

## CHAPTER 11

# Impact of Early Brain Insult on the Development of Social Competence

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Social interaction constitutes the fundamental fabric of human existence. Children are continually reading the actions, gestures, and faces of those around them and actively seeking to recognize their underlying mental states and emotions, in order to determine what they are thinking and feeling, and what they will do next. The manner in which a child operates within a social environment, by relying on social skills and interacting with others, is critical for developing and forming lasting relationships and for participating and functioning within the community (Beauchamp & Anderson, 2010; Blakemore, 2010; Cacioppo, 2002). What appears to happen so naturally is, in actual fact, a highly complex process involving the activation of a distributed neural network and the culmination of the individual's life experiences.

Advances in the social neurosciences demonstrate that social skills are intimately linked with neurological and cognitive functions (Adolphs, 2001). For example, to be socially competent, an individual must attend to others and inhibit inappropriate behaviors (executive functions), communicate effectively (language skills), and interpret others' meanings/interactions (social cognition). These specific skills, which contribute to social function, have been linked to specific brain regions (e.g., theory of mind [ToM] has been linked to prefrontal cortices); however, the end products, the social functions we observe in daily behavior, are most likely to be represented by an integrative, distributed neural network. Brain regions identified as contributing to this social network include (among other regions) aspects of the prefrontal cortex and temporoparietal junction, insula, and amygdala (Adolphs, 2001). As has been demonstrated for cognitive functions, it is likely that this network develops and becomes refined through childhood and

adolescence (Beauchamp & Anderson, 2010). An injury to the brain, particularly during the formative childhood years, has the potential to disrupt this network and to result in social dysfunction (Yeates et al., 2007).

The importance of the child's environment has been well established in the developmental psychology literature, with distal factors (e.g., socioeconomic status) and more proximal influences (e.g., family environment) all implicated in the development of intact social functions (Ackerman & Brown, 2006; Bowlby, 1962; Bulotsky, Fantuzzo, & McDermott, 2008; Guralnick, 1999; Masten et al., 1999). These links are also supported by studies of children raised in atypical environments. For example, there is a wealth of research describing Romanian children raised in conditions of severe environmental deprivation. These studies clearly illustrate the potential for such environments to have a negative impact on social development, as well as the cognitive skills that mediate this development (Belsky & de Haan, 2011; Bos, Fox, Zeanah, & Nelson, 2009; Raizada & Kishiyama, 2010).

Social skills emerge gradually through infancy and childhood, consolidating during adolescence. This progression reflects a dynamic interplay between the individual and his or her environment. In the first few months of life, the infant begins to smile and engage with others, and to imitate the actions of these others in an interactive manner. By 5–8 months of age, infants display evidence of goal-directed social behavior. At 3–4 years children can describe the mental states or beliefs of others as distinct from their own (Saxe, Carey, & Kanwisher, 2004), and by 7–8 years they can begin to predict the behavior of others from past experiences (Rholes, Newman, & Ruble, 1990). Social decision making and judgment emerge later, in early adolescence (Van Overwalle, 2009). During this protracted developmental process, any disruption of typical maturation processes will have the capacity to impair future progress. The influence of both family and environmental factors on social development is well established (Belsky & de Haan, 2011; Bos et al., 2009). Findings emerging from the social neurosciences also illustrate the close association between these social skills and underlying brain function (Adolphs, 2009; Van Overwalle, 2009).

Disruption to social function at any stage across the lifespan may have negative implications for a range of domains, including mental health, academic progress, career achievement, and quality of life. Such disruption in early life may interfere with a child's capacity to acquire and develop social skills. An example of such disruption in childhood is early brain insult (EBI). It is well established that brain insult occurring during childhood can result in physical dysfunction, cognitive and communication deficits, behavioral problems, and poor academic performance (Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2009). Less research has examined social function in children with EBI, however, given that many social skills are rapidly emerging through childhood, it is highly likely that victims of such insults will have compromised social development.

This chapter aims to review the current literature examining social outcomes from EBI, using the theoretical frameworks described by Anderson and Beauchamp (Chapter 1, this volume; Beauchamp & Anderson, 2010) and Yeates et al. (2007). These authors suggest that the broad domain of social function may be divided into a series of subdomains—for example, social adjustment, social interaction, and social cognition. We use these categories to structure our review of the empirical evidence. Whenever possible, we also discuss the influence of brain-related and environmental factors for social skills in the context of EBI.

## Early Brain Insult

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EBI refers to injury or insult to the developing central nervous system (CNS). Such insult may occur during the prenatal, perinatal or postnatal periods. The underlying injury mechanisms vary, but can generally be classified into one of the following categories: traumatic, vascular, developmental, infective, or neuroplastic. Location and extent of resultant damage will also vary: unilateral or bilateral; focal or diffuse; frontal or extrafrontal; cortical or subcortical. Similarly, the primary functional consequences of EBI are wide-ranging and include neurological deficits (e.g., seizures), speech and language difficulties (e.g., dysarthria, dyspraxia), motor impairment (e.g., paresis, incoordination), cognitive disabilities (e.g., problems with attention, memory, executive function, social cognition), and behavioral disturbances (e.g., poor self-regulation). Secondary consequences are also common: academic failure, poor vocational success, communication problems, and social dysfunction. Clearly both the etiology and symptomatology are heterogeneous. The unifying factor for all types of EBI is that they occur in the context of a rapidly developing brain, where (1) cerebral organization is likely to be incomplete; (2) neurobehavioral skills are only beginning to emerge; (3) serious damage has the potential to derail the genetic blueprint for typical CNS development; and (4) environmental factors, such as deprivation or enrichment, may have a significant influence on development.

