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Emerging narrative discourse skills 18 months after traumatic brain injury in early childhood

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Abstract

This study examined the longer term effect of traumatic brain injury (TBI), approximately 18 months post-injury, on emerging narrative discourse skills of 85 children with orthopaedic injury (OI), 43 children with moderate TBI, and 19 children with severe TBI who were between 3 years and 6 years 11 months at injury. Children with TBI performed worse than children with OI on most discourse indices. Children with severe TBI were less proficient than children with moderate TBI at identifying unimportant story information. Age and pragmatic skills were predictors of discourse performance.

Approximately 160 per 100,000 children under the age of 5 years suffer a traumatic brain injury (TBI) annually, making TBI one of the most common causes of death and disability among children. Recent epidemiological data suggest that children under 5 years are at greater risk for TBI-related emergency department visits and hospitalizations in comparison to children 5–14 years (Center for Disease Control and Prevention, National Center for Injury Prevention and Control, 2000; Langolis, Rutland-Brown, & Thomas, 2006). Children who are injured at a younger age are vulnerable to widespread impairments in cognition, behaviour, and social functioning, with little evidence for recovery. This susceptibility may be related to the extensive neuronal myelination and frontal lobe maturation occurring during early childhood (Anderson, Catroppa, Morse, Haritou, & Rosenfeld, 2005, Anderson *et al.*, 2006). Moreover, the network of frontal, temporal, parietal, and limbic regions thought to sub-serve many aspects of cognition and social functioning are especially

vulnerable to insult following pediatric TBI (Beauchamp & Anderson, 2010; Yeates *et al.*, 2007).

Although some language functions may be relatively spared following pediatric TBI, specific deficits with verbal and language skills have been identified, including problems with verbal learning and memory, verbal fluency, written expression, and naming (Ewing-Cobbs & Barnes, 2002; Ewing-Cobbs *et al.*, 1997). Deficits in inferencing and pragmatics skills have also been documented (Barnes & Dennis, 2001; Dennis, Purvis, Barnes, Wilkinson, & Winner, 2001). In an initial study of the post-acute effects of TBI in early childhood on cognitive outcomes, using the same sample reported on here, children with moderate-to-severe TBI performed worse than their peers with orthopaedic injury (OI) on measures of verbal memory (sentence repetition, story memory), but not other language functions (object naming, verbal fluency, verbal comprehension, pragmatics; Taylor *et al.*, 2008). However, in a follow-up study with assessments 6, 12, and 18 months post-injury, the children with moderate to severe TBI performed worse than their peers with OI on verbal measures of pragmatics, fluency, and memory, indicating persisting and emerging language-based deficits over time (Gerrard-Morris *et al.*, 2009). In a related vein, we have found deficits in certain aspects of theory of mind skills in the TBI group compared to the OI group at baseline and 12 months post-injury (Walz *et al.*, 2009, 2010).

A growing body of literature suggests that narrative discourse deficits occur commonly following TBI in children. For example, children with severe TBI have been found to produce narratives with less language, poorer episodic structure, less complexity, reduced global content, and poorer interpretation of story meaning compared to typically developing peers (Brookshire, Chapman, Song & Levin, 2000; Chapman *et al.*, 1992, 1997, 2001, 2004; Chapman, Levin, Wanek, Weyrauch, & Kufera, 1998; Reilly, Bates, & Marchman, 1998). Children with moderate-to-severe TBI and post-acute language impairment demonstrated fewer propositions and more sequencing errors at a 3-year post-injury assessment compared to children with TBI but without acute language impairment (Ewing-Cobbs, Brookshire, Scott, & Fletcher, 1998). Most recently, Chapman *et al.* (2006) found that children, 8–14 years, with mild and severe TBI did not summarize story content or retrieve specific story information as well as typically developing peers. Working memory, but not immediate memory for a word list, was significantly correlated with discourse indices.

Producing narrative retells and engaging in interpretation of story content involves many cognitive processes, including basic language skills, such as receptive vocabulary, and higher-order language skills, such as pragmatics and making inferences (Barnes & Dennis, 2001; Brookshire *et al.*, 2000; Chapman *et al.*, 1992, 1998; Chapman, Levin, Matejka, Harward, & Kufera, 1995; Dennis & Barnes, 1990). Models of discourse skills include multiple memory systems, such as immediate memory and working memory (Chapman *et al.* 1998, 2006). Finally, discourse performance is likely to be related to executive functions such as set shifting, working memory, and problem solving (Brookshire *et al.*, 2000; Chapman *et al.*, 2006; Dennis, 1991; Hanten, Levin, & Song, 1999). Research suggests that narrative discourse skills begin to develop around 2 years, when children can reference events from the past. Children 4–6 years can tell a structured story with a beginning, middle, and end; 7-year olds have developed basic synthesis and interpretative skills; and 9- and 10-year olds can articulate elaborated narratives developed around a central theme. Studies of typically developing children suggest that the sophistication of narrative discourse skills continues to develop through adolescence (Brookshire *et al.*, 2000; Chapman *et al.*, 1995, 1997, 1998).

