



Theory of Mind in Adults with Traumatic Brain Injury

Seyyedeh Maryam Fazaeli,¹ Seyed Amir Amin Yazdi,^{2,*} Shahla Sharifi,¹ Davood Sobhani-Rad,³ and Mohammad Reza Ehsaei⁴

¹Department of Linguistics, Ferdowsi University of Mashhad, Mashhad, Iran

²Department of Psychology, Ferdowsi University of Mashhad, Mashhad, Iran

³Department of Speech Therapy, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran

⁴Department of Neurosurgery, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

*Corresponding author: Department of Psychology, Ferdowsi University of Mashhad, Mashhad, Iran. E-mail: yazdi@um.ac.ir

Received 2017 January 23; Revised 2017 July 24; Accepted 2017 September 06.

Abstract

Context: Theory of mind (ToM) is one of the social cognition skills. Deficits of ToM in individuals with traumatic brain injury (TBI) impact adversely on their social functioning and generally, their life style.

Objectives: The current study aimed to assess ToM skill among adults with TBI.

Data Sources: The terms of traumatic brain injury, head injury, closed head injury, head trauma, social cognition, theory of mind, mind reading, and adult were searched in databases of PubMed, PubMed Central, Google Scholar, ScienceDirect, Taylor and Francis Online, Willey Online Library, and Springer.

Data Selection: The inclusion criteria were the recruitment of adult subjects with TBI and relevance to ToM skills. Exclusion criteria were relevance to the other social cognition (other than ToM) and non-social cognition skills in TBI, and relation to ToM skills in children and adolescents with TBI.

Data Extraction: Type of study, sample size, task name, type of task, control question, and results were the main categories considered in the current review.

Results: The current review study covered 35 articles about different types of ToM impairment in individuals with TBI. The majority of the studies were case-control comparisons on ToM in TBI populations regardless of the lesion location, including story-based tasks. TBI patients are impaired in mental state inference (ToM), and non-mental state inference.

Conclusion: Patients with TBI were impaired in mental tasks (ToM) and non-mental tasks (more in non-mental verbal tasks compared with non-verbal ones), which indicated that persons with TBI had no special impairment in ToM skills.

Keywords: Social Cognition, Theory of Mind, Traumatic Brain Injury, Adults, Systematic Review

1. Context

This section addresses the following issues: traumatic brain injury (TBI), theory of mind (ToM) skill, and tasks of ToM. TBI is one of the acquired brain injuries, a non-degenerative and non-congenital injury to the brain caused by external mechanical force (1). TBI results from motor vehicle accidents, battles, assaults, and accidents (2). TBI, the main cause of disability in the world, is a life-changing event. Effects of TBI might be categorized as physical, mental, memory, emotional problems, and behavior changing (3). Cognitive deficit is another consequence of TBI (4).

The ToM, as a human cognitive ability, is biologically programmed to evolve during the special developmental stages in healthy human beings (5). It is believed that ToM ability has a domain-specific nature (6). It is argued that

the ability to explain and interpret others' behaviors is the core of human relationships (7). Theory of mind is a form of social cognition (4). Social cognition enables people to predict others' behavior, share the experiences and have effective communication (2). Theory of mind is an ability to attribute mental states such as beliefs, desires, and intentions (8) to self and others and use this knowledge to predict and explain behaviors and actions (9). According to the brain lesion studies, frontal lobes have a fundamental role in ToM abilities (10-12). Furthermore, ToM depends on a large brain network that consists of parietal-temporal areas (13).

