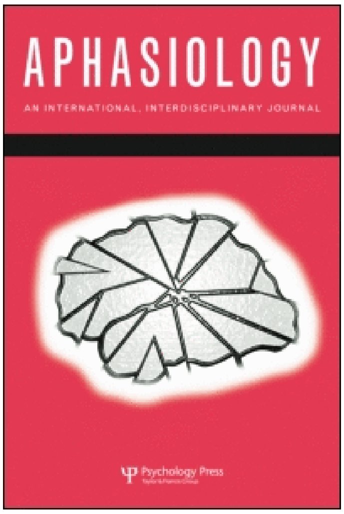

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Sheri T. Stronach [a]; Lyn S. Turkstra [a]
[a] University of Wisconsin-Madison, Madison, WI

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Theory of mind and use of cognitive state terms by adolescents with traumatic brain injury

Sheri T. Stronach and Lyn S. Turkstra
University of Wisconsin-Madison, Madison, WI, USA

Background: There is growing evidence of impaired social cognition in individuals with traumatic brain injury (TBI). Social cognition tests, however, place demands on domain-general cognitive functions such as auditory working memory, so that test scores might reflect the influence of these factors on test performance rather than domain-specific social cognition impairments. As an alternative, we examined conversations of adolescents with TBI for evidence of cognitive state terms.
Methods and Procedures: Participants were 16 adolescents with TBI, who were divided into two groups (TBI-Low and TBI-High) based on scores on a test of theory of mind (ToM), and 8 typically developing (TD) adolescents matched to participants in the TBI groups for age and race. Each participant completed a 3-minute conversation with a peer or researcher partner, and conversations were analysed to determine the number of cognitive state terms relative to total words produced.
Outcomes and Results: The TBI-Low group expressed significantly fewer cognitive state terms and significantly fewer self- vs other-referenced terms than either the TBI-High or TD group. There was no significant difference between the TD and TBI-High groups. The findings were not related to generally impoverished language in the TBI-Low group, as the three groups were similar on measures of lexical diversity.
Conclusions: The findings support the hypothesis that adolescents with TBI have domain-specific deficits in social cognition, beyond what might be accounted for by the cognitive demands of social cognition tests. Given the relation of social cognitive ability to important life outcomes, these skills should be included in the evaluation of individuals with cognitive-communication disorders after TBI.

Theory of mind (ToM) is defined as the ability to generate inferences about others' mental states and use those inferences to understand and predict behaviour (Gillot, Furniss, & Walter, 2004). Examples of mental states include thoughts, beliefs, desires, emotions, intentions, or attitudes (Gillot et al., 2004; Silliman et al., 2003). ToM is thought to distinguish primates from other animal species. While many species use nonverbal cues to predict behaviour, such as recognising a certain body posture as an indicator of aggression, humans also explicitly imitate and respond to

Address correspondence to: Lyn S. Turkstra, Department of Communicative Disorders, University of Wisconsin-Madison, 1975 Willow Drive, Madison, WI 53706, USA. E-mail: lsturkstra@wisc.edu

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others' cognitive states (Stone, Baron-Cohen, & Knight, 1998). There is evidence that this is true in non-human primates as well (Brune & Brune-Cohrs, 2006), although this continues to be a subject of debate (Barrett, Henzi, & Rendall, 2007).

ToM DEVELOPMENT

Previous research has shown that the use of ToM is automatic, rapid, and universal, and has a well-defined developmental sequence in humans (Stone et al., 1998). ToM can first be seen at about 15 months of age, when toddlers begin to recognise pretend play (Onishi, Baillargeon, & Leslie, 2007). At about 18 months of age, typical toddlers demonstrate joint attention and protodeclarative pointing (Stone et al., 1998). By the age of 2 years, children understand the cognitive state of *desire*, indicated by the use of the word *want* (Stone et al., 1998). They can infer emotions that are related to a given situation or behaviour and begin to talk about perceptual and affective experiences, using words such as *look* and *feel* (Johnston, Miller, & Tallal, 2001). Also, some children at this age are able to understand that emotions can be independent of the situation or facial expression (Silliman et al., 2003). The ability to understand false beliefs develops by age 3 or 4 years, when children realise that other people have beliefs about the world that are different from their own (Stone et al., 1998). Children of this age use terms to describe cognitive states, such as *think*, *know*, and *remember* (Johnston et al., 2001). Second-order false belief, or a belief about other people's beliefs, is developed between the ages of 6 and 7 years. At this time, children understand that other people also have ToM abilities.

The ability to understand faux pas develops between ages 9 and 11 years (Stone et al., 1998). A faux pas occurs when an individual makes a comment that is inappropriate to the situation without recognising that it is inappropriate. For example, an individual might tell a joke about people from Wisconsin without realising that the listener is *from* Wisconsin. The understanding of faux pas requires the recognition that the individual did not know that what he or she said was inappropriate, and an empathetic affective component of realising that the comment would cause someone else to feel upset or insulted (Stone et al., 1998). This is evidence that typically developing ToM integrates multiple skills, including language as well as other cognitive functions (Silliman et al., 2003).

