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First-order theory of mind skills shortly after traumatic brain injury in 3 to 5-year-old children

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Abstract

Post-acute effects of early childhood traumatic brain injury (TBI) on first-order theory of mind (ToM) skills were examined in 86 children with orthopedic injury (OI), 42 children with moderate TBI and 17 children with severe TBI aged 3 to 5 years at the time of injury. Three-year-olds with TBI performed more poorly than 3-year-olds with OI on an appearance-reality task. The severe TBI group was impaired on false-contents tasks compared to the moderate TBI and OI groups. Age and IQ were strong predictors of ToM performance; however, the relationship between ToM and IQ was not as strong for children with TBI.

Introduction

One of the most active areas of research in the development of social cognition has been centered around the construct of perspective taking or mentalizing abilities, often referred to as ‘theory of mind’ (ToM) skills. ToM tasks assess a person's ability to take another's point of view or to think about other people's mental states and use this perspective to understand and predict behavior. Developmental psychologists have long studied the emergence of first-order ToM competence using false-belief tasks, with particular focus on the developmental period of 3 to 5 years of age. First-order ToM tasks assess the child's ability to understand false-beliefs and engage in perspective taking with scenarios that involve deception and ignorance. For example, a child might be presented with a milk container that is filled with juice (i.e., false contents) or a scenario where a chocolate bar is (unbeknownst to them) moved to another location (i.e., false location). Success on first-order ToM tasks increases dramatically during

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the preschool years, with many 3-year-olds failing the tasks but most 4- and 5-year-olds succeeding, although performance varies with tasks demands such as linguistic complexity.

Understanding social development and the cognitive precursors to social competence has particular relevance for young children because ToM skills appear to undergo rapid development during early childhood. Moreover, development of adequate social cognition has been linked to school readiness. Children who show adequate social information processing 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).

Although the literature on social cognitive development in typically developing children is quite extensive, little is known about the impact of pediatric brain disorders or brain injury on social cognition. Traumatic brain injury (TBI) in young children is a leading cause of lifelong disability. Approximately 160 per 100,000 children under the age of 5 years suffer a TBI. Recent epidemiological data suggest that children under the age of 5 years are at greater risk for TBI-related Emergency Department visits and hospitalizations in comparison to children aged 5-14 years (Center for Disease Control and Prevention, 2000; Langolis, 2006). Despite some evidence that the social deficits following TBI are more debilitating than the cognitive and physical consequences, research on social outcomes of pediatric TBI is scant (Janusz et al., 2002; Yeates et al., 2004, 2007). Short- and long-term social outcomes following TBI have particular relevance for young children, yet this age group has been neglected in TBI outcome research. Social skills are less well established in these children compared to older children and adolescents and are a critical component of learning readiness (Blair, 2002). A better understanding of the cognitive and behavioral mechanisms that contribute to social outcomes is needed to design appropriate interventions. Certain neuropsychological abilities, such as ToM skills, are likely to affect social competence. That is, connectedness to others and appropriate social responses require the ability to consider another person's point of view (Dennis, 1991; Yeates et al., 2007).

Due to the timing and nature of the insult to the brain, children suffering TBI during the early childhood years are at high risk for deficits in the neuropsychological abilities that are thought to lay the foundation for social information processing skills and influence social behavior (Janusz et al., 2002; Stuss & Anderson, 2004; Yeates et al., 2004, 2007). ToM skills and related neuropsychological abilities are emerging rapidly during early childhood, and young children may therefore be particularly susceptible to impairment in these skills following TBI. This susceptibility may be due in part to the fact that neuronal myelination and frontal lobe maturation are occurring at rapid rates during early childhood (e.g., Anderson et al., 2005, 2006). Moreover, the network of frontal, temporal, parietal, and limbic regions thought to subserve ToM skills and related neuropsychological abilities are especially vulnerable to insult in cases of pediatric TBI (Grady & Keightley, 2002; Haten et al., 2008; Yeates et al., 2007).

