks.

The current study is important in terms of understanding how children's social functioning develops as well as gaining a solid understanding of which factors and skills are important for a child to be able to function in a social world. Specifically, the current study showed that family functioning, internal behaviours, ecological EF and ToM are all important factors to consider with regard to social functioning. Having a greater understanding of social functioning has implications for improving the quality of life of people who experience various degrees of social dysfunction since the specific areas that need to be addressed can be identified more easily and thus targeted in rehabilitation and therapy. Furthermore, this was the first known study to investigate the relationship between ToM and social functioning in children with TBI, despite many claims that ToM is an important developmental milestone in a child's social development (Tonks et al., 2007b; Walz et al., 2009; Wellman et al., 2001). In light of these findings, Study 2 of the current thesis aims to further explore ToM in children with TBI.

CHAPTER 5: Study 2

As highlighted in Study 1, and in accordance with Beauchamp and Anderson's (2010) SOCIAL model, children's social cognition is an important predictor of social functioning. Social cognition involves an individual perceiving, understanding and interpreting a range of social cues and stimuli (R. Adolphs, 2001; Beauchamp & Anderson, 2010) and thus involves an element of both emotion recognition and theory of mind (ToM). As summarised in Section 3.2, ToM refers to one's ability to think about another person's mental states, such as their thoughts, beliefs, intentions and desires (Bibby & McDonald, 2005; Perner & Lang, 2000). It has been contended that there are two types of ToM: cognitive and affective (J. Henry et al., 2006). Cognitive ToM refers to individuals making inferences about another person's cognitive state (e.g., their intentions, desires and beliefs), whilst affective ToM requires an individual to be able to infer another's feelings and motivational states (e.g., happy or sad, attracted or repelled, and friendly or hostile). Facial expression identification tasks do not simply measure affective ToM since more complex distinctions are often made and affective ToM involves an element of inference through social interaction. The 'Reading the Mind in the Eyes' test, as described in Section 3.3, measures affective ToM as it requires individuals to look at a picture of a person's eyes and infer what is being thought or felt (Tonks et al., 2007b; Tonks et al., 2008). Although this task is designed to measure affective ToM (J. Henry et al., 2006), it appears more similar to emotion recognition tasks, since it requires individuals to identify an emotion from the eyes of a facial expression. Furthermore, it fails to incorporate an element of inferring social interaction. Thus, there is clearly a need for the development of a task that provides a purer assessment of affective ToM by making inferences through social interaction and that also controls for cues given through facial expressions.

As discussed in Section 3.2, tasks designed to measure an individual's social cognition have relied on an element of emotion recognition and/or ToM. These tasks have been presented in various formats, including visually or verbally, and research has recently investigated the importance of task modality (Bibby & McDonald, 2005). The following sections will discuss the influence of task modality on social cognition, in both healthy individuals and individuals post TBI.

5.1 Emotion Recognition: Effect of Task Modality

Emotion recognition tasks have highlighted the importance of spoken language, showing a label-superiority effect. A label-superiority effect refers to one's ability to demonstrate more accurate emotional knowledge when presented with the verbal label for an emotion, as opposed to a picture/photograph of the facial expression. This effect is evident in verbal tasks where children are told emotion-eliciting stories (Camras & Allison, 1985), are asked to complete an emotion-eliciting story (Russell, 1990; Russell & Widen, 2002) or to specify a cause for the emotion (Widen & Russell, 2004), as well as in non-narrative tasks where pictures tell the story and labels are used to identify the answer (Widen & Russell, 2002). Although research suggests that children recognise emotions more accurately for labels in both verbal and non-verbal tasks, it is not known whether verbal or non-verbal tasks provide children with greater emotional knowledge.

Researchers examining the emotion recognition abilities of individuals following TBI have also used an array of tasks. McDonald and Saunders (2005), Knox and Douglas (2009) and Williams and Wood (2010) suggest that adults with TBI are able to recognise emotions more accurately from visual-dynamic scenes, such as short videos, as opposed to visual-static scenes, such as photographs or pictures of faces. It is suggested that this difference is a result of the presence of additional cues available in the dynamic displays, which often provide the

observer with context. Croker and McDonald (2005) showed that adults with TBI were able to recognise emotions more accurately when the emotion was presented in context, through the use of a story, as opposed to emotions that were presented without context. Alternatively, the finding that individuals with TBI use visual-dynamic scenes better than visual-static scenes to process emotions, may be a result of different neural systems being used to process the dynamic and static information. Since dynamic information is typically processed in the parietal lobe and static information is processed by the limbic system, temporal lobes and medial frontal cortices (R. Adolphs et al., 2003), it is possible that the differences seen between static and dynamic displays were a result of the TBI itself, since TBI typically affects the frontal and temporal lobes (S. Crowe, 2008).

Despite the large amount of research using both visual and verbal stimuli for emotion recognition tasks with TBI populations (Croker & McDonald, 2005; Kucharska-Pietura et al., 2003; Marquardt, Rios-Brown, Richburg, Seibert, & Cannito, 2001; Milders et al., 2003), only a handful of studies have actually compared performances between visual and verbal modalities (Zupan, Neumann, Babbage, & Willer, 2009). Furthermore, such studies have only been conducted with adult TBI populations, and so there is a need for research on children with TBI in this area. In a study of adults with TBI, Spell and Frank (2000) compared visual and verbal emotional stimuli of both children and adults, using pictures of old/young faces and verbal prosody of old/young voices. The results were mixed, as adults with TBI were able to recognise significantly more emotions when the emotion was presented visually (static faces) as opposed to verbally (prosody) when faces/voices of children were used. However, they were better at recognising emotions verbally when faces/voices of adults were used. In comparison, McDonald and Saunders (2005) showed that adults with TBI were able to accurately recognise significantly more emotions from the faces of adults than from the voices of adults. This later finding supports Spell and Frank's (2000)

claim that emotions are easier to recognise when they are presented visually, due to the concrete-static nature of photos, as opposed to through verbal prosody. McDonald and Saunders (2005) claim that this finding is a result of higher cognitive demands being required in the verbal condition, namely executive functions and processing speed (both of which are affected by TBI). It is also important to note that these verbal tasks used prosody to convey emotions. Despite the mixed findings in adults with TBI, comparisons are yet to be made in a paediatric TBI population. That is, in comparison to healthy controls, children with TBI have only been shown to have difficulty recognising emotions from facial expressions and vocal prosody (Tonks et al., 2007b), from verbal vignettes, facial expressions and visual scenes (Pettersen, 1991), as well as at selecting and matching facial emotional expressions (Tonks et al., 2008).

5.2 Theory of Mind: Effect of Task Modality

Emotion recognition tasks are similar to affective ToM tasks in that individuals are asked to recognise and identify an emotion. However, affective ToM tasks are more complex than emotion recognition tasks, and contain an element of inferring information from social interactions. As noted in Chapter 3, research has introduced various tools to measure children's ToM, including both visual and verbal based tasks. Whilst the majority of ToM tasks are presented through a verbal story (e.g., Dennis et al., 1998; Rowe et al., 2001), a small number of studies have incorporated a non-verbal component, generally in the format of cartoons (Bibby & McDonald, 2005; Gallagher et al., 2000; Sarfati, Passerieux, & Hardy-Bayle, 2000).

The medial prefrontal cortex has been shown to be activated in both story- and cartoon- based ToM tasks in healthy individuals (Gallagher et al., 2000). Despite this evidence, only a few researchers have compared ToM performance across task modality.

Bibby and McDonald (2005) compared healthy controls and adults with TBI on verbal and visual ToM tasks. In the visual cartoon condition, adults were shown a single cartoon and were asked to make inferences about a character's false belief and a non-mental inference (i.e., inferences about physical causation). In the verbal story condition, adults were told a short story and were also asked questions about the character's false belief and a non-mental inference question. Non-mental inferences were seen to be important to assess, in order to clarify whether any deficit present is specific to social reasoning. Their study showed that both healthy controls and adults with severe TBI achieved significantly lower scores on the cartoon ToM task than the verbal story ToM task. With regard to the non-mental inference tasks, adults with TBI performed significantly more poorly than controls for both the visual and verbal tasks. Furthermore, both TBI and control groups were significantly better at the non-mental inference task than the second-order false belief tasks. In summary, this suggests that TBI results in a general deficit in inference-making and problem solving. However, Bibby and McDonald failed to keep the storyline consistent across the visual and verbal tasks, which may have caused the visual tasks to be harder to interpret than the verbal tasks since the length and content of the tasks differed.

A study by Kobayashi, Glover, and Temple (2007), comparing visual and verbal ToM performance in healthy adults and children, did keep the two tasks consistent with regard to content. Kobayashi et al. showed that both children and adults were able to infer the thoughts and beliefs of characters significantly better when a task was presented verbally as opposed to visually. Thus, the results of both Kobayashi et al. and Bibby and McDonald concur that cognitive ToM is easier when the task is presented verbally, as opposed to visually. However, both studies failed to control for verbal ability; an important issue given that past research has consistently shown that verbal ability significantly influences emotional understanding (Egan, Brown, Goonan, Goonan, & Celano, 1998; Hanten et al., 2008; Herba & Phillips, 2004;

Lepannen & Heitanen, 2001), and specifically performance on ToM tasks (Astington & Jenkins, 1999; Ruffman et al., 2003). Furthermore, the ToM task used in both studies assessed cognitive ToM, as individuals were required to infer characters' thoughts and beliefs, and thus the effect of modality on affective ToM remains unknown.