Discourse abilities are likely to affect social competence. That is, connectedness to others and appropriate social responses require the ability to engage in expressive social

communication (Beauchamp & Anderson, 2010; Dennis, 1991; Yeates *et al.*, 2007). Understanding social development and the cognitive precursors to social competence has particular relevance for young children because social communication skills undergo development throughout childhood. Social cognitive skills, such as discourse, have been linked to school readiness. Children who show adequate social cognitive skills are rated by teachers as more academically advanced and teachable (Blair, 2002). Development of social competence during the preschool and early school-age years has been linked to later academic success and emotional well being in typically developing children. Unless children achieve minimal social competence by early school age, they are at risk for poor adjustment into adulthood (Ladd, 1999; Parker & Asher, 1987).

We are not aware of any studies that have investigated longer term emerging narrative discourse skills in children with a history of TBI during early childhood (before age 7 or 8). To address this need and examine longer term consequences of TBI in young children, we administered an experimental narrative discourse task to children who were injured between 3 years and 6 years 11 months, as part of a comprehensive child and family assessment approximately 18 months post-injury. We hypothesized that children with TBI would display deficits on the narrative discourse task compared to children with OI. We also examined whether age at assessment, injury severity, language pragmatics, and verbal memory were predictors of discourse skills in our sample. Our purpose in considering these factors was to determine if we would find injury group differences in discourse performance that were not solely a function of pragmatics and verbal memory skills or chronological age. Finally, we explored whether discourse skills were predictors of psychosocial functioning.

Method

Participants

The study was approved by the institutional review boards of participating hospitals and informed consent was obtained in writing prior to participation. Children were recruited from consecutive inpatient admissions from 2003 to 2006 of children with TBI or OI at three tertiary care children's hospitals and a general hospital, all of which had Level 1 trauma centres. Eligibility criteria included age at injury between 3 years and 6 years 11 months, no documentation in the medical record or in parent interview of child abuse as a cause of the injury, and English as the primary spoken language in the home. Children with a history of autism, mental retardation, or a neurological disorder prior to injury were excluded. Eligibility for the TBI group included a blunt trauma to the head requiring overnight admission to the hospital and either a Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974) score of <13 or a GCS of 13–15 with evidence for TBI-related brain abnormalities from computed tomography or magnetic resonance imaging. Consistent with previous investigations (Anderson *et al.*, 2006; Taylor *et al.*, 1999), severe TBI was defined as one resulting in a GCS score of 8 or less, and moderate TBI was defined as a GCS score of 9–12 or a higher GCS score in the presence of abnormal neuroimaging. The GCS score assigned to the child was the lowest one recorded post-resuscitation. To provide an estimate of the effects of TBI that accounted for both pre-injury risk exposure and the experience of hospitalization, children admitted to hospitals for OI but without TBI were included as a comparison group. Inclusion criteria for the OI group were a documented bone fracture in an area of the body other than the head that required an overnight hospital stay and the absence of any evidence of loss of consciousness or other findings suggestive of brain injury.

A total of 87 children with moderate to severe TBI and 119 children with OI and their caregivers were enrolled in the study. Recruitment rates for families contacted were somewhat higher for the TBI group (54% TBI vs. 35% OI). Examination of pre-enrolment screening data indicated that recruitment rates for the TBI group were higher for children

with the highest GCS scores. However, comparison of participants with non-participants on census-based estimates of neighbourhood family income failed to reveal differences. Children and caregivers participated in assessments shortly after injury and at 6, 12, and 18 months post-injury. The discourse measure was only included in the 18-month post-injury child assessment. The discourse measure was administered to 147 children, including 62 children with TBI (19 severe and 43 moderate) and 85 with OI. Four children with moderate TBI who completed the 18-month assessment were unable to complete the discourse measure because they were unable to understand the task (all were under 5 years). Retention rates were similar across the groups (76% TBI vs. 71% OI). Attrition was not related to group, sex, race, or census-based estimates of neighbourhood family income.

Procedure and measures

Data were collected as part of a comprehensive evaluation of the child and family 18 months post-injury (for details on other outcomes 18 months post-injury see Gerrard-Morris *et al.*, 2009). The entire neuropsychological battery, including the experimental narrative retell task, was independently scored by two individuals. The two individuals who scored all of the narrative task data were blind to participant identity and group. Discrepancies were discussed and reconciled as necessary. The intra-class correlations for the scores for each of the discourse measure indices ranged from .80 to .96, reflecting good to excellent agreement (Shrout & Fleiss, 1979, Cicchetti & Sparrow, 1981).