To our knowledge, only three studies have examined ToM skills following pediatric TBI. Snodgrass and Knott (2006) assessed 12 children aged 6-12 years with moderate to severe TBI and frontal lobe damage who were 1-7 years post-injury. The 12 children with a history of TBI were compared to 12 non-injured control children using a range of ToM tasks. They found that the TBI group performed worse than the control group on the advanced ToM task (reading the mind in the eyes task, Baron-Cohen et al., 1997), but not on the first-order belief or deception tasks. Turkstra, Dixon, and Baker (2004) assessed the first- and second-order ToM abilities of 22 adolescents aged 13 - 22 years with a history of TBI who were 1 – 12 years post-injury. The comparison group comprised 48 typically developing adolescents. The adolescents with TBI performed more poorly than the typically developing group on a second-order ToM task. However, the groups did not differ on a first-order ToM task. The authors also failed to find significant correlations between performance on first- or second-order ToM tasks and age of injury or injury severity. Finally, Dennis et al. (in press) assessed ToM skills in 43 children aged 7-16 years who were at least 1 year post injury. They found that the TBI group's performance was significantly below normative data on a speech act measure of ToM (Wiig & Secord, 1985). They did not find performance differences between those injured at age 5 or earlier in comparison to those injured at age 6 or later.

We are not aware of any studies that have investigated ToM skills after TBI in 3- to 5-year-old children. The primary aim of the present study was to investigate the effects of TBI during early childhood on developing ToM skills at a post-acute assessment conducted shortly after injury. To provide an estimate of the effects of TBI that accounted for pre-injury risk exposure as well as the experience of hospitalization, children admitted to hospitals for orthopedic injuries (OI) but without TBI were recruited as a comparison group. Children were first grouped by age level to investigate age effects. We hypothesized that within these age groups, children with TBI would displays deficits in ToM skills compared to children with OI. Second, children were grouped by injury severity (OI, moderate TBI, and severe TBI) to examine severity effects. We hypothesized that ToM deficits would be most pervasive for children with severe TBI. Finally, we explored whether children's age, overall cognitive ability, and injury severity, were predictors of ToM skills in our sample. Our purpose in considering these factors was to determine if we would find injury group differences in ToM performance that were not solely a function of overall intellectual functioning and/or chronological age.

Method

Participants

The study was approved by the institutional review boards of all 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 centers. Eligibility criteria included age at injury between 3 years, 0 months and 5 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 previous history of autism, mental retardation, or a neurological disorder 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 < 13 or a GCS of 13-15 with evidence for TBI-related brain abnormalities from computed tomography (CT) or magnetic resonance imaging (MRI). 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. Inclusion in the OI group required 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 66 children with moderate to severe TBI and 96 children with OI and their caregivers who met these criteria were enrolled in the study. Recruitment rates for families contacted were somewhat higher for the TBI group. Examination of pre-enrollment 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 neighborhood family income failed to reveal differences.

Children participated in a comprehensive post-acute assessment of child and family functioning as soon as possible after discharge from the hospital, with an upper limit of around 3 months post-injury (range 8 to 104 days, see Table 1 for further details). This time frame was selected to examine the initial impact of the injury on neurobehavioral functioning. Reasons for failure to test children included injuries that precluded testing (2 TBI), difficulties in arranging for travel for the assessment (2 TBI, 2 OI), inability to understand the ToM task instructions (1 TBI), and enrollment before the ToM battery was added to the neuropsychological assessment (2 TBI, 8 OI). Children who were not assessed did not differ significantly from those assessed on measures of socioeconomic status (SES), race, or sex. Sample demographic characteristics are presented in Table 1.

Procedure and Measures

The child ToM assessment was administered as part of a more comprehensive evaluation of the child and family (see Stancin et al., 2008; Taylor et al., 2008; Wade et al., 2008). As part of the larger assessment, children completed a series of seven first-order ToM tasks and two control tasks. Each of the ToM tasks involves two questions: a ToM question and a memory/comprehension question. Each ToM task was scored as correct or incorrect according to standard scoring procedures widely used in developmental psychology (e.g., Carlson & Moses, 2001; Flavell, Flavell, & Green, 1983; Flavell, Green, & Flavell, 1986). To pass a ToM task, the child was required to answer both the ToM question and the memory/comprehension question correctly. The Differential Ability Scales (DAS, Elliot, 1990) was administered as part of the larger test battery, and the General Conceptual Ability (GCA) composite score included in the data analysis as a global composite measure of postinjury cognitive functioning.