ToM IN EVERYDAY LIFE

ToM ability and other aspects of social cognition appear to be critical for survival in a complex social world, where procedural and declarative knowledge of social rules is insufficient to meet the demands for complex, strategic, cognitive assessment (Barrett et al., 2007). It is therefore unsurprising that social cognitive impairments are associated with limitations in important life skills such as interpersonal communication (Shamay-Tsoory, Tomer, & Aharon-Peretz, 2005; Watts & Douglas, 2006) and academic achievement (Silliman et al., 2003). It is likewise unsurprising that acquired impairments in social cognition might be particularly penalising for children and adolescents, who are in the process of developing social skills and social networks (Berndt & Hoyle, 1985; Englund, Levy, Hyson, & Sroufe, 2000). Given its biological significance and potential effects on long-term outcome, the evaluation of social cognition in dynamic social contexts is an important component of communication assessment in children and adolescents.

ToM IN INDIVIDUALS WITH TRAUMATIC BRAIN INJURY

There is growing evidence that traumatic brain injury (TBI) affects ToM ability (Bibby & McDonald, 2005; Channon, Pellijeff, & Rule, 2005; Havet-Thomassin, Allain, Etcharry-Bouyx, & Le Gall, 2006; Martin & McDonald, 2005; Turkstra, Dixon, & Baker, 2004). The term ToM was not used in the TBI literature until fairly recently, but there was previous evidence of social cognition impairments in the literature on *pragmatic* communication functions after TBI; that is, in aspects of communication that depend on consideration of the listener, physical, and linguistic context (Dennis & Barnes, 1990; Galski, Tompkins, & Johnston, 1998; Hartley, 1995; McDonald, 1993a, 2000; Turkstra, McDonald, & Kaufmann, 1996; Yeates et al., 2004). When this literature is viewed from the perspective of current notions of social cognition, it appears that many of the behaviours described could be attributed at least in part to underlying deficits in social cognitive processes such as ToM.

One might predict that TBI would cause impairments in social cognition, as the areas of the brain most commonly injured are those associated with social cognition in both typical and clinical populations. Although there is some debate about the neuroanatomical substrate of social cognition (Adolphs, 1999; Critchley et al., 2000a), the results of most studies support the importance of the frontal lobes (Martin & McDonald, 2003; Stuss, Gallup, & Alexander, 2001), particularly the ventromedial prefrontal cortex (Moll, Zahn, de Oliveira-Souza, Krueger, & Grafman, 2005; Shamay-Tsoory et al., 2005, although see an alternative view in Bird, Castelli, Malik, Frith, & Husain, 2004), as well as the amygdala (Baron-Cohen et al., 2000) and temporal lobes (Critchley et al., 2000b; Garrett, Menon, MacKenzie, & Reiss, 2004; Schultz, Imamizu, Kawato, & Frith, 2004); and temporo-parietal junction (Apperly, Samson, Chiavarino, & Humphreys, 2004). ToM may also engage the right hemisphere in normal adults, given the finding that adults with right hemisphere stroke made errors on ToM tasks involving ignorance and false belief (Happé, Brownell, & Winner, 1999). It has been noted, however, that many participants in studies of frontal lobe or right hemisphere dysfunction actually had damage that included both frontal lobe and right hemisphere regions (McDonald, 1993b), which may explain the overlap in deficits presented.

ToM IN ADOLESCENTS WITH TBI

Although there have been few studies of adolescents with TBI, there are reasons to suspect that they would perform poorly on ToM tasks. As just noted, many typical ToM tasks require cognitive functions such as working memory and executive function, which are known to be impaired in adolescents with TBI (Turkstra & Holland, 1998). Also, as in children and adults, TBI in adolescents often is associated with impairments in pragmatic aspects of communication (Johnson, Thomas-Stonell, Rumney, & Oddson, 2006; Turkstra et al., 1996; Wiseman-Hakes, Stewart, Wasserman, & Schuller, 1998) and social problem solving (Janusz, Kirkwood, Yeates, & Taylor, 2002). Impaired ToM might be expected to be particularly penalising at this age, as adolescence is an important stage for the development of social understanding and social behaviour (Bosacki, 2003), as well as a time at which individuals move further away from their parents to align with peers (Berndt, 1979).

Turkstra, McDonald, and DePompei (2001) developed video stimuli to test social cognition in adolescents with TBI, based on social communication skills that adolescents identified as important in their social lives (Turkstra, 2000). The stimuli were 30-second video vignettes depicting adolescent actors in extemporaneous social interactions. Each interaction focused on positive or negative instances of one of six target behaviours: sincerity, humility, sharing talking time in a conversation, speaking at the level of the listener (i.e., taking his or her knowledge into account), being a good listener, and detecting nonverbal cues to end a conversation.