Discourse—Because of the young age of the children, the measure used was a narrative story retell, ‘The Crow and the Peacocks’ (see Appendix). The task required the child to listen to a conceptually complex, abstract story involving perspective taking and a moral. The child was given instructions as follows, ‘I am going to read you a story called the Crow and the Peacocks. Listen to the story carefully and try to remember as much as you can. When I am done, I am going to ask you to tell the story back to me. I am also going to ask you a few questions about the story’. After the story was read to the child, the examiner said, ‘Now you tell me the story. Tell me everything you can remember’. Then the examiner said, ‘Sometimes there are important lessons about life that we can learn from a story.

What lesson can we learn from this story?’ Next, the child was asked four questions about the explicit content of the story (i.e., facts) and four questions about the implicit (i.e., inferential) content of the story. Finally, they were asked to rate 10 statements from the story as important or unimportant to the main message or lesson (five of each). The retelling was audiotape-recorded and later transcribed verbatim for analysis of language and information structures (e.g., Brookshire *et al.*, 2000; Chapman *et al.*, 1992, 1995, 1997, 1998, 2001, 2006). The language structure domain focuses on the lexical and sentential level of language production. ‘The Crow and the Peacocks’ story contains 287 words and 20 thematic units, defined as an independent clause and all the dependent clauses that modify it (see Appendix). Two language structure variables were analysed: (1) the total number of words in the child’s story production and (2) the total number of thematic units. We also created a language structure overall score by summing the number of words and the number of thematic units. The information structure domain focuses on the information and meaning conveyed in the language production. The story consists of 34 informational units or core propositions and six gist propositions that were established *a priori*. Each child’s retell was coded with respect to whether each of these 40 propositions was present or not in the retell. Two information structure measures were analysed: (1) the number of core propositions (out of 34) and (2) the number of gist propositions (out of six) in the child’s production. We also created an information structure overall score by summing the number of core propositions and the number of gist propositions. The correlations between the two language variables and the two information variables used in each composite were highly significant ($r = .94$

and .88, respectively, $p < .001$). To address possible concerns about multiple comparisons, we considered the language structure and information structure overall scores as our major outcome measures.

Pragmatics and verbal memory—The pragmatic judgment subtest of the Comprehensive Test of Spoken Language (CASL, Carrow-Woolfolk, 2000) and the Story Recall subtest of the Woodcock–Johnson Scales of Achievement – Third Edition (WJ-III; Woodcock, McGrew, & Mather, 2001) were administered as part of the larger test battery and were included in the data analyses as standardized measures of language pragmatics and verbal memory, respectively. These neuropsychological measures were selected because they are purported to measure cognitive skills also tapped by the experimental narrative retell task. They are both expressed as standard scores ($M = 100$, $SD = 15$).

Psychosocial outcomes—Behaviour problems were assessed using the preschool (for children < 6 years) and school-age (for children 6 or older) forms of the Child Behaviour Checklist (CBCL; Achenbach & Rescorla, 2000, 2001). The CBCL is a widely used parent-report measure of child behaviour. Previous studies of TBI have demonstrated that the CBCL is sensitive to behavioural changes following pediatric TBI (Schwartz *et al.*, 2003). Analyses were based on the Externalizing Problems scale (e.g., aggression, defiance) and the Internalizing Problems scale (e.g., withdrawal, anxiety) that are expressed as T -score ($M = 50$, $SD = 10$).

Parents rated their child's executive functioning using the Behaviour Rating Inventory of Executive Functioning (BRIEF, Gioia, Espy, & Isquith, 2000; Gioia, Isquith, & Guy, 2000; Gioia, Isquith, Retzlaff, & Espy, 2002), either the preschool version for children 2–5 years or the school-age version for children 5 or older. The total summary score (T -score) from this scale, General Executive Composite (GEC), was used as a measure of overall executive functioning.

Parents rated their child's social competence using the Social Competence composite of the Preschool and Kindergarten Behaviour scales – Second Edition for children younger than 6 years (Merrell, 2002) and the Home and Community Social and Behaviour scales for children aged 6 or older (HCSBS; Merrell & Caldarella, 2002). Both measures have demonstrated satisfactory reliability and validity (e.g., Merrell, Streeter, & Boetter, 2001). The corresponding summary scores (T -score or standard score) from each measure were transformed to a z -score with a mean of 1 and a standard deviation of 0.

The infant/preschool (for children < 6 years) and school-age (for children 6 or older) versions of the Adaptive Behaviour Assessment System – Second Edition (ABAS) were used to assess adaptive functioning (Harrison, & Oakland, 2003). The ABAS demonstrates good reliability and has been shown to be sensitive to developmental differences and clinical disorders (e.g., Harrison, & Oakland, 2003). Social functioning was summarized by the social subscale score, which is expressed as a standard score ($M = 100$, $SD = 15$).