5.3 Development of Emotional Understanding

As summarised in Chapter 3, children's socio-cognitive abilities generally improve with age. A popular measure of cognitive ToM is the false belief task, a task that requires individuals to be able to understand that others have a belief different to their own. It is generally accepted that three-year-olds fail false belief tasks, but in typically developing children such tasks are mastered by four to five years of age (Baron-Cohen et al., 1985; Wellman et al., 2001). Affective ToM, often measured by the 'Reading the Mind in the Eyes' test, has also been shown to improve with age. When developing the test, Baron-Cohen, Wheelwright, Scahill, Lawson, and Spong (2001) showed that children improved significantly with age. Specifically, ten- to fourteen-year-olds performed significantly better than children aged between six and ten years. This is the only known study to investigate the development of affective ToM skills in children, and thus further research is warranted. Although significant developments in emotion recognition have been observed in children between three-and-a-half and five years (Boyatzis, Chazan, & Ting, 1993), there is a lack of research assessing the development of affective ToM in this younger age range.

5.4 Aims and Hypotheses

The primary aim of this study was to gain a greater understanding of children's affective ToM abilities in both healthy controls and children with TBI, by examining the effect of visual versus verbal task modality. As noted above, researchers assessing affective ToM have failed to use tasks that involve an element of inferring emotional states from social

interactions. Thus, this study aimed to develop such a task. As recognised by Bibby and McDonald (2005), such a task should incorporate a non-mental inference component to determine whether impairment is specific to social reasoning. Therefore, by using a story book that is comprised of either words or pictures, the aim of this study was to investigate the difference between children's use of pictorial and narrative cues in their understanding of a story book's emotional and factual content.

It was hypothesised that:

1. Children with TBI would have significantly worse understanding of the story book's factual and emotional content than typically developing children.
2. Both typically developing children and children with TBI would have a greater understanding of the story book's emotional content from the narrative cues rather than from the pictorial cues.
3. Both typically developing children and children with TBI would have an equal understanding of the story book's factual content from the narrative and pictorial cues.
4. Children's emotional and factual understanding of the story book would significantly improve with age.

5.5 Method

5.5.1 Participants

Participants were 76 children between the ages of 4 and 6.5 years ($M = 65$ months, $SD = 6.51$). There was a total of 39 males and 37 females. Typically developing children ($n = 59$)

were recruited from public primary schools in the Hobart area and had a mean age of 5.48 years (65.73 months; $SD = 5.98$). Various local schools were contacted and invited to participate in the research. Three schools agreed to participate and children were recruited into the study if their parent returned the consent form to the classroom teacher. Children with TBI ($n = 17$) were recruited from emergency presentations at the Royal Hobart Hospital (RHH) between January 2009 and September 2011. Families were initially contacted by an RHH staff member to determine if they were interested in hearing more about the study from the researchers. Of those who agreed to be contacted ($n = 50$), 17 participated in the study. The parents of the remaining 33 children were either unable to be contacted ($n = 16$), chose not to participate ($n = 16$) or were excluded based on the following criteria: the child had (i) a first language was not English ($n = 0$) (ii) a history of a neurological and/or neurodevelopmental condition (e.g., autism, epilepsy) ($n = 0$), or (iii) experienced more than one severe TBI ($n = 1$). The final group of children with TBI had a mean age of 5.21 years (62.47 months; $SD = 7.76$).

Within the TBI group, children's families were contacted to participate in the research as soon as practical. Children were therefore assessed at various times post injury; ranging between two and 32 months post injury ($M = 17.88$ months, $SD = 9.78$). As in Study 1, injury severity was classified as mild, moderate or severe according to the child's GCS scores and/or PTA scores on their RHH file. There were ten (59%) males and seven (41%) females, and there were 16 (94%) mild injuries and one (6%) severe injury. Both of these statistics are consistent with previous research which indicates that males are more likely than females to sustain a TBI, and mild injuries are more prevalent than moderate or severe injuries (L. Crowe et al., 2009; Kraus, 1995).

5.5.2 Materials and Procedure

Prior to commencement of the study, informed consent forms were signed by the School Principal (for typically developing children, who were assessed at school) and the child's parent/guardian. The Peabody Picture Vocabulary Test –third edition (PPVT-III; L. Dunn & Dunn, 1998) was administered first, according to the manual's instructions (L. Dunn & Dunn, 1998), followed by the story book (see below).

5.5.2.1 Receptive Vocabulary

The PPVT-III is a non-verbal multiple choice measure of receptive vocabulary that has satisfactory reliability, with test-retest coefficients ranging between .91 and .94 (L. Dunn & Dunn, 1998). When administering the PPVT-III, the experimenter read a word aloud and the participant was required to point to/identify which one of the four pictures depicted the spoken word. Standard scores were derived, based on the child's age. Scores were used as a measure of receptive vocabulary and an estimate of verbal intelligence (Lindner & Rosen, 2006; Pettersen, 1991).

5.5.2.2 The Story Book

The story book was developed by the experimenter and depicted typical events at a child's birthday party (e.g., a girl called Sally receiving presents from her friends). Two versions of the same story were created, one with pictures only and the other with words only. Children were randomly allocated to either condition, with approximately half of the typically developing group and half of the TBI group allocated to each condition. The story had six episodes, and each episode was designed to elicit one of the six basic emotions in one of the story's characters (happiness, sadness, anger, disgust, surprise and fear). An example of the 6 episodes can be seen in Table 5.1 and the complete visual and verbal versions are shown in Appendix B, Tables B1 and B2.

Table 5.1.

Example of the six episodes in the birthday story and the emotion intended to be elicited.

Episode	Emotion
Sally is having a birthday party and all of her friends come to the party.	Happiness
Sally's mum drops the birthday cake on the floor and it falls to pieces.	Sadness
Lucy is building a big sand castle. As she finishes, Tom comes over and kicks it down.	Anger
Ben is playing with a box. All of a sudden it pops open and the Jack jumps out of the box.	Surprise
Ben is hiding behind the couch, and then running away from Sally's pet bird whilst the other children are playing with it.	Fear
Sally and Tom are eating birthday cake. Tom eats too much cake and vomits on his shoes whilst standing next to Sally.	Disgust

Both the verbal and pictorial conditions of the story were developed with the aim of presenting the child with the same information; the only difference being the style of presentation. In the words-only condition children were told the story verbally by the experimenter, in a neutral tone, whilst the child looked at a blank page in the book. The pages of the book were turned by the experimenter. Each episode consisted of two to three brief sentences, with a mean of 27.5 words per episode. In the pictures-only condition, children were shown the entire story in pictures. Each episode contained two illustrated scenes, each shown on a separate page in the book. The experimenter often gave comments such as “*Oh,*

look” to direct children’s attention to the pictures as she turned through the pages, but otherwise no verbal input was provided. The experimenter maintained a neutral facial expression during this period.

At the end of each visual and verbal episode, all children were asked both a fact- and an emotion- based question (described below). Therefore, every child was asked 12 questions in total; six emotion-based and six factual-based. To ensure that children’s answers to the questions were a true reflection of their knowledge, and not from information gained directly within the book, care was taken to ensure that there were no fact and emotion based cues explicitly available in either condition of the story book. Specifically, characters’ facial expressions were removed in the pictorial condition, and comments about the character’s feelings or facial expressions were avoided in the verbal condition. Similarly, no pictorial or verbal clues were provided which would allow children to answer the factual questions, and participants therefore had to infer meaning from the pictures or words. Thus, children were required to rely on their factual and emotional knowledge of the world to accurately answer the questions. As an example, the episode of the pictorial condition intended to elicit happiness can be seen in Figure 5.1. In the verbal condition, the experimenter read the script *“It is Sally’s birthday. She is having a party. Sally’s friends come to the party and they all bring her a present”*.

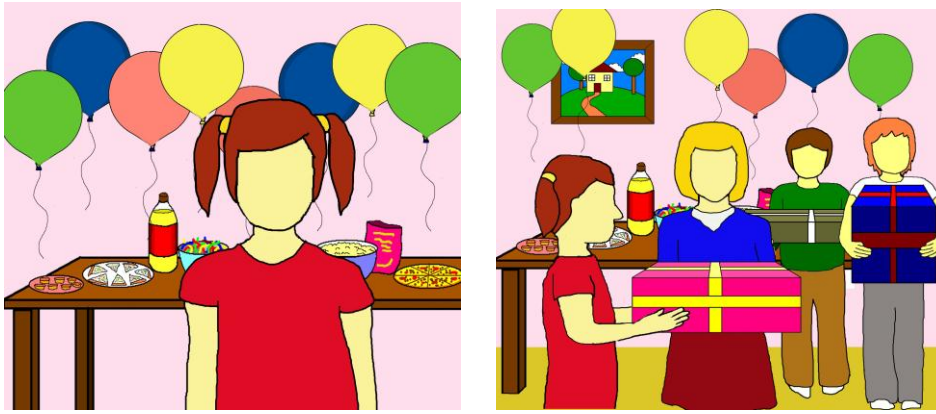


Figure 5.1. Example of the “happy” episode in the picture condition

Following presentation of the two pictures/short sentences, children were asked two questions for each section; one emotional and one factual question. In the example above, intended to depict a happy emotion, the factual question asked children what accessory (not shown in the picture) they thought Sally would wear, and the emotional question asked them how they thought Sally would feel. Children were asked to point to the correct answer by choosing between the four alternative pictured answers (see Figure 5.2). Specifically, in the emotion question, children were asked to point to one of four facial expressions, and in the fact question they were asked to point to one of four objects.