For these children, elevated risk of social dysfunction may be attributed to a number of factors. First, *brain regions and networks* important for social function may be damaged. Current understandings of the biological bases of social function suggest that many brain regions may be involved, and that these may be linked via a distributed neural network. Of particular relevance to the developing child is that many brain regions identified as contributing to social function undergo protracted development (e.g., prefrontal regions) and are thus vulnerable in the context of EBI.

Second, *medical factors* may restrict opportunities for social interaction. For example, a hemiplegia will reduce a child's mobility and thus his or her capacity to interact independently with peers during informal play and sporting activities. Speech difficulties may lead to reduced expressive language fluency, which will reduce opportunities for communication with peers. Seizures may cause those around the child to feel wary or anxious about the child's well-being and thus influence social interactions. Furthermore, many instances of EBI can be conceptualized as chronic illnesses: They are associated with ongoing medical care and health concerns, as well as frequent absences from school, and thus limit typical exposure to social interactions.

Third, a child's *temperament and adjustment* to his or her condition will contribute to the child's social function. It is not uncommon for children experiencing a serious illness to experience depressed self-esteem—in response to “feeling different” from their peers; for the medical reasons noted above; or because of their psychological responses to often life-threatening illness, which can commonly translate into social anxiety and withdrawal. An additional symptom common to early stages of recovery from brain injury is excessive fatigue, which can severely impair a child's motivation and endurance of social interactions, further limiting social exposure. In response to these medical problems, some parents will be overprotective of their vulnerable children, potentially restricting the children's opportunities for engaging independently with peers.

Finally, a *child's environment*, and parents and other family members in particular, can either support or undermine social development following EBI. Not surprisingly, in

the wake of EBI, the family routine can be disrupted. Parents may need to attend hospital and outpatient appointments, and some families may experience financial hardship associated with caring for their children. The associated burden may increase stress and family dysfunction. A secondary impact of early brain insult is the elevated risk of clinically significant stress for parents (McCarthy et al., 2010), with up to one-third of parents presenting with such symptoms even 6 months after diagnosis. Such parental psychopathology has been shown to have a negative impact on the quality of the family environment and on a child's well-being, with recent research identifying a clear link between such factors and children's social and behavioral adjustment (V. Anderson et al., 2006; Yeates, Taylor, Walz, Stancin, & Wade, 2010).

### ***Social Function and EBI: What Are the Challenges?***

A review of the literature investigating social outcomes following EBI reveals a relative dearth of information. Various factors may contribute to this current situation. First, until recently, health care professionals working with children with EBI have failed to recognize the importance of the social dimension for recovery and reintegration; they have concentrated primarily on physical and neurobehavioral domains. This is well illustrated in a study conducted by Bohnert, Parker, and Warschawsky (1997), who reported that when health care professionals and parents were asked to rank the relative importance of health, education, and friendships for an injured child, they agreed that friendships were of least importance. In contrast, children ranked friendships as their top priority. Furthermore, in the past, social function has tended to lack a clearly defined neural substrate, resulting in a tendency for health care professionals to see this area of function as the domain of the family and school. Today, although the social neuroscience framework is not yet fully defined, it is clear that the CNS plays a critical role in subsuming social functions and must be considered in any formulation of social dysfunction.

More recently, there has been an increasing interest in the behavioral consequences of EBI and, related to these, post-EBI social symptoms. As a result, research interest has also turned to this domain; however, as described below, much of the work to date has lacked a theoretical basis and has failed to take advantage of the rich body of knowledge available from other disciplines. These include the fields of developmental psychology and developmental psychopathology, which focus on typical development of social skills and on developmental conditions where social dysfunction is well established (e.g., autism spectrum disorders), respectively.

The final limitation to accumulating knowledge relates to the current dearth of reliable and psychometrically sound measurement tools. Within the social domain, there are few developmentally driven and appropriately age-normed social assessment measures. Most available standardized options are either rating scales or questionnaires, and commonly canvas only parents' or teachers' perceptions. Many of these are global measures of adaptive ability, behavior, or quality of life, which include a small subset of socially relevant items. A smaller group of measures is specific to social skills such as relationships, social interaction, social participation, and loneliness (Crowe, Beauchamp, Catroppa, & Anderson, 2011). An even smaller selection of more empirical measures is available, mostly tapping aspects of social cognition (including empathy, perspective taking, and intent attribution). Although many of these possess good face validity, most have no normative data, and their psychometric properties are largely undocumented. In summary,

social measures with clinical applicability are scarce, and this scarcity impedes progress in integrating social assessment into clinical practice and treatment (see Muscara & Crowe, Chapter 6, this volume).

### ***Social Function and EBI: Theoretical Frameworks***

In response to a largely atheoretical approach to the investigation of social consequences of EBI, two complementary neuropsychological models of social function have recently been described (Beauchamp & Anderson, 2010; Yeates et al., 2007). Both highlight the importance of typical brain development for social competence. They each propose that a disruption to development, via an injury or insult to a child's brain, can have significant consequences for the child's acquisition of social skills and knowledge and social function.

Yeates et al. (2007; see also Yeates et al., Chapter 10, this volume) present a heuristic describing social outcomes within a developmental psychology framework and with a focus on outcomes from TBI. Three important components of social function are highlighted: social information processing, social interaction, and social adjustment. Social outcomes are conceptualised as susceptible to insult-related risk factors (e.g., type and severity of insult and brain atypicalities), as well as non-insult-related factors (including parenting style, family function, and socioeconomic status).

Beauchamp and Anderson (2010) offer a similar framework, although with less focus on brain insult specifically. These authors place their emphasis on the mediating role of brain (development and integrity) and environment (family, temperament) on neurobehavioral skills (attention/executive function, communication, and social cognition), and consequently on social competence.

The following review of the research examining the social consequences of EBI draws on the models described by Yeates et al. (2007) and Beauchamp and Anderson (2010) as frameworks for available findings.

