Exploratory analyses of emotion recognition difficulties in children with acquired brain injury

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CONTENTS

Abstract

Socio-emotional behaviour problems are common in children following acquired brain injury (ABI), and have been linked to an underlying impairment in the ability to recognise emotional expression from other peoples' faces and eyes. This study aimed to extend previous research by exploring the relationships between emotion recognition, cognitive functioning, and nature of neurological injury. As previous research has typically focussed on children with traumatic brain injury, this study included a more representative sample of the types of focal and diffuse/multi-focal ABI seen in routine clinical practice. Exploratory analyses were conducted on the performance of 14 children with ABI compared with 67 non-ABI controls on measures of emotion recognition from faces and eyes. Children with ABI performed significantly worse than children without ABI on both measures. This deficit remained when controlling for cognitive functioning on the faces task, but not on the eyes task. There was no predictive relationship between emotion recognition performance and scores on a measure of socio-emotional behaviour in the ABI group, although relationships between performance on some cognitive measures and socio-emotional outcomes were found. No significant relationships were found between timing or type (focal or diffuse/multi-focal) of ABI, and emotion recognition performance. The findings highlight the presence of emotion recognition difficulties in a group of children not pre-selected for emotion recognition or socio-emotional difficulties, suggesting that emotion recognition difficulties may be more prevalent than previously anticipated. Further research with a larger ABI sample and longitudinal design would be beneficial in clarifying the potential developmental emergence of predictive relationships between emotion recognition and socio-emotional outcomes.

Keywords: Emotion recognition; child; brain injury; social cognition; theory of mind

Introduction

Difficulties with socio-emotional behaviour (the ability to recognise and interpret others' emotional states and intentions and adjust one's own emotional responses and behaviour, to enable effective social interaction; Bachevalier and Loveland, 2006; Milders, Ietswaart, Crawford and Currie, 2008) are common among children following acquired brain injury (ABI). These difficulties are typically characterised by emotional distress, conduct problems and difficulties with peer relationships (Anderson, 2003; Chapman et al., 2010; Fuemmeler, Elkin and Mullins, 2002), which can endure into adulthood, and have been associated with adverse outcomes such as an increased risk of mental health difficulties (Horneman, Folkesson, Sintonen, Von Wendt, and Emanuelson, 2005). Nevertheless, relatively few studies have explored the factors that may lead to the development of socio-emotional difficulties in children following ABI.

Although socio-emotional difficulties may be partly related to factors such as adjustment and loss post-ABI (Middleton, 2001), the ABI itself has also been implicated as a causal factor (Anderson, 2003). ABI may result in difficulties with a range of cognitive functions (eg. processing speed, attention, memory, executive functioning, and visuo-perceptual/visuo-spatial functioning; Middleton, 2001) that may have an important role in synchronicity and guiding adjustment of behaviour according to social rules and demands (Anderson, Damasio, Tranel and Damasio, 2000; Ylvisaker and Feeney, 2002). It seems plausible, therefore, that cognitive impairment following ABI may contribute to difficulties with social interaction.

However, effective social functioning may also be underpinned by specific skills in recognising emotionally-valenced cues expressed by the eyes, face and voice, in order to determine the intentions and emotional responses of other people (Tonks et al., 2008a). Research has increasingly highlighted the possibility that ABI may lead to deficits in recognising others' emotional states, which may contribute to or exacerbate some of the difficulties in social interaction that can occur following ABI (Ietswaart, Milders, Crawford, Currie and Scott, 2008). To date, research has predominantly investigated emotion recognition skills in adults with ABI, and findings have indicated that ABI may be associated with specific or more general impairments in recognising emotion (see Appendix 1a). This is likely to reflect differential damage to the multiple brain structures thought to be involved in emotion recognition, which include the amygdala, basal ganglia, anterior cingulate and inferior frontal gyrus, and the orbitofrontal, right parietal (particularly the somatosensory cortex) and occipitotemporal cortices (Adolphs, 2002; Shamay-Tsoory, Aharon-Peretz, and Perry, 2009). The involvement of white matter tracts, possibly through connections between limbic structures and somatosensory cortices, has also been indicated (Green, Turner and Thompson, 2004). Emotion recognition therefore appears to involve a widely distributed network of brain structures.

However, findings regarding the precise relationship between emotion recognition and socio-emotional outcomes are mixed, with some studies suggesting no correlation in adults with traumatic brain injury (TBI) (Milders, Fuchs and Crawford, 2003; Milders et al., 2008) although the interpretation of these findings may be limited by the small sample sizes involved. In contrast, Knox and Douglas (2009) reported a significant correlation between face emotion recognition and scores on a measure of social integration in adults with severe TBI, which remained when controlling for cognitive functioning. However, it remains unclear to what extent correlational findings reflect a *causal* relationship between emotion recognition deficits and socio-emotional behaviour outcomes.

One possibility is that appropriate socio-emotional behaviour is dependent on the integration of emotion recognition and theory of mind (ToM) skills, which may constitute different types of empathy that are important for effective social interaction (Shamay-Tsoory et al., 2009). Shamay-Tsoory et al. (2009) report findings suggesting that 'emotional empathy' (ie. emotion recognition), thought to be a more automatic and basic level of empathy, is functionally and anatomically dissociable from the more complex 'cognitive empathy', which requires perspective-taking and mentalising (ie. ToM). This model of dissociable systems is in line with Frith and Frith's (1999; 2001) proposals of two functionally separate neural networks underpinning the two empathy systems (see Appendix 1b). However, Shamay-Tsoory et al. (2009) acknowledge that while the empathy systems are dissociable, this does not mean that they are always separate – overlap and integration of the two systems may occur. Interestingly, Henry, Phillips, Crawford, Ietswaart and Summers (2006) reported that in a sample of 16 adults with TBI, there was no correlation between performance on a face emotion recognition task, and a ToM task. This appears to be in accordance with models of dissociable empathy systems. However, Henry et al. (2006) also note that ToM performance was correlated with performance on a measure of executive functioning (verbal letter fluency). The authors suggest that aspects of executive functioning, including cognitive flexibility and self-regulation, may in part underlie difficulties with ToM, and in turn contribute to difficulties with social interaction. While these conclusions are limited by the small sample size of Henry et al.'s (2006) study, they highlight the issue that social interaction is likely to depend on a more complex array of factors than two distinct and localised empathy systems. Further research is needed to clarify the precise relationship between empathic and cognitive functions mediated by shared areas of the brain (eg. the prefrontal cortex).

The research literature regarding emotion recognition difficulties and their relationship with socio-emotional behaviour in children with ABI is even less well established, and is further complicated by the need to consider ABI in the context of the child's developing brain. Early skills in recognising emotional cues from eyes, faces and vocal prosody are thought to undergo a critical period of development before the transition from childhood to adolescence (Tonks, Williams, Frampton, Yates and Slater, 2007a; Tonks et al., 2008a; see Appendix 1c), suggesting that emotion recognition abilities develop in line with the increasingly complex demands of the social environment (Turkstra, 2000). The emergence of more sophisticated social interaction is thought to be mediated by the development of the prefrontal cortex (Tonks et al., 2008a), although it is unclear to what extent this relates to more advanced cognitive skills, or specific empathy skills. Developmental perspectives also highlight the point that ABI occurring during a critical maturational period is of particular significance, as there is likely to be ongoing influence on other later emerging skills (Anderson et al., 2009). Consequently, early damage to brain areas involved in emotion recognition or empathy may not become fully manifested until later childhood or adolescence, when social interaction becomes increasingly complex (Turkstra, 2000).

Few research studies have explored the impact of childhood ABI on emotion recognition. Petterson (1991) reported that a sample of 20 head-injured children were impaired relative to controls in recognising emotions presented visually and verbally, and were more often rated by their parents as exhibiting socially inappropriate behaviour. However, no significant correlation between emotion recognition and behaviour difficulties was found. Snodgrass and Knott (2006) reported that 12 children with TBI were impaired relative to controls on measures of emotion recognition and advanced ToM, but relationships with socio-emotional behaviour were not investigated. Tonks, Williams, Frampton, Yates and Slater (2007b) found that 18 children with ABI were impaired relative to 67 healthy controls on measures of emotion recognition from faces and vocal prosody (Florida Affect Battery (FAB); Bowers, Blonder and Heilman, 1999) and eyes (Reading the Mind in the Eyes test (RMET); Baron-Cohen, Wheelwright, Spong, Scahill and Lawson, 2001). These difficulties were not solely explained by cognitive difficulties or problems with perceptually processing faces, suggesting specific impairments in recognising emotion. There were some indications of a relationship between emotion recognition performance and behaviour difficulties identified on the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1999), although this could not be confirmed due to the small sample size. Tonks et al. (2008b) further explored the relationship between emotion recognition and cognitive impairments in a case series study of seven children with ABI identified as experiencing emotional or behavioural difficulties. The findings indicated three profiles: deficits in cognitive functioning and emotion recognition; deficits specific to one or more cognitive domain, with intact emotion recognition; and deficits affecting only emotion recognition. However, the authors acknowledged the limited generalisability of the case series findings. In a longitudinal study, Schmidt, Hanten, Li, Orsten and Levin (2010a) found that 75 children with TBI were impaired relative to 69 children with orthopaedic injuries on measures of facial and prosodic emotion recognition, but exhibited some improvement over time. However, the trajectory of improvement was influenced by the socio-economic status and age at injury of the child. These findings highlight the complex interaction of factors influencing emotion recognition following ABI, as well as the likely importance of contextual factors in recovery post-ABI (Yeates et al., 2004). However, Schmidt et al. (2010a) did not investigate the relationship between emotion recognition and cognitive functioning.

A large proportion of the ABI participants in previous research (Tonks et al., 2007b; 2008b; Schmidt et al., 2010a) had TBI. The typical pattern of brain injury associated with TBI suggests that it is likely that emotion recognition or empathy difficulties would be expected (McDonald and Saunders, 2005; see Appendix 1d). Ietswaart et al. (2008) suggest that the multi-focal and diffuse nature of TBI may be more associated with general, rather than selective, emotion recognition difficulties. Conversely, it is plausible that discrete, focal lesions may be associated with more specific impairments. However, the impact of focal ABI on emotion recognition has not been extensively explored, although there has been recent interest in emotion recognition skills in children treated for brain tumours. Bonner et al. (2008) reported that a group of 51 children treated for brain tumours made a significantly greater number of errors on a facial emotion recognition task compared to an 'illness comparison' group of 31 children with juvenile rheumatoid arthritis. This difference remained significant when IQ was controlled for, but only for the recognition of emotions in adult (rather than child) faces. Impaired emotion recognition was associated with social functioning difficulties on the Child Behaviour Checklist (CBCL; Achenbach, 1991). Bonner et al. (2008) also found a trend for younger age at diagnosis, and history of cranial radiation therapy (CRT), to predict poorer performance on the emotion recognition task. These findings provide support for 'early vulnerability' models of ABI (suggesting that early ABI is associated with greater difficulties than ABI in later childhood; Anderson et al., 2009), and emphasise the need to consider the impact of treatment variables (see Appendix 1e).

Associations between childhood epilepsy and socio-emotional difficulties have also been indicated (Korneluk, Kuehn, Keene and Ventureyra, 2003), but few studies have specifically explored emotion recognition skills in children with brain lesions related to epilepsy. Golouboff et al. (2008) compared 29 children with right or left temporal lobe epilepsy (TLE), with eight children with frontocentral epilepsy (FCE; constituting an epileptic control group), and 37 healthy controls, on a measure of facial emotion recognition and the CBCL. All children with epilepsy made more errors than controls on the emotion recognition task, although this difference was only significant for children with left TLE. There was also evidence of differential performance related to different facial expressions (see Appendix 1f). An association between early seizure onset and greater impairment of emotion recognition was also found in the TLE group, again providing support for the early vulnerability model of ABI. Behavioural difficulties identified on the CBCL were related to impaired recognition of fear expressions in the right TLE group only. The authors suggest that reduced fear sensitivity in children with right TLE may reflect a more general impairment in emotional behaviour, related to right hemisphere damage.

The research literature regarding the impact of other types of focal ABI on emotion recognition ability is scarce. No studies were found investigating emotion recognition difficulties following childhood stroke, for example, although some indications of social functioning difficulties post-stroke have been reported (Mosch, Max and Tranel, 2005).

To summarise, research regarding the impact of childhood ABI on emotion recognition skills, and the relationship with socio-emotional outcomes, is in its early stages. However, findings suggest that ABI may lead to specific impairments in emotion recognition that are not solely accounted for by cognitive deficits (Tonks et al., 2007b; 2008b). Models of social cognition suggest that emotion recognition may be an important component of empathy, needed to understand and relate to others effectively (Frith and Frith, 1999; 2001). Additionally, emotion recognition accuracy has been associated with greater social adjustment in non-ABI children (Leppanen and Hietanen, 2001). It is therefore plausible that emotion recognition difficulties may be a factor in the development of socio-emotional difficulties commonly observed following ABI. Furthermore, given the poor outcomes associated with impaired social interaction, such as rejection by peers and difficulty maintaining employment (Turkstra, Williams, Tonks and Frampton, 2008), and the subsequent implications for mental health services, it seems pertinent that effective assessment of emotion recognition skills should be considered within clinical practice, so that appropriate support can be provided if necessary. However, impaired emotion recognition is unlikely to be detected by routine neuropsychological assessment, meaning that the needs of children with these difficulties may currently be unmet within clinical services (Tonks et al., 2008b). Incorporating emotion recognition assessment into routine clinical practice necessitates a better understanding of the relationship between ABI, emotion recognition, cognition, and socio-emotional outcomes. While some research findings have begun to describe the relationship between emotion recognition and cognitive functioning, little is known about the impact of different types and locations of ABI. Studies have frequently focussed on children with TBI, and it is unclear to what extent these findings can be generalised to the wider population of children with ABI, which may include a broad range of aetiologies.