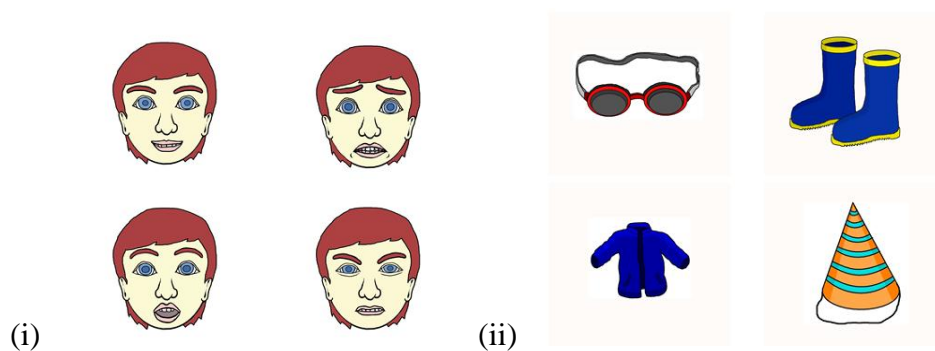


Figure 5.2. Example of the four alternative answers to the (i) emotion question, and (ii) fact question in the “happy” episode.

Children were asked to point to the answer, rather than to produce a verbal response. This was because we did not wish to make the task relatively more difficult for children with TBI, who have been shown to have poor language expression and word finding skills (V. Anderson et al., 2004; V. Anderson et al., 1997; Morse et al., 1999). Care was taken when developing the four alternative choices within each episode to ensure that there was no ambiguity with answers. For example, it is possible that Lucy could feel sad or angry when her sand castle was knocked down by Tom. However, as the four alternative choices were limited to angry, scared, disgusted, and surprised, the most likely response is angry. Children scored one point for an accurate response, and they therefore could score up to a total of six for the fact questions and six for the emotion questions. Children's raw scores were converted to percentages.

The story book was designed by the experimenter, and the illustrations created by an assistant using the computer program Paint. The pictured scenes used child characters, and not adults, since posed expressions by adults are described as idealized and prototypic (Boyatzis et al., 1993), and have been shown to be more difficult for children to interpret (Spell & Frank, 2000). Furthermore, the facial expressions (see Figure 5.3) shown in the question sections were gender-neutral and did not represent any one particular character from the story book. This was done to ensure that children's answers were a reflection of their abstract understanding of emotions. Furthermore, care was taken to focus on the emotive features that distinguish the various facial expressions; the eyes, eyebrows, and mouth (L. Sullivan, Kirkpatrick, & MacDonald, 1995).

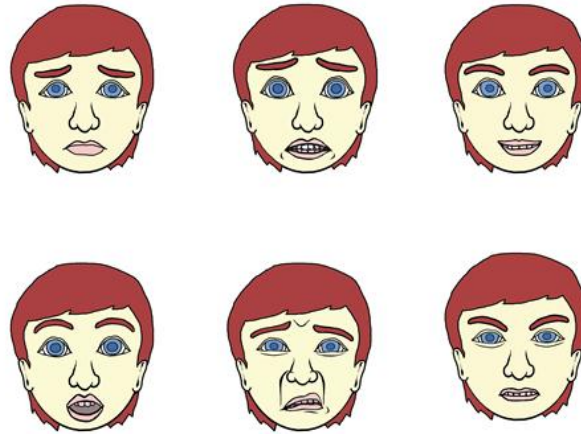


Figure 5.3. The six facial expressions used for the story book's emotion-based questions (Top row: sad, scared and happy. Bottom row: surprised, disgusted and angry)

The six emotive faces (happy, sad, angry, surprised, scared and disgusted) were piloted on 55 undergraduate university students. Students were shown the six facial expressions and were asked to write which emotion was being depicted for each. Four of the faces – happy, sad, angry, and scared – were clearly recognised, in that at least 95% of respondents came up with the intended facial expression. The faces representing the most difficult facial expressions to depict out of the six, surprised and disgusted, were more ambiguous, in that only 56% and 4% of students suggested these intended facial expressions, respectively. Thus, in an attempt to make these expressions clearer, the drawings were slightly altered to accentuate the intended expressions. The final six facial expressions were subsequently piloted on 10 different university students. All 10 students correctly recognised the six emotions, indicating that the final illustrated facial expressions appropriately reflected the desired emotion.

Two versions of each story book were created to counterbalance the presentation order of the episodes and the positioning of the four alternative answers. Participants within each condition were randomly allocated to one of the two versions. Consistent with previous

research (e.g., Widen & Russell, 2002a), the child was always presented with the happy section first as a way of enhancing the child's confidence when answering the questions. Presentation time was approximately 10 minutes for both the pictorial and verbal book. This meant that the demands on short term memory, when answering questions for each story type, should also have been approximately equal.

Both the pictorial and verbal conditions of the entire story book, including the 12 questions (six emotion-based and six fact-based), were piloted on 17 university students, 10 of whom were involved in the pilot for facial expressions. Students were shown/told the stories and were required to answer the questions by pointing to the illustrated facial expressions and objects. All 17 students correctly answered the 12 questions for the verbal story, and 16 correctly answered the 12 questions for the pictorial story. This near-perfect performance suggests that adults understood both the verbal and visual conditions of the story book equally well, and found both the fact and emotion questions to be relatively unambiguous.

5.5.2.2.1 The Story Book: Emotion Recognition

To ensure that children were able to recognise each facial expression, an emotion recognition element was added to the end of the story book. This section of the story book was developed after some typically developing participants had already been tested and therefore the total number of children included in the emotion recognition analyses was reduced ($n = 51$ out of 76). This component of the book comprised of six pages, with each page showing the six facial expressions in a random array. Children were told the emotion label, and were asked to point to the facial expression that depicted that emotion. This method was repeated for each of the six emotions; however each label was said with a new page of facial expressions. Although the same six expressions were presented, the location of

each face changed on the page. This was done in an attempt to reduce the chance of children choosing faces through a process of elimination. Children's answers for accuracy of emotion recognition were scored out of six and converted to percentages.

5.5.3 Design and Analyses

Results were analysed using SPSS statistical package (IBM SPSS statistics package 20.0, 2011). Prior to all analyses, the data were assessed for the assumptions of a multivariate analysis. Children's scores for the emotion and fact questions were converted to z -scores. Absolute values greater than 3.29 were deemed to be significant outliers at $p < .001$ (Field, 2005), but no such outliers were identified. The assumption of normality was met for the emotion question, as determined by inspection of histograms and normal Q-Q plots. Although performance on the fact question was negatively skewed, this reflects children's high performance on these questions and is thought to be an accurate reflection of the population. Furthermore, since ANOVAs are robust to the assumption of normality (Tabachnick & Fidell, 2001), the data were not transformed as adjustments would lose valuable information. Finally, the assumption of homogeneity of variance was met for each of the analyses described below on the premise that Levene's test was non-significant or that the variance ratio was less than two (Field, 2005).

Unless otherwise stated, all significance levels were reported at $p = .05$ or better. Effect size was measured by Partial Eta Squared (η^2) with .01 a small effect, .25 a medium effect and .40 a large effect (Tabachnick & Fidell, 2001). All raw data can be found on the attached DVD under Study 2.

5.6 Results

5.6.1 Analysis of Variance

A 2 x 2 x 2 mixed design Analysis of Covariance (ANCOVA) was used to measure children's factual and emotional understanding of the story book. There were two between-subjects variables: group (typically developing or TBI) and book type (picture or verbal), and one within-subjects variable, question type (fact and emotion). The one covariate was receptive vocabulary.

The whole sample had a higher than average skill in receptive vocabulary ($M = 112.76$, $SD = 12.39$). Typically developing children and children with TBI had mean receptive vocabulary scores, as measured by the PPVT-III, of 116.27 ($SD = 9.54$) and 100.59 ($SD = 13.68$), respectively. An independent t -test revealed that typically developing children have significantly greater verbal ability than children with TBI, $t(20.69) = 4.43$, $p < .001$, $\eta^2 = .21$.

Before analysing the data on the children's responses to the fact and emotion questions, after either the pictorial or verbal story, it was important to rule out any potential effects of episode presentation order, in terms of the story book version shown, as well as the effects of children's sex and ability to accurately recognise the facial expressions. The descriptive statistics for children's performance on the fact and emotion questions using version A and B are shown in Table 5.2.