### **Social Function and EBI: What Do We Know?**

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Over the past few years, in keeping with the emergence of social neuroscience and the recognition of the debilitating and persisting impact of these problems, research has begun to describe social outcomes associated with EBI. The limited research available has demonstrated deficits in the cognitive skills central to social function (e.g., executive function and communication skills) (Anderson, Catroppa, et al., 2009; Catroppa & Anderson, 2005; Didus, Anderson, & Catroppa, 1999; Hanten et al., 2008; Janusz, Kirkwood, Yeates, & Taylor, 2002; Long et al., 2011). While not directly assessing links between these deficits and social function, these studies have provided a platform for conceptualizing the presence of social dysfunction. Only a very small number of studies have attempted to examine possible links between specific cognitive domains implicated in social function and social outcomes (Ganesalingam, Sanson, Anderson, & Yeates, 2007; Ganesalingam, Yeates, Sanson, & Anderson, 2007; Ganesalingam et al., 2011; Greenham, Spencer-Smith, Anderson, Coleman, & Anderson, 2010; Muscara, Catroppa, & Anderson, 2008), and these early results support the presence of such relationships.

### ***Social Outcomes from Traumatic Brain Injury***

Traumatic brain injury (TBI) is the most common cause of death and morbidity in childhood. It occurs as a result of a blow to the head, which characteristically leads not only to localized brain damage at the site of impact and the *contrecoup* site (i.e., the area opposite the impact site), but also to more diffuse axonal injury. Due to the shape of the skull, and the effects of injury forces, some brain regions are more vulnerable to damage than others. These include the frontal and temporal regions of the brain and white matter. More recently, several additional subcortical structures have also been found to be affected in the context of child TBI, including the hippocampus, corpus callosum, and amygdala (Beauchamp et al., 2011). Many of these regions, highlighted in Plate 11.1 on the color insert, have also been implicated as contributing to the social brain; this suggests that children with TBI may be particularly vulnerable to social difficulties of an organic basis.

The vast majority of research into social development after early insult to the CNS has focused on TBI. Children with TBI have been reported to show lower levels of self-esteem and adaptive behavior than controls, and higher levels of loneliness and behavioral problems (Andrews, Rose, & Johnson, 1998), as well as more difficulties in peer relationships (Bohnert et al., 1997). For example, Yeates and colleagues (2004) examined social functioning in 109 children with TBI (ages 6–12). They showed that parents of children with moderate to severe TBI reported their children to have poor social and behavioral functioning. No substantial recovery in social function was reported over the 4 years after injury, and in some cases levels of social functioning worsened. These findings are consistent with previous studies with smaller samples, which have also examined social functioning in children with TBI (Andrews et al., 1998). Although long-term outcomes are only just emerging as a research focus, studies of such outcomes are also beginning to identify links between poor social function following child TBI on the one hand and persisting social maladjustment and reduced quality of life on the other (Anderson, Brown, & Newitt, 2010; Cattalani, Lombardi, Brianti, & Mazzucchi, 1998).

### ***Social Adjustment***

*Social adjustment* is best described as “the degree to which children get along with their peers; the degree to which they engage in adaptive, competent social behavior; and the extent to which they inhibit aversive, incompetent behavior” (Crick & Dodge, 1994, p. 82). The majority of studies examining social adjustment have done so by administering broad-band parent questionnaires. Some of these studies have used questionnaires tapping behavioral function—for example, the Child Behavior Checklist (Asarnow, Satz, Light, Lewis, & Neumann, 1991; Poggi et al., 2005) and the Strengths and Difficulties Questionnaire (e.g., Tonks, Williams, Yates, & Slater, 2011). Others have used measures tapping adaptive abilities—for example, the Vineland Adaptive Behavior Scales or the Adaptive Behavior Assessment System (e.g., Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2001; Fletcher, Ewing-Cobbs, Miner, Levin, & Eisenberg, 1990; Ganesalingam et al., 2011). Overall, these studies have been divided in their findings. Some have reported evidence that children and adolescents with TBI display greater social incompetence than control groups, as demonstrated by poorer parent ratings for socialization

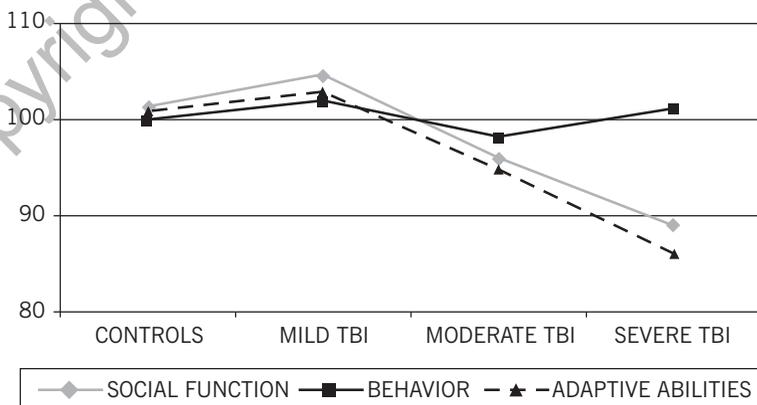
and communication skills (Fletcher et al., 1990; Max et al., 1998; Levin, Hanten, & Li, 2009; Poggi et al., 2005); in contrast, others have reported no significant group differences (Anderson et al., 2001; Hanten et al., 2008; Papero, Prigatano, Snyder, & Johnson, 1993; Poggi et al., 2005). Whether greater injury severity leads to poorer social adjustment is as yet unclear. Some studies have suggested that children with severe TBI are more impaired in socialization, communication, and/or social competence than children with milder injuries (Asarnow et al., 1991; Fletcher et al., 1990; Max et al., 1998; Yeates et al., 2004), but other studies have failed to find these dose–response relationships (Papero et al., 1993).