The main aim of the current study was to build on existing research by exploring the relationships between nature of ABI, emotion recognition, and cognitive functioning. In contrast to previous research, a heterogeneous sample of children with ABI was recruited consecutively through a Paediatric Neuropsychology service, in order to provide a more representative sample of the types of ABI that may be seen clinically (Ietswaart et al., 2008). Additionally, emotion recognition tasks were incorporated into routine neuropsychological assessments, rather than identifying participants retrospectively. A subsidiary aim was to explore the relationship between emotion recognition ability and socio-emotional behaviour. While it was beyond the scope of this study to determine the longer-term behavioural outcomes of emotion recognition difficulties, information about early behavioural consequences will be beneficial in providing baseline data that could be used to inform future research.

Based on previous findings, it was hypothesised that:

- Children with ABI will be impaired relative to children without ABI on the emotion recognition tasks.
- The relative impairment in emotion recognition task performance in children with ABI will remain when controlling for cognitive functioning (executive functioning, working memory, visuo-spatial functioning and processing speed).
- In line with early vulnerability models of ABI, younger age at ABI will be associated with poorer performance on the emotion recognition tasks, which will remain when controlling for cognitive difficulties.
- Children with focal ABI may present with more selective emotion recognition difficulties than children with diffuse/multi-focal ABI (Ietswaart et al., 2008).
- In children with ABI, poorer performance on the emotion recognition tasks will be associated with greater socio-emotional behavioural difficulties as identified by SDQ scores.

Method

Participants

Eighteen children with a history of ABI, who were referred for neuropsychological assessment (on an outpatient or inpatient basis) within an NHS Paediatric Neuropsychology service, were identified as eligible participants. Both new referrals and children attending for follow-up appointments were invited to participate. Three children did not attend their neuropsychological assessment appointments, and the parents of one child declined participation due to concerns about the time involved in completing the emotion recognition measures. The fourteen remaining children were consecutively recruited on invitation to attend for neuropsychological assessment. All children met the following inclusion criteria:

- Aged 9-15 years at time of assessment. This age group was selected on the basis of the emergence of more sophisticated social communication skills occurring in line with increasingly complex social interaction during the transition to adolescence (Turkstra, 2000). This age group was also utilised in the study by Tonks et al. (2007a) assessing emotion recognition skills in non-ABI children.
- Objective evidence of ABI (eg. based on MRI/CT scan; Glasgow Coma Scale score < 13 following TBI; diagnosed neurological condition).

The following exclusion criteria were applied:

- Pre-morbid history of learning disability or severe behavioural difficulty.
- ABI occurring perinatally, or at < 1 month old.
- Difficulties that would preclude completion of measures (eg. significant uncorrected visual impairment).

The demographic characteristics of the ABI participants are indicated in Table 1.

Participant number	**Gender**	**Age (years)**	**Age at ABI (years)**	**Time since ABI (years)**	**Nature of ABI**
1	F	10.08	1.50	8.58	*Tumour*: MRI – R temporal (anterior/medial) low grade ganglioma. Associated complex partial seizures leading to resection of tumour at age 7.
2	F	9.00	4.33	4.67	*Stroke*: CT – R hemisphere arterial ischaemic stroke.
3	M	9.75	5.42	4.33	*Tumour*: MRI – R temporal (lateral) tumour. Absence seizures, leading to resection of R temporal lobe (including mesial structures) at age 8.
4	F	15.17	14.33	0.84	*Encephalitis*: Anti-NMDA receptor encephalitis. Presented with dystonia, expressive/receptive language difficulties.
5	M	11.75	6.00	5.75	*Epilepsy*: MRI – lesion to L amygdala and parahippocampal gyrus, extending superiorly into white matter above choroidal fissure.
6	M	12.92	12.42	0.50	*TBI (fall)*: Undisplaced occipital fracture, raised intra-cranial pressure; post-concussive generalised seizure. Small frontal contusion on CT.
7	M	10.25	2.50	7.75	*Tumour*: CT and MRI – posterior fossa (cerebellar) fibrillary astrocytoma. Associated hydrocephalus. Tumour resected at age 3.
8	F	15.33	7.67	7.66	*Subdural empyema*: In L cerebello-pontine angle. Shunt & ommaya reservoir for hydrocephalus. MRI – lesions to R superior frontal gyrus, R occipital cortex.
9	M	9.58	2.83	6.75	*Haemorrhage into arachnoid cyst*: CT – L Sylvian fissure. Treated by burr hole drainage/cystoperitoneal shunt. Previous complex partial seizures.
10	F	13.92	6.00	7.92	*Tumour*: MRI – tumour affecting pituitary & hypothalamus. Tonic-clonic seizure pre-diagnosis. Treated by chemotherapy; craniospinal radiotherapy.
11	M	10.08	8.25	1.83	*TBI (RTA)*: CT – multiple facial skull fractures with orbital involvement. R frontal subdural haemorrhage. Post-injury bacterial meningitis.
12	M	13.83	1.08	12.75	

					Pneumococcal meningitis: MRI – R hippocampal sclerosis; R superior/middle gyrus (later resected due to seizures); small lesion in L superior frontal gyrus.
13	M	14.00	13.92	0.08	*TBI (RTA)*: MRI indicated bilateral frontal contusions and subarachnoid haemorrhage.
14	M	12.92	0.08	12.84	*E. Coli Meningitis*: MRI – R cerebral infarction: extensive atrophy of R cerebral hemisphere in distribution area of middle cerebral artery.
Mean (SD)	**-**	**12.04 (2.22)**	**6.17 (4.69)**	**5.88 (4.14)**	**-**

Table 1: Demographic characteristics of ABI participants (MRI = Magnetic Resonance Imaging; CT = Computerised Tomography; R = Right; L = Left; SD = Standard Deviation; RTA = Road Traffic Accident)

Power analyses conducted prior to recruitment were based on the only published study found (Tonks et al., 2007b) that had used the emotion recognition tasks to be used in this study (FAB and RMET – see Measures section) with a paediatric ABI population. Tonks et al. (2007b) reported that children with ABI performed significantly worse than children without ABI on the FAB and RMET. With 80% power and alpha set at 0.05, power calculations (see Appendix 2a) indicated that 11-19 participants with ABI would be required to find a significant difference from controls on the RMET, while 12-29 would be required to find a significant difference from controls on the FAB Select Affect task.

Participant data were compared with control data from 67 non brain-injured children (34 males; 33 females) aged 9-15 years (mean = 11.91 years, standard deviation = 1.74), obtained with permission from a previous study (Tonks et al., 2007a) which utilised the same emotion recognition tasks. Control participants were recruited by Tonks et al. (2007a) from two primary schools and one secondary school; 150 children were invited to participate and 67 were recruited following parental consent. Assessment of control participants took place within schools in two-day blocks. As the ABI participants in the current study were consecutively recruited, participants were only matched to controls in terms of age range (ie. 9-15 years), in order to maximise the representativeness of the ABI sample.

Procedure

Agreement was obtained through the NHS Trust for data obtained as part of an audit conducted within the Paediatric Neuropsychology service to be used for secondary exploratory analysis (see Appendix 2b and 2c for the Trust Audit Department application form and agreement). This audit data includes information about the use of emotion recognition tasks (selected in collaboration with the Paediatric Neuropsychology service) as part of routine clinical practice. Ethical approval for the secondary analysis of this data was obtained from the University of Exeter School of Psychology Ethics Committee (see Appendix 2d). An honorary contract with the NHS Trust was obtained by the researcher to enable access to participant information.

A cross-sectional design was used. Eligible participants were invited to contribute to this study by providing their assessment data for secondary analysis. A consent form routinely used by the Paediatric Neuropsychology service (see Appendix 2e), which includes the option of consenting to assessment data being used anonymously for audit or research purposes, was sent out to the parents of potential participants with other information routinely sent out prior to neuropsychological assessment. On attending their assessment appointment, participants and their parents who had given consent were provided with a participant information sheet regarding the purpose of this study (see Appendix 2f), and reminded that they were entitled to withdraw their consent at any time.

The Strengths and Difficulties Questionnaire (SDQ; Goodman, 1999 – see Measures section) was sent out to participants prior to neuropsychological assessment, in accordance with routine practice in the Paediatric Neuropsychology service. The emotion recognition tasks, and additional cognitive assessments (see Measures section) were incorporated into the assessment session, alongside other cognitive assessments routinely used within the service.

Following the assessment, test scores and background information (eg. nature and timing of lesion) were obtained from participants' files by the researcher, and collated in an anonymous format on a participant data form (see Appendix 2g). Information about the neurological consequences of lesions (eg. seizures) and treatment approaches (eg. radiation therapy) was also collected. However, while it is acknowledged that neurological consequences and treatment approaches may influence the structural integrity and development of the brain (Anderson et al., 2009), the focus of this study was on exploring the relationship between the primary lesion site(s) and emotion recognition abilities.

Measures

The parent-report version of the SDQ (see Appendix 2h) was administered to provide a measure of socio-emotional behaviour. The SDQ is a widely-used screening measure of psychological adjustment, consisting of 25 questions which assess functioning across the following domains: Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Pro-social Behaviour. A 'Total Difficulties' score is also obtained. The SDQ has good psychometric properties. Stone et al (2010) report good internal consistency (α = 0.80), test-retest reliability (r = 0.76), and inter-rater agreement (r = 0.44) for the Total Difficulties score, and moderate-good internal consistency (α = 0.53-0.76), test-retest reliability (r = 0.65-0.71), and inter-rater agreement (r = 0.26-0.47) for all other domains. Regarding construct validity, satisfactory factor loadings (≥ 0.40-<0.70) have been indicated for most items, confirming the five-factor structure, and high sensitivity and specificity (0.71-0.92) have been demonstrated for all domains (Stone et al, 2010).

Table 2 details the emotion recognition measures used, which were selected on the basis of their inclusion in previous research investigating emotion recognition skills in children with ABI (Tonks et al., 2007b), and without ABI (Tonks et al., 2007a). The measures were administered by an assistant psychologist (under supervision of the Consultant Paediatric Neuropsychologist), or by the researcher, and took approximately 10-15 minutes.

Measure	Subtest	Description	Psychometric Properties
FAB (Bowers, Blonder and Heilman, 1999)	• Identity Discrimination	• Control task assessing whether difficulties in identifying affect are related to general perceptual processing deficits. • 20 trials requiring participants to identify whether two simultaneously presented faces are of the same or different people. • Stimuli are monochrome photographs of women displaying neutral facial expressions, with hair covered to exclude responding based on non-facial cues (see Appendix 2i for sample stimuli). • Task completion yields an accuracy score.	• Effectively distinguishes between performance of head-injured and healthy adult controls (Milders et al., 2003). • Good test-retest reliability demonstrated in adults (*r* = 0.89-0.97; Bowers et al., 1999). • Psychometric data for children have not been published. • As normative data for children have not been published by Bowers et al (1999), normative data from Tonks et al. (2007a) were used for comparison.
	• Select Affect	• Assesses ability to recognise emotion from faces. • 20 trials requiring participant to identify an emotion named by the examiner from an array of five simultaneously presented faces (of the same person), each expressing a different emotion (happy, sad, angry, neutral, or frightened). • Stimuli are monochrome photographs of women (see Appendix 2j). • Task completion yields an accuracy score, and information about error types (eg. number of angry faces incorrectly identified).	
RMET-child version (Baron-Cohen et al., 2001)	-	• Assesses ability to identify subtle emotional states from 28 monochrome photographs of eyes (16 male; 12 female) (see Appendix 2k). • Task completion yields an accuracy score.	• Psychometric data for the use of the RMET with child ABI populations has not been published. • As normative data for children have not been published by Baron-Cohen et al. (2001), normative data from Tonks et al. (2007a) were used for comparison.

Table 2: Details of emotion recognition tasks

The FAB consists of five facial affect subtests and four vocal prosody subtests. However, as the aim of this study was to provide a means of screening for emotion recognition difficulties that could be easily incorporated into routine neuropsychological assessments, only the Identity Discrimination and Select Affect tasks were administered, in order to minimise administration time. The Select Affect task was included on the basis of previous research (Tonks et al., 2007b) indicating that it is the most effective of the facial affect subtests in distinguishing between ABI and non-ABI children.

Measures of cognitive domains that may be impaired following ABI (executive functioning, processing speed, working memory and visuo-spatial functioning) were incorporated into the assessment (Table 3). Measures were selected on the basis of those utilised by Tonks et al. (2007b) – however, in consultation with the Paediatric Neuropsychology service, equivalent measures that reflect those more typically used within the service were substituted for some of those used by Tonks et al. (2007b). For example, NEPSY-II Block Construction was used in place of VOSP Cube Analysis.

Measure	Subtests	Purpose	Psychometric Properties
WISC-IV (Wechsler, 2004)	• Digit Span • Symbol Search	Measure of working memory. Measure of processing speed.	• Good internal consistency (α = 0.87 for Digit Span, and 0.79 for Symbol Search; Wechsler, 2004) • Good test-retest reliability (*r* = 0.83 for Digit Span and 0.80 for Symbol Search; Wechsler, 2004) • Construct validity findings confirm four-factor structure (Wechsler, 2004). • Good convergent validity with other Wechsler batteries based on index scores (eg. correlations of 0.72-0.88 with the WISC-III for Verbal Comprehension Index and Perceptual Reasoning Index; Wechsler, 2004)
NEPSY-II (Kirk, Korkman and Kemp, 2007)	• Block Construction • Initial Letter Word Generation	Measure of visuo-spatial functioning. Measure of verbal fluency (considered to be a sensitive measure of executive functioning; eg. Crawford and Henry, 2005)	• Moderate-good internal consistency across subtests (α = 0.62-0.98; Kemp and Korkman, 2010) • Moderate-good test-retest reliability (*r* = 0.54 for Word Generation; *r* = 0.76-0.80 for Block Construction, depending on age group; Brooks, Sherman and Strauss, 2010) • Good inter-rater agreement (*r* = 0.93-0.99; Kemp and Korkman, 2010) • Construct validity unclear as cognitive domains are theoretically-derived, rather than based on factor analysis (Brooks et al, 2010).

