Measuring domain-specific deficits in self-awareness in children and adolescents with acquired brain injury: Component analysis of the Paediatric Awareness Questionnaire

Short Title: Domain-specific self-awareness in children and adolescents with ABI

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Abstract

Self-awareness has been found to vary across different functional domains for adults with acquired brain injury (ABI); however, domain-specific self-awareness is yet to be investigated following paediatric ABI. This study aimed to validate the Paediatric Awareness Questionnaire (PAQ) as a multi-domain measure of self-awareness and to investigate domain-specific self-awareness in children with ABI. One hundred and ninety-seven children and adolescents (8-16 years, M = 12.44, SD = 2.62) with mixed causes of ABI (70% with traumatic brain injury) and their parents (n = 197) were recruited through consecutive rehabilitation appointments and completed the PAQ. The 37 items of the parent version of the PAQ were subjected to a principal component analysis with varimax rotation. A five-component solution (29 items) explained 64% of the variance in the PAQ items. Components revealed five domains of self-awareness: socio-emotional functioning, activities of daily living (ADLs), cognition, physical functioning, and communication. Internal consistency of the components ranged from acceptable to excellent (α = .70-.95). The analysis identified that children had poorer self-awareness of cognitive functioning than socio-emotional functioning, ADLs, and communication skills. Overall, the findings identify five components (i.e., functional domains) of self-awareness and provide some support that self-awareness varies across domains following paediatric ABI.

Keywords: Acquired brain injury, self-awareness, metacognition, children, adolescents

Introduction

Self-awareness refers to the ability to accurately appraise one's self and personal abilities (Toglia & Kirk, 2000). In the context of acquired brain injury (ABI), impaired self-awareness refers to the tendency to overestimate one's functioning and has been found to be associated with poorer functional outcomes in both adults and children (Lloyd et al., 2020; Ownsworth & Clare, 2006; Sherer & Fleming, 2014, 2019). Developmental theorists propose that self-awareness is a multi-dimensional construct, whereby the accuracy of children's self-perceptions varies across skill domains throughout development (Damon & Hart, 1998; Harter, 2012). Research on the development of self-awareness after ABI in adults also indicates different trajectories for self-awareness domains, with self-awareness of physical and motor impairments found to emerge earlier in recovery than self-awareness of cognitive, behavioural, and emotional difficulties (Hart et al., 2009; Sherer & Fleming, 2019; Toglia & Kirk, 2000). Although research indicates that children and adolescents often display impaired self-awareness at a global level (Lloyd et al., 2017; 2020), there is a lack of research on domain-specific differences in self-awareness after paediatric ABI. The Paediatric Awareness Questionnaire (PAQ) was developed to assess self-awareness of different domains of functioning in children and adolescents after ABI (Lloyd et al., 2017). While preliminary research supports the use of the PAQ as a reliable and valid measure of self-awareness as a global construct (Lloyd et al., 2017), it has yet to be validated for examining domain-specific self-awareness. Greater understanding of the nature of self-awareness in childhood may guide the focus of rehabilitation interventions for improving self-understanding and adjustment to ABI.

In their early conceptualisation of self-awareness after ABI, Prigatano and Schacter (1991) referred to the "specificity" of awareness syndromes, proposing that self-awareness deficits may be domain-specific (i.e., restricted to a particular function such as sensory or motor skills) or global in nature (i.e., a generalised lack of awareness extending across functional domains; see also McGlynn & Schacter, 1989). Other theorists have similarly proposed that self-awareness in the context of neurological disorder varies according to the “object of awareness” or specific domain of functioning for which awareness is examined (Markova & Berrios, 2006; Ownsworth, Clare & Morris, 2006). Likewise, in Toglia and Kirk’s (2000) Comprehensive Dynamic Interactional Model, self-awareness is conceived to vary according to the “domain of concern” (e.g., physical, cognitive & perceptual, interpersonal and emotional).

Consistent with these theoretical perspectives, research on adults with ABI indicates that self-awareness varies across functional domains. Specifically, self-awareness is more impaired for cognitive, behavioural and socio-emotional aspects of functioning, as compared to sensory/motor and physical functioning and basic self-care competencies (Hart et al., 2003, 2004, 2009; Hoofien et al., 2004; Trahan et al., 2006). Furthermore, longitudinal studies have demonstrated that while self-awareness generally improves in the first few months post-discharge after traumatic brain injury (TBI; Fleming & Strong, 1999; Geytenbeek et al., 2017; Hart et al., 2009; Richardson et al., 2015), the degree of recovery varies across domains of functioning. For example, Fleming and Strong (1999) found that self-awareness at 3-months post-injury was most impaired for performance on activities with a greater cognitive or socio-emotional component and was least impaired for basic activities of daily living ([ADLs] e.g., bathing, dressing), overt emotional responses, and memory tasks. At 12-months post-injury, self-awareness improved for most aspects of functioning, except for instrumental ADLs (i.e., managing finances, driving a car), and emotion perception skills. In a severe TBI sample, Hart et al. (2009) found that self-awareness at 12-months post-injury was relatively accurate in the motor/sensory domain on the Awareness Questionnaire (AQ; Sherer et al., 1998) but was impaired in the cognitive/affective domain. Similarly, Richardson et al. (2015)

found that self-awareness was better at longer post-injury time periods (120 to 240 months) than earlier time periods for the motor/sensory domain but not the cognitive/affective domain on the AQ following mild to severe TBI.

