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Theory of Mind in Mild Traumatic Brain Injury

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Theory of mind (ToM) or the ability to think about other people's mental states to understand and predict others' behaviour is a part of social cognition. The social and communicative impairment is a natural consequence of ToM deficit. Those who have sustained a Traumatic Brain Injury (TBI) have been found to demonstrate difficulties in everyday social interactions and communications. The presence of these difficulties, which are thought to be associated with ToM deficits, raises the question of whether patients with TBI have impairment in ToM. The present study investigates ToM in eight adult subjects with frontal lobe damage, following mild TBI across first and second order tasks of ToM in Malayalam. The results add to the growing evidence that more attention should be focused on employing additional tests of ToM during evaluation and address these deficits during the management of communication and social deficits.

Keywords: Theory of mind, Traumatic Brain Injury, First order tasks, Second order tasks

Human behaviour is a system of complex and dynamic interactions requiring an innate, and highly developed cognitive capacity (Adolphs, 2001). In order to grasp and execute rules of this complex system, an aspect known as social cognition is required. Social cognition (or social intelligence) is defined as the ability to interpret others' behaviour in terms of mental states, to conceptualise relationships between oneself and others, to use these concepts to guide one's own behaviour, and predict that of others (Baren-Cohen et al., 1999). It has been suggested that this ability may be independent of general intelligence, with different information processing demands (Adolphs, 2001; Baron-Cohen et al., 1999). One key aspect of social cognition is Theory of mind (ToM). It refers broadly to the ability to understand others' emotions, motivations, and thoughts and to understand their behavior accordingly (Bibby & McDonald, 2005). This ability helps an individual to think about other people's mental states (eg. thoughts, beliefs, intentions, and desires) and use them to understand and predict others' behaviour. A wide range of different approaches have been used to assess ToM. These approaches have varied in terms of factors such as subjects they were designed for (ranging from normal adults to children with autism) and their capacity to distinguish between different developmental levels of ToM (eg. first-order, second-order and applied uses of ToM inferences).

The specific mechanism and neural pathways of ToM are not well understood (Happe, Malhi, & Checkley, 2001) and remain controversial. A considerable amount of evidence from imaging studies has suggested that the frontal lobe activity is necessary for this ability (Goel, Grafman, Sadato & Hallett, 1995; Channon & Crawford, 2000). There are evidences that provide considerable support for the role of the right frontal lobes in ToM as well (Tranel, Bechara, & Denburg, 2002; Stuss, Gallup, & Alexander, 2001).

Theory of Mind is a part of social cognition, and social impairment is a natural consequence of a deficit in ToM. Specifically, a ToM deficit has been linked to difficulties using gestures to affect how others feel as well as taking account of others' interests in conversation (Fletcher et al., 1995), withdrawal from social contact (Happe et al., 2001), insensitivity to social cues, indifference to others' opinions, poor foresight, egocentrism, lack of restraint and inappropriate affect (Rowe, Bullock, Polkey, & Morris, 2001), pedantic speech, inappropriate non-verbal communication and inability to follow social rules (Bowler, 1992), and difficulty applying theoretical social knowledge to the real situation (Stone, Baron-Cohen & Knight, 1998). Furthermore, research has suggested that impaired ToM may also be

associated with communication difficulties. In particular, it has been linked to problems comprehending non-literal speech, such as sarcasm, irony, humour, and deceit (e.g. Channon & Crawford, 2000; Happe, 1993).

One group that has been found to demonstrate many of the social and communication difficulties outlined above are people who have sustained a traumatic brain injury (TBI). Subjects with TBI have been shown to have impaired social competence (Spatt, Zebenholzer, & Oder, 1997); to be socially isolated (Lezak, 1995); and to have difficulties with non-literal language (Dennis, Purvis, Barnes, Wilkinson, & Winner, 2001). They have also been described as having poor insight, talkativeness and inappropriate expressions of affection (Santoro & Spiers, 1994); reduced empathy (Eslinger, 1998); lack of foresight, tact and concern (Lishman, 2001); egocentrism and inappropriate levels of social interaction (McDonald & Pearce, 1996); impaired understanding of non-verbal signals (Lezak, 1995); and difficulty applying social knowledge (Dimitrov, Grafman, & Hollnagel, 1996). The overlap between these observations and the social difficulties thought to be associated with ToM deficits raises the question of whether patients with TBI have impairment in ToM.