Theory of mind has a multidimensional functioning and thus, different tasks are considered for its assessment (14). The first-order false belief task refers to the ability to differentiate between own belief and other person's beliefs (15). Success in this type of tasks is by the age of four (14,

16, 17). Failure of three-year-old children in standard tasks of false belief is due to their limitation in language knowledge (18). The second-order false belief is more complex than the first-order false belief, and refers to the ability to infer what a person is thinking on the third person's belief (15). Understanding of this level of ToM occurs by the age of six or seven years (19). Social faux pas test (10) is a more complicated task than the second order false belief. This test is designed for children aged nine to eleven years (14, 20). "Reading the minds in the eyes" is another task of advanced ToM (21), albeit it only involves the first stage of ToM, and attribution of mental states would only target part of ToM (22). This advanced ToM test is used in the studies related to children (22) and adults (23, 24).

TBI is one type of the brain injuries related to ToM. In other words, lesions after TBI occurrences can be different according to the size, location, and various causes that might underline ToM poor skills in patients with TBI (25).

Most frequently, behavioral disorders following TBI include disinhibition, irritability, aggression, sexual acting out, reduced anger control, immature behavior, egocentrism, rigidity, impaired social perception, social awkwardness, depression, and social isolation (26). Following TBI, effective rehabilitation of behavioral disorders depends on identification of factors involved in the formation of those behavioral disorders (27). One of these factors is ToM. Since deficit in this cognitive skill imposes familial, social, and professional burden, it necessitates understanding of the ToM deficits after TBI.

2. Objectives

Psychosis, behavioral disorders, and sometimes, physical impairments caused by TBI received the most attention; while little is paid to deficits of social cognition such as ToM from TBI in the sustained persons. Although ToM disorders create serious difficulties in personal and social lives of this clinical population, ToM deficits in individuals with TBI lead to problems in their social functioning and generally, their life style. The current study aimed at reviewing all of the studies (as far as authors know) investigating the nature of ToM impairments in adults with TBI.

3. Data Sources

Preferred reporting items for systematic reviews and meta-analyses (PRISMA) is a standard guideline including 27 items for systematic and meta-analysis reviews (28). As with all research methodologies, the current study followed this protocol to review the studies. The current review study used articles collected from PubMed, PubMed

Central, Google Scholar, ScienceDirect, Taylor and Francis Online, Wiley Online Library, and Springer. English keywords were traumatic brain injury, head injury, closed head injury, head trauma, social cognition, theory of mind, mind reading, and adult.

4. Data Selection

Inclusion criteria to select articles were: a, conduction on adult patients with TBI; and b, relation to ToM skill. Exclusion criteria for articles were: a, relation to the other social cognition (other than ToM) and non-social cognition skills in TBI; b, relation to ToM skill in children and c, adolescents with TBI. There were two reasons to consider only adults' ToM skill: 1, adults use linguistic and cognitive resources to understand ToM which are different from those of children (29); 2, in adolescents, there is a progressive development of social cognition including ToM skill; hence, the adolescents' performance would show a lower accuracy than that of adults (30). In the reviewed studies related to adults with TBI, participants aged 16 to 68.

5. Data Extraction

Reviewing the selected articles was conducted according to a data extraction form developed by the researchers in line with the aims of the study. These cases were type of study, sample size, name of task, type of task, control questions, and results.

6. Results

The current study just searched the articles published until 2015. The oldest article belonged to 1994. Selection stages of studies are displayed in Figure 1. Regarding the keywords, 94 articles were found in the databases. After removing duplicate articles, 66 articles remained and titles and abstracts of them were read. After excluding 23 articles, the remaining 43 were studied closely. According to the exclusion criteria, 35 records were studied in the current review study; 29 articles were specific to TBI regardless of lesion sites and six articles were specific to local lesions caused by TBI.