The ToM battery consisted of two appearance-reality tasks, three false contents tasks, two false location tasks, and two control tasks. The ToM tasks involved a discrepancy between what the child expects and reality (i.e., a false-belief). After discovering the reality, the child was asked about their or a puppet's expectation before discovery. All of these tasks have been widely used in the developmental psychology literature and were administered using the procedures developed and described in published research. One of the appearance-reality tasks involved a discrepancy between real and apparent identity (a candle that looks like an apple) and the other involved a discrepancy between real and apparent color (a picture of a red object that looks black when held behind a green filter) (Carlson & Moses, 2001; Flavell, Flavell, & Green, 1983; Flavell, Green, & Flavell, 1986). For the three false-contents tasks, the child was asked to identify the contents of containers with unexpected contents. For example, the child was shown a milk carton and asked what was inside. The child was then given the carton and opened it to discover the true contents (e.g,. crayons). Then the child was asked, “When you first saw this carton, before you opened it, what did you think was inside, milk or crayons?” (Carlson & Moses, 2001; Gopnik & Astington, 1988: Perner, Leekam, & Wimmer, 1987). For the two false-location tasks, the child was asked to identify the location of objects (Carlson & Moses, 2001; Wimmer & Perner, 1983). For example, the examiner had a puppet “Sally” that put candy in a jar and then left. A different puppet “Anne” came and took the candy and ate it. Then “Sally” came back and the child was asked, “Where does Sally think the candy is?” Finally, two mental state control tasks were administered (Carlson & Moses, 2001). They were designed to parallel the false-contents and false-location tasks, but did not include references to mental states (Carlson & Moses, 2001; Gopnik & Astington, 1988). The questions were similar in syntax to the test questions in the false-contents and false-location tasks.

We created a ToM total score by summing across six of the seven tasks (score range from 0 to 6). We excluded the color filter appearance-reality task because a portion of the 3 year-olds were not familiar with the colors and thus did not complete the task. To help address concerns about multiple comparisons, we considered the ToM total score as our major outcome measure.

We also created a false contents score by summing across the three false contents tasks (score range from 0 to 3), a false location score by summing across the two false location tasks (score range from 0 to 2), and a control score by summing across the two control tasks (score range from 0 to 2). We did not create an appearance-reality score because, as stated above, a number of the 3 year-olds were missing on one of the two appearance-reality tasks.

Results

Group differences on demographics and relationship with ToM performance

Age group differences—Using chi-square analyses for the dichotomous demographic variables (maternal education, sex, race) and analysis of variance for the continuous variables (census median family income, DAS GCA, days from injury to assessment), we compared the two injury groups (TBI and OI) within each age group (3, 4, or 5-years-old). As indicated in Table 1, 5-year-olds with OI had significantly higher IQ scores than 5-year-olds with TBI, $F(1,60) = 4.27$, $p = .04$. Among 4- and 5-year-olds, children with OI had a shorter time from injury to assessment than their respective TBI comparison group, $F(1, 43) = 7.17$, $p = .01$ and $F(1, 60) = 7.45$, $p = .008$. None of the other group comparisons were significant.

Severity group differences—Using chi-square analyses for the dichotomous demographic variables (maternal education, sex, race) and analysis of variance for continuous variables (census median family income, DAS GCA, days from injury to assessment, age at assessment), we compared the three severity groups (OI, moderate TBI, and severe TBI). The severe TBI group had a lower mean IQ score (mean = 82. 47, SD = 14.78) than both the moderate TBI group (mean = 96.05, SD = 18.16) and the OI group (mean = 99.48, SD = 15.59), $F(2, 142) = 7.76$, $p = .001$. The moderate TBI group (mean = 45.21, SD = 22.33) and severe TBI group (mean = 44.62, SD = 23.44) had more days between injury and assessment than the OI group (mean = 32.98, SD = 15.07). The groups did not differ significantly in other demographic characteristics.