A smaller number of studies have incorporated findings from multiple respondents to investigate social adjustment. Ganesalingam and colleagues (Ganesalingam, Sanson, Anderson, & Yeates, 2006, 2007; Ganesalingam, Yeates, et al., 2007) used both parent ratings and direct child measures, and found that children with moderate and severe TBI were rated by parents as more socially impaired than uninjured children. Similarly, on the direct child measures, survivors of child TBI self-reported poorer emotional and behavioral self-regulation and more frequent aggressive, avoidant, or irrelevant solutions to social problems than uninjured children. These authors found no differences between children with severe and moderate TBI.

Our research team has recently conducted a study tracking 10-year functional outcomes from early TBI (age at injury > 7 years). Using parent report measures, we found differences between injury severity groups (mild, moderate, severe) for social skills and adaptive abilities, but with fewer severity effects for behavioral outcomes, as illustrated in Figure 11.1 (Anderson, Godfrey, Rosenfeld, & Catroppa, in press). These findings highlight the persistence of postinjury social dysfunction over the long term.

### Social Interaction

*Social interaction* refers to the social actions and reactions between individuals or groups modified to their interaction partners (Beauchamp & Anderson, 2010). To study this aspect of social function, Bohmert and colleagues (1997) and Prigatano and Gupta (2006)



**FIGURE 11.1.** Functional outcomes 10 years following childhood TBI.

each investigated friendships of children who had sustained a TBI. Bohnert et al. (1997) employed both children and parents as respondents, and found no differences between children with and without TBI in friendship networks or on the Friendship Quality Questionnaire (Parker & Asher, 1993). In contrast, Prigatano and Gupta (2006), using parent ratings, reported results that supported a dose-response relationship. Specifically, children with severe TBI reported less close friendships than children with moderate or mild TBI, and children with moderate TBI had less close friendships than children with mild TBI.

In an early study conducted by Andrews and colleagues (1998), a series of questionnaires tapping various aspects of social interactions was administered to children and parents. Findings showed that children with TBI experienced higher levels of loneliness and had a higher likelihood of aggressive or antisocial behaviors than controls. Similarly, Dooley, Anderson, Hemphill, and Ohan (2008) investigated aggressive responses in adolescents with a history of TBI, compared to a healthy control sample. These authors found that although a frequently used broad-band measure, the Child Behavior Checklist (Achenbach, 1991), detected no group differences in aggressive behavior, the use of an aggression-specific measure showed greater sensitivity, identifying that history of TBI was related to higher rates of both reactive and proactive aggression. Such findings suggest that to accurately identify and characterize the social consequences of EBI, it is important to use tools sensitive to this domain.

These contradictory outcomes are difficult to interpret and are most likely to be explained by methodological differences, including TBI definition, composition of control groups, small sample sizes, and measurement tools. In an attempt to provide some clarity regarding the presence of social interaction difficulties and their persistence into adulthood, we recently conducted a retrospective study and surveyed a sample of 160 survivors of child TBI; we used a quality-of-life scale, a modified version of the Sydney Psychosocial Reintegration Scale (Tate, Hodgkinson, Veerbangsa, & Maggiotto, 1999). As shown in Figure 11.2, adult survivors of severe child TBI reported significant problems in multiple areas of their lives, including relationships and work and leisure activities. Few

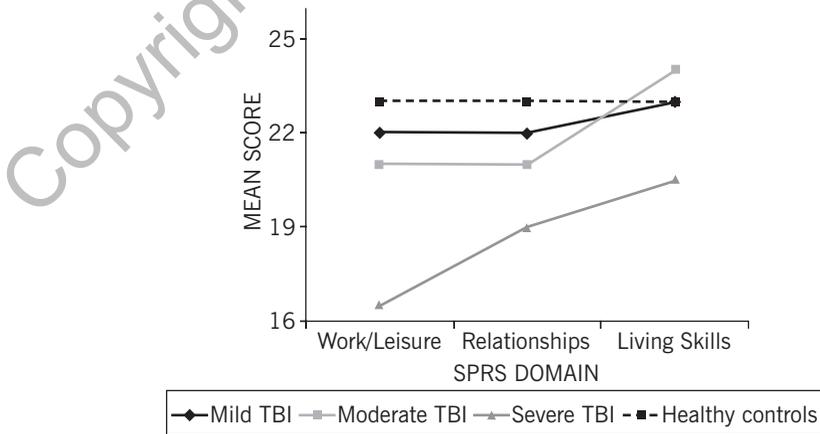


FIGURE 11.2. Quality of life in adult survivors of childhood TBI.

of these individuals reported having a stable group of friends or a life partner, and only a small number were gainfully employed. Furthermore, engagement in leisure activities, such as sports or social groups, was rare. Mild and moderate TBI was related to more typical function in social participation and other domains (Anderson et al., 2010). These findings provide strong support for the lasting effects of TBI (especially severe TBI) on problems in social interaction, and for their secondary repercussions.

### *Social Cognition*

*Social cognition* refers to the mental processes used to perceive and process social cues, stimuli, and environments (Beauchamp & Anderson, 2010). In contrast to social adjustment and social interaction, measurement within this domain is largely based on direct child assessments, although most of these are currently restricted to experimental tools. This domain of social function appears to have attracted the most recent attention, with a growing number of recent studies investigating outcomes in this area after child TBI. Below, we have grouped this research into studies examining social problem solving, social communication, and social information processing (incorporating ToM and emotion perception).

#### SOCIAL PROBLEM SOLVING

Several recent studies have investigated social problem solving in children and adolescents after TBI, using direct child measures. Hanten et al. (2008) and Janusz et al. (2002) both used Interpersonal Negotiation Strategies (INS; Yeates, Schulz, & Selman, 1990), a child-based tool, to measure social problem solving. The INS consists of hypothetical interpersonal dilemmas that involve four social-solving problem steps: defining the problem, generating alternative strategies, selecting and implementing a specific strategy, and evaluating outcomes. Hanten et al. (2008) found that children with a TBI scored significantly lower on the INS from baseline through to 1 year after TBI, with no differential improvement in performance 1 year after TBI in both the TBI and control groups. Similarly, Janusz et al. (2002) reported that children with TBI scored significantly lower on social problem solving. Furthermore, children with TBI were able to generate solutions to social problems, but had difficulty choosing the optimal solution. These authors also investigated performance differences between injury severity groups, but detected no severity effects between those with severe and moderate TBI.