Existing research on ToM deficits in TBI is very limited, with many studies on acquired impairment of ToM, explicitly excluding TBI patients (eg. Mazza, De Risio, Sudan, Roncone, & Casacchia, 2001). In one of the few published reports that included subjects with TBI, Stone et al., 1998 demonstrated a specific (i.e. dissociable) impairment on more difficult ToM tasks ("faux pas" tasks) in five TBI patients with bilateral damage to the orbito-frontal cortex. However, Bach, Happe, Fleminger, and Powell (2000) did not find evidence of a ToM deficit in a TBI subject with acquired orbito-frontal damage and social problems. The interpretation of much of what people say and do is affected by the social context in which it takes place. This comprises the setting, the people present, the relationship among them, and their beliefs, and intentions. Despite intact ability to process syntactic and semantic aspects of language, there is a lack of processing of pragmatic communication in patients with TBI. Therefore, it is clear that further research is merited to examine the possibility of a specific ToM deficit after TBI which could be an attributing factor for the communication & social interaction difficulties.

Need for the study

Ability to interpret pragmatic language appropriately in social interactions is fundamental to successful functioning in many aspects of everyday life, and is commonly disrupted by brain damage. These interpersonal communication problems may be linked, in part, to deficits in theory of mind (ToM), the ability to accurately perceive the attitudes, beliefs, and intentions of others. Most of the previous studies assessing ToM to date have focused on developmental trends in young children or impairment in clinical population with social deficits (eg., those with schizophrenia, and autism). There is very little known about the changes in ToM that accompany adult traumatic brain injury, especially in the Indian context. The behavioural, communicative, and social changes observed after a traumatic brain injury are usually a greater burden for relatives than physical or cognitive impairment. The finding of a specific ToM impairment in TBI would provide further evidence for currently accepted concept of modular nature of ToM. It would also have important implications for the rehabilitation of social difficulties in this group. The present study attempts to investigate social cognition in TBI patients using two theory of mind (ToM) tasks.

Objectives:

1. Do subjects with Traumatic Brain Injury (TBI) demonstrate impairment in making inferences about other people's mental states (ToM) as compared to normal individuals?

2. And, if so, is there a performance difference in the TBI subjects between the two tasks of ToM, that is, First order ToM and Second order ToM?

Method

Participants:

Eight patients with TBI (6 males, 2 females) with mean age of 46.12 years were recruited for the present study. The mother tongue of all participants is Malayalam and they were right

handed, and had suffered a mild head injury, with the testing being done 4-15 days post-head injury. Demographic details of the patients given in Table-1 show the participant's age, gender, occupation, and handedness along with the clinical features. Clinical records and informal clinical evaluation revealed that they did not have severe amnesia, aphasia, or agnosia, and their basic cognitive processes were grossly intact at the time of testing. Eight control subjects were also recruited from relatives of brain injury subjects and general community who were similar to patients in demographic profile. They had no history of neurological or psychological problems or severe head injury and were chosen similar to the demographic details of the TBI subjects.

Table 1. Demographic details and clinical characteristics of TBI subjects (N=8)

No	Age	Occupation	Etiology	Site of lesion	Time-post injury (days)
1	35	Lecturer	RTA	Left frontal	10
2	55	Nurse	RTA	Subarachnoid	12
3	48	Business	RTA	Left frontal & occipital	8
4	84	Business	Fall	Left frontal	4
5	18	Student	RTA	Sub arachnoid	15
6	29	Paramedical	RTA	Left frontal	10
7	40	Business	RTA	Left frontal	4
8	60	Business	Fall	Right frontal	8

RTA – road traffic accident

Design and Procedure:

The study was approved by the concerned hospital. All participants gave their informed consent prior to inclusion in study. Subjects were each tested in a single session of 20 minutes in a less noisy and less distractive room environment.