Table 3: Cognitive measures incorporated into routine assessments

Results

All ABI participants completed the emotion recognition tasks. However, data were missing for two participants on three of the four cognitive measures, due to insufficient time during the assessment session. SDQ data were unavailable for two participants. Missing data were taken into account during the analysis.

Statistical analyses were conducted using SPSS version 16.0. Due to the small ABI sample size, and indications that assumptions of normality and homogeneity of variance were not met for data from some variables (see Appendix 3a), group comparisons using non-parametric analyses were appropriate.

Demographic comparisons

No significant difference was found in the age of participants in the ABI (median = 12.33) and the non-ABI (median = 11.92) groups (U = 457.0, z = -0.150, p = .881), or in the proportion of males and females in the ABI and non-ABI groups (χ^2 (1) = 0.852, p = .356) (see Appendix 3b).

ABI and non-ABI group comparisons of task performance

The performance of the ABI and non-ABI groups on the emotion recognition measures is summarised in Figure 1.

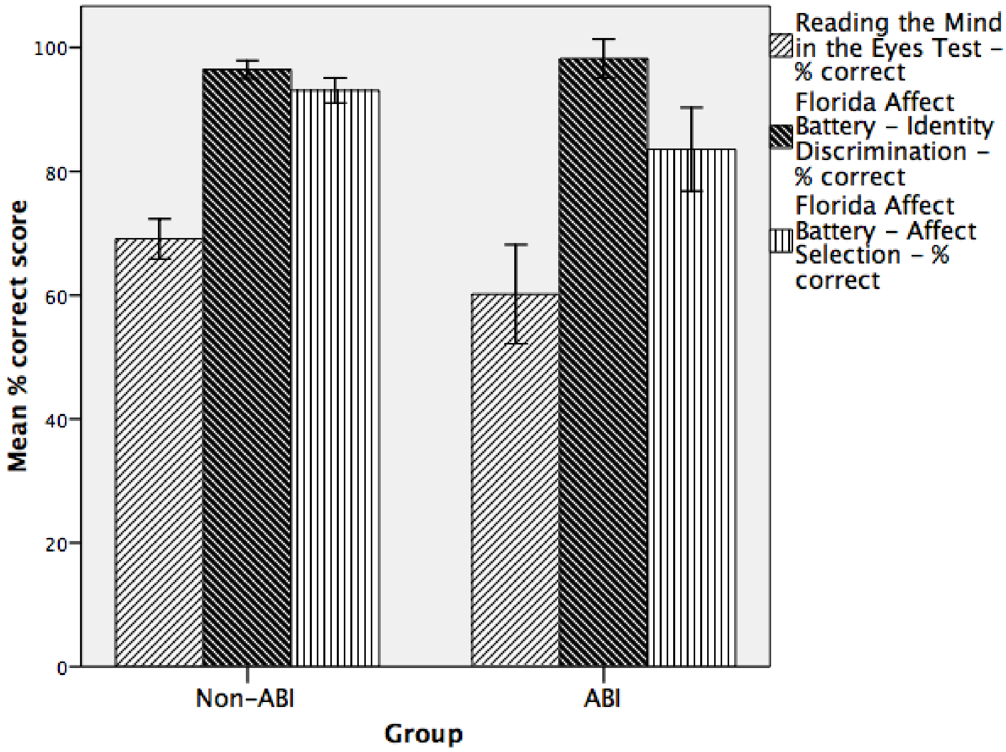

Figure 1: Mean scores of non-ABI and ABI groups on RMET, FAB Identity Discrimination and FAB Select Affect tasks (error bars represent 95% confidence interval)

With Bonferroni corrections applied to take into account the number of comparisons being made (α adjusted to 0.02), Mann-Whitney *U* group comparisons (see Appendix 3c) indicated that the ABI group performed significantly worse than the non-ABI group on the RMET (ABI group median = 64.00; non-ABI group median = 71.40; U = 291.50, z = -2.22, 1-tailed p = .013, r = -.25), and the FAB Select Affect task (ABI group median = 85.00; non-ABI group median = 95.00; U = 229.00; z = -3.09, 1-tailed p = .001, r = -.34). However, there was no significant difference between the ABI and non-ABI groups on the perceptual control task, FAB Identity Discrimination (ABI group median = 100.00; non-ABI group median = 100.00; U = 347.50, z = -1.77, 1-tailed p = .039, r = -.20), suggesting that errors on the emotion recognition task were not accounted for by general difficulties with the perceptual processing of faces.

With regard to the clinical significance of the lower FAB Select Affect and RMET scores in the ABI group, five ABI participants' scores fell more than two standard deviations below the non-ABI mean on the FAB Select Affect task, and a further two participants' scores fell more than one standard deviation below the non-ABI mean (see Appendix 3c). On the RMET task, one ABI participant's score fell more than two standard deviations below the non-ABI mean, while four participants' scores were more than one standard deviation below the non-ABI mean. All other ABI participants' scores fell within one standard deviation of the non-ABI mean on each task.

Further analyses were conducted to determine to what extent the group differences in FAB Select Affect and RMET performance were accounted for by cognitive functioning. The performance of the ABI and non-ABI groups on the cognitive measures is summarised in Table 4, in addition to Mann-Whitney *U* group comparison statistics (see Appendix 3d).

Measure	**ABI (*n* = 14)**		**Non-ABI (*n* = 67)**		**Mann-Whitney *U* Test**	
	Mean (SD)	**Median**	**Mean (SD)**	**Median**	***U***	***p*-value (2-tailed)**
WISC-IV Digit Span	7.58 (2.02)	7.50	9.07 (3.03)	8.00	294.00	.137
WISC-IV Symbol Search	7.33 (3.34)	7.50	10.43 (3.50)	11.00	206.50	.007
NEPSY-II Letter Fluency	9.42 (3.87)	10.50	9.96 (2.84)	9.00	424.00	.880
NEPSY-II Block Construction	8.92 (3.94)	8.50	8.48 (1.48)	9.00	425.00	.889

Table 4: ABI and non-ABI group performance (scaled scores) on cognitive measures (SD = Standard Deviation)

With α adjusted to 0.01, Table 4 indicates that the ABI group performed significantly worse on the WISC-IV Symbol Search task compared to the non-ABI group (U = 206.50, z = -2.68, p = .007, r = -.30). However, no other significant differences were found between ABI and non-ABI group performance on the other cognitive measures.

Analysis of covariance (ANCOVA) was used to explore the effect of controlling for cognitive functioning on the ABI and non-ABI group differences on the RMET and FAB Select Affect tasks[1]. Only three of the cognitive variables (WISC-IV Digit Span, NEPSY-II Letter Fluency, and NEPSY-II Block Construction) met the assumption of independence of the covariate and independent variable (Field, 2009), and were therefore appropriate to use as covariates (see Appendix 3e). For the RMET, only NEPSY-II Block Construction was significantly related to the RMET score (F (1, 74) = 11.00, p = .001, partial η^2 = .129).

[1] It is acknowledged that analysis of variance is a parametric test, while in the current study, ANCOVA has been used with non-parametric data which do not meet the assumptions of parametric tests (eg. normality; homogeneity of variance). However, there is no non-parametric equivalent of ANCOVA available through SPSS (Field, 2009) that could have been used as an alternative. It was considered that given the relative robustness of the *F* statistic to violations of these assumptions (Field, 2009), it was appropriate to use ANCOVA in the current study provided that the outcome of analyses was interpreted with caution given the possibility of an inflated Type 1 error rate.

When controlling for WISC-IV Digit Span, NEPSY-II Letter Fluency, and NEPSY-II Block Construction, the difference in RMET scores between the ABI and non-ABI groups was no longer significant (F (1, 74) = 3.16, p = .079, partial η^2 = .04).

None of the cognitive variables (WISC-IV Digit Span, NEPSY-II Letter Fluency, or NEPSY-II Block Construction) were significantly related to FAB Select Affect performance (see Appendix 3e). The significant difference in FAB Select Affect scores between the ABI and non-ABI groups remained when controlling for all three cognitive variables (F (1, 74) = 9.77, p = .003, partial η^2 = .117).

Simple regression analyses (see Appendix 3f) were conducted to explore the potential impact of WISC-IV Symbol Search on RMET and FAB Select Affect performance in the ABI group. WISC-IV Symbol Search performance was not found to be a significant predictor of RMET performance (β = .293, p = .356), accounting for 8.6% of the variance in the model, or FAB Select Affect performance (β = .235, p = .461), accounting for 5.5% of the variance in the model. Additionally, in exploring the relationship between NEPSY-II Block Construction and RMET score, it was found that NEPSY-II Block Construction performance was not a significant predictor of RMET performance in the ABI group (β = .289, p = .339), accounting for 8.3% of the variance in the model (see Appendix 3f).

Correlational analyses indicated that RMET and FAB Select Affect performance were not significantly correlated in the ABI group (τ = .329, p = .127) or non-ABI group (τ = .154, p = .103) (see Appendix 3g).

Effect of timing of ABI on task performance

To investigate whether earlier ABI is associated with poorer emotion recognition task performance, the ABI group was sub-divided into groups based on timing of ABI. In a study by Anderson et al. (2009), children with ABI were sub-divided into four post-natal age groups (in addition to congenital and peri-natal groups), based on the timing of cerebral growth spurts (Kolb and Whishaw, 2003). A similar approach was used in the current study. However, given the small ABI sample size, and research suggesting developmental changes in emotion recognition skills occurring at approximately age eight, ten and fourteen (Baron-Cohen et al., 2001; Tonks et al., 2008a), ABI participants were sub-divided into two groups, an 'early ABI' group (≥1 month to six years), and a 'late ABI' group (seven years and older).

The performance of the early ABI (n = 9) and late ABI (n = 5) groups on the emotion recognition tasks is indicated in Figure 2.

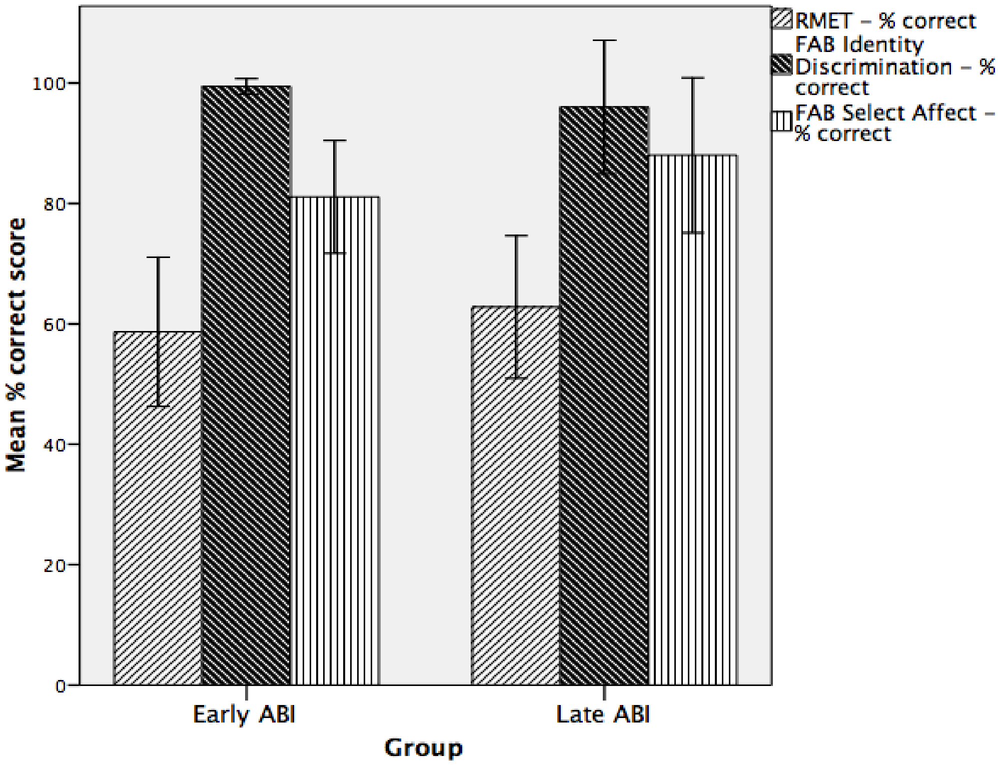

Figure 2: Mean scores of early ABI and late ABI groups on RMET, FAB Identity Discrimination and FAB Select Affect tasks (error bars represent 95% confidence interval)

Mann-Whitney *U* group comparisons (see Appendix 3h) indicated that there were no significant differences between the performances of the early and late ABI groups on the RMET, FAB Identity Discrimination or FAB Select Affect tasks.

Focal ABI and diffuse/multi-focal ABI group comparisons of task performance

To investigate how the nature of ABI lesion influences emotion recognition ability, the ABI group was sub-divided into two groups based on the presence of primarily focal or diffuse/multi-focal lesions. The aim was to explore whether participants with focal ABI may present with more specific deficits in emotion recognition (eg. for specific facial expressions) than participants with diffuse/multi-focal ABI (Adolphs et al., 1995; Ietswaart et al., 2008). Categorisation of ABI participants was based on the primary lesion site(s), as evidenced by CT or MRI scan. Consequently, participants identified as having focal lesions typically included those affected by tumours or stroke (participants 1, 2, 3, 5, 7, 9, 10 and 14; see Table 1), while those with diffuse/multi-focal lesions were typically those who had sustained TBI or infections (participants 4, 6, 8, 11, 12 and 13; see Table 1).