Results

Demographic and clinical variables

Severity group differences—Group comparisons (TBI vs. OI and severe TBI vs. moderate TBI) were conducted using chi-square analyses for dichotomous demographic variables (sex, race, maternal education, cause of injury, imaging) and analysis of variance for continuous variables (census median family income, age at injury, age at assessment, time from injury to assessment, days hospitalized). The average hospital stay was shorter for the OI group compared to the TBI group and shorter for the moderate TBI group compared

to the severe TBI group. The moderate TBI group was more likely to have acute abnormal clinical imaging than the severe TBI group. This is likely an artefact of the fact that we include children with GCS of 13–15 and abnormal imaging in the moderate group. The distribution of causes of injury for the TBI group were consistent with national trends for young children, with a substantial proportion of both the TBI and OI groups sustaining injuries due to falls (Langolis *et al.*, 2006). A significant group difference in cause of injury reflected higher rates of transportation-related injuries in the TBI groups compared with the OI group. See Table 1 for details.

Group comparisons (TBI vs. OI and severe TBI vs. moderate TBI) were conducted using analysis of variance for the continuous neuropsychological and psychosocial variables. The TBI group had significantly lower scores than the OI group on all the measures except for the ABAS Social scale. The severe TBI group had significantly lower scores than the moderate TBI group on all the scales. See Table 2 for details.

Relationship with discourse performance—Collapsed across groups, we examined correlations of the language and information structure scores with demographic and clinical variables. Language and information structure scores were not correlated with months from injury to assessment, census median family income, maternal education, sex, or race. Higher narrative retell scores for both language and information structures were correlated with older age at injury and older age at assessment, $r = .43$ and $.49$, $p < .01$ for both. Within the TBI group, discourse performance was not correlated with lowest GCS score or abnormal imaging.

For the TBI and OI groups, we examined correlations of the language and information structure scores with the neuropsychological and psychosocial variables, as well as the other discourse measure indices. For both groups, discourse indices were mostly highly correlated with each other and the neuropsychological variables. For the most part, discourse indices were not significantly correlated with psychosocial variables. See Table 4 for details.

Group differences on discourse performance

Analyses of covariance were conducted to compare the groups on the language structure scores (overall, word count, T -units), information structure scores (overall, core, and gist propositions), memory for story content (implicit and explicit), and recognition of story meaning (important and unimportant story information) co-varying for age. Two planned single degree-of-freedom Helmert contrasts (TBI vs. OI and severe TBI vs. moderate TBI) were used for each analysis of covariance. Because of the experimental nature of the discourse measure and the lack of published age standards, the alpha level was set at 0.05. In comparison to the OI group, the retells for the TBI group had fewer thematic units [contrast estimate (SE) = 1.76 (0.74), $p = .019$]. The TBI group also had retells with less information [contrast estimate (SE) = 2.32 (1.03), $p = .025$] including fewer core propositions [contrast estimate (SE) = 1.76 (0.81), $p = .032$] and fewer gist propositions [contrast estimate (SE) = 0.57 (0.24), $p = .021$]. The TBI group was not as adept as their OI peers at answering questions about explicit story content [contrast estimate (SE) = 0.99 (0.44), $p = .024$] and identifying unimportant story information [contrast estimate (SE) = 0.88 (0.24), $p = .001$]. The other TBI group versus OI group contrasts were not significant [language score: contrast estimate (SE) = 16.67 (9.51), $p = .082$; word count: contrast estimate (SE) = 14.91 (8.82), $p = .093$; implicit questions: contrast estimate (SE) = 0.38 (0.32), $p = .234$; important statements: contrast estimate (SE) = -0.10 (0.24), $p = .686$]. The severe TBI group was not as proficient as the moderate TBI group at identifying unimportant story information as such [contrast estimate (SE) = -0.96 (0.38), $p = .012$]. None of the other severe TBI group versus

moderate TBI group contrasts were significant (p -value range .148–.978). See Table 3 for details.

Relationship between discourse performance and child characteristics

Two hierarchical linear regressions were conducted to examine associations of the discourse performance (language and information structure) with child and injury characteristics. Age at assessment was entered in the first step. Dummy variables representing planned independent contrasts of the combined TBI group to the OI group and the severe TBI group to the moderate TBI group were entered as predictors in the second step. CASL pragmatic judgment and WJ-III story recall scores were entered in a third step to determine if group differences were a function of pragmatic language skills and verbal memory abilities as measured on standardized cognitive tests. Interactions of group (dummy variables) with each of the standardized neuropsychological tests were entered in a fourth step but were eliminated from both models because they were not significant. For the model predicting language composite performance, age entered in step 1 accounted for 17% of the variance, $F_{\text{change}}(1, 134) = 28.21, p < .001$. The addition of the group contrasts in step 2 accounted for an additional 3% of the variance, $F_{\text{change}}(2, 132) = 1.91, p = .15$. The addition of the CASL pragmatic judgment and WJ-III story recall scores to the model in step 3 accounted for an additional 11% of the variance, $F_{\text{change}}(2, 130) = 10.19, p < .001$. The total model was also significant, $F(5, 130) = 11.46, p < .001$. Similarly, for the model predicting information structure performance, age entered in step 1 accounted for 23% of the variance, $F_{\text{change}}(1, 134) = 40.58, p < .001$. The addition of the group contrasts in step 2 accounted for an additional 4% of the variance, $F_{\text{change}}(2, 132) = 2.88, p = .06$. Finally, the addition of the CASL pragmatic judgment and WJ-III story recall scores to the model in step 3 accounted for an additional 17% of the variance, $F_{\text{change}}(2, 130) = 19.65, p < .001$. Consistent with these findings, the total model was significant, $F(5, 130) = 20.04, p < .001$. Significant effects for age and performance on standardized tests of pragmatic judgment and verbal recall reflected a positive association of these variables with the discourse scores. TBI was negatively associated with information composite performance. See Table 5 for details.