Somewhat contrary to other research, a cross-sectional study by Hurst et al. (2019) found that adults with severe TBI (mean post-injury time: 35 months; *SD* = 44 months) had significantly poorer self-awareness on the ADLs domain than on the interpersonal and emotional domains of the Patient Competency Rating Scale (PCRS; Prigatano & Altman, 1990). However, an item-level analysis identified that TBI participants had poorer self-awareness of their competencies related to instrumental ADLs (i.e., preparing meals, managing finances, driving, meeting responsibilities) than basic ADLs (i.e., dressing, personal hygiene, washing dishes, doing laundry). The authors attributed this finding to the increased complexity of these tasks involving higher-order cognitive functions, and individuals' potentially greater reluctance to acknowledge difficulties in activities that have greater implications for their self-identity. Although findings in the adult ABI literature generally support the domain-specific nature of self-awareness, conceptualisations for paediatric brain injury need to account for the typical development of self-awareness throughout childhood.

Developmental theorists propose that self-awareness, or accurate perceptions of one's own competencies and characteristics begins to emerge in infancy and becomes more coherent, complex, and organized in late adolescence and early adulthood (Damon & Hart, 1998; Harter, 2012). Supported by neuro-developmental and socio-cultural factors, self-awareness proceeds from awareness of concrete, physical abilities, and behaviours to more abstract, psychological, and social attributes (Damon & Hart, 1998; Rochat, 2003). Young children (i.e., < 8 years) often overestimate their own competencies and hold unrealistically positive self-perceptions (Damon & Hart, 1998; Harter, 2012). Accuracy of self-appraisal typically increases with age, with children in late childhood usually able to recognise both strengths and weaknesses in their abilities (Harter, 2012). The increase in accuracy, or more realistic self-appraisals, may in part explain the decrease in self-esteem often observed in early to middle adolescence (Harter, 2012). Such developmental perspectives highlight the importance of monitoring the emergence of self-awareness across different skill domains after paediatric ABI.

However, a systematic review of self-awareness after paediatric TBI by Lloyd et al. (2015) identified that most studies examined self-awareness of a specific domain of functioning or used total scores on questionnaires measuring different skills, thus reflecting global self-awareness. Self-awareness was commonly assessed using self- and informant ratings (i.e., deriving discrepancy scores between parent and child ratings) or performance-based measures (i.e., accuracy of prospective or retrospective judgements of task performance). Relative to typically developing controls, children with TBI were found to have impaired self-awareness in the domains of communication (Douglas, 2010), executive functioning (Josman et al., 2000a), and memory (Crowther et al., 2011, Hanten et al., 2000, 2004; Josman et al., 2000b). Studies published after this review also found that children with TBI displayed impaired self-awareness of problems with memory (Geurten et al., 2017) and executive functioning (Krasny-Pacini et al., 2015; Geurten et al., 2016). Other studies compared child and parent ratings of ability on questionnaires assessing diverse functional skills, deriving global discrepancy indices (Beardmore et al., 1999; Lloyd et al., 2017, 2020). For example, Beardmore et al. (1999) found that children with TBI (n = 21) reported fewer problems overall than their parents, and that poorer self-awareness was associated with higher self-esteem. The authors noted that common areas of disagreement between parent ratings and child self-ratings related to motor problems, planning difficulties, and fatigue, whereby children overreported their functioning relative to parents.

The review by Lloyd et al. (2015) highlighted the lack of tools that have been specifically developed to assess self-awareness after paediatric ABI. To address this gap, the Paediatric Awareness Questionnaire (PAQ) was developed as a multi-domain measure of self-awareness for children and adolescents with ABI (Lloyd et al., 2017). The PAQ consists of 37 items designed to broadly assess competencies relevant to children's functioning in the home and community that are commonly affected by TBI. These competencies relate to physical functioning, cognitive and language abilities, ADLs, interpersonal skills, and emotional/behavioural functioning. Using parallel versions for children, parents, or clinicians, respondents rate the child's ease at performing functional activities. Larger negative discrepancy scores on the PAQ (i.e., parent total scores minus child total scores) are indicative of poorer self-awareness.

Research using the PAQ found that children injured at a younger age and with more severe injuries, and those with greater family dysfunction have poorer self-awareness (Lloyd et al., 2017, 2020). Further, poorer self-awareness was associated with lower adaptive functioning and greater emotional and behavioural problems for children as rated by parents but was also associated with more positive self-concept and fewer symptoms of depression and anxiety as rated by children (Lloyd et al., 2020). However, to date, the PAQ has only been used to assess self-awareness as a global construct. To have greater utility in clinical practice, it would be advantageous for the PAQ to assess children's profile of self-awareness across different functional domains to monitor changes in self-perceptions and response to interventions.