Relationship with ToM performance—For the entire sample, the performance on the ToM total score was correlated with the demographic and clinical variables. ToM performance was not correlated with days from injury to assessment, census median family income, maternal education, race, or abnormal imaging. Better ToM performance was significantly correlated with older age, $r = .54$, $p < .001$, higher DAS GCA, $r = .49$, $p < .001$, and female gender, $r_s = .18$, $p = .03$.

Frequency and Nature of ToM Deficits

Within each of the three age groups, we compared the pass rates on the two appearance-reality (apple-candle and color filter) ToM tasks of the TBI group with the OI group using chi-square analyses. Among 3-year-olds, children with TBI performed significantly worse than children with OI on the apple-candle appearance-reality task, $X^2(1, 36) = 5.11$, $p = .02$, with 13% (2/16) of the 3-year-olds with TBI passing the task compared to 48% (10/21) of the 3-year-olds with OI. No other group differences were significant. Within each of the three age groups, we compared performance of the TBI group with the OI group on the false location score, the false contents score, the control score, and the ToM total score using analyses of variance. There were no significant group differences.

Next, we analyzed the data by injury severity (OI, moderate TBI, and severe TBI) across ages. Pass rates on the two appearance-reality ToM tasks were not significantly different between the three groups. Analyses of variance conducted on the false location score, the false contents score, the control score, and the ToM total score revealed that children with severe TBI (mean = 0.75, SD = 1.06) performed significantly worse on the false contents score compared to children with OI (mean = 1.58, SD = 1.22) and children with moderate TBI (mean = 1.59, SD = 1.20), F (2, 138) = 3.42, $p < .05$. No other group differences were significant.

Relationship between ToM Performance and Child Characteristics

Hierarchical linear regression was conducted to examine associations of the ToM total score with child and injury characteristics (see Table 4). After each step was entered, non-significant predictors were removed before proceeding to the next step. Age, sex, and dummy variables representing contrasts of each TBI group to the OI group were entered as predictors in the first step. There was no main effect for sex, so sex was removed from the model. Given the injury group differences on the DAS GCA, this variable was entered in a second step to determine if group differences were a function of intellectual ability. Interactions of group with cognitive ability and age were entered in the third step. The group x age interaction was not significant and hence was dropped from the model. Age and the contrasts between the TBI and OI groups entered in step 1 accounted for 31% of the variance, F change (3, 134) = 19.76, $p < .001$. The addition of the DAS GCA to the model in step 2 accounted for an additional 18% of the variance, F change (1, 133) = 45.96, $p < .001$. Finally, the interaction terms for group and DAS GCA entered in step 3 accounted for an additional 3% of the variance, F change (2, 131) = 3.73, $p < .05$. Consistent with these findings, the total model was also significant, F (6, 131) = 22.96, $p < .001$. Significant effects for age and DAS GCA reflected a positive association of these variables with the ToM. The significant interactions of the group contrasts with DAS GCA can be interpreted as revealing either a stronger association between IQ and ToM performance for the OI group than for the TBI groups, or more pronounced effects of TBI at a higher level of cognitive ability.

Discussion

The primary goal of this study was to examine the post-acute effects of TBI on first-order ToM skills in 3- to 5-year-old children. Contrary to expectations, TBI did not adversely affect the ability of our TBI sample as a whole to engage in representation of mental states at a developmental level comparable to their peers. We should emphasize that our lack of group differences on false-belief tasks does not rule out the possibility of differences on other aspects of mentalizing or social perspective taking (Bloom & German, 2000). We would also point out that our findings are consistent with two previous studies that failed to demonstrate deficits in first-order ToM tasks in children who sustained TBI at later ages than those in our sample (Snodgrass & Knott, 2006; Turkstra, Dixon, & Baker, 2004).