Initial group comparisons of overall emotion recognition task performance were made. The performance of the focal ABI (n = 8) and diffuse/multi-focal ABI (n = 6) groups is indicated in Figure 3.

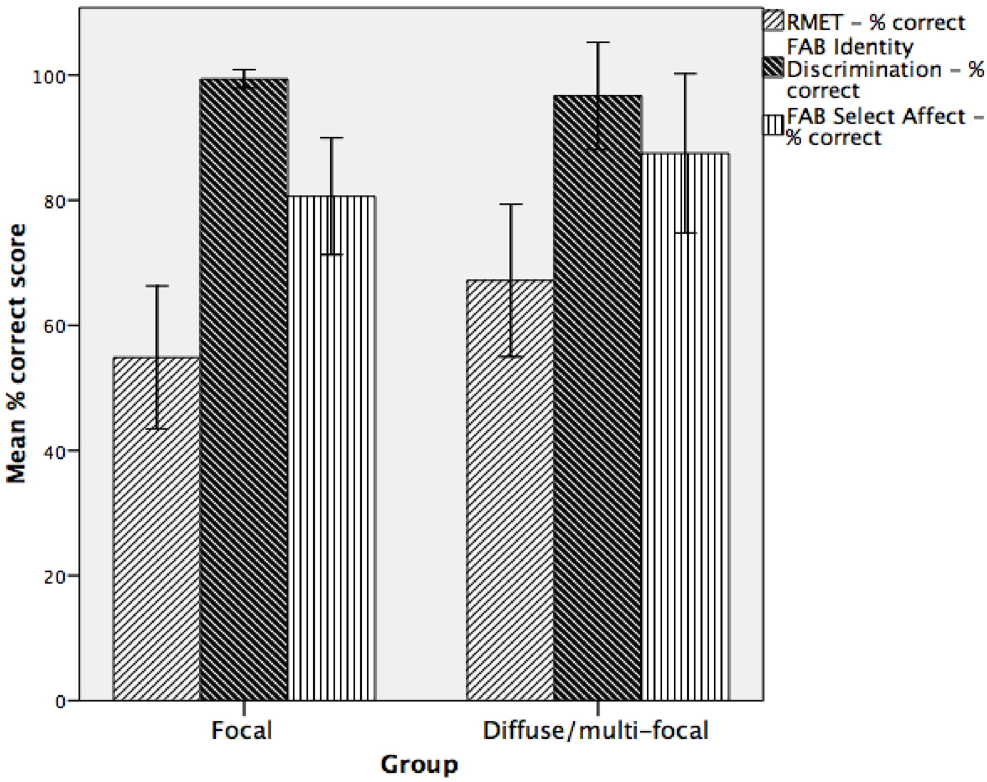

Figure 3: Mean scores of focal ABI and diffuse/multi-focal ABI groups on RMET, FAB Identity Discrimination and FAB Select Affect tasks (error bars represent 95% confidence interval)

Mann-Whitney *U* group comparisons (see Appendix 3i) indicated that no significant differences were found between the focal and diffuse/multi-focal ABI groups' performance on the RMET, FAB Identity Discrimination or FAB Select Affect tasks.

To explore any differences in patterns of performance that may relate to lesion type (eg. deficits in recognising specific emotional expressions), error scores for the five facial expressions on the FAB Select Affect task were compared between the two groups (Table 5).

FAB Select Affect errors	Focal ABI (n = 8)		Diffuse/multi-focal ABI (n = 6)	
	Number of errors (total = 31)	**% of total errors**	**Number of errors (total = 15)**	**% of total errors**
Happy	2	6.5	1	6.7
Frightened	5	16.1	3	20.0
Sad	3	9.7	4	26.7
Angry	6	19.3	3	20.0
Neutral	15	48.4	4	26.7

Table 5: Focal ABI and diffuse/multi-focal ABI group error types on the FAB Select Affect task

As indicated in Table 5, all children tended to make fewer errors with happy facial expressions than frightened, sad, angry or neutral expressions, and the focal ABI group tended to make more errors with neutral faces than other expressions. However, Mann-Whitney U group comparisons (see Appendix 3i) indicated that there were no significant differences in the error types made by the focal and diffuse/multi-focal ABI groups.

Predictors of socio-emotional behaviour difficulties in children with ABI

As indicated in Table 6, children in the ABI group were reported by their parents to have significantly greater difficulties (indicated by higher scores, except for Pro-social Behaviour which is indicated by lower scores) with all SDQ domains, compared to children in the non-ABI group.

SDQ Domain	ABI (n = 14)		Non-ABI (n = 67)		Mann-Whitney U Test		
	Mean (SD)	**Median**	**Mean (SD)**	**Median**	U	***p*-value (2-tailed)**	r
Total Difficulties	19.00 (5.51)	19.00	6.93 (4.72)	6.00	37.00	<0.001	-0.56
Emotional Symptoms	4.92 (2.23)	4.50	1.61 (1.95)	1.00	94.50	<0.001	-0.48
Conduct Problems	3.42 (2.19)	2.50	1.18 (1.38)	1.00	131.50	<0.001	-0.43
Hyperactivity/Inattention	6.92 (2.78)	8.00	3.07 (2.64)	3.00	132.50	<0.001	-0.42
Peer Relationship Problems	3.75 (2.42)	4.00	1.10 (1.47)	1.00	132.00	<0.001	-0.43
Pro-social Behaviour	6.25 (2.67)	6.50	8.28 (1.79)	9.00	195.00	0.004	-0.32

Table 6: ABI and non-ABI group SDQ scores and Mann-Whitney *U* comparison statistics (SD = Standard Deviation)

Based on clinical cut-offs (Goodman, 1999), the ABI group mean scores fell within the ‘abnormal’ range for Total Difficulties, and the ‘borderline’ to ‘abnormal’ range for all other domains except Pro-social Behaviour, which was in the ‘normal’ range. All non-ABI group mean scores fell within the ‘normal’ range.

Based on the hypothesis that emotion recognition difficulties may contribute to difficulties with interpreting and responding to social situations, simple regression analyses (see Appendix 3j) were conducted to determine how effectively performance on the FAB Select Affect task predicted SDQ scores in the Peer Relationship Problems domain in the ABI group. FAB Select Affect performance was selected as a predictor given that difficulties on this task in the ABI group do not appear to be due to cognitive difficulties. FAB Select Affect performance was not found to be a significant predictor of SDQ Peer Relationship problems (β < .001, p = 1.000). Similarly, FAB Select Affect performance was not found to be a significant predictor of SDQ scores in two other domains likely to be associated with socio-emotional behaviour difficulties, Conduct Problems (β = .098, p = .761; accounting for 1% of the variance), and Emotional Symptoms (β = .318, p = .313; accounting for 10.1% of the variance). Additionally, FAB Select Affect performance was not a significant predictor of the SDQ Total Difficulties score (β = .263, p = .409), accounting for 6.9% of the variance in the model (see Appendix 3j).

Given the lack of predictive relationships between emotion recognition performance and SDQ outcomes, simple regression analyses were conducted to explore whether SDQ scores in the ABI group might be predicted by cognitive functioning. Of the four cognitive variables, only NEPSY-II Block Construction was found to be a significant predictor of SDQ Peer Relationship Problems (β = -.831, p = .002), accounting for 69.1% of the variance in the model. WISC-IV Digit Span (β = .724, p = .018) and Symbol Search (β = .766, p = .010) were also found to be significant predictors of SDQ Conduct Problems, accounting for 52.5% and 58.8% of the variance in each model respectively (see Appendix 3j).

Discussion

The findings of this study indicate that children in the ABI group made a significantly greater number of errors on the RMET and FAB Select Affect tasks than children in the non-ABI group. These differences in performance were associated with medium effect sizes (r = -.25 and r = -.34 respectively) according to Cohen's criteria (Field, 2009). Additionally, the poorer ABI group performance appeared to represent clinically significant outcomes (greater than one or two standard deviations below the non-ABI mean) for seven ABI participants on the FAB Select Affect task, and five ABI participants on the RMET task.

Errors made by the ABI group on the FAB Select Affect task do not appear to be due to general difficulties with the perceptual processing of faces, given that there was no significant difference in the performance of the ABI and non-ABI groups on the control task, FAB Identity Discrimination (both groups performed close to ceiling on this task). Furthermore, the difference in performance of the ABI and non-ABI groups on the FAB Select Affect task remained when controlling for cognitive performance (p = .003, partial η^2 = .117). However, the difference in the performance of the ABI and non-ABI groups on the RMET was no longer significant when controlling for cognitive performance (p = .079, partial η^2 = .04). This suggests that errors on the RMET task may be accounted for by cognitive factors, although it was not possible to identify predictive relationships between the cognitive variables and RMET performance, in the ABI group.

The hypothesis that earlier age at ABI would be associated with poorer emotion recognition performance was not supported by the findings of this study. Additionally, there were no significant differences between the overall performance on the RMET and FAB, or the types of errors made on the FAB Select Affect task, between ABI participants with focal or diffuse/multi-focal lesions. This finding suggests that similar outcomes may be found regardless of lesion type, underlining the idea that emotion recognition may depend on a widespread network of brain structures, and indicating that it may be important to assess emotion recognition in children with all types of ABI.

The SDQ scores indicated that the ABI group had greater difficulties with all domains of functioning compared to the non-ABI group. These findings are consistent with other studies indicating significant social and behavioural difficulties following childhood ABI (eg. Greenham, Spencer-Smith, Anderson, Coleman and Anderson, 2010). However, the hypothesis that socio-emotional behavioural difficulties would be predicted by emotion recognition difficulties in the ABI group was not supported. Instead, cognitive variables were found to have predictive relationships with two SDQ domains that appear to particularly reflect socio-emotional behaviour: NEPSY-II Block Construction was a significant predictor of SDQ Peer Relationship Problems, and WISC-IV Digit Span and Symbol Search were significant predictors of SDQ Conduct Problems.

These findings are largely consistent with those of Tonks et al. (2007b), although the ABI v non-ABI group difference in performance on the RMET did not remain when controlling for cognitive functioning, as it did in the study by Tonks et al. (2007b). However, Tonks et al. (2007b) did not use NEPSY-II Block Construction as a covariate when controlling for cognitive functioning on the RMET; in the current study, this task was found to be significantly related to RMET performance, and accounted for a greater proportion of the variance than the other cognitive variables used as covariates (see Appendix 3e). However, a significant predictive relationship between NEPSY-II Block Construction and RMET performance in the ABI group was not found. Nevertheless, NEPSY-II Block Construction performance was related to greater reported difficulties on the SDQ Peer Relationship problems domain in the ABI group. While executive functioning is frequently implicated as having an important role in social interaction (Anderson et al., 2000), it is possible that visuo-spatial skills are also of particular importance in processing and responding effectively to social information. Tonks et al. (2009) reported that impaired visuo-spatial functioning may be associated with greater impact of reported difficulties on the SDQ, and further research would be beneficial in clarifying how these findings relate to emotion recognition skills.

The finding that RMET performance may be accounted for by cognitive functioning reflects the findings of Henry et al. (2006), although in the latter study only executive functioning was assessed. The finding in the current study of no significant correlation between RMET and FAB Select Affect performance in the ABI or non-ABI group is also consistent with Henry et al.'s (2006) findings, highlighting the possibility that the two tasks may tap into different processes, which appears consistent with models of dissociable aspects of empathy (Frith and Frith, 1999; 2001). In line with this model, it is plausible that performance on the RMET may involve the more complex, higher-level empathy skills associated with cognitive empathy, that are perhaps more dependent on the integrity of cognitive functions than the more 'basic' emotional empathy skills that are likely to be utilised for the FAB Select Affect task. An alternative explanation is that the RMET and FAB Select Affect tasks simply differ in their complexity; subjectively, many of the RMET stimuli appear to present more subtle emotional expressions that those of the FAB, and the RMET also requires participants to choose between four different words for each stimulus, which may present greater challenges to cognitive functions such as comprehension, working memory and processing speed.

The finding of no predictive relationship between emotion recognition difficulties and socio-emotional outcomes reflects the findings of Milders et al. (2003; 2008), and appears to call into question the clinical relevance of the identification of emotion recognition difficulties. However, as indicated earlier, the SDQ data from this study only provides baseline information about socio-emotional functioning, and one possible explanation is therefore that longitudinal follow-up of socio-emotional behaviour is necessary in order to identify predictive relationships (ie. in relation to the possible developmental emergence of socio-emotional difficulties). Additionally, it is likely that the power of the regression analyses was significantly limited by the small ABI sample size. The findings of the intra-group comparisons (early v late ABI; focal v diffuse/multi-focal ABI) are also likely to have been limited by the small ABI sample. A larger sample would enable more detailed comparisons to be made (eg. by dividing the ABI group into a larger number of 'age at ABI' groups, as in Anderson et al., 2009), and would also permit sub-groups to be defined based on lesion location (eg. right frontal; left temporal) in order to clarify which brain areas are most associated with emotion recognition functioning, and whether specific areas are associated with the recognition of specific categories of emotion. Related to this, it would be of interest to explore in a larger sample whether certain emotions are easier to recognise than others, as suggested by the (albeit limited) observation that children with ABI tended to make fewer errors with happy faces compared to other expressions, while the focal ABI group tended to make more errors when identifying neutral faces. Previous research has suggested that negative emotions may be more difficult to recognise than positive emotions following ABI (eg. Croker and McDonald, 2005), although this may be a reflection of task difficulty, as the same pattern has been observed in healthy control participants (Ietswaart et al., 2008).