Adolescents with TBI were similar to their peers in their ability to detect social errors such as monopolising a conversation. However, they differed significantly in their ability to make mental state inferences, as most of the errors made by the adolescents with TBI were related to the detection of sarcasm and bragging, and the effects these behaviours had on the listener (i.e., first- and second-order ToM). The findings suggested that adolescents with TBI had impairments in ToM. There were two factors, however, that limited attribution of the results to a domain-specific impairment in social cognition.

The principal limitation in attributing ToM task errors to a domain-specific impairment in social cognition was that task performance could have been influenced by participants' cognitive impairments, including impairments in working memory and executive function. There has been considerable debate about the relations among executive function, working memory, and social cognition in individuals with acquired brain injury (e.g., Havet-Thomassin et al., 2006; Martin & McDonald, 2005; Rowe, Bullock, Pokley, & Morris, 2001), developmental disabilities such as autism (Mundy & Markus, 1997), and typical development (Mutter, Alcorn, & Welsh, 2006; Sabbagh, Xu, Carlson, Moses, & Lee, 2006). In many cases, correlations among tests of these three constructs are taken to indicate a relationship among the underlying constructs. An alternate hypothesis, however, is that the format of typical social cognition tasks places a significant load on working memory and executive function. Consistent with this, adults with frontal lobe injury perform more poorly on social cognition tasks with greater demands on working memory and inhibitory control (Apperly et al., 2004). Thus, as has been noted in studies of other cognitive processes (Sabers, 1996), it is difficult to differentiate shared constructs from shared variance due to measurement aspects of the tasks.

A second reason to question whether adolescents with TBI have domain-specific impairments in ToM is that they are similar to their peers in knowledge about mental states and their effects on behaviour (Turkstra et al., 2004). Thus, it was possible that the adolescents with TBI in the study by Turkstra and colleagues (2001) had the concept of ToM but failed to show it on a task that had a relatively high working memory demand.

In summary, there is emerging evidence of impaired social cognition in individuals with TBI, specifically impairments in ToM. However, the existing literature does not permit the differentiation of domain-specific impairments in social cognition from impairments in task performance due to cognitive deficits that are not specifically social. The evidence that adolescents' knowledge about mental states is relatively intact (Turkstra et al., 2004) raises the possibility that they simply fail to demonstrate that knowledge when asked to judge the behaviours of others in real time. The evidence of working memory impairments in this population further supports the notion that ToM task failure might reflect the interaction of measurement factors with cognitive impairments beyond ToM.

EVIDENCE OF ToM IN DISCOURSE

One potential source of information about ToM is adolescents' conversations, specifically their use of words that reflect an appreciation of their own and others' mental states. There is a large body of research examining discourse in individuals with TBI (see review by Coelho, Ylvisaker, & Turkstra, 2005), including studies linking discourse features to neuropsychological functions such as inference and synthesis ability (Chapman et al., 2004; Dennis & Barnes, 1990) and executive function (Brookshire, Levin, Song, & Zhang, 2004; Chapman, Levin, Wanek, Weyauch, & Kufera, 1998), as well as to psychosocial outcomes (Galski et al., 1998; Togher, Hand, & Code, 1996). To the authors' knowledge, however, discourse analysis has not been used to study ToM in individuals with TBI.

Methods for analysing ToM in discourse may be found in studies in other populations. For example, Johnston, Miller, and Tallal (2001) assessed ToM in children with specific language impairment (SLI), by examining their use of cognitive state predicates on a narrative task. A cognitive state predicate is a verb or verb phrase that asserts something about the cognitive state of the subject (e.g., "he *thinks* he will go", or "I *made her* do it"). Cognitive state predicate use provides evidence of ToM abilities because an understanding of the underlying cognitive state is implied in the use of the term. The study aim was to examine the role of language in the development of ToM, given prior evidence that ToM is in part dependent on talk about mental states (see review by Miller, 2006).

Johnson and colleagues (2001) found that children with SLI used cognitive state predicates as frequently as peers matched for grammatical knowledge, but less frequently than peers matched for age and nonverbal IQ. The results were interpreted as support for the view that some level of syntactic knowledge might be necessary for the acquisition of mentalising ability (Tager-Flusberg, 1999). Consistent with this, there is some evidence that adults with very severe SLI perform poorly on language-based ToM tests (Clegg, Hollis, Mawhood, & Rutter, 2005). When language demands are controlled, however, individuals with SLI perform normally on false belief tasks (Colle, Baron-Cohen, & Hill, 2007; Miller, 2004). Further, individuals with TBI developed their language skills prior to injury, so it is unlikely that their errors on social cognitive tasks are due to underlying syntactic deficits.