Table 5.2

Mean and standard deviation scores for children's performance on the fact and emotion questions from version A and B of the story book.

	Version A	Version B
Fact Question	77.63 (18.29)	81.58 (20.06)
Emotion Question	44.74 (19.02)	40.35 (18.84)

Two independent-samples t -tests confirmed that there was no significant difference between version A and version B on children's performance on the fact, $t(74) = -.71$, $p = .48$, $\eta^2 = .007$, and emotion questions, $t(74) = 1.13$, $p = .26$, $\eta^2 = .02$. A series of independent t -tests showed that males ($n = 39$) and females ($n = 37$) did not differ significantly on factual understanding, $t(74) = -.85$, $p = .40$, $\eta^2 = .007$, emotional understanding, $t(74) = .69$, $p = .49$, $\eta^2 = .003$, or receptive vocabulary, $t(74) = .39$, $p = .70$, $\eta^2 = .002$. Thus, story book version and sex were not included in any subsequent analyses.

As described above, emotion recognition scores were calculated on a subsample of children ($n = 51$) to determine if they could recognise the facial expression as the depicted emotion. Children's emotion recognition scores ranged from 33 to 100% correct. As all scores were converted to percentages from a total score of six, this indicates that all children were able to recognise at least two of the six facial expressions. An independent-samples t -test was conducted to compare the emotion recognition scores for TBI ($n = 17$, $M = 77.35$, $SD = 19.46$) and typically developing ($n = 34$, $M = 79.38$, $SD = 20.51$) children. Although there was a trend for children with TBI to have poorer recognition scores, there was no significant difference between the two groups for emotion recognition, $t(49) = .38$, $p = .75$,

$\eta^2 = .002$. Pearson correlation coefficients were calculated to determine the association between children's scores on emotion recognition and the dependent variables. For the sample as a whole, emotion recognition was not significantly related to receptive vocabulary ($r = .10, p = .50$), to percentage of emotion questions correctly answered ($r = .05, p = .74$), nor to the percentage of factual questions correctly answered ($r = -.18, p = .20$). Furthermore, given the small variety of scores seen in the emotion recognition variable (taken as a percentage, children's scores were limited to 33, 50, 67, 83 or 100) a series of independent t -tests were also conducted to ensure that children's ability to recognise emotions did not influence their performance on the dependent variables. To do this, the emotion recognition variable was divided into high and low, based on the median score of 70. There was no significant difference between children in the high ($n = 32, M = 45.31, SD = 21.68$) and low ($n = 19, M = 37.72, SD = 16.52$) emotion recognition groups for emotional understanding, $t(49) = -1.32, p = .20, \eta^2 = .03$. There was also no significant difference between children in the high ($M = 76.04, SD = 20.71$) and low ($M = 79.82, SD = 23.29$) emotion recognition groups for factual understanding, $t(49) = 0.60, p = .55, \eta^2 = .007$. In summary, these results indicate that children's ability to recognise each of the facial expressions did not influence their understanding of the story book and thus the emotion recognition variable was removed from future analyses.

Table 5.3 reports the descriptive data for children's emotional and factual understanding after both the pictorial and verbal story books. It was noted that there was a ceiling effect for children's responses to the factual questions. There was a trend for children who were told the verbal condition of the story book to perform better on the emotion questions than children who were shown the pictorial condition of the story book. Furthermore, there was a trend for typically developing children to outperform children with TBI for both types of questions.

Table 5.3

Descriptive statistics for children's emotional and factual understanding, expressed as a percentage, across group and book type.

Group	Book Type	N	Emotional Question		Factual Question	
			<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
TD	Pictorial	31	37.63	15.50	82.26	13.56
	Verbal	28	50.60	18.97	82.74	18.42
	Total	59	43.79	18.28	82.49	15.91
TBI	Pictorial	10	33.33	19.25	71.67	20.86
	Verbal	7	45.24	23.00	66.67	33.33
	Total	17	38.24	21.05	69.61	25.84
Total	Pictorial	41	36.59	16.34	79.67	16.03
	Verbal	35	49.53	19.59	79.52	22.54
	Total	76	42.54	18.94	79.61	19.17

An ANCOVA was run to measure children's factual and emotional understanding of the story book. Receptive vocabulary was controlled for since it could affect children's ability to understand the questions. The results indicate that there was no significant main effect for group, $F(1, 71) = 0.98, p = .36, \eta^2 = .01$, book type, $F(1, 71) = 2.17, p = .15, \eta^2 = .03$, or for question type, $F(1, 71) = 0.77, p = .38, \eta^2 = .01$. Similarly, there was no significant

interaction between question type and group, $F(1, 71) < .01, p = .98, \eta^2 = .00$, nor between question type, group and book type, $F(1, 71) = 0.04, p = .84, \eta^2 = .00$. A significant interaction existed between question type and book type, $F(1, 71) = 4.39, p < .05, \eta^2 = .06$. From the means shown in Table 5.3, this result indicates that children who were read the verbal story were able to understand the story's emotional content significantly better than children who were shown the picture story. In contrast the type of book shown/told did not significantly affect children's understanding of the story's factual content (see Figure 5.4).

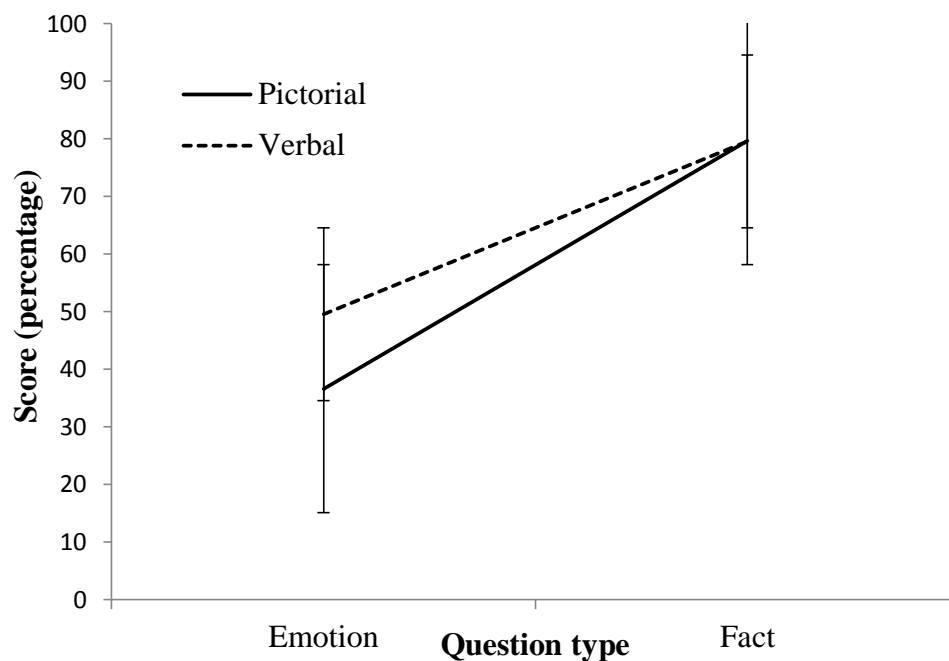


Figure 5.4. Mean percentage of children's correct answers to the emotion and fact questions from both the verbal and pictorial story books, where errors bars represent the standard error.

There was also a significant interaction effect between question type and the covariate, receptive vocabulary, $F(1, 71) = 4.39, p < .05, \eta^2 = .06$. The means shown in Table 5.3 suggest that children's ability to answer both the fact- and emotion-based questions varied as a result of their vocabulary ability. Specifically, children's verbal ability was significantly related to their understanding of the story's factual content ($r = .41, p < .01$) but not the

emotional content ($r = .06, p = .64$). This indicates that the assumption of homogeneity of regression slopes was violated and therefore suggests that receptive vocabulary is an invalid covariate. Since children's ability to answer both types of questions varied as a function of their verbal ability, it was decided that question type would be analysed separately and the receptive vocabulary variable would be analysed as an independent variable rather than a covariate. Furthermore, since there were no significant main or interaction effects of group, group was removed from subsequent analyses.

To include receptive vocabulary as an independent variable, children's scores needed to be converted to a categorical variable. Therefore, scores were categorised into high or low based on the median score of 110. Children in the lower verbal ability group ($n = 30$) had a mean PPVT-III score of 101.40 ($SD = 9.59$) and those in the higher verbal ability group ($n = 46$) had a mean score of 120.17 ($SD = 7.38$).

5.6.1.1 ANOVAs on children's understanding of emotions and facts

Table 5.4 shows the descriptive statistics for children's emotional and factual understanding across book type and the new category of verbal ability.

Table 5.4

Descriptive statistics for children's emotional and factual understanding, expressed as a percentage, across verbal ability and book type.