Warschausky, Cohen, Parker, Levendosky, and Okun (1997) used a similar paradigm, the Social Problem Solving Measure (Pettit, Dodge, & Brown, 1988), to assess solutions to social problems in children ages 7–13 years. Children with TBI provided significantly fewer peer entry solutions in social engagement situations than control children, but the groups did not differ with regard to the number of solutions to peer provocations. In a study from our team (Muscara et al., 2008), we investigated the relationship between executive function and social function 10 years after child TBI. This study extended the work of Yeates et al. (2004), which had previously proposed that social problem solving is a mediator between neurocognitive function and social skills, rather than a direct link. We found that greater executive dysfunction was associated with less sophisticated social problem-solving skills and poorer social outcomes. Furthermore, the maturity of social problem-solving skills was found to mediate the relationship between executive function

and social outcomes in TBI, providing the first empirical evidence for a link between executive and social skills in the context of childhood acquired brain injury.

#### SOCIAL COMMUNICATION

This domain of social function refers specifically to the child's ability to draw meaning from complex language. Tasks tapping these pragmatic language skills include aspects of cognitive function (e.g., working memory and executive function), as well as abilities more commonly considered as social cognition—such as the identification of irony and sarcasm in conversation, and the ability to draw inferences from linguistic information and to distinguish truth from falsehoods (Turkstra, Dixon, & Baker, 2004; Turkstra, Williams, Tonks, & Frampton, 2008). Using the Video Social Inference Test with a group of adolescents after TBI, Turkstra et al. (2008) demonstrated that child TBI was associated with poorer identification of sarcasm and irony and with greater difficulties interpreting inference in both photographs and stories. Dennis, Guger, Roncadin, Barnes, and Schachar (2001) have reported similar findings with younger children, showing deficits in understanding deceptive emotions, literal truth, irony, and deceptive praise.

#### SOCIAL INFORMATION PROCESSING

Studies investigating social information processing have focused primarily on ToM and emotion perception in school-age children and adolescents. For example, Turkstra et al. (2004, 2008) measured ToM in adolescents with TBI, using a second-order belief task and a pragmatic judgment test. They found that, in contrast to healthy controls, adolescents with TBI were deficient in judging whether a speaker was talking at the listener's level and in recognizing when an individual was monopolizing a conversation. In contrast, the group with TBI performed similarly to controls on a first-order belief task (identifying a good listener), as well as on a faux pas test and the Strange Stories test.

Walz, Yeates, Taylor, Stancin, and Wade (2010) also examined ToM in a group of children who had sustained TBI between 3 and 5 years of age, and found few differences between the children with TBI and controls. These authors observed that as ToM skills would only be emerging in typically developing children at the time these children sustained their injuries, their results required follow-up. Of note, this group also demonstrated significant problems on ToM tasks, particularly for children with severe TBI. These studies highlight the need for a developmental perspective, as well as the importance of taking into account both age at injury and age at assessment when interpreting study findings.

Children and adolescents with TBI have also been reported to have more difficulty than controls in recognizing emotions. Tonks, Williams, Framton, Yates, and Slater (2007) found that children with TBI were more impaired than control children in recognizing emotions expressed in the eyes, but showed equivalent competence in recognizing facial emotions, suggesting that adding context assisted social information processing.

In summary, the weight of evidence indicates that children sustaining TBI are at elevated risk of experiencing social deficits, including social adjustment, social interaction, and social cognition. These problems persist over the long term after TBI. Further

work is needed to describe the potential impact of injury-related factors (e.g., severity, age at insult) and environmental influences on these social consequences.

### **Social Outcomes from Pediatric Stroke**

Pediatric stroke (PS) is a relatively uncommon occurrence, affecting approximately 7 of every 100,000 children. PS is an acute cerebrovascular event that can occur at any stage during childhood, but is perhaps most frequent in the perinatal period. There are two forms of PS: *arterial ischemic stroke* and *hemorrhagic stroke*. Arterial stroke is caused by a blockage or obstruction of an artery due to a clot, resulting in disrupted blood flow and relatively focal damage. Hemorrhagic stroke, in contrast, involves the rupture of an artery, often leading to more diffuse brain damage. Depending on the type of stroke and the artery affected, brain lesions caused by PS will vary in severity, extent, and location (Gomes, Rinehart, & Anderson, 2011). Infarcts in the middle cerebral artery will affect dorsolateral frontal cortex, basal ganglia, and white matter, whereas anterior cerebral artery stroke leads to bilateral lesions in orbitofrontal, temporal, and parietal cortices. Given the distributed nature of the social brain network, it is not surprising that damage from PS may lead to social problems.

Children recovering from stroke often have unique social challenges due to functional and physical impairments. According to the Canadian Paediatric Ischaemic Stroke Registry, there are long-term functional and neurological deficits in 60–85% of cases (Sofranas et al., 2006). Motor impairments are common, with as many as 30–60% of children experiencing effects ranging from mild weakness to severe hemiplegia (Brower, Rollins, & Roach, 1996; Ganesan et al., 2000; Gordon, Ganesan, Towell, & Kirkham, 2002). Hearing and visual impairments may reduce a child's capability to encode and interpret subtle social cues that are based on both verbal and nonverbal behaviors. Specifically, visual difficulties can cause unusual eye contact and lead to subsequent social difficulties, which may mirror the reciprocal communication deficits present in autism spectrum disorders.