Prediction of psychosocial outcomes by discourse performance

Five hierarchical linear regressions were conducted to examine whether discourse performance was a significant predictor of psychosocial outcomes (CBCL Externalizing, CBCL Internalizing, BRIEF GEC, PKBS/HCSBS, ABAS) controlling for age at assessment and group. Age and dummy variables representing contrasts of the combined TBI group to the OI group and the severe TBI group to the moderate TBI group were entered as predictors in the first step. Because of the extremely high correlation between the language and information structure scores ($r = .89, p < .01$; see Table 4), we selected one discourse variable to enter into the regressions. We selected the information structure score because it measured conveyance of story information and meaning in the language production. Interactions of group with the information structure score were entered in the third step, but were eliminated from the models because they were not significant (see Table 4). Severe TBI was a significant predictor of psychosocial outcomes in all of the models except CBCL Internalizing Problems scores. That is, severe TBI was associated with more externalizing problems, more executive dysfunction, poorer social functioning, and less social competence 18 months post-injury. With age at assessment, TBI, and severe TBI in the models, information structure was not a significant predictor of psychosocial outcomes. See Table 6 for details.

Discussion

The primary goal of this study was to examine the longer term effects of TBI on emerging discourse skills during early childhood. The findings indicate a deleterious effect of moderate to severe TBI during early childhood on longer term emerging discourse skills 18 months post-injury. In comparison to children with OI, children with moderate to severe TBI showed reduction in the amount of language produced (i.e., number of *T*-units) and less expression of relevant story information (core propositions) and central semantic meaning (gist propositions). Children with TBI also demonstrated poorer memory for story content (explicit questions) and more difficult recognizing unimportant story facts as such (identification of unimportant statements). Recognition of unimportant story details was significantly poorer in the severe TBI group compared to the moderate TBI group. These findings suggest that language discourse skills are especially sensitive to TBI. That is, there is a lowered threshold for deficits as compared to some other cognitive and behavioural outcomes. On the other hand, our findings also suggest that children with severe TBI may have additional deficits in aspects of memory or higher order language skills (identification of irrelevant story information) that impact their narrative discourse performance (Gerrard-Morris *et al.*, 2009). Indeed, pragmatics and story recall skills were poorer in the severe TBI group compared to the moderate TBI group, and performances on these neuropsychological tasks were predictive of discourse performance. In sum, young children with moderate to severe TBI appear to have deficits in both the language and information aspects of narrative retell. These findings are consistent with the extant literature on discourse skills following pediatric TBI and extend the findings to children injured and assessed earlier in childhood (Brookshire *et al.*, 2000; Chapman *et al.*, 1992, 1997, 2001, 2004; Ewing-Cobbs *et al.*, 1998; Reilly *et al.*, 1998).

Given that the discourse retell task used was an experimental measure without age-based norms, finding that age was a strong predictor of discourse performance regardless of injury group is not surprising. Processing large amounts of oral information, condensing the information, and abstracting the central meaning and important information, are cognitive skills that continue to improve into adulthood (Brown & Day, 1983; Chapman *et al.*, 2006). Longitudinal studies are needed to further elucidate the development of discourse skills in typical and clinical populations, such as children with a history of TBI. Longitudinal studies following early childhood pediatric TBI will shed light on whether or not discourse skills worsen, remain stable, or improve relative to the OI group over time and as children get older.

Our results also confirmed that discourse skills are cognitively complex and related to the child's competency in other cognitive domains. Discourse performance was related to other social communication skills (pragmatics) and immediate memory as measured on standardized testing. These findings are also consistent with the literature relating discourse to other neuropsychological skills (Chapman *et al.*, 2006; Ewing-Cobbs *et al.*, 1998). Importantly, discourse skills are linked to learning potential and school achievement (Brown & Day, 1983; Malone & Mastropieri, 1992). Thus, future research should examine the relationship between discourse skills and other neuropsychological abilities (such as working memory) as well as the relationships between discourse skills and educational outcomes.