7. Discussion

In the examined studies, various tasks were used to assess ToM in persons with TBI including 32 story-based verbal tasks, 10 video-based verbal tasks, 20 picture-based tasks including verbal and non-verbal, one questionnaire-based task and one conversation-based task. Evidently,

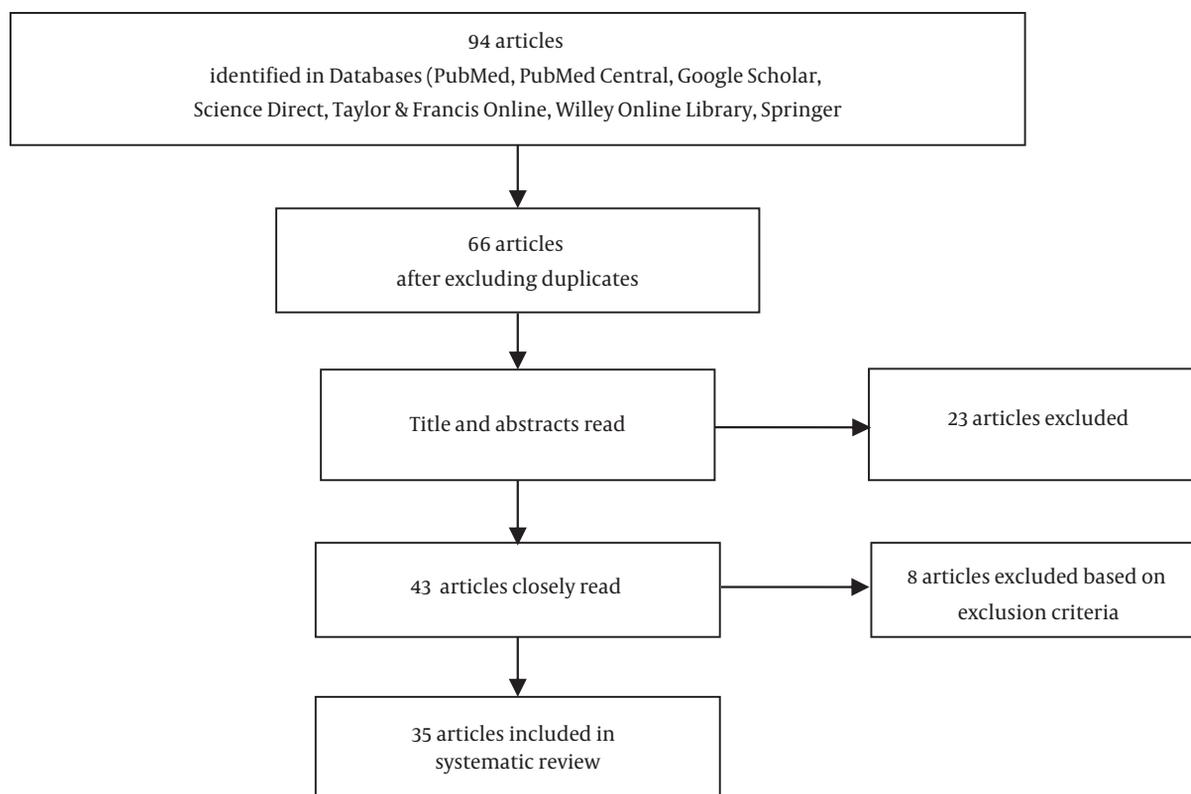


Figure 1. Article selection process flowchart

to appraise ToM in TBI, the number of verbal tasks was more than that of non-verbal ones. It seems that non-verbal tasks are particularly sensitive to identification of ToM skill, whereas verbal ones demand language skills. If individuals with TBI are not impaired in language abilities, the verbal tasks of ToM would be especially able to recognize ToM skill. An advantage of video-based conversational interaction tasks is that conversation formed between two or more characters and participants (persons with TBI) can observe the real conversation in visual and auditory situations, simultaneously. Nonetheless, in the verbal story tasks, the participants with TBI only see and listen or see and read the interactions between the characters that should be visualized in their minds. An advantage of the story- and visual-based tasks compared to 'reading the mind in the eyes' is that the former involves the situation in which participants should judge the situations from the third person perspective while in RME, participants should be the judge of mental states presented in the target pictures (31).