Accordingly, the first aim of this study was to validate the PAQ as a multi-domain measure of self-awareness. It was hypothesised that a principal component analysis would identify domains consistent with the content areas conceptualised in developing the PAQ, including physical functioning, cognitive and language abilities, ADLs, interpersonal skills, and emotional/behavioural functioning. Parent ratings on the PAQ were used for this analysis as significant other ratings typically provide the benchmark for gauging the accuracy of self-awareness ratings in individuals with ABI (Fleming et al., 1996).

The second aim was to investigate domain-specific self-awareness following paediatric ABI. It was hypothesised that children's self-awareness would be most impaired (i.e., greater parent-child discrepancy) on cognitive, interpersonal and emotional/behavioural domains as compared to ADLs and physical domains. As an exploratory aim, demographic and injury-related factors associated with domain-specific self-awareness were also investigated.

Method

Participants

Children with TBI and their parents were recruited through consecutive clinic appointments between August 2015 and March 2020 (Lloyd et al., 2017, 2020). Children with other types of ABI were recruited consecutively from the same clinic between January 2016 and March 2017 as part of a separate project (Hendry et al., 2020). All participants were recruited via outpatient clinics at the Queensland Paediatric Rehabilitation Service (QPRS) at the Queensland Children's Hospital, Brisbane, Australia. Children were initially screened by treating clinicians to determine eligibility according to the following criteria: aged 8-16 years, a medical diagnosis of brain injury, medically stable (including not in post-traumatic amnesia and no current seizures), and sufficient cognitive and language abilities to complete the questionnaires. Children were excluded from the study if they had a pre-injury diagnosis of a psychiatric, neurological or severe developmental disorder, or a background of suspected abuse or neglect, as identified by medical records, discussion with treating clinicians or self-report. Children were also excluded if they or their parents had significant current mental health concerns or acute distress that precluded them from completing questionnaires. Participant recruitment outcomes and characteristics of the current sample are reported at the start of the Results section.

Measures

Socio-Demographic and Injury-Related Information. Parents completed a socio-demographic background questionnaire detailing the child's age, sex, ethnicity, parental education, and household income. Injury characteristics were collected via review of medical records. These included date of injury, age at injury, cause of injury, and lowest Glasgow Coma Scale Score (GCS) and duration of post-traumatic amnesia (PTA) for participants with TBI. Imaging (CT or MRI) data were also obtained from medical records when available.

Self-Awareness. Children and their parents completed the child and parent versions of the PAQ (Lloyd et al., 2017). As outlined previously, the PAQ is a 37-item questionnaire used to assess children and adolescents' (8-16 years) competency across a range of functional areas typically affected by brain injury, including cognition and language, physical functioning, ADLs, interpersonal skills, and emotional/behavioural functioning. The child and a parent or clinician rate the ease with which the child is currently able to perform functional activities on a 6-point Likert-type scale ("Can't do" = 1, "mostly hard" = 2, "a bit hard" = 3, "a bit easy" = 4, "mostly easy" = 5, "very easy" = 6). Psychometric properties of the PAQ have previously been reported (Lloyd et al., 2017), with the measure demonstrating excellent internal consistency (α = .93 – .97), good to excellent test-retest reliability (r = .84 - .90) and evidence of known-groups and convergent validity. The parent PAQ ratings were subjected to principal component analysis and results regarding components and subscales derived from this analysis are reported in the Results section.

Procedure

Ethical clearance was obtained from the Children's Health Queensland Human Research Ethics Committee and Griffith University Human Research Ethics Committee. Children with ABI were screened for eligibility and recruited into the study from outpatient clinics by treating health professionals. Children and their parents were provided with information on the study, and both the parent and child were asked to provide informed consent. Following consent procedures, children and parents independently completed the measures. The importance of parents and children completing the questionnaires independently was emphasized. Where possible, the researcher or a clinician supervised each child's completion of the PAQ and assisted as required.

Data Analysis

Data analysis was conducted using the Statistical Package for the Social Sciences version 27. Assumptions for parametric analyses were examined and managed according to procedures outlined by Tabachnick and Fidell (2013). Eight children had missing self-report data on the PAQ and were excluded from analysis. In relation to the first aim, the Kaiser-Meyer-Olkin test was used to determine sampling adequacy, and Bartlett's test of sphericity was performed to verify suitability of the data set for data reduction. Inter-item correlations were screened for correlations greater than .80 in line with recommendations by Field (2018). A principal component analysis with varimax rotation was conducted using the parent version of the PAQ, with the number of components initially extracted based on eigenvalues >1. Items loading less than .40 on any component, and those with substantial cross-loading across components (i.e., multiple high loadings with a difference of <.10 between loadings) were successively removed, starting with the lowest absolute item loading, with the analysis repeated after each step. The solution was deemed acceptable when remaining items loaded satisfactorily on one component ($\geq$.40), with minimal cross-loading on a second component.

Cronbach's alpha was used to determine the internal consistency of subscales derived from the principal component analysis.