Book Type	Verbal Ability	N	Emotional Question		Factual Question	
			M	SD	M	SD
Pictorial	Lower	16	37.50	14.27	75.00	20.18
	Higher	25	36.00	17.80	82.67	12.25
	Total	41	36.59	16.34	79.67	16.03
Verbal	Lower	14	42.86	21.40	70.24	27.09
	Higher	21	53.97	17.40	85.71	16.90
	Total	35	49.52	19.59	79.52	22.54
Total	Lower	30	40.00	17.83	72.78	23.36
	Higher	46	44.20	16.00	84.06	14.47
	Total	76	42.54	18.93	79.61	19.17

A 2 x 2 between-subjects Analysis of Variance (ANOVA) was performed on children's understanding of the story book's emotional content. The two independent variables were book type (verbal, picture) and verbal ability (higher, lower). There was a significant main effect for book type, $F(1, 72) = 7.80, p < .01, \eta^2 = .10$, indicating that emotional understanding of the story book was significantly better for children who were

provided with the story's verbal cues ($M = 49.52$, $SD = 19.59$) as opposed to the story's pictorial cues ($M = 36.59$, $SD = 16.34$). Children's emotional understanding did not significantly differ with regard to their verbal ability, $F(1, 72) = 1.32$, $p = .25$, $\eta^2 = .02$, and there was no significant interaction between verbal ability and book type, $F(1, 72) = 2.28$, $p = .14$, $\eta^2 = .03$.

A 2 x 2 between-subjects ANOVA was performed on children's understanding of the story book's factual content. Similar to the previous analysis, the two independent variables were book type (verbal, picture) and verbal ability (higher, lower). There was a significant main effect for children's verbal ability, $F(1, 72) = 6.97$, $p < .05$, $\eta^2 = .09$, which indicated that children who had a higher receptive vocabulary score ($M = 84.06$, $SD = 14.49$) were significantly better at understanding the story's factual content than those who had a lower vocabulary ability ($M = 72.78$, $SD = 23.36$). Children's factual understanding did not differ with regard to the type of book they were shown, $F(1, 72) = 0.04$, $p = .85$, $\eta^2 = .00$. There was also no significant interaction between verbal ability and book type, $F(1, 71) = 0.79$, $p = .38$, $\eta^2 = .01$.

5.6.2 Effects of Age and Injury Characteristics

To determine the influence of age on children's emotional and factual understanding, Pearson correlation coefficients were calculated. Although there was a significant relationship between age and children's factual understanding ($r = .35$, $p < .01$), age did not significantly correlate with emotional understanding ($r = .09$, $p = .45$). However, since significant emotional development occurs within the pre-school years (Boyatzis et al., 1993), this relationship was examined further by dividing children into an older and younger age group based on the median age of 65 months. Children in the younger age group ($n = 31$) had a mean age of 4.89 years (58.71 months; $SD = 3.90$), whilst children in the older age group (n

= 45) had a mean age of 5.78 years (69.33 months; $SD = 3.85$). In the younger cohort, children's age was significantly related to their factual understanding of the story book ($r = .36, p < .05$), but the correlation between age and emotional understanding was not significant ($r = -.16, p = .41$). In the older cohort, age was significantly related to both children's factual ($r = .33, p < .05$) and emotional understanding ($r = .46, p < .01$) of the story book.

Despite the lack of significant differences between children with and without a history of TBI, there are several injury characteristics worth exploring within the TBI sample. It is important to note, however, that these analyses were exploratory due to the small number of TBI children assessed ($n = 17$). Within the TBI sample, there was no significant correlation between time since injury and children's verbal ability ($r = .18, p = .50$), factual understanding ($r = -.10, p = .60$) and emotional understanding ($r = -.38, p = .58$). It should be noted that this final correlation approaches statistical significance, and suggests that children's emotional understanding becomes poorer over time; a result that may be more apparent with a greater sample size. Injury severity was not examined due to the small number of participants within each sub-group.

5.7 Discussion

The current study had four hypotheses, of which one was refuted, two were fully supported and one was partially supported. The first hypothesis, that children with TBI would perform significantly more poorly than typically developing children at answering emotional and factual questions about a story book, was not supported. Although there was a trend for children with TBI to perform more poorly on the factual and emotional questions than typically developing children, the difference between the two groups did not reach statistical significance. The second hypothesis, that children would understand significantly more of the

story book's emotional content from the verbal cues as opposed to the pictorial cues, was supported. Furthermore, the hypothesis that there would be no difference between the pictorial and verbal versions of the story book on children's performance in answering factual questions was also supported. Finally, the hypothesis that children's performance in answering emotional and factual questions would increase with age was only partially supported. Specifically, children in the older cohort (65 - 80 months) showed significant improvements with age on the emotional questions, but children in the younger cohort (50 - 65 months) did not. Both age cohorts showed significant improvements on the factual question with an increase in age.

In contrast to the first hypothesis, typically developing children and children with TBI did not differ significantly on either the factual or emotional questions based on the story book. With regard to the emotional question, this result contradicts numerous studies that have shown that TBI significantly diminishes children's ability to recognise, understand and interpret emotions (e.g., H. Levin & Hanten, 2005; Pettersen, 1991; Schmidt et al., 2010; Tonks et al., 2007b; Walz et al., 2010). More specifically, this result contradicts past research that has shown that children with TBI perform more poorly than controls on a measure of affective ToM (Tonks et al., 2007b; Tonks et al., 2008). However, it is important to note that past research examining affective ToM has relied on the 'Reading the Mind in the Eyes' test, a task that fails to accurately measure children's understanding of others' emotions since the task does not consider the ability to make inferences about social interactions. Thus it is possible that the additional information provided to children in the current study, by way of introducing social interactions in a story book, enabled them to successfully understand and recognise another's emotions. Research with adults has shown that those with a TBI perform no differently to non-head injured adults on an emotion recognition task when context is provided (Crocker & McDonald, 2005). Adults with TBI have also been shown to perform

better on emotion recognition tasks where more information is provided, such as in tasks involving dynamic stimuli as opposed to static stimuli (S. McDonald & Saunders, 2005). It is therefore possible that the emotion recognition deficit seen in past research in children with TBI is a result of the type of task employed. Contextualised tasks, such as the one employed in the current study, provide children with more information than tasks that simply show a facial expression, and it is therefore possible that the additional information provided to the child in the present research resulted in a more detailed understanding of the story. This is an important finding given contextualised tasks are a more accurate reflection of day-to-day life.

With regard to the performance on the factual question, the current study showed no significant difference between typically developing children and children with TBI. This was also an unexpected finding given that the factual question required an element of inference and problem solving. This result implies that a history of TBI does not affect children's ability to infer information, which does not align with previous research that shows that TBI leads to difficulties with inference-making and problem solving (Bibby & McDonald, 2005; Lezak, 1995). Although it is arguable that accurate completion of the factual question required an inference to be made, it is also possible that this question was easier than those in past research since it relied on basic inferences on world knowledge, supported by the ceiling effect. For example, if the child attended to the story and knew it was a birthday party, their basic knowledge of the world would allow them to answer the question to say that guests would most likely wear a party hat. Thus, this result concurs with past research which has shown that TBI does not generally impact children's crystallised intelligence, such as general or world knowledge (V. Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2000).

An alternative explanation for the lack of support for the two parts of the first hypothesis relates to the sample of children involved in the current study. That is, it is possible that this non-significant group difference is a consequence of the large number of

mild TBI cases included in the current sample; an important issue since previous research has shown that children's difficulty with recognising emotions generally occurs following a moderate or severe TBI (Dimoska et al., 2010; Tonks et al., 2008). Although some research assessing socio-emotional ability has included children with mild TBIs in the brain-injured sample group (Ietswaart et al., 2007; Tonks et al., 2007b) it is important to note that unlike the current study, these studies have had a proportional number of mild, moderate and severe injuries. Research investigating the effects of mild TBI in children to date has failed to examine children's socio-emotional deficits. Rather it has tended to focus on postconcussional symptoms (Ponsford et al., 1999), behavioural outcomes (V. Anderson, Catroppa, Morse, et al., 2001; McKinlay, Dalrymple-Alford, Horwood, & Fergusson, 2002; McKinlay, Grace, Horwood, Fergusson, & MacFarlane, 2010), academic difficulties (McKinlay et al., 2002; Satz, 2001), and general cognitive abilities (V. Anderson, Catroppa, Morse, et al., 2001; Satz, 2001). Although Wall, Williams, Morris, and Bramham (2011) recognised that children's self-reports of empathy and emotion recognition were lower in children with mild head injuries compared to those without, the authors also highlighted the need for more research in this area. The current study has done this, using a more objective measure of emotion recognition than self-report, and has shown that no significant differences in the ability to answer emotion-based questions were observed between typically developing children and those with a mild head injury.

Furthermore, as noted above, although the current study showed no significant group differences on children's understanding of the story book, that there was a trend suggesting that TBI children were worse at emotional and factual understanding than typically developing children. Thus, it is possible that the relatively small number of TBI children in the sample made it unlikely that this difference could have reached statistical significance, especially given the small effect size. Finally, as the children in the current study had mainly

suffered mild TBIs it is possible that children had recovered from any deficits present after the injury had recovered by the time they were assessed, since the average assessment time post injury was 17 months. Previous research that has shown emotion recognition deficits in children with TBI, assessed children at an average of 11 months (Pettersen, 1991) and 3.5 years (Tonks et al., 2007b) post-TBI. However, these studies included children with moderate and severe TBIs, and cognitive deficits following a mild TBI generally recover by 3 months post-injury (Ponsford et al., 1999).