Two types of ToM tasks were used namely, First-order ToM stories and Second-order ToM stories. One story of each type was given to all the patients and control groups. The stories were drawn from previously published studies (adapted from Sullivan, Winner & Hopfield, 1995). Each story was one to two paragraphs long and described characters involved in a range of activities such as buying an ice-cream and household chores. First order ToM related to character's lack of knowledge about a physical situation (e.g.: a practical joke).The Second order ToM stories related to character's knowledge (or lack of knowledge) about another characters beliefs or intentions (eg.: buying an ice-cream).

Each subject was asked four questions one after the other. In the case of the ToM stories, the questions were as follows:

(1) A general question implicitly requiring an inference to be made about a character's mental state. Subjects were asked to explain the character's words or actions, although the reason behind these actions had not been directly stated in the story.

(2) A follow-up question explicitly asking about mental states.

(3) Two further follow-up questions. These also explicitly referred to mental states, but were presented in a forced choice format (yes or no). For each story, the correct answer to one of the questions was yes and the other no, so that the possibility of response bias could be excluded.

Stories were in the order of First-order ToM story, followed by Second-order ToM story. The entire story was repeated once if the subject requested it. No other assistance was given and although general encouragement was provided throughout the session, no feedback was given about the correctness of the answers. All subjects with TBI and controls were tested individually and their responses to questions were recorded verbatim using a digital voice recorder and which was later broadly transcribed for analysis.

Results

As revealed from Table-3, for the first order task, the mean values for all the parameters including implicit question, explicit question, and forced choice were higher for controls than subjects with TBI. Statistically, there was a significant difference between controls and TBI subjects on all the parameters of implicit (.002), explicit (.009) and forced choice questions (.009) with sig 2-tailed value lesser than 0.05. Similarly, on second order task, as indicated in the Table, it can be deduced that the mean values for implicit question, explicit question, and forced choice were lower in subjects with TBI as compared to controls. Statistically, significant differences were

Table 2: Comparison of the mean values of first-order and second-order story tasks between TBI and controls:

	First order story task			Second order story task		
	TBI	Control	t	TBI	Control	t
Implicit Question	.437 (.320)	.937 (.176)	3.864*	.187(.258)	.937(.176)	6.769*
Explicit Question	.250 (.377)	.750 (.267)	3.055*	.187(.258)	.875(.353)	4.438*
Forced-choice Question	.500 (.462)	1(.000)	3.055*	.312(.372)	.937(.176)	4.292*

* p<.05

observed between the two groups on all measures of implicit, explicit, and forced choice questions with sig 2-tailed value lesser than 0.05. On comparison of mean values across tasks within the TBI group, higher values are obtained in first order compared to second order.

Discussion

The present study was conducted to investigate whether patients immediately (10-15 days post trauma) after TBI, demonstrate deficit in the domain of ToM, and if so, how much is the difference and whether the performance varies on the tasks used. The findings of the current study reveal that there is a significant impairment in subjects with TBI compared to controls and on ToM tasks; performance on first order was relatively better compared to second order task of ToM though poorer than control subjects.

Poorer performance in TBI, compared to adults, suggests that subjects with TBI have an impairment in the ability to make inferences, which are consistent with reports of impaired reasoning and problem-solving in this group (Lezak, 1995). This impairment could probably be attributed to the social and communication difficulties present. Many studies in the literature have reported similar findings; however, the clinical population that was studied was of severe category (Channon & Crawford, 2000; Bibby & McDonald, 2005). The presence of ToM deficits in even mild TBI calls attention for greater focus on this aspect of deficit in TBI. Except one case, all the cases had lesion after the traumatic brain injury in frontal lobe. This is consistent with neuroimaging studies of presence of ToM deficits in frontal lobe lesions. (Rowe et al., 2001) and supports the role of frontal lobe in theory of mind tasks.