For the second aim, subscale scores for self-awareness domains were calculated by averaging the item level discrepancy scores (parent rating minus child rating) for items loading on each component as determined by the principal component analysis. Repeated measures ANOVA was used to compare levels of self-awareness across these subscales. Pairwise comparisons were used to determine the nature of differences, with an adjusted alpha applied. To investigate the exploratory aim, correlations and one-way ANOVAs were used to examine demographic (e.g., age, gender) and injury-related (age at injury, time since injury, aetiology of injury, injury severity) factors associated with domain-specific self-awareness. Age at injury was categorised into five groups (i.e., infancy [($\leq$ 2 years of age], early childhood [3-6 years of age], middle childhood [7-9 years of age], late childhood [10-12 years of age, and adolescence [13-16 years of age]), consistent with previous research (Anderson et al., 2005; Crowe et al., 2012; Lloyd et al., 2020). For children with TBI, injury severity was classified as mild, moderate or severe, based on lowest GCS in the first 24-hours post-injury (note: for children injured under age 5 years, the paediatric version of the GCS was used; Simpson & Reilly, 1982).

Results

Sample Characteristics

As shown in Figure 1, 349 children were deemed eligible to participate over the recruitment period. Of these, 140 children either did not participate or have parent versions of the PAQ completed. Data for 197 children were available for aim one, which represents an adequate sample size for principal component analysis according to the COSMIN checklist (Mokkink et al., 2010), equating to 5.3 participants per item on the PAQ. A comparison of the current sample (n = 197) and children who were eligible but did not participate or have parent PAQs completed (n = 298) indicated no significant differences in terms of sex, χ^2 = 1.106, p =.293, age at assessment, t(439.81) = -0.373, p = .709, age at injury, t(433.81) = 0.78, p = .439, time since injury, t(423.88) = 0.91, p = .363, or type of injury (TBI or other ABI), χ^2 = 1.082, p = .298.

Of the 197 child participants, the majority (67%) were male and had sustained TBI (70%), primarily from motor vehicle accidents. Other causes of injury included stroke (10.7%), brain tumour (9.1%), infection (8.6%) and hypoxia (2.0%). Children's mean age was 12.44 (SD = 2.62) years, and they were on average 3.42 years post-injury and aged 9.02 years (SD = 4.55) at the time of injury. Most parent respondents were mothers (86.2 %) and the mean years of education completed by parents was 13.9 years. Demographic and injury characteristics of the sample are summarized in Table 1.

Descriptive Data on the PAQ Total Scores

As shown in Table 2, children consistently rated their functioning higher than parent ratings across the four main aetiology groups. One-way ANOVA on the 37-item PAQ indicated no significant between-group differences in child total, parent total, and parent-child discrepancy score for the four main aetiology groups (Parent PAQ: F[4, 192] = 0.52, p = .721, n_p^2 = .01; Child PAQ: F[4, 185] = 0.56, p = .693, n_p^2 = .01; PAQ Discrepancy Total: F[4, 185] = 0.83, p = .587, n_p^2 = .02). Data were subsequently pooled for further analysis.

Principal Component Analysis of the PAQ and Domain-specific Discrepancy Scores

The 37-item parent PAQ was submitted to a principal component analysis with varimax rotation. The Kaiser–Meyer–Olkin test verified sampling adequacy for the analysis, KMO = .93, p < .01, and all KMO values for individual items were > .87, which is well above the acceptable limit of .50 (Field, 2018). Inter-item correlations ranged from .01 to .79. Bartlett's test of sphericity, χ^2 (666) = 4862.89, p < .001, indicated that correlations between items were sufficiently large for data reduction purposes. Communalities were all within the acceptable range (.50 - .78; Field, 2018).

Six components with eigenvalues > 1 were initially extracted and explained 64.53% of the variance. Although no items loaded < .40, seven items loaded > .40 on more than one component (cross-loadings), with small differences between loadings (i.e., < .10). These items were removed individually with the analysis re-run after each step. Additionally, item 29 ('Can remember names of all children in class [or classes]') which loaded > .40 on the physical component was removed on theoretical grounds, as all other items on that component related to physical functioning. The final 29-item five component solution explained 64.04% of the variance. Items loading highly (> .40) on each component reflected five distinct self-awareness domains of *Socio-Emotional*, *Activities of Daily Living (ADLs)*, *Cognitive*, *Physical*, and *Communication*. Item loadings for the final solution are displayed in Table 3. Internal consistencies of these components were all within the good to excellent range (α = .81 - .95) for the parent version of the PAQ, as shown in Table 4. Internal consistencies of these components applied to the child version of the PAQ were all within the acceptable to excellent range (α = .70 - .92), also shown in Table 4.

Domain-Level Differences in Self-Awareness

Subscale scores were calculated by averaging the item-level discrepancy scores (parent rating minus child rating) on each component, as derived from the principal component analysis. The descriptive data for the resulting PAQ self-awareness subscales are presented in Table 4. A repeated measures ANOVA with a Greenhouse-Geisser correction was used to determine if self-awareness varied across domains. Mean item parent-child discrepancy scores significantly differed between subscales; $F(3.58, 673.20) = 5.4$, $p < .001$, $n_p^2 = .028$. Pairwise comparisons with adjusted alpha ($p < .01$) revealed that children's self-awareness of their cognitive function (M = -0.49, SD = 1.14) was significantly poorer than self-awareness of socio-emotional function (M = -0.19, SD = 0.89), $p < .001$, ADLs (M = -0.22, SD = 0.65), $p < .001$, and communication (M = -0.26, SD = 0.22), $p = .002$. There were no other significant domain-level differences ($p > .01$).