The second and third hypotheses relate specifically to the presentation modality of the story book. The finding that children gained greater emotional understanding from a story with verbal cues than pictorial cues supports the research of Kobayashi et al. (2007) and Bibby and McDonald (2005), who found that adults performed better on a false belief task, when the task was conveyed through words as opposed to through pictures. The current study extended these findings to show that children can complete affective ToM tasks more successfully when the task is presented verbally. This finding highlights the importance of parents and teachers providing children with verbal cues during story book interactions. Furthermore, the result indicates that parents should talk to and facilitate discussion with children about their own and others' feelings, as also recommended by Kuebli, Butler, and Fivush (1995) and J. Dunn, Bretherton, and Munn (1987).

With regard to the factual questions, the results supported the hypothesis to show that presentation modality did not influence children's ability to infer factual information from the story book. This supports the research by Bibby and McDonald (2005) who showed that type of presentation did not influence adults' performance on a non-mental inference task, and extends their research to show similar results in children. By four years of age, it was expected that the present participants would be able to interpret the factual content through both pictures and words. The negatively skewed data for children's performance on the

factual question support this claim, by showing that majority of children were able to accurately infer meaning from the story and use this to identify factual information.

Furthermore, this result indicates that children were able to accurately interpret meaning from the story, and therefore suggests that the story book was a reliable and age-appropriate measure.

The current study also found that children's factual understanding varied as a function of their verbal ability. This finding suggests that children's verbal ability is related to their general knowledge of the world; an unsurprising finding which corroborates previous research showing a significant positive relationship between children's performance on the PPVT and their general world knowledge (Cunningham & Stanovich, 1991). In comparison, children's emotional understanding in the present study did not vary as a result of their verbal ability. This finding does not align with past research (Egan et al., 1998; Hanten et al., 2008; Herba & Phillips, 2004; Lepannen & Heitanen, 2001), which has shown that verbal ability plays a key role in emotional understanding. It should be noted, however, that in studies where children's verbal ability is above average, as it was for most of the children in the current study, previous research has found no significant relationship between verbal ability and emotion recognition (Lindner & Rosen, 2006). It is therefore possible that children's high verbal scores negated any significant relationships. It is likely that children's above-average intelligence is a result of the fact that the primary schools and participants who were willing to participate in the research came mainly from a higher SES. Despite the lack of a significant group difference on children's understanding of the story book, a significant group difference was apparent for children's verbal ability. That is, children with a TBI had significantly lower verbal intelligence than typically developing children. This result concurs with the findings of past research (see Section 1.4.1) which indicate that children with TBI have lower intellectual ability than age-matched healthy controls (V. Anderson et al., 2004;

Catroppa et al., 2007; Goldstrohm & Arffa, 2005) and children with orthopaedic injuries (Goldstrohm & Arffa, 2005; Taylor et al., 1999). In particular, childhood TBI has been shown to result in deficits of the verbal domains of intelligence (Ewing-Cobbs et al., 1997).

To consider the effect of the characteristics of the TBI on children's understanding of the story book's content, subsequent analyses were conducted. Due to the limited sample size, these analyses were exploratory in nature. The length of time between children's injury and the time of their assessment varied greatly (from 2 to 32 months); however, time since injury did not significantly relate to children's factual or emotional understanding of the story book, nor to their verbal ability. The emotional understanding result fails to align with previous research which suggests that children's emotional recognition skills improve over time (Schmidt et al., 2010). Future research should aim to explore the effect of time since injury and injury severity on children's affective ToM post TBI.

The fourth hypothesis, that children's performance on the emotional and factual questions would improve with age, was partially supported. The results suggest that between the ages of five-and-a-half and six-and-a-half years, children's emotional understanding of the story book significantly increases with age. This significant positive correlation supports previous research which shows a link between children's age and emotional development (Boyatzis et al., 1993; Herba, Landau, Russell, Ecker, & Phillips, 2006). In comparison, an inverse relationship was found for children younger than five-and-a-half-years of age.

Although it was not significant, the result suggests that the emotional understanding of children between the ages of four and five-and-a-half years decreases with age. This finding is surprising, and may indicate that the current results are unreliable in regard to indicating an improvement of affective ToM with age. To obtain a more reliable answer to this question, future research should consider comparing a large number of children from a series of age groups. A reliable statistical test to assess change over time, such as latent growth modelling,

may also be useful. In comparison, both younger and older children showed significant improvements on the factual question with age. This result is not surprising, and supports previous researchers who have found that children's general knowledge improves with age (Wechsler, 2003).

In the current study, further analyses were also conducted to investigate the effects of both sex and children's ability to recognise the facial expressions. The results indicated that there was no significant difference for sex on children's verbal ability or their understanding of the story book's factual and emotional content. This finding supports previous research which showed that sex does not influence children's intellectual ability (Hyde & Linn, 1988), nor their ability to recognise and understand emotions (Camras & Allison, 1985; Lepannen & Heitanen, 2001). It should be noted, however, that there are some confounding findings in the literature on the difference between males and females in regard to emotional understanding. That is, some researchers conclude that females have a significant advantage over males in regard to recognising and interpreting emotions (Lepannen & Heitanen, 2001; McCure, 2000). In conclusion to the confounding results, many claim that the contradictory findings may not be directly attributable to sex, but rather be a reflection of children's development or methodological biases within studies (Herba & Phillips, 2004; Schmidt et al., 2010).

Finally, the results suggest that children's ability to recognise the facial expressions from the verbal label was not related to their ability to understand the story book's emotional content, a particularly relevant analysis given that the same illustrated facial expressions were used across the two tasks. Thus, this result suggests that children's ability to understand and infer characters' emotions from a story book is independent of their ability to identify facial expressions. Although this task was initially implemented as a check, to determine that children's answers to the emotion questions were not influenced by a difficulty with recognising the illustrated facial expressions, it actually raised some interesting results. The

emotion understanding task used in the current study was intended to measure children's affective ToM, as children were required to infer the emotional state of another by interpreting a social interaction. In contrast, the emotion recognition task was purely that, a measure of children's ability to identify an emotion. Although both tasks seem to involve an element of socio-emotional cognition, Frith and Frith (1999; 2001) argue that they actually rely on separate neural networks. The ventral stream links the orbitofrontal cortex with regions next to the amygdala and is responsible for recognising differences in emotional expressions, whilst a dorsal stream connects the medial prefrontal cortex with the anterior cingulate and the superior temporal sulcus, and is responsible for ToM. Thus the current study provides support for this theory by showing that children's emotion recognition skills and ToM skills are not related. Similar results have been shown in individuals with TBI (J. Henry et al., 2006) and schizophrenia (Brune, 2005a).

5.7.1 Limitations and Suggestions for Future Research

There are several methodological considerations to consider in the current study. As discussed above, the sample of children with TBI was comparatively small. Given the trend for children with TBI to perform more poorly than typically developing children on both the factual and emotional questions from the story book, the small sample of TBI children may have precluded the difference from reaching statistical significance. Future research should therefore replicate the current study with a large sample of TBI children. A larger TBI sample would also allow for a more reliable analysis of the difference between book versions on the ability of children with TBI to understand the book's factual and emotional content. In the current study, the analyses required that children with and without a history of TBI were combined into one group, which therefore limited the conclusions that could specifically be drawn about children with a history of TBI. The current study also failed to control for SES

and intelligence, something future research should consider given the effect such variables can have on the outcome of children with TBI (Anderson et al., 2005).

The current study also raised several questions, primarily in regard to how children with more severe types of TBI would perform on the story book tasks. Given that children with moderate and severe TBI are more likely than those with a mild TBI to incur socio-cognitive difficulties (Dimoska et al., 2010; Tonks et al., 2008) and the current study did not have access to a sample of children with more severe TBIs, it was beyond the scope of the analyses to determine how children with such impairments would interpret the story book. That is, as the current study's TBI sample were mainly children who had sustained a mild TBI, it is likely that the TBI group did not have socio-emotional difficulties and this is why they performed no different to the typically developing children. Thus, in light of the TBI sample, the robustness of this study's conclusions and the pattern of the results remain to be confirmed.

Finally, the results of the current study may have been affected by the scoring approach utilised in the birthday story. To gain a more accurate understanding of a child's emotional knowledge, future researchers may wish to consider assessing each emotion numerous times, using a two or three vignettes, as opposed to one. This would enable an average score to be calculated. In addition, it may also be of interest to assess older children's emotional knowledge using a broader array of emotions in the story book.