The present study used the analysis approach described by Johnson and colleagues (2001) to search for evidence of mental state knowledge in the conversational discourse of adolescents with TBI. The study hypothesis was that, given the high probability of injury to structures considered essential for ToM, as well as evidence of ToM impairments in other, similarly injured groups (Rowe et al., 2001; Shamay-Tsoory et al., 2005; Stone et al., 1998; Stuss et al., 2001), adolescents with TBI would use fewer mental state terms than their peers, reflecting a true deficit in social cognition. As language form typically is not affected in children and adolescents with TBI (Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987), and the participants would have developed peer-appropriate social knowledge prior to the injury, one might argue that impairments on ToM tests could reflect measurement aspects of the tests (i.e., the influence of domain-general cognitive factors) rather than a domain-specific deficit in ToM. Differences in extemporaneous use of mental state terms, however, would lend support to the notion that adolescents with TBI have true impairments in understanding mental states.

METHOD

Participants

The participants were 24 adolescents: 16 with TBI and 8 typically developing peers matched for age and race. Participant details are listed in Tables 1 and 2. Participants were recruited from area schools, community sources, and two level-I trauma hospitals. They were required to have no history (pre-morbidly in the case of adolescents with TBI) of language or learning disability, special education services, gifted status, or psychiatric or neurologic disorder affecting cognitive function. All were speakers of Standard American English and reported no hearing loss or uncorrected loss of visual acuity. Participants with TBI had sustained a moderate to severe TBI at least 6 months prior to the study and after the age of 2 years. The age criterion was chosen so that differences in ToM abilities could be attributed to a change from premorbid abilities rather than failure to develop ToM.

The participants were divided into three groups: (1) adolescents with TBI whose scores were two or more standard deviations below the mean for typically developing (TD) adolescents on the ToM task used in the study by Turkstra and colleagues (2001) ($n = 8$; TBI-Low Group); (2) adolescents with TBI whose scores were within one standard deviation of the mean for TD adolescents on the ToM task ($n = 8$; TBI-High Group); and (3) TD adolescents who also had scores within one standard deviation of the typical mean on the ToM task ($n = 8$; TD Group). Average scores for the ToM task are presented in Table 1. The rationale for the inclusion of the two TBI groups was to differentiate the general effects of TBI from specific impairments in social cognition. Participants in the two TBI groups did not differ significantly in age, $F(2, 21) = .01$, age at injury $t(8) = 1.06$, or time since injury, $t(8) = -1.54$, all ps $> .05$, and were similar in the proportion of moderate vs severe injuries.

The three groups were approximately equal in the proportion of males vs females. The parents of 13 participants provided employment and education information (TD, $n = 4$; TBI-High, $n = 5$, TBI-Low, $n = 4$), and a Kruskal-Wallis Test revealed no significant difference across groups in scores on the Hollingshead four-factor index of socioeconomic status (Hollingshead, 1975), $\chi^2(2) = 1.18$, $p > .05$.

TABLE 1
Participant demographic characteristics

	TD (n = 8)	*TBI-High* (n = 8)	*TBI-Low* (n = 8)
Mean age	17.22	17.32	17.37
Males:Females	5:3	6:2	5:3
Race			
African American	2	1	2
Caucasian	5	7	6
Latino or Hispanic	1	0	0
Partner			
Peer	5	2	3
Project staff	3	6	5
Percent correct on ToM task (*SD*)	93.32 (4.91)	93.63 (3.51)	76.25 (2.66)

TABLE 2
Injury characteristics for participants with traumatic brain injury (TBI), derived from medical records and participant or parent report

Participant	*Age at test y,m*	*Age at injury y,m*	*Time post injury y,m*	*Cause of injury*	*Injury severity*
TBI-High 1	13,6	9	4,6	Hockey accident	Moderate
TBI-High 2	15,9	3,6	12,3	Fall	Severe
TBI-High 3	16,6	13,7	2,11	Pedestrian-MVA	Severe
TBI-High 4	16,11	5	11,11	Fall	Moderate
TBI-High 5	18,1	17	1,0	MVA	Severe
TBI-High 6	18,2	15,0	3,2	Ejected from car	Moderate
TBI-High 7	18,4	12,6	5,10	Assault	Severe
TBI-High 8	21,10	20,10	1,0	MVA	Severe
TBI-Low 1	13,7	12,6	1,1	Fall from bicycle	Moderate
TBI-Low 2	14,6	11,2	3,4	Pedestrian MVA	Severe
TBI-Low 3	16,9	12,10	3,11	MVA	Severe
TBI-Low 4	16,10	10,0	6,10	Pedestrian MVA	Moderate
TBI-Low 5	17,7	16,5	1,2	MVA	Severe
TBI-Low 6	18,7	17,9	0,10	MVA	Severe
TBI-Low 7	19,9	18,2	1,7	MVA	Severe
TBI-Low 8	20,4	17,10	2,6	MVA	Severe

MVA = motorvehicle accident.