We did not find discourse skills to be a significant predictor of psychosocial outcomes. However, these null results may reflect a lack of sensitivity of our measures of discourse or the absence of a strong association of these skills to the behavioural measures administered in this study. The lack of a relationship between discourse performance and psychosocial outcomes does not rule out the possibility that discourse skills play an important role in

social functioning as assessed by other means, such as more direct measures of social competence or peer relationships. Our findings highlight the importance of injury severity in predicting psychosocial outcomes in young children. More severe TBI is clearly associated with greater disruption of behavioural and adaptive outcomes (Chapman *et al.*, 2010, Yeates, Taylor, Walz, Stancin, & Wade, 2010). Another possibility is that as children get older, their social communication skills might play a more significant role in their peer relationships and development of friendships. Discourse deficits, as an aspect of pragmatics, could lead to problems with social communication that have longer term deleterious consequences (Yeates *et al.*, 2007). Thus, we look forward to continuing to follow this cohort and examining the relationship between discourse skills and behavioural reputation and popularity with peers throughout elementary school and into the middle and high school years.

Floor effects may have influenced the results because of the young age of the cohort and the length of the story. The beginning school age period that occurs at about 5 years is an important period for the emergence of basic narrative skills (e.g., Chapman *et al.*, 1998). This was the mean age for our cohort, and thus, these skills were just beginning to emerge. Indeed, the total number of core and gist propositions produced was low for all participants regardless of group. We were unable to report data on the response to the question about the story lesson or moral because most children responded that they did not know. We plan to continue to follow this cohort to examine the impact of TBI on the ongoing development of discourse skills in children injured during early childhood, particularly as they progress towards more advanced discourse skills such as summarization.

The small number of children in the severe TBI group may have affected the findings. However, for the most part, the means between the severe TBI and moderate TBI groups were comparable suggesting that discourse deficits are apparent after both moderate and severe TBI. The gap between the moderate and severe TBI groups may widen over time as social and higher order cognitive skills develop in children with OI but fail to develop in children with a history of TBI (Gerrard-Morris *et al.*, 2009).

The current findings have potential clinical implications. Although clinical pediatric neuropsychologists routinely assess skills such as memory and executive functions, social communication and other higher order linguistic skills are often not considered. This may be in part due to the lack of standardized measures available for broad clinical use. However, some standardized tasks are available and others, such as the experimental task used in this study, are being normed with plans for commercial publication. Our findings also suggest that discourse skills should be considered as a target for speech and language therapy and cognitive rehabilitation to enhance learning and school outcomes (Malone & Mastropieri, 1992; Peterson, Jesso, & McCabe, 1999).

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Appendix

The Crow and the Peacocks Story

(Episode 1)

One day a crow flew by a yard where some peacocks used to live. He saw five feathers on the ground that had fallen off the peacocks. The pretty reds, greens, and blues in the peacock feathers made the crow's own black feathers seem plain and boring. The crow picked up the feathers he found and very carefully tied them on his tail and then strutted towards where the peacocks were now sitting. At first the peacocks thought it was another peacock joining them. But when he came closer, they discovered the truth. The peacocks flew down and began pecking at the crow and pulling off the borrowed feathers. First they pulled off a red feather, then the green, then the blue. Soon all the feathers were gone. The crow felt sad and ran away from the peacocks.

(Episode 2)

The lonely crow hung out in the forest for a long time, not knowing where to go. Two hours later, he finally flew back to the other crows, who had been watching his behaviour from far away. The crows were enjoying lunch under a shady tree and did their best to ignore him. The crow knew that he had better think of something to keep the other crows from being upset with him. First, he told them he was only trying to steal the peacock feathers. Then he told them he was making fun of the peacocks and the way they walked. But, the other crows had been watching him too long to believe his excuses. They were very annoyed with him because they knew the true reason for his behaviour. The crows told him to get lost, and the unpredictable crow learned a very important lesson that day.

Memory for story content

Explicit content questions

1. 'What did the crow do with the peacock feathers?'
2. 'Who did the peacocks think the crow was at first?'
3. 'What did the peacocks do to the crow?'
4. 'What were the crows doing while the crow was in the peacock's yard?'

Implicit content questions

1. 'Why did the crow wear the peacock feathers?'
2. 'How did the peacocks feel when they found out it was really a crow?'
3. 'Why did the crow give excuses to the other crows?'
4. 'Why were the other crows annoyed?'

Recognition of story meaning

Important statements

1. The crow tried to look like a peacock.
2. The crow tried to fool the peacocks.
3. The peacocks eventually discovered the truth about the crow.
4. The crow finally flew back to his own kind.
5. The other crows were annoyed by the fickle crow's behaviour.

Unimportant statements

1. There were five feathers in the peacock yard.
2. One of the feathers he found was blue.
3. The peacocks pulled off the red feather first.
4. The crow was in the forest for 2 hr.
5. The other crows were sitting under a shady tree.