Correlates of Domain-Specific Self-Awareness

In relation to the exploratory aim, self-awareness did not differ across PAQ subscales according to child gender or cause of injury ($p > .05$). Children's age at assessment was positively associated with self-awareness of ADLs and cognition (r = .19 - .21, $p < .05$). Further, time since injury was significantly and negatively correlated with self-awareness of socio-emotional functioning (r = -.20), ADLs (r = -.24), cognition (r = -.20), and communication (r = -.17). However, these associations were no longer significant once age at injury was controlled for ($p > .05$). Notably, in this sample longer time since injury was strongly associated with younger age at injury (r = -.82, $p < .001$).

One-way ANOVAs demonstrated that self-awareness differed within each domain according to age at injury. Descriptive data, omnibus results for ANOVAs, and pairwise comparisons are reported in Table 5. Pairwise comparisons with an adjusted alpha ($p < .01$) revealed that, overall, children injured at younger ages (e.g., ≤ 2 years or 3-6 years) had poorer self-awarenss than those injured at older ages (e.g., 7-9 years, 10-12 years, or 13-16 years).

For children with TBI, one-way ANOVAs revealed that self-awareness also significantly varied across domains according to injury severity (see Table 6). Pairwise comparisons with an adjusted alpha ($p < .017$) revealed that children with mild TBI displayed better self-awareness of their ADLs, cognition, and communication than those with severe TBI. In the communication domain, those children with mild TBI had significantly better self-awareness than those with moderate TBI. There was no significant effect of injury severity on self-awareness of social-emotional functioning or physical functioning ($p >.017$.

Discussion

A growing body of research indicates that children and adolescent have impairments in self-awareness following TBI (Lloyd et al., 2015; 2017, 2020; Wolfe et al., 2015). However, to date, self-awareness has either been conceptualised and measured as a global construct or examined for a specific domain of functioning. Understanding the profile of self-awareness across functional domains after paediatric TBI is important to guide therapy interventions to improve self-understanding and psychological adjustment. This study aimed to validate the PAQ as a multi-domain measure of self-awareness and investigate domain-specific self-awareness in children and adolescents with brain injury.

Underlying Dimensions of the PAQ

Results of a principal component analysis of the parent version of the PAQ supported conceptualisation of self-awareness as a multi-dimensional construct. Broadly consistent with the hypothesis and with the content areas guiding development of the PAQ (Lloyd et al., 2017), the analysis identified five components of self-awareness: socio-emotional functioning, ADLs, cognitive functioning, physical functioning, and communication. These domains are largely consistent with the factor-derived subscales of self-awareness measures in the adult brain injury literature such as the AQ (cognitive, behavioural/affective & motor/sensory; Hellebrekers et al., 2017; Sherer et al., 1998), and the PCRS (ADLs, emotional, interpersonal & cognitive functioning; Hellebrekers et al., 2017; Leatham et al., 1998; Sveen et al., 2015). Each PAQ subscale derived from the component analysis was found to have acceptable to excellent internal consistency. Overall, the findings support the validity of the 29-item PAQ (with 8 items removed from the original 37-item measure) as a multi-domain measure of self-awareness and indicate the appropriateness of using subscales to measure domain-specific self-awareness following childhood ABI.

Domain-Specific Self-Awareness After Paediatric ABI

In relation to the second aim, in partial support for the hypothesis, children with ABI demonstrated poorer self-awareness of their cognitive functioning as compared to their socio-emotional functioning, ADLs and communication. Contrary to the hypothesis, self-awareness was greatest for socio-emotional functioning, with the small mean item discrepancy score (M = -0.19) suggesting that children's perceptions of their behaviour in social situations was generally consistent with their parents' perceptions. It is possible that regular feedback on behaviour (e.g., behaving in public, waiting their turn, and rule following) heightened their self-awareness in this domain. A further unexpected finding is that children's self-awareness of their physical functioning was not greater than self-awareness of cognitive and interpersonal (i.e., socio-emotional and communication) domains. Such findings are contrary to those in the adult brain injury literature (Hart et al., 2009; Hoofien et al., 2004) and theories of the typical development of self-awareness in children, whereby accurate self-appraisal of more concrete and observable functions (e.g., motor and sensory skills, performance on self-care tasks) emerges before accurate self-perceptions of more abstract and higher-order functions (Damon & Hart, 1998; Rochat, 2003). Notably, the items on the physical subscale of the PAQ refer mainly to fatigue (e.g., not becoming tired on activities) and participation in sports (e.g., playing sport as well as their friends) rather than sensory and motor skills per se. Such items may relate to children's sense of independence and sporting prowess; hence acknowledging one's problems in this domain might pose a threat to their autonomy and social identity.

Overall, the findings provide partial support for the notion that self-awareness is domain-specific or varies according to functional skills following paediatric ABI. Such findings build upon previous studies which identified that children lack self-awareness of specific functional domains, including executive functioning (Krasny-Pacini et al., 2015;

Geurten et al., 2016; Josman et al., 2000a), memory (Crowther et al., 2011; Geurten et al., 2017; Hanten et al., 2000, 2004; Josman et al., 2000b), and communication (Douglas, 2010). The current study is the first to demonstrate that children's self-perceptions of their cognitive abilities is poorer than perceptions of their socio-emotional functioning, ADLs and communication.