However, our analyses did reveal that 3-year-old children with TBI performed more poorly than same aged children with OI on one of the two appearance-reality measures administered, the apple-candle task. Typically developing children under 4 years are prone to realism errors on false-belief tasks (Rice et al., 1997). For the apple-candle task, a typically developing 3-year-old child would say that the object is a candle and looks like a candle, once they discover the reality that the object is really a candle. Specifically, although similar percentages of children at this age level in the TBI and OI groups (63% versus 71%) said the object looked like an apple, a much lower percentage of those with TBI (38% versus 71%) went on to say that the object was really a candle. One explanation is that the appearance (i.e., looking like an apple) was significantly more salient for the children with TBI and thus, they showed a bias towards that property of the object. Another possibility is that the 3-year-old children with TBI were hampered by the information processing and working memory demands of the task. Once the object was sitting in front of them again, looking like an apple, they were unable to hold in their mind that they had discovered the object was really a candle (Rice et al., 1997). The performance of 3-year-olds on our second appearance-reality task was likely confounded with knowledge of colors, leaving us with a reduced and potential biased sample of 3-year-olds, particularly within the TBI group. Eighteen of the 21 3-year-old children with OI were able to complete the color filter task, but only 9 of 16 3-year-olds with TBI knew colors well enough to do so.

Analyses revealed that children with severe TBI were significantly impaired relative to the OI group and the moderate TBI group on the false contents score, with results from post-hoc analyses suggesting that the children with severe TBI were more prone to realism errors. Across all three of the false contents tasks, only 25% (4/16) of the children with severe TBI were able to acknowledge their previous belief that they had expectations for what was in the container that differed from reality, compared with around 50% (44/86) of those with OI. Although the findings from our appearance-reality and false-contents tasks could appear contradictory, the tasks may elicit different biases in children with TBI (Rice et al., 1997; Flavell et al., 1986). In other words, for children with TBI the appearance may have been the more salient property in the candle-apple task, whereas the reality was the more salient property in the false-contents tasks. Moreover, performance on both tasks likely was impacted by the cognitive consequences of moderate-to-severe TBI (Taylor et al., 2008). Recent research suggests that poor performance on ToM tasks following pediatric TBI is related to communication skills and executive functions, such as language pragmatics, working memory, and cognitive inhibition (Dennis et al., in press; Dennis et al., 2001; Dennis, 1991; Yeates et al., 2007).

Our regression analysis revealed that age and overall cognitive ability were strong predictors of first-order ToM performance independent of injury type, a result consistent with the normative developmental literature. These findings indicate that false-belief tasks are cognitively complex and that performance is related to children's cognitive competencies (Bloom & German, 2000). Interestingly, although IQ was strongly related to performance in healthy children, task performance was independent of IQ following moderate or severe TBI. One plausible explanation for this finding is that the children with TBI have selective (i.e., IQ-independent) impairments in cognitive domains related to ToM skills, rendering IQ a relatively poor predictor. In children without TBI, in contrast, IQ may be more representative of other ability domains, making IQ a better predictor of ToM. Another possibility is that the first-order ToM tasks are too difficult for children with lower IQ regardless of injury type, with floor effects on the ToM tasks precluding detection of group differences in children of lower ability.

More generally, the findings suggest that children who sustain TBI in early childhood are susceptible to deficits in first-order ToM skills, but that these deficits are likely to be subtle and dependent on children's age and overall cognitive functioning. One explanation for the lack of more uniform deficits in these skills is that TBI renders young children most vulnerable to impairment in the specific skills that are emerging and undergoing rapid development at the time of injury. In support of this possibility, the post-acute effects of TBI may not be readily apparent on tasks that have been previously mastered (e.g., appearance-reality tasks for 5-year-olds) or are yet to develop (e.g., false-contents tasks for 3-year-olds).

The results of this study invite exploration and speculation about the specific mechanisms and neural pathways involved in performance on ToM tasks following early childhood TBI. Because imaging available on our sample at the time of injury was limited for the most part to acute CT scans, we lacked the more probing measures of brain status (e.g., using magnetic resonance imaging) that would be needed to relate the integrity of specific brain regions or networks to the ToM tasks. However, one potential basis for the deficits in ToM observed in this study is the susceptibility of children with TBI to brain insults in anterior and medial frontal regions. Evidence that insults to these regions contribute to deficits in social skills and social information processing may help account for the differences observed (Yeates et al., 2007).