Elicitation of conversations

Each participant was instructed to engage in a videotaped conversation with either a partner of his or her choice or one of the project staff members. The number of peer vs project staff member partners is presented in Table 1. The researcher asked each participant to talk for at least 1 minute about each of three topics, and told the participants that anything they said in the conversations would be kept confidential. The participants were allowed to choose their own topics, or topics were suggested by the researcher based on previous studies of adolescents' conversations (Turkstra, 2000). Typical topics included movies, friends, music, sports, the weekend, or events at school or work. A researcher timed the conversations out of view of the participants, and asked participants to change topic after the first natural break in conversation past the 1-minute mark. Three different topics were used to minimise any potential confound associated with topic choice. For example, one of the conversational partners might not have much to say on a given topic, which might bias talking time data.

All procedures were approved by the institutional review boards corresponding to the participant recruitment sources.

Analysis of language transcripts

Transcripts were analysed using the Systematic Analysis of Language Transcripts (SALT Version 8.0), a computer program developed at the University of Wisconsin-Madison (Miller & Chapman, 1994–2004). The software was developed for efficient analysis and interpretation of language samples. SALT allows analysis of the structural forms of language, pragmatic behaviour, and semantic content, including lexical, syntactic, semantic, pragmatic, rate, fluency, and error categories. The language of one or more speakers can be analysed in the same transcript, and then compared to a reference database.

A dedicated SALT program was designed for this project, based on the Predicate Coding Program (PCP) used by Johnston and colleagues (2001). The PCP was a complex search routine that was used within SALT to locate the logical predicates in a language sample and then classify each predicate according to its possible meanings. The PCP contained a lexicon of 700 surface predicates that are used by children aged 0–5 years, including terms such as *forget*, *pretend*, *understand*, and *wish*. Each conversation was transcribed and segmented into utterances by trained transcribers, then submitted to SALT for analysis. For each transcript, SALT generated a list of cognitive predicates that occurred within that transcript.

Examination of the transcripts revealed a variety of cognitive state terms beyond predicates (e.g., *desperate*, *funny*, *bored*). These terms also reflect awareness of thoughts of self and others, and therefore were added to the SALT search list. The final list of cognitive state terms is presented in the Appendix. Two examiners checked each word to determine whether it was being used to describe a cognitive state, as some of the words identified by SALT could be used either as cognitive state terms or to describe physical states or serve as fillers. For example, the word *know* can be used as a cognitive predicate in the context of "Did you *know* that since my mom passed away, they all moved around", or as a filler as in "Go to the mall, you *know*, like I always do". After the SALT analysis, the transcripts were examined by hand by both investigators, to ensure that all terms found were describing cognitive states and no terms were overlooked. The inter-rater agreement for identification and categorisation was 97.5%.

The main dependent measure was the total number of cognitive state terms used divided by the total number of utterances. An utterance was defined as a unit that would lose its essential meaning if divided further or as an independent clause and its modifiers (Miller & Chapman, 1994–2004). This was done to account for any potential differences in the length of the conversations. The number of cognitive state terms was compared across the three groups using a one-way analysis of variance (ANOVA). The specific hypothesis was that participants in the TBI-Low group would use fewer cognitive state terms in conversation than those who scored within the typical range on the ToM task (the TD and TBI-High groups). The criterion alpha level was 0.05 and data were analysed using SPSS (2005) statistical software. For descriptive purposes, several of the standard language measures available in SALT were also calculated.

RESULTS

The results for the standard language measures and cognitive state terms are presented in Table 3, and the results for cognitive state terms vs ToM task scores are shown in Figure 1. The three groups were similar on the standard language variables examined, including the type-token ratio, a measure of lexical diversity. For the use of cognitive state terms, there was a main effect of group, $F(2, 21) = 3.76$, $p < .05$. Post-hoc comparisons revealed a significant difference between the TBI-Low group and both the TBI-High group, $t(7) = -2.26$, $p < .05$, ES = 1.20, and the TD group, $t(7) = -2.13$, $p < .05$, ES = .93. There was no significant difference between the TD and TBI-High groups, $t(7) = .33$, $p > .05$. The lack of a significant difference was

TABLE 3
Average data for SALT standard language measures and use of mental state terms

	TD	*TBI-High*	*TBI-Low*
Words	340.50 (89.37)	433.75 (168.55)	310.88 (227.59)
Different Words	138.75 (41.45)	155.75 (49.88)	117.25 (62.45)
Type/Token Ratio	.50 (.08)	.45 (.06)	.49 (.11)
Mazes	9.25 (5.85)	12.00 (5.78)	9.25 (10.95)
Utterances	47.25 (14.36)	59.38 (12.63)	44.75 (12.94)
Mental State Terms	16.38 (8.83)	22.38 (8.12)	10.25 (5.87)
Mental State Terms/Utterance	.35 (.15)	.37 (.09)	.22 (.11)

TD = typicallydeveloping; TBI = traumaticbrain injury. Standard deviations are in parentheses.

unlikely to be due to insufficient power, as a sample size of 568 would be required to detect a significant effect with a power of .80, alpha = .05.