In contrast to the range of studies documenting social dysfunction in the context of child TBI, relatively little work has been done investigating social outcomes of PS. There is, however, evidence of disruption to at least some of the cognitive skills underpinning social competence. For example, recent studies have identified significant deficits in executive skills and attention in victims of PS (Long et al, 2011), while the seminal work of Bates and colleagues (2001) has detailed the nature of communication problems in the context of PS.

Three general reviews (deVeber, MacGregor, Curtis, & Mayank, 2000; Ganesan et al., 2000; Goodman & Graham, 1996) have provided some insight into research on social outcomes following PS. As in TBI research, the social measures used in this research have commonly been broad-band in nature, including the Child Behavior Checklist (Achenbach, 1991; Achenbach & Edelbrock, 1983) and the Vineland Adaptive Behavior Scales (Sparrow, Balla, & Cicchetti, 1984). deVeber et al. (2000) focus largely on neurological and physical outcomes, and only mention the social domain briefly. Goodman and Graham (1996) highlight that children with PS require additional assistance for optimal school and home participation, and Ganesan et al. (2000) report that 37% of parents of children with PS were “concerned” about their child's behavior.

### *Social Interactions*

A handful of studies have commented on this area of social function in the context of PS, using specific measures to characterize the quality of social interactions. A recent study by Everts et al. (2008) examined children who suffered stroke from birth to 18 years; qualitative reports indicated low peer acceptance, mood instability, and decreased social support from peers for many participants, though these domains were not explicitly measured. De Schryver, Kappelle, Jennekens-Schinkel, and Boudewyn Peters (2000) also documented changes in social behavior and companionship, as reported by parents of children with PS.

Steinlin, Roellin, and Scroth (2004) studied a small group of 16 survivors of PS and detected significant changes in social interactions, including a qualitative difference in friendships with peers, as reported by parents. Findings emphasised children's difficulties in implementing social skills in real-life situations, linking these problems to the impact of cognitive deficits (e.g., processing speed), though this relationship was not statistically tested. It should be noted that these results were based solely on qualitative questions related to integration with peer groups and family, and so they need to be interpreted with caution.

### *Social Participation*

*Social participation* is defined by the World Health Organization (2001) as involvement in life situations—for example, sporting and recreational activities. To date, patterns of social participation following PS remain relatively unknown. One study (Hurvitz, Warschausky, Berg, & Tsai, 2004) investigated 29 adults at an average of 12 years following PS. Results demonstrated a high proportion of high school graduations; 90% of participants were employed; and 79% of the adult survivors could drive. Despite these positive outcomes, living skills, communication, and socialization were in the moderately low range. Age at stroke onset was found to have no association with outcomes. The impact of non-insult-related factors was not examined.

Tonks et al. (2011) have also recently studied social participation in children with PS and other acquired brain insults ( $N = 135$ ). They found that, compared to healthy controls, the children with PS demonstrated a restricted level of diversity and intensity across a range of activities: recreational, social, and self-improvement. This pattern was common across the sample and was not related to severity of brain insult. These authors also highlighted the key role of intact social participation for children's general health and quality of life. In similar studies, parents of children with serious acquired brain injuries have reported that their children show reduced participation in peer-related activities and daily routines (Bedell & Dumas, 2004).

### *Potential Contributors to Psychosocial Outcomes*

#### BRAIN-RELATED PREDICTORS

Neuropsychological factors and their contribution to social outcomes after stroke have been compared across child and adult participants. Mosch, Max, and Tranel (2005) matched children ( $n = 29$ ) and adults ( $n = 29$ ) who had sustained a stroke, with respect

to size, location, and hemisphere affected. Impairments in social adjustment (employment/educational status, interpersonal functioning, clinician rating) were measured with the Child Behavior Checklist and the Vineland Adaptive Behavior Scales, as well as a psychiatric diagnostic tool, the Schedule for Affective Disorders and Schizophrenia for School-Age Children—Present and Lifetime Version (Kaufman et al., 1997). Social competence in adults was associated with right-hemisphere lesions, whereas children with stroke displayed mild and moderate social deficits regardless of the side of lesion. Though adults with left-hemisphere lesions had speech and language impairments, their child counterparts obtained average scores. Trauner, Panyard-Davis, and Ballantyne (1996) have also examined social recovery, describing 17 children with a history of stroke prior to 6 months of age (including prenatal, perinatal, and childhood strokes). Using the Personality Inventory for Children (Wirt, Lachar, Klinedinst, Seat, & Broen, 1977). They found that regardless of lesion laterality, children with focal strokes had greater impairment than healthy controls on several subscales, including General Adjustment, Social Skills, and Social Desirability. Extrafrontal lesions were associated with difficulties in emotional communication and processing of affective information. The results from both of these studies (Mosch et al., 2005; Trauner et al., 1996) suggest that regardless of lesion laterality, PS may lead to reduced social competence, even when language skills remain intact. It should be noted that the variable age at stroke onset in these studies may have led to an exaggeration of difficulties in the context of acquired stroke, as deficits may be more severe in children with prenatal/perinatal lesions than in those with childhood stroke (Nass & Trauner, 2004).

Following childhood stroke, severity, often indexed by lesion size, may be a useful predictor of outcome; however, to date relationships among IQ, behavioral and social outcomes, and infarct volume have not been found (Everts et al., 2008; Nass & Trauner, 2004). Similarly, a small body of PS research has demonstrated that localization of infarction is predictive of functional outcome (Long et al., 2011; Roach, 2000). In contrast, the work of Max and his colleagues has consistently documented a relationship between lesion location and psychosocial function following PS. For example, lesions involving the putamen or orbitofrontal cortex have been linked to traits of attention-deficit/hyperactivity disorder in samples with PS (Max et al., 2002, 2005). Overall, however, studies investigating the general impact of lesion size and location have been inconclusive (Nass & Trauner, 2004; Steinlin et al., 2004).