Another limitation relates to the inclusion of children with heterogeneous ABI aetiologies. Although it was considered important to expand on previous research (that has typically focussed on children with TBI) by including a more representative sample of children with a range of ABI aetiologies, this also led to greater complexity in determining the factors influencing emotion recognition performance. Specifically, it was not possible to determine to what extent performance was related to the primary lesion, or to secondary effects on brain structure and function associated with subsequent seizures or treatments such as CRT. Additionally, unlike with children with TBI, it was difficult to determine the precise age at onset of ABI in children with tumours, for example. Furthermore, the heterogeneous sample meant that it was not possible to objectively control for ABI severity; previous research with TBI samples (eg. Schmidt et al., 2010a) has used standardised measures of severity, such as the Glasgow Coma Scale, but a similar approach was not possible in the current study.

There are also some potential limitations with regard to the measures used. In relation to the cognitive tasks, it is notable that the ABI group differed from the non-ABI group on only one of the four measures (WISC-IV Symbol Search). This is likely to reflect the wide range in scores for each measure (eg. scaled scores of 2-15 on NEPSY-II Block Construction) within the small ABI sample, highlighting the variable cognitive consequences of ABI. However, it is also possible that other aspects of cognitive functioning, not measured by the four brief tasks in the current study, may have influenced emotion recognition performance. As indicated earlier, the four tasks were selected on the basis of previous research (Tonks et al., 2007b), in addition to providing brief measures of cognitive domains frequently impaired following ABI, using assessments commonly utilised within the Paediatric Neuropsychology service. However, it would be useful in future research to incorporate a more comprehensive assessment of cognitive functioning to provide a more complete picture of the relationship between cognitive and emotion recognition skills.

In relation to the emotion recognition measures, it is unclear to what extent the FAB stimuli provide a valid measure of the skills required to recognise emotion in real-world contexts. In addition to the potential lack of ecological validity of including only monochrome images of adult females, the emotional expressions presented do not perhaps reflect the subtlety of expressions likely to be encountered in daily life. Better quality stimuli are perhaps provided by the NEPSY-II Affect Recognition subtest, which consists of colour images of children of both genders; the test also provides age-stratified norms for children, which are not currently available for the FAB. However the NEPSY-II Affect Recognition task only assesses the ability to match images depicting the same emotion, rather than emotion recognition through naming, and it is unclear to what extent the skills involved in these tasks differ. Additionally, there has been some debate in the literature regarding the relative difficulty of recognising emotion from static compared to dynamic stimuli. Static images allow the observer more time to recognise emotional cues, whereas dynamic, rapidly-changing stimuli (which more accurately reflect real-world experiences) may place greater demands on the working memory, attentional and information processing capacity of the observer, which are likely to be compromised following ABI (Knox and Douglas, 2009). However, cues from facial movement may provide important information that facilitates the recognition of emotion from dynamic stimuli (McDonald and

Saunders, 2005). It would also be beneficial in future research to investigate response times rather than accuracy, as this may provide a more sensitive measure of impairment (Ietswaart et al., 2008) – in rapidly-changing, complex real-world situations, it is intuitive that being able to respond efficiently as well as accurately is likely to be of importance in maintaining appropriate social interaction. It would also be of interest to incorporate eye-tracking into assessments of emotion recognition, to clarify whether difficulties may be in part due to differences in the way individuals visually process emotional cues from faces.

A final issue relates to the fact that this study took an individualised approach, in that it focussed on the relationship between neurological damage, cognitive functioning, and emotion recognition skills, and how they might impact socio-emotional behaviour, but did not consider the potential impact of external or relational factors on socio-emotional outcomes. Lower socio-economic status, fewer family resources and poorer family functioning have been shown to exacerbate social difficulties following childhood TBI (Yeates et al., 2004). Schmidt et al. (2010b) found that family functioning influenced emotion recognition performance on a prosody task, but not on a faces task, in 75 children with TBI. Further research is needed to clarify the reasons for this differential outcome, and explore more generally the interaction between family/environmental, cognitive, neurological and emotion recognition variables, using a longitudinal approach. From a clinical perspective, existing findings regarding the moderating impact of family factors implicate the need to involve families during assessment and intervention with children with ABI (Bowen, Yeates and Palmer, 2010).

In summary, this study extends the findings of previous research by demonstrating that difficulties in recognising emotional expressions from faces may occur following a range of different types of childhood ABI, and may not be accounted for by changes in cognitive functioning. These difficulties were observed in an unbiased sample of children with ABI who were not previously identified as having socio-emotional difficulties, suggesting that emotion recognition difficulties may be more prevalent than previously anticipated. Indeed, half of the ABI participants presented with clinically significant difficulties with facial emotion recognition, which are unlikely to have been detected by routine neuropsychological assessment. The identification of difficulties while using the emotion recognition measures in routine clinical practice demonstrates the potential importance as well as the feasibility of incorporating emotion recognition tasks into standard assessments. However, the relationship between emotion recognition skills and socio-emotional outcomes is unclear from the current study. Future research with a larger ABI sample and using a longitudinal design would enable predictive relationships, that may emerge developmentally, to be clarified. It would also be possible to gain a clearer understanding of the developmental course of emotion recognition skills by investigating the impact of timing of ABI, as well as to explore how lesion location and type influences emotion recognition performance, and consider how environmental factors may influence emotion recognition performance and socio-emotional outcomes. A more comprehensive understanding of the complex relationship between emotion recognition and cognition may also help to clarify whether the RMET and FAB Select Affect tasks reflect different constructs of empathy, and how deficits in these constructs may relate to poorer socio-emotional outcomes following ABI.

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Appendices

Appendix 1: Expanded Introduction

Appendix 1a: Further information regarding emotion recognition difficulties in adults with ABI

Some studies of adults with ABI have indicated impairments selective for particular categories of facial emotion expression, such as fear after amygdala lesions (Adolphs, Tranel, Damasio and Damasio, 1995). Other research suggests that the amygdala has a role in the recognition of more complex 'social' emotions, such as guilt or admiration (Adolphs, Baron-Cohen and Tranel, 2002). Differences in recognising emotion from different modalities have also been reported. Hornak, Rolls and Wade (1996) reported a dissociation between emotion recognition from faces and voices, while also demonstrating general emotion recognition difficulties following orbitofrontal damage. Other findings suggest that different brain systems may be involved in recognising emotion from static or dynamic visual displays (McDonald and Saunders, 2005), although it is unclear to what extent this is a reflection of the differing cognitive demands of the different tasks. In a longitudinal study, Ietswaart et al. (2008) reported that face and voice emotion recognition difficulties observed shortly after (mean = 2.1 months) traumatic brain injury continued to be apparent at one-year follow-up. The authors observe that the early emergence of emotion recognition deficits may suggest that they contribute to the development of social behaviour difficulties, and that the lack of spontaneous recovery highlights the need for rehabilitation of emotion recognition skills.

Appendix 1b: Further information regarding model of dissociable empathy systems

Frith and Frith (1999; 2001) propose that there are two functionally separate neural networks underpinning the two empathy systems: a 'ventral' stream linking the orbitofrontal cortex and amygdala and surrounding structures (the emotion recognition/emotional empathy system), and a 'dorsal' stream connecting the medial prefrontal cortex, the anterior cingulate and the superior temporal sulcus (the ToM/cognitive empathy system). Shamay-Tsoory et al. (2009) provide support for this model, with findings indicating a double dissociation between deficits in emotional and cognitive empathy in individuals with inferior frontal gyrus or ventromedial prefrontal cortex lesions respectively. This model of dissociation contrasts with an alternative perspective which views emotional empathy as a pre-condition to the more complex cognitive empathy (ie. that cognitive empathy is dependent on the integrity of emotional empathy, implying that impaired emotional empathy will necessarily result in impaired cognitive empathy; Shamay-Tsoory et al., 2009). However, Shamay-Tsoory et al. (2009) acknowledge that while the cognitive and emotional empathy systems appear to be dissociable, this does not mean that they are always separate – overlap and integration of the two systems may occur. Furthermore, as indicated earlier, other brain structures (eg. amygdala; right somatosensory cortex) have also been implicated in emotion recognition, suggesting there may be a wider network of structures important for emotional empathy than the inferior frontal gyrus alone (Shamay-Tsoory et al., 2009). Further research is required to clarify how the functions mediated by this array of brain structures is integrated to enable effective social interaction, and how ABI leads to difficulties with this domain of functioning.

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Appendix 1c: Further information regarding normal development of emotion recognition skills

Improvement in facial expression recognition is thought to occur in phases at around 10 and 14 years of age, which appears to coincide with periods of maturation in the brain (Kolb and Whishaw, 2003). Tonks, Williams, Frampton, Yates and Slater (2007a) explored the development of emotion recognition skills in 67 healthy children aged 9-15 years, utilising the Florida Affect Battery (FAB; Bowers, Blonder and Heilman, 1999) and Reading the Mind in the Eyes test (RMET; Baron-Cohen, Wheelwright, Spong, Scahill and Lawson, 2001) to assess the ability to recognise emotions from faces, voices and eyes. A significant improvement in recognising emotions from faces and eyes was found to occur at around 11 years of age, which was not thought to be directly related to the development of cognitive functioning (although cognitive skills are thought to support social interaction skills). The authors acknowledge that the interpretation of some of their findings is difficult (eg. it is unclear why 11 year olds made fewer errors than older children), however, and may reflect the small sample size. However, Baron-Cohen, Wheelwright, Spong, Scahill and Lawson (2001) also suggest that similar developmental phases in the ability to recognise emotion from eyes occur at around eight and ten years of age. Other findings suggest a developmental improvement in the ability to recognise vocal prosody (Morton and Trehub, 2001). These findings indicate that emotion recognition abilities develop in line with the increasing demands of the social environment (Tonks et al., 2008a).

Appendix 1d: Further information regarding TBI and emotion recognition

TBI is typically associated with white matter damage due to diffuse axonal injury, and multi-focal lesions concentrated in the orbitomedial frontal and temporal lobes due to the movement of the brain within the skull in the case of a sudden impact (eg. a road traffic accident, a common cause of TBI – Hawley, Ward, Long, Owen and Magnay, 2003). As indicated earlier, white matter damage has been implicated in emotion recognition difficulties (Green et al., 2004). Additionally, the areas of vulnerability to damage in TBI overlap with those thought to be involved in emotion recognition and ToM (eg. prefrontal cortex, amygdala), suggesting that it is likely that emotion recognition or empathy difficulties would be observed following TBI (McDonald and Saunders, 2005). In children, damage to the prefrontal cortex may be particularly significant – as the prefrontal cortex develops throughout childhood and adolescence, damage may lead to subsequent compromised development, and the late emergence of cognitive and/or emotion recognition and empathy difficulties (Williams and Mateer, 1992).

Appendix 1e: Further information regarding impact of cranio-spinal radiation therapy

In addition to the impact of the brain tumour itself, treatments such as cranio-spinal radiation therapy (CRT) may be associated with cognitive difficulties including attention, processing speed, memory and visuo-spatial difficulties (Mulhern, Merchant, Gajjar, Reddick and Kun, 2004). In particular, CRT has been associated with reduced white matter volume, which is implicated in difficulties with attention in children treated for brain tumours (Reddick et al., 2003). Associations between attention difficulties and impaired social functioning have been indicated both in brain tumour survivors (Patel, Lai-Yates, Anderson and Katz, 2007), and in other conditions involving attention difficulties, such as ADHD – indeed, children with ADHD have also been shown to be impaired in recognising emotion from faces (Pelc, Korneich, Foisy and Dan, 2006). It seems likely, therefore, that socio-emotional difficulties are at least partly related to general cognitive difficulties.

Appendix 1f: Further information regarding emotion recognition related to epilepsy

In the study by Golouboff et al. (2008), children with left temporal lobe (TLE) were impaired relative to controls in recognising neutral faces or faces expressing fear, while children with right TLE were impaired in recognising disgust, and those with frontocentral epilepsy (FCE) were impaired in recognising happiness. The authors do not clearly account for these different patterns of impairment, although they suggest that the mesial temporal lobe structures may be involved in processing ‘negative’ emotions generally, while the unexpected impairment observed in children with FCE may be due to the secondary impact of seizures on the maturation and functioning of the prefrontal cortex. The authors did not extensively explore the relationship between emotion recognition and cognitive difficulties, but acknowledged that the left TLE group had an earlier age of seizure onset, and poorer verbal ability compared to the right TLE group, which may account for some of the differences in impairment patterns.

Appendix 2: Expanded Method

Appendix 2a: Further details of power analysis

Power analyses were calculated based on findings by Tonks et al. (2007b) of significantly worse performance by children with ABI compared to children without ABI on emotion recognition measures (FAB and RMET). The data from this study are indicated in Table 1 below.

Measure	Subtest	ABI (*n* = 18) Mean (SD)	Controls (*n* = 67) Mean (SD)	ANOVA F (1, 82)	p value
FAB faces	Identity discrimination	94.2 (6)	96.4 (6)	0.96	NS
	Select affect	84.7 (13.8)	93.1 (8.3)	5.32	0.024
RMET	-	55.5 (17.8)	69.1 (13.2)	4.23	0.043

Table 1: Performance of children with ABI and non brain-injured controls on the Florida Affect Battery (FAB) faces tasks, and the Reading the Mind in the Eyes Test (RMET). SD = standard deviation; NS = not significant.

The finding of no significant difference between the ABI and control groups on the FAB Identity Discrimination subtest (the control task, as indicated previously) indicates that children with ABI are not impaired in recognising the identity of faces. However, children with ABI performed significantly worse than controls on the other tasks of the FAB and the RMET, indicating difficulties recognising emotions from faces and eyes, that occur independently of the ability to visually discriminate other aspects of faces (ie. identity).