Table 1

Demographics and clinical data for participants completing discourse measure.

Group	Severe TBI <i>n</i> = 19	Moderate TBI <i>n</i> = 43	OI <i>n</i> = 85	<i>F</i> or ²	<i>p</i>
Age in years at injury, mean (range)	5.01 (3.64–6.63)	5.19 (3.06–6.93)	5.11 (3.15–6.95)	0.19	.83
Age in years at 18 months post-injury assessment, mean (range)	6.66 (5.43–8.31)	6.85 (4.68–8.58)	6.74 (4.67–8.70)	0.29	.75
Months from injury to assessment, mean (<i>SD</i>)	19.65 (1.09)	19.99 (1.08)	19.56 (1.15)	2.14	.12
Abnormal Imaging, <i>n</i> (%) ^b	11 (58%)	37 (86%)	N/A	5.97	.02
Cause of injury, <i>n</i> (%) ^{a,b}					
Passenger in motor vehicle	5 (26%)	2 (5%)	2 (2%)	26.52	3.01
Other transportation	5 (26%)	12 (28%)	9 (11%)		
Fall	8 (43%)	28 (65%)	73 (86%)		
Other	1 (5%)	1 (2%)	1 (1%)		
Days hospitalized, mean (<i>SD</i>) ^{a,b}	10.79 (20.85)	2.56 (1.98)	1.32 (1.04)	12.46	3.01
Males, <i>n</i> (%)	12 (63%)	24 (56%)	44 (52%)	1.36	.51
White race, <i>n</i> (%)	11 (58%)	34 (79%)	67 (79%)	2.80	.25
Maternal education greater than high school, <i>n</i> (%)	12 (63%)	27 (63%)	42 (49%)	2.41	.30
Census Tract Median Family income, <i>M</i> (<i>SD</i>)	\$60,405 (\$27,687)	\$63,091 (\$27,639)	\$61,806 (\$19,667)	0.09	.91

^aTBI and OI group or

^bSevere and Moderate TBI group difference significant.

Table 2

Means and standard deviations on related neuropsychological and psychosocial measures for participants completing discourse task.

Group	Severe TBI <i>n</i> = 19	Moderate TBI <i>n</i> = 43	OI <i>n</i> = 85	<i>F</i>	<i>p</i>
WJ-III Story Recall ^{a,b}	102.16 (16.63)	111.60 (9.59)	114.72 (10.65)	9.66	.001
CASL Pragmatic Judgment ^{a,b}	97.00 (15.63)	106.42 (13.79)	109.96 (13.12)	6.85	.001
CBCL Externalizing ^{a,b}	56.58 (13.45)	48.79 (11.57)	46.29 (10.07)	6.50	.002
CBCL Internalizing ^{a,b}	53.58 (13.04)	48.02 (9.10)	44.88 (9.52)	6.30	.002
BRIEF GEC ^{a,b}	62.68 (14.38)	50.43 (11.40)	48.05 (11.29)	11.98	.001
PKBS/HCSBS Social Competence ^{a,b}	-.59 (1.19)	.34 (1.03)	.48 (.77)	10.58	.001
ABAS Social ^b	93.61 (18.92)	105.14 (14.94)	106.16 (13.539)	5.78	.005

Note.

^aTBI and OI group or

^b severe and moderate TBI group difference significant; WJ-III, Woodcock-Johnson Tests of Achievement Third-Edition; CASL, Comprehensive Assessment of Spoken Language; ABAS, Adaptive Behaviour Assessment System (standard score mean of 100 and standard deviation of 15 with higher scores representing better performance); CBCL, Child Behaviour Checklist; BRIEF, Behaviour Rating Inventory of Executive Function (*T*-score mean of 50 and standard deviation of 10 with higher scores representing more problems); PKBS, Preschool and Kindergarten Behavior Scales; HCSBS, Home and Community Social and Behaviour Scales (*z*-scores with higher scores representing more of the construct).

Table 3

Means and standard errors on discourse measure 18 months post-injury co-varying for age at assessment.

Measure	Severe TBI <i>n</i> = 19		Moderate TBI <i>n</i> = 43		OI <i>n</i> = 85	
	Adj. M	SE	Adj. M	SE	Adj. M	SE
Language overall score (<i>T</i> -units + words)	51.58	12.89	46.97	7.87	65.95	5.80
Number of thematic units ^a	4.79	1.01	4.23	0.61	6.27	0.45
Word count	46.79	11.95	42.74	7.29	59.68	5.38
Information overall score (core + gist, out of 40) ^a	4.77	1.39	4.72	0.85	7.07	0.63
Total number of core propositions (out of 34) ^a	4.03	1.10	3.88	0.67	5.72	0.50
Total number of gist propositions (out of six) ^a	0.74	0.33	0.84	0.20	1.36	0.15
Memory for story content						
Total score on explicit content questions (out of eight) ^a	3.14	0.59	4.15	0.37	4.64	0.26
Total score on implicit content questions (out of eight)	1.88	0.43	2.19	0.27	2.42	0.19
Recognition of story meaning						
Correct identification of important statements (out of five)	2.93	0.31	2.85	0.21	2.80	0.15
Correct identification of unimportant statements (out of five) ^{a,b}	2.42	0.32	3.38	0.21	3.78	0.15

^aTBI < OI;

^bSevere TBI < moderate TBI; Adj., Adjusted.