5.7.2 Implications

The implications of this study relate to how improvements can be made to children's emotional understanding. Although these findings are relevant to typically developing children, they are particularly important for children with TBI since socio-cognitive skills are typically impaired after a head injury (See Chapter 3). Regardless of TBI history, children

were able to gain more emotional knowledge from the story book when the story was presented verbally, as opposed to pictorially. This suggests that in order to teach children about emotions and understanding other's feelings in social contexts, verbal input is imperative. Thus, a verbal story book may be an effective tool to use in a social cognitive rehabilitation program for children. To help children understand characters' feelings and the book's storyline, parents and/or teachers could use emotion words and verbal descriptions more frequently, rather than relying on just pointing to pictures. Because of the link between social cognition and social functioning (Beauchamp & Anderson, 2010), development of a rehabilitation technique for children's social cognition following TBI is imperative to improve their social functioning. This is particularly relevant since social dysfunction is not only a common consequence of TBI, but is also described as the most devastating outcome (Driscoll et al., 2011). Furthermore, guidelines recommend that rehabilitation programs for people with TBI should focus on improving social functioning (Driscoll et al., 2011; Ylvisaker, Turkstra, & Coelho, 2005).

Social skills programs often involve an emotion recognition element since accurate interpretation of others' affect is critical for social interactions (C. Bornhofen & McDonald, 2008b). However, there is limited research exploring the efficacy of such programs in brain-injured adults, and the treatment of social perception deficits has largely been ignored in the paediatric TBI population (Driscoll et al., 2011; Radice-Neumann, Zupan, Tomita, & Willer, 2009). This is despite significant evidence highlighting social cognitive deficits in children with TBI (see Chapter 3) and the large body of literature examining the efficacy of emotion perception treatment in clinical populations such as schizophrenia (Combs et al., 2007; Combs, Tosheva, Wanner, & Basso, 2006; Formmann, Steit, & Wolwer, 2003; Penn et al., 2000), autism (Bolte et al., 2002; Bolte et al., 2006) and intellectual disabilities (McAlpine, Singh, Kendall, & Ellis, 1992; McKenzie, Matheson, McKaskie, Hamilton, & Murray, 2000).

Research exploring social cognitive interventions for adults with TBI has shown promising results in that individuals can relearn affect recognition skills following an ABI (C. Bornhofen & McDonald, 2008a; C. Bornhofen & McDonald, 2008c; S. McDonald, Bornhofen, & Hunt, 2009; Radice-Neumann et al., 2009). However, there are a number of limitations present in this body of research. Participants involved in the research vary with the type of head injury sustained (e.g., the classification of ABI included participants not only with a TBI, but also those with haemorrhages following ruptured aneurysms, hypoxia and status epilepticus), and the small sample sizes has meant that the results cannot be widely generalized. Furthermore, the small number of studies in this area makes it difficult for researchers and practitioners to understand what part of the treatment program is beneficial (Driscoll et al., 2011). More importantly, there is an obvious lack of research exploring the efficacy of intervention aimed at improving affect recognition skills of children with TBI (Driscoll et al., 2011; Radice-Neumann et al., 2009).

In particular, C. Bornhofen and McDonald (2008a) discuss the need for research to focus on improving the emotion perception abilities of people with TBI. They highlight the importance of carrying out such rehabilitation within a contextualised framework, so that the day-to-day functioning of participants is clearly emphasised. There is clearly a need for the development of an effective intervention strategy targeting affect perception in children with TBI. Story books are an effective tool used to teach children about social interactions and thus it is suggested that story books can also be used in rehabilitation to teach children about identifying and interpreting emotions within social contexts. Parents describe story book reading to be a daily joint activity that generally involves more than one book per sitting (Debaryshe, 1993). This dyadic activity has been shown to be important to a child's development, aiding secure attachments (Bus & van Ijzendoorn, 1988), children's literacy and language skills (Aram & Aviram, 2009; Fletcher & Reese, 2005), socio-emotional

development (Aram & Aviram, 2009) and children's theory of mind (Adrian, Clemnte, Villanueva, & Riffe, 2005; Dyer, Shatz, & Wellman, 2000). Therefore, it appears that story books may be an appropriate tool for children's rehabilitation. Furthermore, reading story books is a technique that parents would be able to continue to use with children in their own time, outside of formal rehabilitation sessions.

In summary, this study aimed to investigate the effect of task modality on children's affective ToM abilities by developing a new measure that required children to infer the emotions of another from a social interaction. To gain a greater understanding of the effect TBI has on children's socio-cognitive status, the study also explored the affective ToM ability of children with a recent history of TBI. The study revealed that children with TBI do not perform significantly more poorly than typically developing children on a measure of affective ToM. However, these results need to be corroborated by future research using a larger group of children with moderate and severe TBIs. Secondly, this study showed that children are able to gain greater understanding of a story book's emotional content when the story is presented verbally, as opposed to visually. In comparison, the type of story book presentation did not seem to influence children's factual understanding of the book. This highlights the importance of words for children's emotional development, and has implications for the rehabilitation of children's social cognition post TBI. Finally, this study is also congruent with the concept that affective ToM is a skill that develops with age, particularly during the early pre-school years.

CHAPTER 6: General Discussion

The current thesis aimed to explore the social competencies of children with TBI. As discussed in Section 1, TBI is an acquired closed head injury that, depending on the severity, results in temporary or permanent neurological dysfunction. Paediatric TBI is a common cause of brain damage and as such results in a high economic cost related to hospital care, injury-related work loss and disability services (Kraus, 1995; Thurman et al., 1999). Paediatric TBI is associated with a range of social, cognitive and behavioural impairments, the severity of which is often linked with the severity of the injury, pre-morbid factors and the child's post-injury environment (V. Anderson et al., 2004; Catroppa & Anderson, 2004; Catroppa et al., 2009; Kinsella et al., 1997; Max et al., 1999; Yeates, 2009). Despite children rating their social functioning to be of primary importance following TBI, this factor is often neglected by parents and health professionals (Bohnert et al., 1997; Driscoll et al., 2011; Warschausky et al., 1997). For this reason, it has recently become an area of interest for researchers (e.g., Beauchamp & Anderson, 2010). As explained in Chapter 2, social interaction is an important part of human life and there are a range of skills needed to be able to function appropriately and sufficiently in a social world. Beauchamp and Anderson (2010) claim that the prevalence, aetiology and predictors of social functioning skills in children have been unclear, and they have therefore developed a biopsychosocial model, SOCIAL, in an attempt to clarify the development of social functioning. Section 2.3 introduces the SOCIAL model and Chapter 3 discusses each of the model's core components by reflecting how they each relate to a paediatric TBI population. Specifically, Section 3.1 discusses the effect TBI has on children's internal and external characteristics. Sections 3.2, 3.3 and 3.4 respectively discuss each of the core cognitive components, social cognition, attention and EF, and communication, and how TBI affects each of these functions. To determine the

predictive nature of these components on children's social functioning, Study 1 attempted to operationalise the SOCIAL model in a paediatric TBI sample.

The aim of Study 1 was to investigate the predictors of children's social functioning following TBI, using Beauchamp and Anderson's (2010) SOCIAL model as a guide. Using a battery of neuropsychological assessments and parental questionnaires, each of the key components of the SOCIAL model were measured in order to determine the key predictors of children's social behaviours and socialisation skills. Five key hypotheses were developed of which two were fully supported, two were partially supported and one was refuted.

Hypothesis one was that familial and intrinsic childhood variables would jointly account for significant variance in children's social functioning post TBI. This hypothesis was partially supported, since higher levels of dysfunctional internal behaviours and poorer family functioning were significant predictors of children's socialisation skills and social behaviours, but SES was not significantly related to either measure of social functioning.

The second hypothesis was that after controlling for familial and intrinsic childhood variables, measures of EF would account for significant variance in children's social functioning post TBI. The results of Study 1 supported this hypothesis, since children's ecological EF skills were shown to provide significant unique and collective contributions to their socialisation skills and social behaviours. Although the concept of EF was hypothesised to predict children's social functioning, the identification of which specific EF measure would be involved in the predictive relationship was exploratory in nature. Aside from the parent rated measure of ecological EF, children's EF was measured by performance based tests that assessed attentional control, processing speed, cognitive inhibition, cognitive switching and planning. None of the performance-based assessment measures were significantly related to either measure of social functioning. The current results refuted hypothesis three, which was that after controlling for familial and intrinsic childhood

variables, measures of pragmatic language would account for significant variance in children's social functioning post TBI. Pragmatic language did not significantly correlate with either of the two social functioning measures, and it was therefore not included in the subsequent analyses. The results of Study 1 supported the fourth hypothesis, which was that after controlling for familial and intrinsic childhood variables, measures of social cognition would account for significant variance in children's social functioning. Theory of mind was shown to play a significant role in predicting children's socialisation skills and social behaviours. Although it was predicted that social cognition would significantly influence social functioning, the specific social cognitive measures were exploratory in nature; an important statement given that affect recognition was not significantly related to either measure of social functioning. Finally, the fifth hypothesis was that after controlling for familial and intrinsic childhood variables, measures of EF, pragmatic language and social cognition would jointly account for significant variance in children's social functioning following TBI. This hypothesis was partially supported, as measures of EF and social cognition made significant unique and joint contributions to children's social functioning, but their pragmatic language skills did not.

Thus, in summary, Study 1 showed that family functioning, internal behaviours, ecological EF and ToM are significant predictors of children's socialisation skills and social behaviours following TBI. These results offer partial support for the SOCIAL model, and future research should attempt to replicate these findings. Section 4.5.4 discusses the study's limitations, and highlights the need for future research to use a larger sample of children with moderate and severe TBIs since injuries of a higher severity are more likely to result in greater social dysfunction.