Correlates of Domain-Specific Awareness

Consistent with previous research on global self-awareness (Lloyd et al., 2015; 2017; 2020), significant correlates of self-awareness included age at injury and injury severity. Children injured at younger ages, particularly during infancy and/or early childhood, typically had poorer self-awareness across domains relative to those injured in later childhood and adolescence. This finding aligns with research demonstrating that children injured at a younger age have poorer cognitive and functional outcomes following paediatric TBI (Anderson et al., 2005; Babikian & Asarnow, 2009). The early vulnerability phenomenon has been attributed to TBI "derailing" children's neurological and cognitive development and their lack of consolidated skills at the time of insult (Anderson et al., 2005). The negative impact of early brain injury on self-awareness may be due to direct effects on the maturation of brain networks underlying the capacity for self-awareness, such as the fronto-parietal control network (e.g., anterior cingulate and insula), and associated development of cognitive processes that support self-awareness, such as attention, memory, cognitive flexibility, perspective taking and theory of mind (Lloyd et al., 2020; Wolfe et al., 2015). Longitudinal research is needed to identify the developmental periods of brain maturation that support neuropsychological processes underlying self-awareness.

The finding that children with severe TBI had poorer self-awareness than those with mild TBI across three of the five domains is consistent with previous self-awareness research in paediatric TBI (Crowther et al., 2011; Lloyd et al., 2017, 2020; Wilson et al., 2011; Wolfe et al., 2015) as well as the broader brain injury literature, which indicates that children with more severe injuries have poorer cognitive outcomes (Anderson et al., 2018; Babikian and Asarnow, 2009). Consistent with previous research (Lloyd et al., 2017, 2020), children with mild TBI did not typically display impaired self-awareness (see negligible and positive mean item discrepancy scores in Table 6). Although this finding may indicate that children with mild TBI can reflect more accurately on their abilities, as noted by Hart et al. (2009), the magnitude of discrepancy scores is limited for those with milder injuries and better functional status because there is less scope for disagreement between raters.

The finding that time since injury was not associated with self-awareness after controlling for age at injury is inconsistent with findings in the adult literature, in which self-awareness tends to be most impaired in the early post-acute stage and improves over time as individuals resume familiar activities and learn about their functional limitations (Geytenbeek et al., 2017; Hart et al, 2009; Ownsworth et al., 2006). One possible explanation for the current findings is that, unlike recovery from brain injury in adulthood, age-related developmental gains are expected alongside children's functional recovery. Hence, parents' expectations of children's functioning and environmental demands typically increase over time. As a result, impairments in self-awareness following brain injury in childhood may appear long-lasting due to the shifting benchmarks against which their competencies are assessed. However, this finding may also be specific to the current sample, which was recruited from a hospital-based outpatient brain injury clinic providing long-term support to children injured at a very young age. As such, a high proportion of children recruited were injured at a young age (31.5 % injured at less than 7 years of age) and had significant ongoing functional impairments. Longitudinal research is needed to examine whether shifts in children's own self-ratings of their functioning or changes in their parents' ratings on the PAQ have greatest bearing on PAQ discrepancy scores (see Richardson et al., 2015).

Study Limitations and Future Research

Limitations of the current study are important to acknowledge. First, the sample was heterogenous in terms of aetiology of injury, severity of injury and time since injury, which affects the ability to generalise the findings to a specific brain injury population. Further, although recruitment was based on consecutive appointments, children were recruited from a single centre, a hospital-based outpatient brain injury clinic providing long-term follow-up. This sampling approach increases the possibility of clinical ascertainment bias and it is unknown to what extent the current sample is representative of the broader paediatric brain injury population. In particular, there may be differences between the families who attend for follow up and those that do not (Lloyd et al., 2020). Third, the PAQ subscales need to be confirmed in future research. Overall, conducting a confirmatory factor analysis of the PAQ in a larger and more homogenous paediatric brain injury sample is recommended.

A further limitation relates to the use of discrepancy scores for measuring self-awareness (De Los Reyes, et al., 2015; Fleming et al. 1996; Geurten et al., 2016; Lloyd et al., 2020). As noted in previous studies (Hart et al., 2009; Richardson et al., 2015), a limitation of the discrepancy-based method is that the size of the discrepancy score is dependent on the magnitude of significant other ratings. Therefore, children rated as having better functioning are likely to have smaller PAQ discrepancy scores because there is less scope for disagreement in the ratings. In future research it would be beneficial to assess self-awareness using a multi-faceted approach, which includes comparison of child, parent, and clinician ratings, as well as performance-prediction approaches (Lloyd et al., 2020). However, the latter approach can be time consuming, requiring objective indices of performance across different domains of functioning.

In terms of future research on domain-specific self-awareness, longitudinal research is needed to investigate potential differences in rates of recovery or emergence of self-awareness across functional domains, and to determine the impact of domain-specific awareness on functional and psychosocial outcomes. It is of particular interest to understand the domains of self-awareness most closely associated with different functional and psychosocial outcomes. For example, self-awareness of cognitive difficulties may promote greater use of strategies for learning and academic achievement at school. Further, self-awareness of socio-emotional difficulties may assist children to interact more effectively with their peers and experience positive social adjustment.