On comparison across the tasks, poor performance on both tasks in TBI gives an indication that there is a broad and general impairment in inference making. However, the subjects' performances on first-order ToM stories were relatively better compared to second order task. This raises the possibility that people with TBI may also have a specific ToM impairment underlying their variation in performance on verbal first-order and second order tasks. This finding is consistent with a number of previous studies that have claimed to have identified a specific ToM impairment in subjects with TBI (Channon & Crawford, 2000). Thus, the current study increases confidence in their claims and illustrates the importance of including evaluation of ToM across various tasks. Even so, despite the apparent independence of first-order ToM and second order ToM, both types of tasks were performed poorly in comparison with controls. Therefore, it remains unclear as to whether the varied ToM performance was, indeed, indicative of a specific weakness or continued to reflect broader deficits in TBI.

The variation in performance across tasks in the present study also indicates the difference in performance on easier versus difficult task. The first-order stories are those in which the main character has acted on a false belief and second-order stories are those in which the main character has acted on a belief about a belief. The second-order stories, a more complex task, require the subject to demonstrate understanding of what one person thinks another person believes ("Raju thinks that Radha thinks. . . "). This understanding is claimed to underlie the ability to distinguish a lie from a joke (Sullivan et al., 1995). It has been suggested that performance on more developmentally advanced ToM tasks provides an index of the severity of the deficit (with milder deficits picked up by more challenging tasks) (Stone et al., 1998). Studies in other clinical

population have found that some high functioning people with autism can pass first-order tasks but will fail second-order ones (Happe, 1993) and others have found that RHD patients' ToM impairment is restricted to second-order tasks (Happe, Brownell, & Winner, 1999).

Qualitative observation revealed that language demands of the questions were significantly related to performance on ToM tasks. Out of types of questions used in each of the story tasks (implicit, explicit, and forced choice), forced choice questions were slightly better in scores than implicit and explicit in both first and second order tasks, which may indicate probably less complex questions that help elicit more accurate responses. However, in controls, not much variation was observed across types of questions. Thus, it is clear that performance on ToM tasks is influenced by the language demands of the tasks. This is consistent with research, emphasising the importance of language for ToM development in children (e.g. Garfield, Peterson, & Perry, 2001). However, this results of the study are preliminary to comment on whether the language demands of the ToM task determine poor performance as all the subjects included in the study were having good verbal output at the verge of discharge from the hospital.

Previous studies done on ToM assessment tasks in TBI had included subjects who completed six months post injury at the time of testing (Bibby & McDonald, 2005). Even though the average duration post injury in the current study is less than two weeks, the finding of impaired ToM implies the necessity of focusing upon ToM tasks at the earliest post injury, once the medical condition is stable, so that the outcome of ToM deficits on social and communication abilities can be focused upon and treated. Consistent with previous studies, the present study also found that literacy played a role in better performance in tasks, the higher the educational level, higher the scores were obtained.

The present findings have implications for the rehabilitation of social and communicative impairments after TBI. The study suggests that a range of factors may impact TBI patients' social and communicative performance. This suggests that, rather than simply applying an existing rehabilitation program to train ToM ability (such as those that have been developed for people with Asperger's syndrome (Attwood, 1998) and schizophrenia (Sarfati, Passerieux, & Hardy-Bayle, 2000), rehabilitation of social & communicative deficits after TBI requires a comprehensive individual assessment, keeping in mind the above findings to determine which factors are impacting on that individual's difficulties. Treatment should be then tailored to address and/or compensate for those identified factors.

Conclusion

The findings of this study show that individuals with TBI do demonstrate impairment on tasks requiring them to make inference about other's mental states. This impairment manifests at first order and second order level of inference with greater deficits at the second order level. It is also revealed that impairment is dependent on the nature of questions that are used to assess the ability of ToM. These deficits in the capacity to infer mental states of others are likely to lead into serious problems in social and communicative functioning in this clinical condition. The results, add to the growing evidence that more attention should be focused on employing additional tests of TOM during evaluation and the need address these deficits during management of communication and social deficits.

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