Given the importance of ToM on children's social functioning shown in Study 1, Study 2 was designed with the aim of exploring ToM in more depth in a paediatric TBI

population. Specifically, Study 2 aimed to develop a measure of affective ToM, a concept that requires an individual to be able to infer another's feelings and motivational states (Henry, Phillips et al. 2006). A visual and verbal version of a story book were developed, which aimed to assess children's understanding of factual and emotional content from social interactions. As this study was using a newly designed tool as a measure of affective ToM, a control group of typically developing children were used as a comparison to children with TBI. Of the four hypotheses, one was refuted, two were supported and one was partially supported. The first hypothesis was that children with TBI would perform significantly more poorly than typically developing children at answering emotional and factual questions about a story book. Although there was a trend for typically developing children to perform better than children with TBI, Study 2 refuted this hypothesis, as there was no significant difference between the two groups. The second hypothesis was supported, as children understood significantly more of the story book's emotional content from the verbal cues as opposed to the pictorial cues. The third hypothesis was also supported, as there was no difference between the pictorial and verbal versions of the story book on children's performance in answering factual questions. Finally, the fourth hypothesis was partially supported. As predicted, children in the older cohort (65 – 80 months) showed significant improvement with age on the emotional questions, but children in the younger cohort (50 – 65 months) did not. A significant positive correlation was shown between children's age and their understanding of the story's factual content. In summary, the results of Study 2 showed that children, whether or not they have had a TBI, are able to gain a greater understanding of a story book's emotional content when the story is presented verbally, as opposed to visually. This highlights the importance of verbal language for children's emotional development.

As discussed in Sections 4.5.5 and 5.7.2, there are several important implications that derive from these studies, including both theoretical and practical implications. Theoretically,

the current results provide researchers and clinicians with a greater understanding of affective ToM and the predictors of social functioning following paediatric TBI. Practically, the implications of the current results could help to develop a social cognitive rehabilitation program for children with TBI. Thus, together Study 1 and 2 emphasise the importance of ToM for children's social development. The current thesis shows that using language is an important part of teaching children about affective ToM and furthermore that ToM is a unique and significant predictor of children's social functioning following TBI. Thus, overall these results imply that emotion-focused vocabulary is an important strategy to use in an attempt to improve children's social functioning.

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Appendix A

Transforming data to meet the assumption of normality

Table A1.

Fisher's coefficients of skewness and kurtosis for all variables before and after reflected square root transformations

Variable	Untransformed		Transformed	
	Z skewness	Z kurtosis	Z skewness	Z kurtosis
Social Problems	2.19	-1.40		
Socialisation Skills	0.11	-2.45		
SES	0.53	-1.98		
FFQ: Intimacy	-3.95**	2.21	0.48	-0.44
FFQ: Conflict	2.29	0.19		
FFQ: Parenting Style	-1.09	1.54		
Internal Behaviour	-1.16	-1.89		
Ecological EF	-1.44	-1.76		
Attention	0.31	-1.76		
Planning	-3.94**	-1.45	-1.23	-0.66
Inhibition	0.59	-2.07		
Switching	0.06	-1.80		

Processing Speed	0.02	-1.63
Theory of Mind	1.83	-0.93
Affect Recognition	-0.43	-0.77
Pragmatic Language	1.85	-0.23

^{**} $p < .01$ ($\alpha = \pm 2.57$)

Partial Correlations

Table A2.

Partial correlations between each of the internal/external variables and social functioning, whilst controlling for the remaining variables

Internal/External Variables	Social Problems	Socialisation
Internal behaviour	.54 ^{***}	-.16
Family functioning	.09	.26
SES	-.11	.01

^{*} $p < .05$, ^{**} $p < .01$, ^{***} $p < .001$

Table A3.





















Partial correlations between each of the cognitive and social functioning variables, whilst controlling for the effect of the remaining variables.

Cognitive Variables	Social Problems	Socialisation Skills
Attention	-.15	.05
Planning	.10	.06
Processing Speed	.15	.16
Inhibition	-.10	-.16
Switching	-.06	.07
Ecological EF	.50***	-.32*
Affect Recognition	.10	.10
Theory of Mind	-.10	.33*
Pragmatic Language	.16	.02
* $p < .05$, ** $p < .01$, *** $p < .001$		

Appendix B

Table B1.

The script and alternate answers from the verbal version of the story book

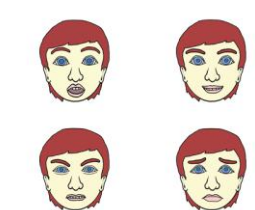
Target Emotion	Narrative	Four alternate answers	
Happiness	It is Sally's birthday. She is having a party. Sally's friends come to the party and they all bring her a present. <i>Point to how you think Sally feels.</i>		
			
	<i>Point to what you think Sally will wear.</i>		
			
Sadness	Sally's mum made a chocolate cake for Sally's birthday. When Sally's mum brought the cake out to eat, she accidentally dropped it. The cake fell to pieces on the floor. <i>Point to how you think Sally feels.</i>		
			
	<i>Point to what you think Sally's mum would have put on top of what she dropped.</i>		
			
Anger	All the children are playing outside. Lucy has just finished building a big sand castle. Tom comes over and kicks the sand castle down in front of Lucy. <i>Point to how you think Lucy feels.</i>		
			

Point to what you think Lucy would have put on top of what she built.

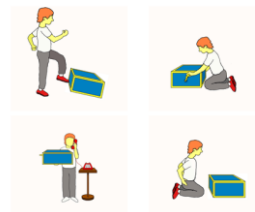


Surprise

The children are all playing inside with toys. Ben is playing with a Jack in the Box. The box pops open and out jumps Jack. *Point to how you think Ben feels.*

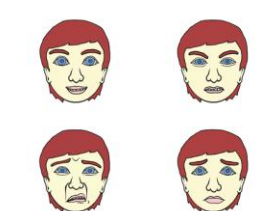


Point to what you think Ben did to open it.



Disgust

Sally and Tom are eating cake. Tom has a very big piece of cake. Tom eats all his cake and feels sick. He vomits all over his shoes. *Point to how you think Sally feels.*

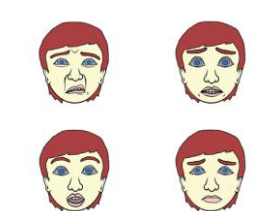


Point to what you think Tom should do now.



Fear

Sally lets her friends pat her bird, but Ben is hiding behind the couch. Now they are patting her bird outside, but Ben runs away. *Point to how you think Ben feels.*


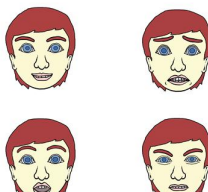


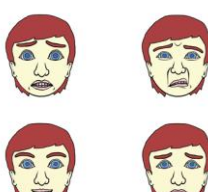
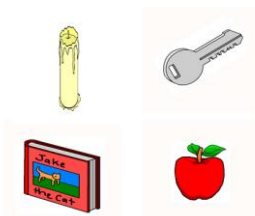
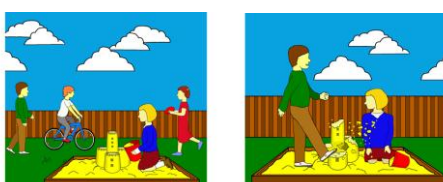
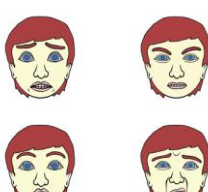
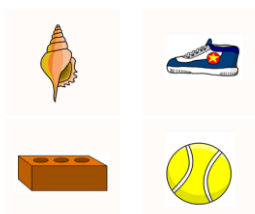


Point to what you think Sally's pet would like most to eat or drink.



Table B2.

The pictures and alternate answers from the visual version of the story book

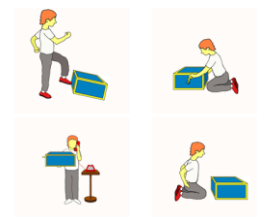
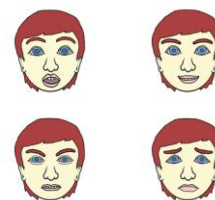
Target Emotion	Pictures	Four alternate answers	
Happiness			
	<p>Point to how you think Sally feels.</p> <p>Point to what you think Sally will wear.</p>		
Sadness			
	<p>Point to how you think Sally feels.</p> <p>Point to what you think Sally's mum would have put on top of what she dropped.</p>		
Anger			
	<p>Point to how you think Lucy feels.</p> <p>Point to what you think Lucy would have put on top of what she built.</p>		

Surprise



Point to how you think Ben feels.

Point to what you think Ben did to open it.

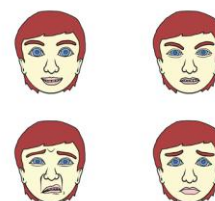


Disgust



Point to how you think Sally feels.

Point to what you think Tom should do now.



Fear



Point to how you think Ben feels.

Point to what you think Sally's pet would like most to eat or drink.