The power analysis was calculated using http://biomath.info/power/ttest.htm. With alpha set at 0.05 and power set at 0.80, calculations were conducted for the FAB Select Affect task and the RMET (not for the FAB Identity Discrimination task given that this is a control task in which ABI children do not perform significantly differently from non-ABI children), using both standard deviation values for each comparison, and taking into account the unequal samples sizes in the study by Tonks et al. (2007b). Based on these calculations, the number of participants required in the ABI group is indicated in Table 2.

	FAB Select Affect task		RMET	
	Smallest SD (8.3)	Largest SD (13.8)	Smallest SD (13.2)	Largest SD (17.8)
Number of participants required in ABI group	12	29	11	19

Table 2: Number of participants required in ABI group using smallest and largest standard deviation values from Tonks et al. (2007b) study for FAB and RMET (SD = Standard Deviation)

The calculations summarised in Table 2 estimate that 12-29 participants are required in the ABI group to find a significant difference between groups on the FAB Select Affect task (most conservative estimate = 29), while 11-19 ABI participants are required to find a significant difference between groups on the RMET (most conservative estimate = 19).

Given the range of required sample sizes indicated by these calculations, it was considered that >30 children with ABI should ideally be recruited to maximise power and enable within-group comparisons to be made (in addition to between group comparisons).

Appendix 2b: NHS Trust Audit Department application form

NHS
NHS Trust

Project Application Form

Quality Improvement & Audit

For Office Use Only

You must liaise with your Speciality Clinical Audit Lead to ensure that this project is included in their programme.

A Review Group, which meets weekly, will assess your application. You will be advised of the Groups decision and any comments they may have made.

The data collected and the results from this audit belong to the Trust and not the Lead Clinician. Written agreement must be obtained before any information is taken away on leaving the Trust.

Please ensure that all audit data collected remains anonymous. All audit reports must contain anonymous results.

Your audit results may be used in internal reports (Clinical Governance Directorate). A summary may also appear in the Trust's Annual Quality Improvement & Audit Report

Once your project is complete, you will be required to compile a report or complete a Summary Form which will be held by the Quality Improvement & Audit Department and entered onto the Trust database.

Project Title: *This may be better expressed as a question (eg. Are patients being referred for an MRI according to the guidelines?)*

Evaluation of the use of enhanced assessment of socio-emotional functioning within routine neuropsychological assessment, for predicting behavioural difficulties in children following acquired brain injury.

Full Name of Applicant: Ingram Wright

Directorate: Neurosciences

If Other

Post held: Consultant Neuropsychologist

Speciality: Neurology

*Email Address:

Department: Neurology

Bleep:

Department Phone:

Mobile:

**Please ensure that this is an e-mail address that you check regularly as we may use it to communicate with you*

Work Contact Address: Neurology Unit

Will this audit be lead jointly or by a single person?

☐ *Jointly*

☒ *Single Person*

Second Applicant Information

Full Name of Applicant:

Directorate:

Post held:

Speciality

*Email Address:

Department:

Bleep:

Department Phone:

Mobile:

Work Contact Address:

Page 1 of 6

NHS Trust

Project Details

Quality Improvement & Audit

What type of initiative is this? Please specify:

What type of initiative is this?	Please specify:	
☐ *Government*	☐ *National Service Framework*	☐ *Risk Issue*
	☐ *NICE*	☐ *Complaint Generated*
	☐ *Royal College*	☐ *Directorate Priority*
☐ *National*	☐ *Patient Panel*	☒ *Local Concern*
	☐ *Trust Audit Priority*	☐ *Multidisciplinary*
	☐ *Re-Audit*	☐ *LARMS*
☐ *Regional*	☐ *Interface Audit*	☐ *Essence of Care*
	☒ *Standard For Better Health*	
	☐ *Other*	
☒ *Local*	☐ *NCEPOD*	

All clinical audits fall under Standards for Better Health domain C5d as well as any others that are relevant

If NICE - Type: Number:

If Interface Audit - Type:

If Essence of Care - Type:

If National Service Framework - Type:

Background: *If a 'Nomination Form' has not been completed and submitted, please explain a little about the background to this topic.*

Emotional and social behaviour problems are common among children following acquired brain injury (ABI). While cognitive impairments associated with ABI may contribute to difficulties in interacting with others, appropriate social functioning is also thought to depend on the rapid processing of emotionally-valenced stimuli, including emotion expressed by the eyes, face and voice (Tonks, Williams, Frampton, Yates and Slater, 2007a). Deficits in the skills involved in recognising others' emotional states may underlie some of the difficulties in social interaction that can occur following ABI (Ietswaart, Milders, Crawford, Currie, and Scott, 2008). Impaired social interaction is associated with poor outcomes (eg. rejection by peers; Turkstra, Williams, Tonks and Frampton, 2008), which are likely to have implications for mental health services.

Research indicates that children with ABI are impaired relative to non-brain injured children in recognising emotional information from faces and eyes, and this impairment is not thought to be solely due to cognitive deficits (Tonks et al, 2007a; Tonks, Williams, Frampton, Yates and Slater, 2008). Impaired emotion recognition is unlikely to be detected by routine neuropsychological assessment, meaning that the needs of children with these difficulties may currently be unmet within clinical services (Tonks et al, 2008). The evaluation of appropriate assessment tools that can be incorporated into routine neuropsychological assessment is therefore important.

Aim: *What is the overall purpose of this project? What would be your ultimate goal? (to provide a..., to offer a..., to ensure that...)*

The overall aim of this project is to evaluate the use of validated emotion recognition measures, alongside established neuropsychological testing, in predicting socio-emotional behavioural difficulties in children with ABI.

Objectives *What do you need to do in order to identify whether you have acheived your aim? (To identify..., To compare, To assess...)*

Objective 1:

To evaluate the validity of the emotion recognition measures for use in clinical practice, by comparing the performance of children with ABI, with children without ABI.

Objective 2:

To explore the relationship between emotion recognition difficulties and cognitive difficulties identified through routine neuropsychological assessment.

Objective 3:

Objective 4:

Should you have any other Objectives, please continue in the Other box below, seperating objectives with a semi-colon " ; "

Other Objectives

Does this project relate to Patient Information (written (Booklets, Leaflets etc.) or verbal)? ☐ *Yes* ☒ *No*

Does this audit plan to capture patient views or experience of treatment and care within ? ☐ *Yes* ☒ *No*

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Evidence: ***What source/s of evidence will you use to support your project? - Local/National/Regional guidelines, NICE, Royal College, Policies, Standards, journals etc.***

List all references to documents/literature as applicable and mail or e-mail copies of local guidelines/protocols/standards being used to the Quality Improvement & Audit department, ensuring that they are the most up to date version.

This project is based on findings reported in the research literature (references included below) indicating that emotion recognition difficulties may occur in children following ABI, and may lead to difficulties with social interaction and associated outcomes (eg. rejection by peers). There are clear clinical implications regarding the need for improved assessment of such children.

Tonks, J., Slater, A., Frampton, I., Wall, S.E., Yates, P., and Williams, W.H., (2008). The development of emotion and empathy skills after childhood brain injury. Developmental Medicine and Child Neurology, 51, 8-16

Tonks, J., Williams, W.H., Frampton, I., Yates, P., and Slater, A., (2007a). Reading emotions after child brain injury: A comparison between children with brain injury and non-injured controls. Brain Injury, 21, 731-739

Tonks, J., Williams, W.H., Frampton, I., Yates, P., and Slater, A., (2007b). Assessing emotion recognition in 9-15 year olds: Preliminary analysis of abilities in reading emotion from faces, voices and eyes. Brain Injury, 21, 623-629

Tonks, J., Williams, W.H., Frampton, I., Yates, P., Wall, S.E., and Slater, A., (2008). Reading emotions after childhood brain injury: Case series evidence of dissociation between cognitive abilities and emotional expression processing skills. Brain Injury, 22, 325-332

Turkstra, L., Williams, W.H., Tonks, J., and Frampton, I., (2008). Measuring social cognition in adolescents: Implications for students with TBI returning to school. Neurorehabilitation, 23, 501-509

Participants

Who will be involved? You should at least inform everyone associated with the topic to allow them the oppurtunity to comment/contribute.

☐ *Other Directorate/Speciality* ☐ *Other Profession*

Speciality	*Name*	*Position*	*Informed*	*Approved*	*Actively Participating*	*Interested in Findings*
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐
			☐	☐	☐	☐

Have you obtained the support of the person who will be able to sanction any changes the project may recommend?

Eg. Consultant, Ward Manager, Business Manager, Clinical Director.

☒ *Yes* ☐ *No*

Name:

Position Held: Clinical Neuropsychologist

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Methodology

Quality Improvement & Audit

How will you obtain your source data? *Please tick all that apply*

[X] *Case Note Review* [ ] *Electronic Database* [ ] *Staff Questionnaire* [ ] *Telephone Interview*

[ ] *Personal Interview* [ ] *Patient Questionnaire* [ ] *Other*

Have you decided what data you will need to collect?

[X] *Yes* ***If you have a Data Collection Form, please send it to the QI&A Department*** [ ] *No*

Method of Data Collection:

[ ] *Prospective* [X] *Retrospective*

Tool for Data Collection:

[ ] *Scannable Form* [X] *Data Collection Form* [ ] *Online Form*

What are the characteristics of your patient group and the criteria for inclusion? *Eg. condition, time period, treatment, age etc*

Participants will be children aged 9-15 years at time of assessment, with a history of ABI. Children will be assessed following referral for neuropsychological assessment at NHS Trust. The chosen age group is based on the emergence of more sophisticated social communication skills occurring in line with increasingly complex social interaction during the transition to adolescence – it is important to understand how ABI might impact these skills. Information about the nature and location of lesions will be obtained.

Sample

Estimated Sample Size: 65-70

Has this sample been agreed by all concerned? [X] *Yes* [ ] *No*

How has the sample size been calculated/agreed?

Approximately 65-70 children with ABI will be included. Agreed

*Do you require the audit team to obtain patient case notes? [ ] *Yes* [X] *No*

Have you identified a patient list? [ ] *Yes* [ ] *No*

** NB: If approved, notes will be obtained by the QIA dept & delivered to an appropriate place chosen by the clinician. It is then the responsibility of the clinician to ensure the notes are sent back to Medical Records after use. If the notes are to be stored in the QIA dept, they will be held for two weeks for viewing and after this period will be returned to Medical Records. If the clinician has not viewed them it will be their departments responsibility to re-order and bear the inherent cost.*
We therefore strongly recommend that schedules be discussed with the QIA dept to ensure notes are available as required.

Who will collect the data?

Myself

Who will analyse the data?

[X] *You or your Colleagues* [ ] *Quality Improvement & Audit Dept* [ ] *Other*

Would you like the Patient Panel to contribute to this project?

[ ] *Yes* [X] *No*

If yes, what assistance is required?

[ ] *Assistance wtih design/data collection form*

[ ] *Assistance with collecting the data*

If no, please give a reason:

Highly Sensitive Patient Data Involved

Who do you anticipate presenting your findings to?

(If you are undertaking a service evaluation and wish to publish your results you may require ethical approval - please discuss with the QI&A department)

Feedback will be offered to participants and their parents, and support needs will be addressed through the Paediatric Neuropsychology service, based on the information obtained from this study (eg. whether intervention for cognitive or emotion

Planned project start date: 01/10/2010

Anticipated end date: 31/03/2011

NHS Trust

Quality Improvement & Audit

Resources Required:

If this project is accepted onto the Trust Priority QI&A Programme, audit resource will be provided by the QI&A department required. For those projects accepted onto Directorate Programmes, note pulling will be available together with and advisory service from the QI&A Department.

- ☐ *Project design*
- ☐ *Audit tools development*
- ☐ *Use of scanner*
- ☐ *Presentation materials*
- ☐ *Report writing*
- ☐ *Questionnaire design*
- ☐ *Questionnaire adminstration*
- ☐ *Patient notes*
- ☐ *Spreadsheet/database*
- ☐ *Facilitation*
- ☐ *Other*

Please ensure that you have sent Evidence (Standards, Guidelines etc) and any draft Data Collection Forms to the QI&A department.

Please also ensure that your Speciality Audit Lead completes the Audit Lead Application form.

Please ensure that you have read and agree to all the conditions specified in this Application form: ☒ *Agree*

Appendix 2c: NHS Trust Audit Department agreement

From: (Clinical Audit)
Sent: 15 September 2010 14:58
To: Ingram Wright
Cc:
Subject: Audit Application - Evaluation of the use of enhanced assessment of socio-emotional functioning within routine neuropsychological assessment, for predicting behavioural difficulties in children following acquired brain injury. - Application Accepted

Dear Ingram Wright

Your project application was submitted to and approved by the Audit Review Group. The following comments were made -

Approved. Please forward copy of data collection form for our records.

Regards

The Quality Improvement and Clinical Audit Department - NHS Trust

Appendix 2d: Letter of ethical approval from University of Exeter

Psychology Research Ethics Committee

Psychology, College of Life & Environmental Sciences

Washington Singer Laboratories
Perry Road
Exeter
EX4 4QG

Telephone +44 (0)1392 264626
Fax +44 (0)1392 264623
Email Marilyn.evans@exeter.ac.uk

To:	**Caroline Shinner**
From:	**Cris Burgess**
CC:	**Huw Williams**
Re:	**Application 2010/002 Ethics Committee**
Date:	**October 5, 2011**

The School of Psychology Ethics Committee has now discussed your application, ***2010/002 – Exploratory analyses of emotion recognition difficulties in children with acquired brain injury***. The project has been approved in principle for the duration of your study.

The agreement of the Committee is subject to your compliance with the British Psychological Society Code of Conduct and the University of Exeter procedures for data protection (http://www.ex.ac.uk/admin/academic/datapro/). In any correspondence with the Ethics Committee about this application, please quote the reference number above.