The group differences were not an artifact of the topics of conversation, as participants in all three groups spoke about similar topics. These topics could be grouped into six categories: entertainment (music, movies); personal plans, interests, or events; work or school; family and friends; world events; and the immediate context (e.g., directions to the research lab). The most common topics in all three groups were personal events and opinions, as might be expected given the topics suggested to participants. Movies, music, and other types of entertainment, and personal events, opinions, and plans were the main theme of 61% of the conversations in the TD group, 83% in the TBI-High group, and 57% in the TBI-Low group.

Another potential influence on the results was the effect of partner, given the difference in the proportion of peer vs research staff partners across the three groups. For example, a participant might have been more likely to talk about thoughts and feelings if his partner was known to him, and also might be more likely to talk about personal information (i.e., use more self-directed cognitive state terms) in that context. This was unlikely to explain the differences between the TBI-Low group and the other two groups, given that the two TBI groups had a similar proportion of peer vs researcher partners; however, to confirm this, data for peer vs partners were compared. The individual cell sizes did not permit a two-way ANOVA of group by partner, so two exploratory one-way ANOVAs were completed.

There was no significant effect of partner on cognitive state term use, $t(22) = 0.01$, $p > .05$. The average number of cognitive state terms was .31 ($SD = .14$) for project staff member partners and .31 ($SD = .13$) for peer partners. Given the high degree of similarity in means and standard deviations, the lack of a significant difference was unlikely to be a reflection of lack of statistical power.

To further explore the nature of the group differences in cognitive state term use, two secondary analyses were completed. First, transcripts were analysed to determine if participants used equal proportions of self- vs other-directed terms. Self-directed terms described the speaker's own cognitive state, for example "*I think* that's good". Other-directed terms described the cognitive state of another person, for example "*She knows* a lot about sports". The percent of self-directed cognitive state terms was 80.22% in the TD group, 88.46% in the TBI-High group, and 69.85% in the TBI-Low group. The relative proportion of self- vs other-directed cognitive

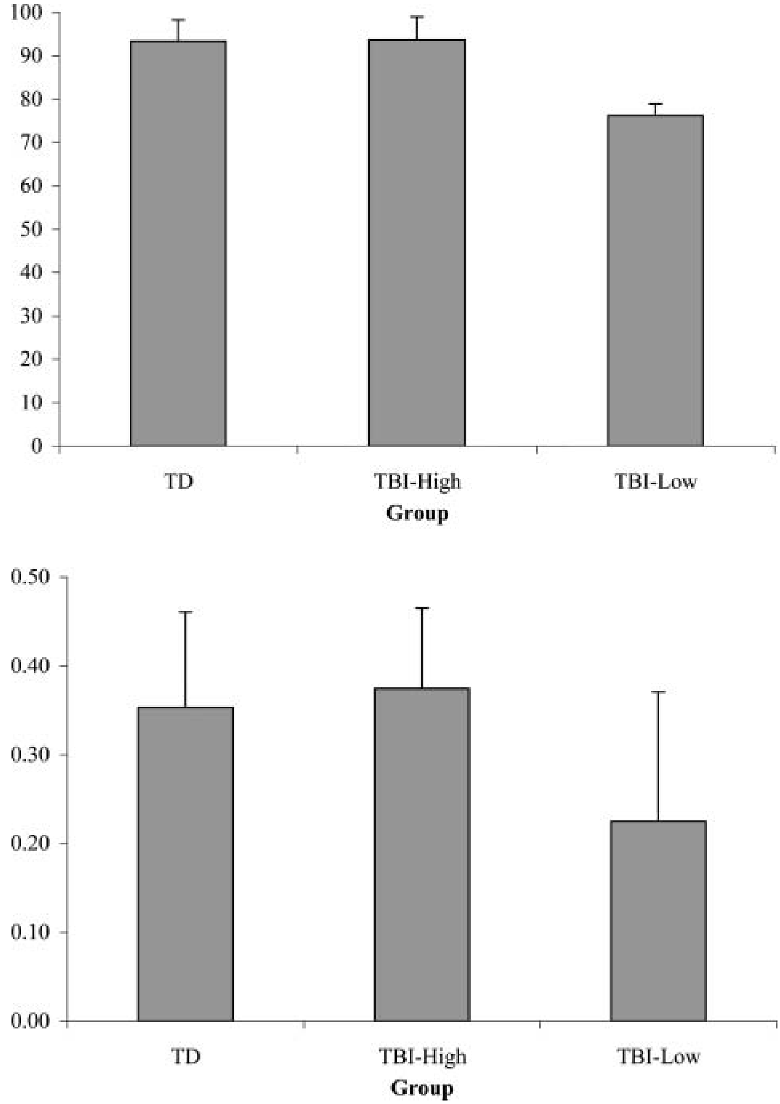

Figure 1. Percent correct on Conversation Task (upper graph) and proportion of mental state terms per utterance in conversation (lower graph).

state terms differed significantly across groups, $\chi^2(2) = 8.04$, $p < .05$. The TD and TBI-High groups did not differ significantly from each other, $\chi^2(1) = 1.27$, $p > .05$; and there were significant differences between the TBI-Low group and both the TBI-High group, $\chi^2(1) = 8.04$, $p < .01$, and the TD group, $\chi^2(1) = 6.78$, $p < .01$.