#### AGE AT STROKE ONSET

Due to the timing of insult and developing brain networks, children suffering from stroke may have greater vulnerabilities to social difficulties and psychopathology than the healthy population. PS presents with unique characteristics, including a defined date of onset, usually a focal location of injury, and often a brain that was premorbidly healthy. As in the cognitive and psychiatric domains (Max, Bruce, Keatley, & Delis, 2010; Westmacott, MacGregor, Askalan, & deVeber, 2009), age at stroke onset may affect social outcomes. Although there have been no studies to date addressing this issue in PS, recent research examining EBI in general suggests that children with injuries sustained in the prenatal period, before 2 years of age (including perinatal stroke), are at greatest risk of social deficits (Greenham et al., 2010). However, the risk of social deficits

is elevated following brain insult at any age during childhood (Anderson, Spencer-Smith, et al., 2009).

#### IMPACT OF CHRONIC ILLNESS

Due to physical limitations, anxiety, absenteeism, parents' concerns, stigmatization, embarrassment, and generally limited opportunities for social interaction, stroke in the early years may disrupt a child's ability to function in his or her typical environment (Middleton, 2001; Nassau & Drotar, 1995). This is consistent with findings in adult stroke research, where withdrawal from professional and social groups, and discontinuation and loss of social identity, are described as leading to decline in quality of life (Haslam et al., 2008). Like their adult counterparts, children are likely to experience a loss of selfhood in the aftermath of PS, with the potential for negative effects on mood, well-being, and overall recovery.

#### ***Social Outcomes from Brain Tumor***

Childhood cancers, and in particular, brain tumors have been related to higher levels of stress and trauma than most other brain-related conditions (McCarthy et al., 2010). Although brain tumors are relatively uncommon in children, treatment advances in childhood cancers have led to improved survival rates and an increasing focus on quality-of-life outcomes. Psychosocial consequences have received considerable attention, although little research to date has focused on the brain bases of these problems. Rather, the emphasis has been on adjustment to life-threatening disease, extended treatment, and the impact these have on self-concept and quality of life. However, regardless of the assessment approach employed or the social domain under study, findings consistently document long-term social problems in these children (Schulte & Barrera, 2010).

#### *Social Adjustment*

Like the studies of children with TBI and PS, research on children with brain tumors has also mainly employed broad-band measurement tools. Using parent- and teacher-based ratings from the Child Behavior Checklist, Aarsen et al. (2006) described poor social adjustment after diagnosis and treatment of brain tumors. Others have replicated this finding, using other measures (Varni, Seid, & Rode, 1999; Bhat et al., 2005; Poretti, Grotzer, Ribi, Schonle, & Bolthausen, 2004; Sands et al., 2005; Upton & Eiser, 2006). Although this finding has not been universal (e.g., Carey, Barakat, Foley, Gyato, & Phillips, 2001), inconsistent results are most likely related to postdiagnosis timing; Mabbott et al. (2005) have noted that social adjustment may appear intact acutely, but problems increase with time since diagnosis.

#### *Social Interaction*

Survivors of childhood brain tumors are also reported to struggle with peer interaction and social participation more generally. Studies describe these children as having fewer friends (Barrera, Schulte, & Spiegler, 2008), and as experiencing limited social opportunities, social isolation, peer exclusion, and bullying (Boydell, Stasiulis, Greenberg, Greenberg, & Spiegler, 2008; Upton & Eiser, 2006; Vance, Eiser, & Home, 2004).

### *Social Cognition*

Bonner et al. (2008) have conducted one of the few studies evaluating social cognition in children with brain tumors. These researchers examined facial expression recognition and found that children with brain tumors made more errors than expected when interpreting facial expressions.

### *Predictors of Social Problems*

#### BRAIN FACTORS

A number of risk and resilience factors have been investigated in the context of childhood brain tumors. Somewhat surprisingly, treatment factors have been shown to have little impact on social outcomes (Schulte, Bouffet, Janzen, Hamilton, & Barrera, 2010). In contrast, there is some evidence that developmental stage is relevant: The greatest social consequences are identified in association with both early diagnosis (social adjustment, social cognition: Foley, Barakat, Herman-Liu, Radcliffe, & Molloy, 2000; Bonner et al., 2008) and diagnosis during adolescence (reduced quality of life: Aarsen et al., 2006). These findings suggest that disturbances in social competence are most likely during “critical periods” of social development. As noted above, and in keeping with observations of increasing brain pathology and neurocognitive impairment with greater time after brain tumor diagnosis, poorer social competence also appears to develop over time; most problems emerge between 7 and 11 years after illness (Kullgren, 2003; Poretti et al., 2004; Aarsen et al., 2006; Mabbott et al., 2005).

#### INTERNAL AND ENVIRONMENTAL FACTORS

Several studies have addressed child-related contributors to social outcomes after childhood brain tumors. For example, a number of studies have identified poorer social competence in survivors with lower levels of intelligence (Poggi et al., 2005; Carey et al., 2001; Holmquist & Scott, 2003). Interestingly, these studies have reported greater links between nonverbal skills and social skills, with less evidence of a relationship between verbal skills and the social domain. Poorer social adjustment and social participation have also been associated with lower body mass index (Schulte et al., 2010). Perhaps contrary to expectations, links with social and family factors have been less compelling (e.g., Kullgren, 2003).

In a review of this literature, Schulte and Barrera (2010) advise caution in interpreting these findings. They note the heterogeneous nature of samples with brain tumors in terms of age at injury and time since diagnosis, as well as retrospective designs and inadequate assessment tools in this research.