I wish you every success with your research.

Cris Burgess
Chair of Psychology Research Ethics Committee

Appendix 2e: Consent form

***NHS* Trust**

Neuropsychiatry, Neuropsychology and Epileptology
Department of Neuropsychology
Hospital

Tel:
Fax:

Consent to Neuropsychological Assessment

This form relates to your child having a neuropsychological assessment. The assessment is an evaluation of your child's thinking skills. It involves undertaking mostly 'pencil and paper' or 'computer based' tasks intended to measure thinking skills, attention and memory ability.

By signing this consent form you agree:

1. That the nature of the neuropsychological assessment has been explained to you, including any risks or side effects.
2. That you have been given an opportunity to ask questions about the assessment.
3. That you understand the likely contribution the results of this assessment may have in terms of your ongoing treatment or medical management.
4. That you agree for your child to undertake the assessment.

	Tick as applicable
I give consent for my data to be stored on a secure database for administration purposes.	❐
I give consent to allow any data that is generated by this assessment to be used, in an ***anonymous*** form, for the purposes of audit, research and teaching, both now and in the future.	❐
I give consent for you to contact educational services for information regarding my child's progress at school/college.	❐
I am happy for you to send a copy of the report to Educational Psychology Services in order to inform them of the outcome of the assessment.	❐
From time to time we may send you information about developments in our service or information about research projects that you might be interested in. Please tick this box if you **would like** to be sent our newsletter.	❐

Please be aware that you can change your mind about the above consent at any time in the future by writing to the above address.

Consent given by: Name___________________________ Signature_____________________ Date _______

Appendix 2f: Participant information sheet

Audit Information Sheet

You and your child are invited to take part in an audit being carried out by the Department of Paediatric Neuropsychology at Hospital, and the University of Exeter. Taking part in this audit is voluntary, and if you decide to participate, you are entitled to withdraw your consent at any time without giving a reason. Before you decide whether to participate, please read the following information.

About the audit

We are interested in understanding more about how brain injury affects children's ability to understand how other people are feeling. Difficulties with doing this may make it harder for children to understand how to interact with other people. Knowing more about how brain injury affects this ability will help to ensure that children who are having problems are given the support they need.

What will participation involve?

As part of the routine assessment with the Paediatric Neuropsychologist, your child will complete some tasks assessing his or her ability to recognise emotions from pictures of faces. Information from these tasks, together with information about your child's brain injury, will be analysed by a trainee clinical psychologist based at the University of Exeter. You will be given feedback about the results of the assessment.

How long will participation take?

The emotion recognition tasks will take about 10-15 minutes to complete (in addition to other routine tests carried out in the assessment session).

Confidentiality

The collected information will be kept anonymous and confidential. All identifying information will be removed, and names will be replaced with participant numbers, which will only be known to the staff involved in the audit.

Further information

If you would like more information or have any questions, please speak to a member of the Paediatric Neuropsychology team.

Appendix 2g: Participant data collection form

Participant Data Form

Participant Number: ___________________

Demographic Information

Gender: Male ☐ Female ☐ Age: __________ years __________ months

Acquired brain injury (ABI) information

Age at ABI: ____________ years ____________ months

Time since ABI: ____________ years ____________ months

Type of ABI: Head injury ☐ Stroke ☐ Tumour ☐ Infection ☐ Other ☐

Details:

Scan evidence: CT ☐ MRI ☐ Time of scan post-ABI: __________________________

Other evidence (eg. neurological): ____

Primary lesion site: ____

____

Other lesion sites: ____

____

Assessment scores

- Strengths and Difficulties Questionnaire (parent-report version)

Domain	Score	Classification
Total Difficulties		
Emotional Symptoms		
Conduct Problems		
Hyperactivity/Inattention		
Peer relationship Problems		
Pro-social Behaviour		

- Reading the Mind in the Eyes Test

  Total correct: ____________ /28 % correct score: ____________

- Florida Affect Battery

  - Identity Discrimination

    Total correct: ____________ /20 % correct score: ____________

    Error types: Same: ________ /10 Different: ________ /10

  - Affect Selection

    Total correct: ____________ /20 % correct score: ____________

    Error types: Happy: ______ /4 Frightened: ______ /4 Sad: ______ /4 Angry: ______ /4
    Neutral: ______ /4

If SDQ, RMET, or FAB not completed, details why: ____
____

Cognitive Assessments

Measure	Score	Scaled Score
WISC-IV – Digit Span		
WISC-IV – Symbol Search		
NEPSY-II – Letter fluency		
NEPSY-II – Block Construction		

If alternative cognitive assessments used, details and scores:

Appendix 2h: Parent-report SDQ

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Appendix 2i: FAB Identity Discrimination task – sample stimuli

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Appendix 2j: FAB Select Affect task – sample stimuli

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Appendix 2k: RMET sample stimuli

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Appendix 3: Expanded Results

Appendix 3a: Tests of normality and homogeneity of variance

The Shapiro-Wilk test of normality indicated that data from several variables in both the ABI and non-ABI groups showed a significant departure from normality (see SPSS output table below). To some extent this is likely to reflect the nature of variables with floor and ceiling effects (eg. it is anticipated that the SDQ Total Difficulties scores would be positively skewed in the non-ABI group (high frequency of low ratings of difficulties), while scores on the FAB Identity Discrimination task are expected to be negatively skewed in both the ABI and non-ABI group (most individuals perform at or close to ceiling on this perceptual control task)). However, given the small sample size in the ABI group (and therefore, small number of data points), normality may be difficult to determine.

Tests of Normality

	ABI or non-ABI	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Age	Non-ABI	.094	67	.200*	.952	67	.011
	ABI	.193	10	.200*	.922	10	.373
Reading the Mind in the Eyes Test - % correct	Non-ABI	.125	67	.011	.947	67	.006
	ABI	.276	10	.030	.889	10	.164
Florida Affect Battery - Identity Discrimination - % correct	Non-ABI	.306	67	.000	.631	67	.000
	ABI	.524	10	.000	.366	10	.000
Florida Affect Battery - Affect Selection - % correct	Non-ABI	.234	67	.000	.801	67	.000
	ABI	.266	10	.043	.914	10	.310
WISC-IV Digit Span - scaled score	Non-ABI	.161	67	.000	.946	67	.006
	ABI	.109	10	.200*	.984	10	.983
WISC-IV Symbol Search - scaled score	Non-ABI	.146	67	.001	.981	67	.381
	ABI	.162	10	.200*	.974	10	.924
NEPSY Initial Letter Word Generation - scaled score	Non-ABI	.139	67	.003	.952	67	.012
	ABI	.165	10	.200*	.933	10	.474
NEPSY Block Construction - scaled score	Non-ABI	.235	67	.000	.842	67	.000
	ABI	.243	10	.097	.939	10	.539
SDQ parent-report - total difficulties	Non-ABI	.151	67	.001	.894	67	.000
	ABI	.150	10	.200*	.941	10	.566
SDQ parent-report - emotional symptoms	Non-ABI	.220	67	.000	.777	67	.000
	ABI	.203	10	.200*	.896	10	.199
SDQ parent-report - conduct problems	Non-ABI	.236	67	.000	.805	67	.000
	ABI	.250	10	.076	.735	10	.002
SDQ parent-report - hyperactivity/inattention	Non-ABI	.143	67	.002	.910	67	.000
	ABI	.267	10	.042	.846	10	.052
SDQ parent-report - peer relationship problems	Non-ABI	.260	67	.000	.753	67	.000
	ABI	.140	10	.200*	.959	10	.778

SDQ parent-report - prosocial behaviour	Non-ABI	.238	67	.000	.845	67	.000
	ABI	.241	10	.105	.859	10	.075

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Levene's test of homogeneity of variance indicated that there were significant differences in the variance between the ABI and non-ABI groups on three variables: the FAB Affect Selection task (F (1, 75) = 5.26, p = .025), the NEPSY-II Block Construction task (F (1, 75) = 41.52, p < .001), and the SDQ Peer Relationship Problems scale (F (1, 75) = 6.39, p = .014) (see SPSS output table below). There was greater variance in the ABI group compared to the non-ABI group for all three variables (FAB Affect Selection: ABI group variance = 163.6, non-ABI group variance = 68.91; NEPSY-II Block Construction: ABI group variance = 17.12, non-ABI group variance = 2.19; SDQ Peer Relationship Problems: ABI group variance = 6.93, non-ABI group variance = 2.16). This may reflect the typical finding of greater variance in performance in clinical relative to non-clinical samples (Henry et al., 2006). Overall, given the potential issues regarding normality and homogeneity of variance, group comparisons using non-parametric analyses were appropriate.

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Age	Based on Mean	.245	1	75	.622
Reading the Mind in the Eyes Test - % correct	Based on Mean	.192	1	75	.663
Florida Affect Battery - Identity Discrimination - % correct	Based on Mean	.146	1	75	.704
Florida Affect Battery - Affect Selection - % correct	Based on Mean	5.261	1	75	.025
WISC-IV Digit Span - scaled score	Based on Mean	1.173	1	75	.282
WISC-IV Symbol Search - scaled score	Based on Mean	.061	1	75	.805
NEPSY Initial Letter Word Generation - scaled score	Based on Mean	3.626	1	75	.061
NEPSY Block Construction - scaled score	Based on Mean	41.515	1	75	.000
SDQ parent-report - total difficulties	Based on Mean	.911	1	75	.343
SDQ parent-report - emotional symptoms	Based on Mean	1.732	1	75	.192
SDQ parent-report - conduct problems	Based on Mean	2.558	1	75	.114
SDQ parent-report - hyperactivity/inattention	Based on Mean	.782	1	75	.379
SDQ parent-report - peer relationship problems	Based on Mean	6.390	1	75	.014
SDQ parent-report - prosocial behaviour	Based on Mean	.835	1	75	.364

Appendix 3b: Group demographic comparisons

Mann-Whitney Test: comparison of age in ABI and non-ABI groups

Ranks

	ABI or non-ABI	N	Mean Rank	Sum of Ranks
Age	Non-ABI	67	40.82	2735.00
	ABI	14	41.86	586.00
	Total	81		

Test Statistics[a]

	Age
Mann-Whitney U	4.570E2
Wilcoxon W	2.735E3
Z	-.150
Asymp. Sig. (2-tailed)	.881

a. Grouping Variable: ABI or non-ABI

Chi-Square: comparison of gender in ABI and non-ABI groups

Gender * ABI or non-ABI Crosstabulation

			ABI or non-ABI		
			Non-ABI	ABI	Total
Gender	Male	Count	34	9	43
		Expected Count	35.6	7.4	43.0
		% within Gender	79.1%	20.9%	100.0%
		% within ABI or non-ABI	50.7%	64.3%	53.1%
		% of Total	42.0%	11.1%	53.1%
		Std. Residual	-.3	.6	
	Female	Count	33	5	38
		Expected Count	31.4	6.6	38.0
		% within Gender	86.8%	13.2%	100.0%
		% within ABI or non-ABI	49.3%	35.7%	46.9%
		% of Total	40.7%	6.2%	46.9%
		Std. Residual	.3	-.6	
Total		Count	67	14	81
		Expected Count	67.0	14.0	81.0
		% within Gender	82.7%	17.3%	100.0%
		% within ABI or non-ABI	100.0%	100.0%	100.0%
		% of Total	82.7%	17.3%	100.0%

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.852[a]	1	.356		
Continuity Correction[b]	.395	1	.529		
Likelihood Ratio	.865	1	.352		
Fisher's Exact Test				.394	.266
Linear-by-Linear Association	.842	1	.359		
N of Valid Cases[b]	81				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 6.57.

b. Computed only for a 2x2 table

Appendix 3c: ABI v non-ABI comparisons of emotion recognition task performance

Descriptive statistics regarding the performance of the ABI and non-ABI groups on the RMET and FAB tasks are indicated in Table 3.

Measure	ABI (*n* = 14)		Non-ABI (*n* = 67)	
	Mean (SD)	Median	Mean (SD)	Median
RMET (% correct)	60.14 (13.87)	64.00	69.08 (13.20)	71.40
FAB Identity (% correct)	98.21 (5.41)	100.00	96.42 (6.02)	100.00
FAB Select Affect (% correct)	83.57 (11.67)	85.00	93.06 (8.30)	95.00

Table 3: ABI and non-ABI group performance on emotion recognition measures (SD = Standard Deviation)

Mann-Whitney *U* group comparison outcomes are indicated in the SPSS output below.

Test Statistics[a]

	Reading the Mind in the Eyes Test - % correct	Florida Affect Battery - Identity Discrimination - % correct	Florida Affect Battery - Affect Selection - % correct
Mann-Whitney U	291.500	347.500	229.000
Wilcoxon W	396.500	2625.500	334.000
Z	-2.221	-1.767	-3.094
Asymp. Sig. (2-tailed)	.026	.077	.002

a. Grouping Variable: ABI or non-ABI

The clinical significance of the lower ABI group RMET and FAB Select Affect scores, compared to the non-ABI means, are indicated in Table 4.