There was no significant effect of partner on the percent of self-directed cognitive state terms, $t(22) = .92$, $p > .05$. The average percent of self-directed comments was 74.75 ($SD = 20.53$) for research staff partners, and 81.13 ($SD = 13.98$) for peer partners. In this case, the lack of a significant difference might be due to the small sample size, as a power analysis indicated that a significant difference with a power of .80 could be obtained with a total sample size of 90.

The second analysis was to compare types of cognitive state terms, using the original classification scheme of Johnston and colleagues (2001). These authors classified terms in the following categories: (1) cognitive state terms that referred to the knowledge state of the speaker, listener, or a third party (e.g., *know*, *think*); (2) evaluative terms (e.g., *cool*, *pretty*); (3) terms that referred to a change in knowledge state (*remember*, *forget*); (4) terms describing actions that would change one's own mental state (e.g., *guess*, *learn*); and (5) communication terms (e.g., *convince*). A sixth category of modal terms (e.g., *should*, *gotta*) was added, as these were not included in the original study by Johnston and colleagues but were produced by the present participants.

The number of cognitive state terms in each category, divided by the total number of utterances, is shown in Table 4. The distribution of term types was similar across groups. That is, most of the terms used by participants in all three groups referred directly to their own or others' mental states. Evaluative terms were also used by all three groups. Verbs referring to changes in mental states were relatively rare, as were verbs referring to communication events. Modal verbs likewise were relatively rare.

DISCUSSION

The purpose of this study was to compare adolescents with TBI to their peers, in their use of cognitive state terms in conversation. It was hypothesised that adolescents with TBI who had low ToM test scores would also use fewer cognitive state terms in conversation than their peers with higher scores, consistent with underlying ToM deficits. The results supported the hypothesis. Participants with TBI who performed poorly on the ToM test also used significantly fewer cognitive state terms than either typically developing participants or peers with TBI who had age-typical scores on the ToM test. It was unlikely that this was due to differences in access to cognitive state vocabulary, as the three groups were similar on a measure of lexical diversity, and speech and language impairments are relatively rare after traumatic brain injury (Ewing-Cobbs, Fletcher, Levin, & Landry, 1985). The differences between TBI groups were not due to differences in injury severity, at least as measured by hospital admission data, as most of the participants in both TBI groups had injuries that would be classified as severe. Also, injury severity is only

TABLE 4
Percent of t-units containing each type of cognitive state term

	TD	*TBI-High*	*TBI-Low*
Cognitive state	16.40	19.37	11.58
Evaluation	10.58	9.68	3.37
Change in cognitive state	0.00	2.95	0.63
Action that causes change in cognitive state	3.17	2.32	0.42
Communication event	2.65	1.47	0.63
Modal verbs	2.12	1.68	0.84

TD = typicallydeveloping; TBI = traumaticbrain injury.

one of many predictors of long-term outcome after paediatric TBI (Keenan & Bratton, 2006).

The findings are consistent with the results of previous studies, which have revealed social cognitive impairments in individuals with acquired brain injury across a variety of tasks (Bibby & McDonald, 2005; Bird et al., 2004; Happé et al., 1999; Havet-Thomassin et al., 2006; Rowe et al., 2001; Shamay-Tsoory et al., 2005; Stone et al., 1998; Stuss et al., 2001). Although the results suggest that adolescents with TBI have a primary deficit in ToM, it should be noted that unstructured conversation places significant demands on working memory and other aspects of executive function, and perhaps this prohibited participants with cognitive impairments from expressing their true ToM skills. In conversation, a speaker needs to keep track of the topic, what he or she wants to say and has already told the other person, as well as the other person's verbal and nonverbal feedback. This is in addition to the demand for cognitive state inferences, including inferences about the partner's background knowledge and interest in the topic. Working memory and executive function have been shown to relate to discourse macrostructure in both typically developing adolescents and their peers with TBI (Brookshire et al., 2004; Van Leer & Turkstra, 1999), and affect performance on false belief tasks in adults with TBI (Apperly et al., 2004). This should be addressed in future research by either varying conversational task demands or factoring cognitive test scores into the between-groups analysis.

A noteworthy limitation of the study was that the conversation elicitation task was uncontrolled. This was done to allow participants to choose their preferred topics, so that the data would not be confounded by factors such as interest in or knowledge about the topic. The risk of allowing participants to choose is that topics might not be comparable in the extent to which they elicited cognitive state terms. However, it appears that this was not the case in the present study, as topics were similar across the three groups.