Study limitations in addition to the absence of comprehensive brain imaging include the lack of information on other severity variables, such as length of post-traumatic amnesia, primarily because of the difficulty of accurately documenting this information in young children. Although our regression analysis considered data from the total sample, a final limitation was the relatively small sample size available for evaluating the effects of age and TBI severity. Without recruiting children from a larger population base, studies of children with TBI falling into restricted age ranges and with highly variable developmental status are likely to continue to face problems of this sort. As other researchers have suggested, outcomes following TBI in early childhood may be even more variable than in other age groups because of the effects of early brain insult on neurogenesis or postinjury skill development (Anderson et al., 2005; Barnes et al., 1999, Ewing-Cobbs et al., 1997, Taylor & Alden, 1997).

The results of this study suggest a number of important research directions as we continue to follow this cohort. Most importantly, following the development of ToM skills over time in this cohort of young children will help to determine if ToM skills worsen, remain stable, or improve over time relative to the OI group. We will also be able to relate the development of ToM skills to the child's social environment and development of social competence and other neurobehavioral skills. For example, further investigation of the relationship between ToM skills and executive functioning will likely contribute to the longstanding debate on the nature of the overlap of these two processes. Given the importance of social and behavioral competence to academic success and emotional well-being, study of the relationship between ToM skills and social competence will be another important future direction. If ToM skills are dependent on social interactions and adequate social communication, we might hypothesize emergence of group differences in ToM performance over time as TBI has an impact on social outcomes and interactions.

Other critical research needs include application of advanced neuroimaging techniques to elucidate the relationship between neural substrates and ToM abilities; assessment of children injured at even earlier ages to determine the effect of TBI sustained prior to the emergence of first-order ToM skills; and efforts to better understand the reasons for children's failures on ToM tasks. Manipulating the information processing demands, such as deception and intention, will be particularly important as the field moves towards developing interventions to improve social outcomes following early childhood TBI. The present findings offer tentative support for deleterious effects of TBI in young children on at least some aspects of first-order ToM skills and emphasize the importance of considering age and overall cognitive ability as predictors of outcome. First-order ToM deficits should be taken into account in assessment and interventions with 3- to 5-year-old children with a history of TBI.

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Table 1

Demographics and clinical data for participants completing first-order tasks

	Age at injury/baseline assessment					
	3 year olds		4 year olds		5 year olds	
Group	**TBI**	**OI**	**TBI**	**OI**	**TBI**	**OI**
n	**16**	**22**	**19**	**26**	**24**	**38**
Maternal education more than HS, n (%)	8 (50%)	13 (59%)	10 (53%)	13 (50%)	6 (25%)	19 (50%)
Census Median Family income, M (SD)	61,410 (22,028)	62,113 (26,597)	58,546 (21,329)	69,446 (25,416)	58,274 (26,941)	61,866 (24,229)
Males, n (%)	11 (69%)	16 (73%)	15 (79%)	14 (54%)	13 (54%)	20 (53%)
White race, n (%)	13 (81%)	18 (82%)	13 (68%)	20 (77%)	16 (67%)	28 (74%)
DAS GCA, mean (SD)[a]	87.25 (14.74)	94.86 (14.18)	94.89 (20.09)	100.15 (19.07)	93.21 (18.85)	101.68 (13.43)
Days from injury to assessment, mean (SD)[b]	40.60 (22.27)	33.39 (16.00)	46.65 (20.70)	32.52 (14.76)	46.82 (24.36)	33.06 (15.12)
Severe TBI severity, n (%)	2 (13%)		9 (47%)		6 (25%)	
Abnormal Imaging, n (%)	16 (100%)		13 (68%)		18 (75%)	

Note:

[a]5 year-old groups differ significantly, $p < .05$

[b]4 and 5 year-old groups differ significantly, $p < .05$.

Table 2

Hierarchical linear regression analysis of predictors of performance on the ToM total score

Predictor	**Beta**
Step 1	
Age**	.54
Moderate TBI vs OI	.05
Severe TBI vs OI	-.11
Step 2	
Age**	.50
Moderate TBI vs OI	.08
Severe TBI vs OI	.04
DAS GCA**	.45
Step 3	
Age**	.49
Moderate TBI*	.82
Severe TBI*	.89
DAS GCA**	.60
DAS × moderate TBI*	-.75
DAS × severe TBI*	-.82

Note: DAS GCA = Differential Ability Scales General Conceptual Ability composite.

* $p < .05$

** $p < .01$.