Table 4

Bivariate correlations between measures for the TBI ($n = 85$) and OI groups ($n = 62$).

	Language	Information	Explicit	Implicit	Important	Unimportant	Story recall	Pragmatic judgment	External	Internal	BRIEF	Social competence	ABAS social
Language	–	.85 [*]	.39 ^{***}	.28	.21	.11	.21	.30	–.01	.12	–.10	–.06	.05
Information	.91 [*]	–	.48 [*]	.42 [*]	.27	.18	.33	.44 [*]	–.09	–.01	–.17	.10	.14
Explicit	.50 [*]	.56 [*]	–	.60 [*]	.06	.32	.40 ^{***}	.52 [*]	.13	.03	–.09	.06	.24
Implicit	.50 [*]	.57 [*]	.48 [*]	–	.07	.28	.34 ^{***}	.37 ^{***}	.15	.11	–.11	.18	.22
Important	.31 ^{**}	.39 [*]	.03	.24	–	–.13	.29	.07	–.11	.03	–.09	–.12	.10
Unimportant	.30 ^{**}	.29	.14	.11	.19	–	.17	.31	–.32	–.15	–.27	.39 ^{**}	.25
Story recall	.27	.34 ^{***}	.33 ^{***}	.27	.13	–.01	–	.60 [*]	–.10	–.10	–.19	.22	.21
Pragmatic judgment	.37 [*]	.41 [*]	.52 [*]	.46 [*]	.26	.11	.60 [*]	–	–.20	.04	–.29	.37 ^{**}	.37 ^{**}
External	–.04	–.09	.04	.02	–.01	–.01	–.10	–.05	–	.64 [*]	.69 [*]	–.74 [*]	–.49 [*]
Internal	.06	–.02	.05	.06	.07	.11	.01	–.09	.56 [*]	–	.63 [*]	–.45 [*]	–.38 ^{**}
BRIEF	–.07	–.12	.02	.01	.05	.10	.01	–.01	.66 [*]	.58 [*]	–	–.66 [*]	–.56 ^{**}
Social competence	.01	.09	.04	.01	–.14	–.04	–.03	.01	–.63 [*]	–.47 [*]	–.69 [*]	–	.78 [*]
ABAS social	–.06	–.02	.08	.02	–.24	.03	–.07	.02	–.34 [*]	–.16	–.43 [*]	.63 [*]	–

Note. Correlations for the TBI group are presented above the diagonal and correlations for the OI group are below the diagonal.

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

Table 5

Summary of hierarchical regression analyses with age, group, and neuropsychological skills as predictors of discourse performance ($n = 136$).

Predictors	Dependent variable (standardized B)	
	Language composite	Information composite
Step 1		
Age at assessment	.42 *	.48 *
Total R^2	.17	.23
Step 2		
Age at assessment	.43 *	.49 *
TBI versus OI	-.16	-.18 **
Severe versus moderate TBI	.03	.01
Total R^2	.20	.27
Step 3		
Age at assessment	.42 *	.49 *
TBI versus OI	-.12	-.13
Severe versus moderate TBI	.13	.14
Pragmatic judgment	.26 ***	.29 *
Story recall	.13	.20 **
Total R^2	.31	.44

Note.

* $p < .001$,

* $p < .05$,

** $p < .01$., OI = 0, TBI or severe TBI = 1.

Table 6

Summary of hierarchical regression analyses with age, group, and information structure as predictors of psychosocial outcomes ($n = 137$).

Predictors	Dependent variable (standardized B)				
	CBCCL External	CBCCL Internal	BRIEF GEC	PKBS/HCSBS Social competence	ABAS Social
Step 1					
Age at assessment	.01	-.03	-.13	.05	.03
TBI versus OI	.10	.16	.09	-.08	-.03
Severe versus moderate TBI	.23*	.16	.30**	-.27*	-.19***
Total R^2	.09	.07	.14	.10	.04
Step 2					
Age at assessment	.06	-.03	-.09	.01	.01
TBI versus OI	.08	.16	.08	-.07	-.02
Severe versus moderate TBI	.23*	.16	.30**	-.27*	-.20***
Information	-.11	-.01	-.08	.07	.04
Total R^2	.09	.07	.15	.10	.05

Note:

* $p < .01$,

** $p < .001$,

*** $p < .05$. OI = 0, TBI or severe TBI = 1.