From a clinical perspective, these findings highlight the importance of assessing children's self-awareness of different functional domains, rather than only using global indices of self-awareness. More detailed assessment of domains of self-awareness would enable clinicians and parents to better understand a child's particular deficits in self-awareness and guide appropriately targeted interventions. The finding that children were least aware of their cognitive abilities suggests that interventions targeting children's self-awareness of cognitive difficulties (e.g., ability to pay attention, remember what they need to and organise themselves) may be beneficial. Occupation-based activities involving multiple cognitive demands (e.g., cooking) have been used effectively to improve self-awareness and self-regulation skills with adults (see Ownsworth et al., 2017; Schmidt et al., 2013). Similar developmentally appropriate occupational activities could be used to facilitate self-awareness of cognitive difficulties with children, with the provision of timely and sensitive feedback (Krasny-Pacini et al., 2015). However, it is important to monitor children's emotional well-being during self-awareness interventions, to support them to process the meaning of task difficulties, develop effective coping strategies and to recognize their strengths and achievements (Lloyd et al., 2020).

Conclusion

This study provides preliminary evidence that the PAQ assesses self-awareness in the five functional domains of socio-emotional functioning, ADLs, cognitive functioning, physical functioning, and communication. Children demonstrated poorer self-awareness of cognitive functioning relative to self-awareness of their socio-emotional functioning, ADLs and communication skills. Consistent with previous research, poorer self-awareness was associated with younger age at injury and more severe injury for children with TBI. This study highlights the value of assessing self-awareness for different functional domains and the need to evaluate interventions targeting children's self-awareness of their cognitive abilities. Further psychometric research on the PAQ, including confirmatory factor analysis, is recommended along with longitudinal research investigating patterns in the development of self-awareness across functional domains following paediatric brain injury.

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Table 1

Demographic and Injury Characteristics for the Sample

	Total (*n* = 197)	TBI (*n* = 137)	Other ABI (*n* = 60)
	M (*SD*), range or *n* (%)	*M* (*SD*), range or *n* (%)	*M* (*SD*), range or *n* (%)
Sex			
Male	132 (67)	92 (67.2)	40 (66.7)
Female	65 (33)	45 (32.8)	20 (33.3)
Age (years)	12.44 (2.62), 8.01-16.96	12.46 (2.71); 8.01-16.96	12.4 (2.45); 8.15-16.75
Age at Injury (years)	9.02 (4.55); 0.08-16.61	9.79 (4.21); 0.08-16.61	7.27 (4.82); 0.08-15.27
Time Since Injury (years)	3.42 (3.96); 0.1-16.46	2.68 (3.48); 0.1-14.62	5.13 (4.46); 0.14-16.46
Parental Education (years)	13.9 (2.78); 8-21	13.86 (2.76); 8-21	13.98 (2.85); 8-21
Household Income (median)[a]	4, 1-10	4, 1-10	4, 1-9
Severity of Injury			
Glasgow Coma Scale		10.19 (4.48); 3-15	
PTA (days)		10.93 (19.59); 0-165	
Mild		45 (32.8)	
Moderate		24 (17.5)	
Severe		68 (49.6)	
Cause of Injury			
Traumatic Brain Injury	137 (69.5)		
Motor vehicle accidents	61 (31.0)	61 (44.5)	
Sport-related	34 (17.3)	34 (24.8)	
Falls/struck by object	32 (16.2)	32 (23.4)	
Animal-related	10 (5.1)	10 (7.3)	

Other ABI	60 (30.5)		
Stroke	21 (10.7)		21 (35.0)
Tumour	18 (9.1)		17 (28.3)
Infection	17 (8.6)		17 (28.3)
Hypoxia	4 (2.0)		4 (6.7)

[a]Household income was coded as: 1 = <$40,000, 2 = $40,000–$60,000, 3 = $60,001–$80,000, 4 = $80,001–$100,000, 5 = $100,001–$120,000, 6 = $120, 001–$140, 000, 7 = $140,001–$160,000, 8 = $160,001–$180,000, 9 = $180,001–$200,000, 10 = > $200,000.

Table 2

Descriptive Data on the 37-item version of the Paediatric Awareness Questionnaire for the Main Aetiology groups (N = 197)

Aetiology group	PAQ Parent Total *M* (*SD*)	PAQ Child Total *M* (*SD*)	PAQ Parent-Child Discrepancy Score *M (SD)*
TBI	165.45 (32.43)	174.85 (30.33)	-9.42 (31.81)
Tumour	156.39 (31.99)	178.18 (24.09)	-17.41 (24.34)
Stroke	160.14 (29.81)	182.63 (20.14)	-21.26 (26.19)
Infection	156.76 (33.74)	168.44 (32.08)	-11.81 (32.04)

Table 3

Principal Component Analysis of the Paediatric Awareness Questionnaire: Components and Item Loadings for the Final Solution (note: items with cross-loadings <.40 were supressed; N = 197)