Participant	FAB Select Affect score (% correct)	RMET score (% correct)
1	80*	46*
2	75**	50*
3	75**	64
4	95	71
5	80*	64
6	95	79
7	60**	50*
8	100	68
9	95	68
10	90	29**
11	90	64
12	75**	46*
13	70**	75
14	90	68

Table 4: Clinical significance of ABI participants' raw scores on FAB Select Affect and RMET tasks, compared to non-ABI means (* = > 1 standard deviation below non-ABI mean on FAB Select Affect task (mean = 93.06, SD = 8.30) or RMET task (mean = 69.08, SD = 13.20); ** = > 2 standard deviations below non-ABI means on FAB Select Affect or RMET tasks. All other scores are within 1 standard deviation of non-ABI mean for each task)

Appendix 3d: ABI v non-ABI comparisons of cognitive task performance

Mann-Whitney Test

Test Statistics[a]

	WISC-IV Digit Span - scaled score	WISC-IV Symbol Search - scaled score	NEPSY-II Initial Letter Word Generation - scaled score	NEPSY-II Block Construction - scaled score
Mann-Whitney U	294.000	206.500	424.000	425.000
Wilcoxon W	372.000	284.500	515.000	516.000
Z	-1.487	-2.683	-.151	-.140
Asymp. Sig. (2-tailed)	.137	.007	.880	.889

a. Grouping Variable: ABI or non-ABI

Appendix 3e: ANCOVA for ABI v non-ABI group comparisons

- **ANCOVA for RMET**

Tests of Between-Subjects Effects

Dependent Variable: Reading the Mind in the Eyes Test - % correct

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3602.446[a]	4	900.611	6.334	.000	.255
Intercept	2973.996	1	2973.996	20.915	.000	.220
WISC_digitspan	78.688	1	78.688	.553	.459	.007
NEPSY_letterfluency	549.306	1	549.306	3.863	.053	.050
NEPSY_blockconstruct	1564.031	1	1564.031	10.999	.001	.129
ABI_or_nonABI	449.769	1	449.769	3.163	.079	.041
Error	10522.473	74	142.196			
Total	379720.180	79				
Corrected Total	14124.919	78				

a. R Squared = .255 (Adjusted R Squared = .215)

- **ANCOVA for FAB Select Affect**

Tests of Between-Subjects Effects

Dependent Variable:Florida Affect Battery - Affect Selection - % correct

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	991.228[a]	4	247.807	3.076	.021	.143
Intercept	20096.500	1	20096.500	2.495E2	.000	.771
WISC_digitspan	143.712	1	143.712	1.784	.186	.024
NEPSY_letterfluency	201.923	1	201.923	2.507	.118	.033
NEPSY_blockconstruct	7.178	1	7.178	.089	.766	.001
ABI_or_nonABI	787.189	1	787.189	9.773	.003	.117
Error	5960.671	74	80.550			
Total	672300.000	79				
Corrected Total	6951.899	78				

a. R Squared = .143 (Adjusted R Squared = .096)

Appendix 3f: Regression analyses (cognitive predictors of ABI group performance)

- **WISC-IV Symbol Search as a predictor of RMET task performance**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.293[a]	.086	-.006	14.012

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	184.240	1	184.240	.938	.356[a]
	Residual	1963.427	10	196.343		
	Total	2147.667	11			

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score

b. Dependent Variable: Reading the Mind in the Eyes Test - % correct

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	53.179	10.121		5.254	.000
	WISC-IV Symbol Search - scaled score	1.226	1.265	.293	.969	.356

a. Dependent Variable: Reading the Mind in the Eyes Test - % correct

- **WISC-IV Symbol Search as a predictor of FAB Select Affect task performance**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.235[a]	.055	-.039	12.570

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92.754	1	92.754	.587	.461[a]
	Residual	1580.163	10	158.016		
	Total	1672.917	11			

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score

b. Dependent Variable: Florida Affect Battery - Affect Selection - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92.754	1	92.754	.587	.461[a]
	Residual	1580.163	10	158.016		
	Total	1672.917	11			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	78.207	9.080		8.613	.000
	WISC-IV Symbol Search - scaled score	.870	1.135	.235	.766	.461

a. Dependent Variable: Florida Affect Battery - Affect Selection - % correct

- **NEPSY-II Block Construction as a predictor of RMET task performance**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.289[a]	.083	.000	13.798

a. Predictors: (Constant), NEPSY-II Block Construction - scaled score

b. Dependent Variable: Reading the Mind in the Eyes Test - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	190.215	1	190.215	.999	.339[a]
	Residual	2094.092	11	190.372		
	Total	2284.308	12			

a. Predictors: (Constant), NEPSY-II Block Construction - scaled score

b. Dependent Variable: Reading the Mind in the Eyes Test - % correct

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	53.045	9.039		5.868	.000
	NEPSY-II Block Construction - scaled score	.967	.968	.289	1.000	.339

a. Dependent Variable: Reading the Mind in the Eyes Test - % correct

Appendix 3g: Correlational analyses of emotion recognition performance

Correlations

	ABI or non-ABI			Reading the Mind in the Eyes Test - % correct	Florida Affect Battery - Affect Selection - % correct
Kendall's tau_b	Non-ABI	Reading the Mind in the Eyes Test - % correct	Correlation Coefficient	1.000	.154
			Sig. (2-tailed)	.	.103
			N	67	67
		Florida Affect Battery - Affect Selection - % correct	Correlation Coefficient	.154	1.000
			Sig. (2-tailed)	.103	.
			N	67	67
	ABI	Reading the Mind in the Eyes Test - % correct	Correlation Coefficient	1.000	.329
			Sig. (2-tailed)	.	.127
			N	14	14
		Florida Affect Battery - Affect Selection - % correct	Correlation Coefficient	.329	1.000
			Sig. (2-tailed)	.127	.
			N	14	14

Appendix 3h: Early v late ABI group comparisons

Descriptive statistics regarding the performance of the early ABI and late ABI groups on the RMET and FAB Select Affect tasks are indicated in Table 5.

Measure	Early ABI (*n* = 9)		Late ABI (*n* = 5)	
	Mean (SD)	**Median**	**Mean (SD)**	**Median**
RMET (% correct)	58.67 (16.13)	64.00	62.80 (9.55)	68.00
FAB Identity (% correct)	99.44 (1.67)	100.00	96.00 (8.94)	100.00
FAB Select Affect (% correct)	81.11 (12.19)	80.00	88.00 (10.37)	90.00

Table 5: Early ABI and late ABI group performance on emotion recognition measures (SD = Standard Deviation)

Mann-Whitney *U* group comparisons are indicated in the SPSS output below.

Test Statistics[b]

	RMET - % correct	FAB Identity Discrimination - % correct	FAB Select Affect - % correct
Mann-Whitney U	20.500	20.000	14.500
Wilcoxon W	65.500	35.000	59.500
Z	-.270	-.547	-1.082
Asymp. Sig. (2-tailed)	.787	.584	.279
Exact Sig. [2*(1-tailed Sig.)]	.797[a]	.797[a]	.298[a]

a. Not corrected for ties.

b. Grouping Variable: Early or Late ABI

Appendix 3i: Focal v diffuse/multi-focal group comparisons

- **Emotion recognition task performance**

Descriptive statistics regarding the performance of the focal ABI and diffuse/multi-focal ABI groups on the FAB and RMET tasks are indicated in Table 6.

Measure	Focal ABI (*n* = 8)		Diffuse/multi-focal ABI (*n* = 6)	
	Mean (SD)	Median	Mean (SD)	Median
RMET (% correct)	54.88 (13.66)	57.00	67.17 (11.62)	69.50
FAB Identity (% correct)	99.38 (1.77)	100.00	96.67 (8.17)	100.00
FAB Select Affect (% correct)	80.62 (11.16)	80.00	87.50 (12.15)	92.50

Table 6: Focal ABI and diffuse/multi-focal ABI group performance on emotion recognition measures (SD = Standard Deviation)

Mann-Whitney *U* group comparisons are indicated in the SPSS output below.

Test Statistics[b]

	RMET - % correct	FAB Identity Discrimination - % correct	FAB Select Affect - % correct
Mann-Whitney U	10.500	22.500	16.000
Wilcoxon W	46.500	43.500	52.000
Z	-1.762	-.318	-1.048
Asymp. Sig. (2-tailed)	.078	.751	.295
Exact Sig. [2*(1-tailed Sig.)]	.081[a]	.852[a]	.345[a]

a. Not corrected for ties.

b. Grouping Variable: Focal or Diffuse/Multi-focal ABI

- **FAB Select Affect task error types**

Mann-Whitney U group comparisons of the error types made on the FAB Select Affect task by the focal and diffuse/multi-focal ABI groups are indicated in the SPSS output below.

Test Statistics[b]

	FAB Select Affect errors - happy	FAB Select Affect errors - frightened	FAB Select Affect errors - sad	FAB Select Affect errors - angry	FAB Select Affect errors - neutral
Mann-Whitney U	22.000	21.000	19.500	19.500	12.000
Wilcoxon W	43.000	42.000	55.500	40.500	33.000
Z	-.362	-.435	-.661	-.650	-1.601
Asymp. Sig. (2-tailed)	.717	.663	.508	.516	.109
Exact Sig. [2*(1-tailed Sig.)]	.852[a]	.755[a]	.573[a]	.573[a]	.142[a]

a. Not corrected for ties.

b. Grouping Variable: Focal or Diffuse/Multi-focal ABI

Appendix 3j: Regression analyses (predictors of SDQ outcomes in ABI group)

- **FAB Select Affect performance as a predictor of SDQ Peer Relationship problems score**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.000[a]	.000	-.100	2.535

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.000	1	.000	.000	1.000[a]
	Residual	64.250	10	6.425		
	Total	64.250	11			

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

b. Dependent Variable: SDQ parent-report - peer relationship problems

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.750	5.387		.696	.502
	Florida Affect Battery - Affect Selection - % correct	.000	.064	.000	.000	1.000

a. Dependent Variable: SDQ parent-report - peer relationship problems

- **FAB Select Affect performance as a predictor of SDQ Conduct Problems score**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.098[a]	.010	-.089	2.289

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.512	1	.512	.098	.761[a]
	Residual	52.404	10	5.240		
	Total	52.917	11			

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

b. Dependent Variable: SDQ parent-report - conduct problems

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.910	4.865		.393	.703
	Florida Affect Battery - Affect Selection - % correct	.018	.058	.098	.313	.761

a. Dependent Variable: SDQ parent-report - conduct problems

- **FAB Select Affect performance as a predictor of SDQ Emotional Symptoms score**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.318[a]	.101	.011	2.222

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5.560	1	5.560	1.127	.313[a]
	Residual	49.356	10	4.936		
	Total	54.917	11			

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

b. Dependent Variable: SDQ parent-report - emotional symptoms

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.048	4.721		-.010	.992
	Florida Affect Battery - Affect Selection - % correct	.060	.056	.318	1.061	.313

a. Dependent Variable: SDQ parent-report - emotional symptoms

- **FAB Select Affect performance as a predictor of SDQ Total Difficulties score**

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.263[a]	.069	-.024	5.576

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.043	1	23.043	.741	.409[a]
	Residual	310.957	10	31.096		
	Total	334.000	11			

a. Predictors: (Constant), Florida Affect Battery - Affect Selection - % correct

b. Dependent Variable: SDQ parent-report - total difficulties

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8.894	11.850		.751	.470
	Florida Affect Battery - Affect Selection - % correct	.121	.141	.263	.861	.409

a. Dependent Variable: SDQ parent-report - total difficulties

- **NEPSY-II Block Construction performance as a predictor of SDQ Peer Relationship problems score**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.831[a]	.691	.656	1.485

a. Predictors: (Constant), NEPSY-II Block Construction - scaled score

b. Dependent Variable: SDQ parent-report - peer relationship problems

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	44.329	1	44.329	20.096	.002[a]
	Residual	19.853	9	2.206		
	Total	64.182	10			

a. Predictors: (Constant), NEPSY-II Block Construction - scaled score

b. Dependent Variable: SDQ parent-report - peer relationship problems

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.941	1.041		7.627	.000
	NEPSY-II Block Construction - scaled score	-.483	.108	-.831	-4.483	.002

a. Dependent Variable: SDQ parent-report - peer relationship problems

- **WISC-IV Digit Span performance as a predictor of SDQ Conduct Problems score**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.724[a]	.525	.465	1.626

a. Predictors: (Constant), WISC-IV Digit Span - scaled score
b. Dependent Variable: SDQ parent-report - conduct problems

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	23.347	1	23.347	8.830	.018[a]
	Residual	21.153	8	2.644		
	Total	44.500	9			

a. Predictors: (Constant), WISC-IV Digit Span - scaled score
b. Dependent Variable: SDQ parent-report - conduct problems

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-2.059	1.940		-1.061	.320
	WISC-IV Digit Span - scaled score	.741	.249	.724	2.971	.018

a. Dependent Variable: SDQ parent-report - conduct problems

- **WISC-IV Symbol Search performance as a predictor of SDQ Conduct Problems score**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.766[a]	.588	.536	1.515

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score
b. Dependent Variable: SDQ parent-report - conduct problems

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26.145	1	26.145	11.395	.010[a]
	Residual	18.355	8	2.294		
	Total	44.500	9			

a. Predictors: (Constant), WISC-IV Symbol Search - scaled score
b. Dependent Variable: SDQ parent-report - conduct problems

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.122	1.109		.110	.915
	WISC-IV Symbol Search - scaled score	.463	.137	.766	3.376	.010

a. Dependent Variable: SDQ parent-report - conduct problems

Appendix 4: Dissemination Statement

It is intended that the findings of this study will be submitted for publication in the *Journal of the International Neuropsychological Society*, and for presentation at conferences such as those held by the International Neuropsychological Society and the International Brain Injury Association.

In addition, the findings will be fed back to the Paediatric Neuropsychology service, in order to inform clinical practice regarding the likely socio-emotional needs of children with ABI and how they may be appropriately assessed within routine practice, and enable consideration of ways of providing appropriate interventions. The research will also be publicised via the University of Exeter Centre for Clinical Neuropsychology Research (CCNR) website, to facilitate dissemination of the findings to service user groups associated with the CCNR. It is intended that the findings will also be communicated to service users in collaboration with relevant charities such as the Child Brain Injury Trust.

Appendix 5: Journal of the International Neuropsychological Society instructions for authors

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