Another potential limitation was the difference in partner characteristics across groups. There were more project staff partners in the TBI groups than the TD group, and there was a trend for participants who conversed with staff partners to use more other-directed cognitive state terms. This trend might have been significant in a larger sample, as indicated by the power analysis. Although the relationship between conversation partners is an important factor to control in the future, it did not account for differences between the TBI groups, as these two groups differed in cognitive state term use, despite the similar distribution of peer vs researcher partners.

Although the identification of brain–behaviour relations was not the purpose of this study, future research might consider whether differences in lesion location underlie performance on both the social cognition and communication tasks. As discussed earlier in this paper, social cognition has been linked to prefrontal cortex function in both human and animal studies, and in both typical and disordered groups. Thus, it would be useful to identify individuals with primarily frontal vs extrafrontal lesions, and consider patterns of behaviour in these two groups, as has been done previously (e.g., Levin et al., 2004). Such a study would inform consideration of basic mechanisms of social cognition and communication.

Age at injury and time since injury likewise would be of interest to consider further in future studies. Participants were matched for age at the time of their participation, so this did not account for differences between TBI groups, and all but two participants with TBI were injured after the time at which the most sophisticated comprehension of mental states is thought to be achieved (i.e., comprehension of faux pas). The two participants who were injured before age 9 had both conversation and mental state scores that were average for their group; that is, they were not outliers in regard to their comprehension or use of mental state terms. These findings argue against meaningful age effects, at least in this age range. However, there was a trend for those with lower ToM scores to have had more recent injuries ($M = 32$ vs 64 months prior to study participation). Perhaps they would be expected to improve over time. The purpose of the present study was to relate use of mental state terms to social cognitive ability, rather than to examine change over time. This would be of interest in future studies, however, to further examine the interaction of spontaneous recovery, development, and educational and rehabilitative interventions. The potential effects of parental education and socioeconomic status would also be worth exploring, as education has been found to relate to pragmatic communication skills in normal adults (Zanini, Bryan, DeLuca, & Bava, 2005).

Analysis of the types of cognitive state terms used by participants revealed mixed results. Participants with lower ToM test scores used relatively fewer self- vs other-directed mental state terms than those in the other two groups. This might suggest that they were less likely to reflect on their own thoughts and feelings, which is consistent with the metacognitive impairments often reported in individuals with TBI (Hanten, Bartha, & Levin, 2000; Kennedy & Yorkston, 2000). This is a small sample size, however, and further research is needed to define the relation of awareness and metacognitive skills to social cognition in discourse. Also, participants with lower scores used similar types of cognitive state terms, including modal verbs indicating obligation and words such as *mean* (i.e., *intend*). Thus, they did not appear to lack concepts of cognitive states overall, which is consistent with the fact that they were injured after ToM had developed. The use of a more detailed qualitative coding scheme might help to develop a cohesive picture of how individuals with TBI are using cognitive state terms, and when they are not. This might include differentiation among one's own vs others' desires, beliefs, and emotions, as has been done previously in studies of children's development of ToM (Adrian, Clemente, Villanueva, & Rieffe, 2005).

CONCLUSIONS

In this study, adolescents with TBI who performed poorly on a test of ToM detection also used significantly fewer cognitive state terms in conversation than did either their typically developing peers or their peers with TBI who had high scores on the ToM test. This finding suggests that adolescents with TBI may have impaired ToM abilities, or at least that they are less likely to demonstrate ToM in contexts beyond standard tests. Further, given the evidence that pragmatic communication and social cognition skills are related to outcomes beyond the laboratory, including social integration (Galski et al., 1998) and perceived communication competence (Watts & Douglas, 2006), the results raise questions about the daily social interactions of adolescents with TBI, and how their social communication might be perceived by others.

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APPENDIX

Mental state terms used by participants: 1 = TDgroup, 2 = TBI-High, 3 = TBI-Low.

allow 1	feel 2, 3	learn 2	stand 2
alright 2	figure 1, 2, 3	let:me 1, 3	stupid 2
amazing 2	find 2	like 1, 2, 3	sucks 2
answer 1	fine 1	love 2	supposed to 1,2, 3
ask 1, 2	forget 3	mean 1, 2, 3	sure 1, 2, 3
awesome 2	forgot 3	miss 2	surprise 1
bad 1, 3	fun 1, 2	need 1, 2, 3	talk 2
believe 3	funny 3	nice 1, 2	tell 1
best 3	gay 3	nuts 3	think 1, 2, 3
better 1, 2, 3	good 1, 2, 3	point 2	thought 2
bored 2	got:to 1	pretty 1	trouble 1
clue 1	gotta 2	remember 2, 3	wanna 2
convince 1	great 1	retarded 2	want 1, 2, 3
cool 1, 2	guess 1	right 1, 2	well 1
decide 3	hate 3	say 1, 2, 3	wonder 2
desperate 2	have:to 1, 2, 3	scared 2	worried 2
dumb 1	hope 2	see 1, 3	worst 1
enjoy 1	into 2	should 2	yell 1, 2
favorite 1, 2	know 1, 2, 3	show 1, 2, 3	