### ***Social Outcomes from Focal EBI***

Focal brain insult is relatively rare in infancy and childhood, where the mechanism of insult is more frequently generalized (e.g., TBI, cerebral infection, hypoxia). Types of focal EBI include developmental conditions (e.g., focal dysplasias), as well as those acquired postnatally (e.g., PS, tumor, penetrating head injury). (PS and tumor have been discussed separately above; we focus in this section on focal EBI in general.) Traditionally, it has

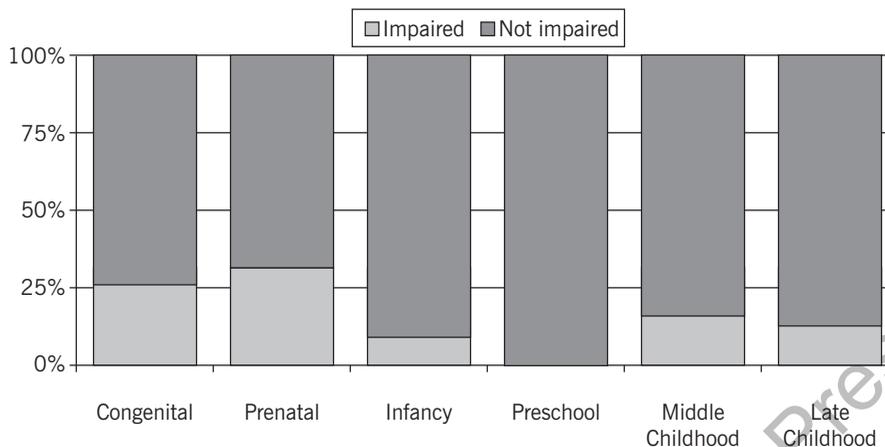
been argued that in the context of the “plastic” developing brain, the functions subsumed by these focal brain regions may be readily reorganized into other health brain regions, with no observable functional deficits. The earliest data describing the impact of focal EBI on social function comes from several case studies. To date, there have been few group studies of social outcomes following focal brain insults in infancy and early childhood. In a recent study, our team has examined the social consequences of focal brain insult sustained in childhood, with the aim of identifying (1) whether focal EBI is linked to social deficits; (2) whether age at insult is a predictor of social deficits; and (3) what additional factors might predict such deficits (Greenham et al., 2010).

The study compared social outcomes for children sustaining focal EBI at different times from gestation to late childhood, to determine whether the EBI was associated with an increased risk of problems. Children with focal EBI were categorized according to timing of insult: (1) congenital ( $n = 38$ ), first–second trimester; (2) perinatal ( $n = 33$ ), third trimester to 1 month after birth; (3) infancy ( $n = 23$ ), 2 months–2 years after birth; (4) preschool ( $n = 19$ ), 3–6 years; (5) middle childhood ( $n = 31$ ), 7–9 years; and (6) late childhood ( $n = 19$ ), after 10 years. Children’s teachers completed questionnaires measuring social function. Results showed that for the total group, children with focal EBI were at a significantly increased risk for social impairment, compared to normative expectations. Somewhat surprisingly, the children with focal EBI did not demonstrate significant deviations from average for self-control, school adjustment, or empathy. Although mean ratings for this group were not severely impaired (i.e., they generally fell within 1 *SD* of expectations), these children were rated as having fewer prosocial behaviors than typically developing peers, with particular difficulties identified for peer relationships. The children with EBI also experienced significantly more emotional symptoms and hyperactivity than population expectations. Our findings are in line with previous group-based studies examining children with brain injury (Andrews et al., 1998; Bohnert et al., 1997; Ganesalingam et al., 2006; Janusz et al., 2002; Yeates et al., 2007) and with case reports (e.g., S. W. Anderson, Barrash, Bechara, & Tranel, 2006; S. W. Anderson, Bechara, Damasio, Tranel, & Damasio, 1999), both of which have consistently identified persisting social and behavioral problems in children with a variety of diagnoses (e.g., TBI, PS, tumor).

Furthermore, focal EBI before age 2 years was associated with the most significant social impairment, whereas children with focal EBI in the preschool years and in late childhood recorded scores closer to average levels.

The study provided only limited evidence for the role of age of insult in predicting social difficulties. Focal EBI before age 3 years conferred particular risk, but significant effects were confined to the domains of peer relations and emotional symptoms. Examination of impairment ratings yielded additional findings (see Figure 11.3). A third to a half of the children who sustained lesions before age 6 scored in the impaired range for social skills. Pre- and perinatal insults were associated with the greatest social problems, whereas all other groups recorded fewer social difficulties.

Although previous research has indicated that lesion characteristics (location, laterality) contribute to cognitive outcome in children, this did not appear to be the case for social outcomes. Lesion location and laterality were not predictive of social outcome, nor was social risk. In contrast, presence of disability (seizures) and family dysfunction were shown to contribute to poorer social outcomes.



**FIGURE 11.3.** Rates of social impairment and age at focal EBI. Adapted from Greenham, Spencer-Smith, Anderson, Coleman, and Anderson (2010). Copyright 2010 and adapted by permission of the authors.

## Conclusions

There is growing interest in the social consequences of EBI; however, evidence to date is relatively scarce. Not surprisingly, the available literature does indicate that the presence of EBI is associated with an elevated risk of social dysfunction across a range of dimensions—social adjustment, social interaction and participation, and social cognition. The ways in which these domains interact with one another and with a child's other skills remain unclear, and the measures generally employed in such studies are not intended for the assessment of social skills specifically. In addition, it appears that the injury-related risk factors established as predictors of cognitive and physical outcomes from EBI (injury severity, lesion location, age at insult) are unable to predict social outcomes in isolation. Rather, findings suggest that environmental factors play a key role. Social context, family function, and child temperament and adjustment to brain insult are all important in determining a child's social outcome. The recent development of theoretical models of social function and EBI (derived largely from the social neuroscience, developmental, and developmental psychopathology literatures), and the findings emerging from longitudinal studies of EBI, show great promise and will facilitate future research in the field.

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