Item	Social-Emotional	ADLs	Cognitive	Physical	Communication
Can behave as he/she should in public	0.78				
Can stop talking when he/she needs to be quiet	0.73				
Can follow the rules at school	0.71				
Can wait to let others take their turn	0.67				
Can tell when he/she is starting to lose his/her temper	0.65				
Can calm down quickly after getting angry	0.64				
Can get along with family	0.61				
Can stop laughing when he/she needs to	0.61				
Can tell when someone else is upset	**0.55**				0.45
Can go to the toilet without help		0.80			
Can take a bath or shower without help		0.77			

Can use the telephone to call home		0.69			
Can feed him/herself		0.68			
Can work out how much money is needed to buy something small (like a drink or lollies)		**0.65**	0.46		
Can type on a computer keyboard		0.55			
Can keep his/her own things tidy			0.70		
Can write neatly for others to read			0.64		
Can remember to bring things needed for homework			0.64		
Can get started on homework without help	0.48		**0.63**		
Can pay attention when learning new things			0.56		
Can remember what he/she has just been asked to do			0.46		
Can walk around for a long time without getting tired				0.81	
Can play sports as well as friends				0.79	
Can keep balance when jumping or hopping				0.77	
Can get through all activities in a day without feeling tired				0.74	
Can say what he/she is thinking to other people					0.81

Can talk to a group of people his/her own age					0.67
Can let others know how he/she is feeling					0.64
Can understand what other people are saying					0.42
Eigenvalue	11.28	2.86	1.90	1.24	1.04
Explained Variance	17.06	12.73	11.51	11.22	10.65

Table 4

Descriptive Data for Domain-Specific Self-Awareness and Internal Consistency of the Paediatric Awareness Questionnaire Subscales (N = 189)

	Mean item discrepancy score *M(SD)*	Cronbach's alpha	
		Parent	Child
PAQ Total (29 items)	-0.29 (0.80)	.95	.92
Social Emotional (9 items)	-0.19 (0.89)	.90	.85
ADLs (6 items)	-0.22 (0.65)	.82	.70
Cognition (6 items)	-0.48 (1.14)	.89	.81
Physical (4 items)	-0.35 (1.17)	.87	.78
Communication (4 items)	-0.26 (1.22)	.81	.74

Table 5

Descriptive Statistics and One-way ANOVAs for the Effects of Age at Injury on Domain-Specific Self-Awareness (i.e., mean item discrepancy score for subscales) on the Paediatric Awareness Questionnaire (N = 189)

Domain (subscales)	≤ 2 years *M* (*SD*)	3-6 years *M* (*SD*)	7-9 years *M* (*SD*)	10-12 years *M* (*SD*)	13-16 years *M* (*SD*)	*F*	*p*	n_p^2
Socio-Emotional	-0.46 (0.80)	-0.59 (0.77)[a]	-0.10 (0.98)	-0.07 (0.83)	0.07 (0.87)[a]	3.84	.005	.08
ADLs	-0.63 (0.74)[abc]	-0.42 (0.90)[d]	-0.19 (0.63)[a]	-0.08 (0.35)[b]	0.00 (0.43)[cd]	5.43	.001	.11
Cognitive	-0.93 (1.00)[a]	-0.97 (1.08)[bc]	-0.44 (1.20)	-0.26 (1.02)[b]	-0.10 (1.09)[ac]	4.58	.002	.11
Physical	-0.48 (1.05)	-0.85 (1.21)[a]	-0.31 (1.33)	-0.17 (1.03)	-0.05 (1.05)[a]	2.75	.003	.06
Communication	-0.76 (0.99)	-0.75 (1.25)[ab]	-0.01 (1.21)[a]	-0.09 (1.20)	-0.01 (1.22)[b]	3.86	.005	.08

Note: the letters in superscript denote significant post-hoc analyses (with adjusted alpha $p < .01$) and reflect pairwise comparisons between the age at injury subgroups for each self-awareness domain

Table 6

Descriptive Statistics and One-way ANOVAs for the Effects of Severity of Injury on Domain-Specific Self-Awareness (i.e., mean item discrepancy score for subscales) on the Paediatric Awareness Questionnaire for children with TBI (N = 133)

Domain	Mild TBI *M* (*SD*)	Moderate TBI *M* (*SD*)	Severe TBI *M* (*SD*)	*F*	*P*	n_p^2
Socio-Emotional	0.10 (0.92)	-0.31 (0.97)	-0.27 (0.93)	2.44	.09	.04
ADLs	0.05 (0.61)[a]	-0.17 (0.60)	-0.31 (0.63)[a]	4.29	.02	.06
Cognitive	0.03 (1.17)[a]	-0.59 (1.11)	-0.59 (1.21)[a]	4.10	.02	.06
Physical	0.15 (1.13)	-0.54 (1.30)	-0.42 (1.19)	3.79	.025	.06
Communication	0.28 (1.09)[ab]	-0.58 (1.16)[a]	-0.34 (1.34)[b]	4.82	.01	.07

Note: the letters in superscript denote significant post-hoc analyses (with adjusted alpha $p < .017$) and reflect pairwise comparisons between the injury severity subgroups for each self-awareness domain

Figure 1

Recruitment flow diagram