Some ToM tasks have control questions without demanding mental states inferences in their answers. These

questions are used to make sure that responding to these questions requires general comprehension of tasks apart from mental state understanding (32). In the examined studies, 17 ToM tasks had the control questions. Although in most of studies, individuals with TBI were not impaired to answer such questions, there were some exceptions in this case (4, 33, 34). For example, due to working memory load of some tasks and problems in individuals with TBI, the patients might not process the story correctly. Therefore, they might not have sufficient correct input to substantiate their belief. Another explanation might be due to the deficit in patients with TBI language skills, which might cause difficulties to understand the contents of the stories. Therefore, it cannot be firmly said that patients with TBI have a specific ToM impairment (33). In some studies (27, 31, 35), the findings of control questions were not mentioned.

Tasks of ToM might be studied from the perspective of memory load in the individuals with TBI. In some studies (36-38), the examiner provided participants with the printed cartoon or text in front of them, read each story out loud and the participants answered the questions. Fur-

thermore, in the task of reading the minds in the eyes, the task was in front of the participants; there was no memorization. Nature of some tasks did not require memory loads and control questions such as conversation-based task (39). In general, to examine ToM skill, particularly in TBI, the tasks are recommended without memory load.

Furthermore, ToM tasks might be examined based on ToM components: cognitive ToM and affective ToM (40-42). Cognitive ToM refers to 'cold cognition' and includes the knowledge about others' beliefs or intentions (43, 44). The cognitive component of ToM, assessed through false-belief or hinting tasks, requires cognitive understanding of the difference between speakers and addressees' knowledge (15). Affective ToM refers to 'hot cognition' and assesses others' emotional states (43, 44). The affective component of ToM is usually evaluated by irony and faux pas tasks, and requires additional 'empathic assessment' of the listener's emotional state (knowledge about emotions) (15). Some studies on adults with acquired damage (44-46) and healthy adults (47, 48) mentioned the dissociation between cognitive and affective aspects of ToM. Therefore, it is claimed that impairment in ToM might be selective. According to the suggested model by Shamay-Tsoory et al. (42), cognitive ToM is a prerequisite for affective ToM, which requires cognitive and emotional aspects of empathy as well. According to the investigated studies, individuals with TBI were not impaired in the first-order false belief tasks (cognitive ToM) (33, 49). However, Bibby and McDonald (36) reported that their participants with TBI were impaired in this task. Moreover, individuals with TBI were impaired in the second-order false belief tasks (cognitive ToM) (33, 36, 37). Faux pas recognition task evaluates cognitive and affective ToM. Individuals with the lesion in orbito-frontal cortex caused by TBI remained intact in the affective aspect (10). On the other hand, individuals with TBI were impaired in both aspects of ToM in this task (4, 31, 35, 50). In 'the awareness of social inference test' (cognitive and affective ToM), persons with TBI were impaired (35, 51-53). In advanced task of 'reading the mind in the eyes' (affective aspect), individuals with TBI were impaired (25, 31, 33, 38, 51, 53-56). However, in the study by Milders et al. (57) participants with TBI were not impaired in 'reading the mind in the eyes'. According to Havet-Thomassin et al., (55) this may be due to the application of the original version of Baron-Cohen et al. task (21) in the study by Milders et al. (57). The revised version (22), improved the power to detect subtle individual differences in social sensitivity (55). Cartoon test (58) included both cognitive and affective aspects (59) that individuals with TBI were impaired in. Nevertheless, according to Bach et al. (27) persons with TBI and without behavioral disturbance were intact in cartoon test (cognitive and affective ToM) and ToM

stories. These researchers asserted that ToM ability can be preserved despite behavioral disturbance. Additionally, individuals with TBI were impaired in inference intention task and character intention task (33, 55) that assess cognitive ToM. Persons with TBI were impaired in 'awareness of social context' (32) that includes both cognitive and affective ToM. Also, Zhang et al., (60) attested that persons with TBI were impaired in cognitive and affective ToM. Ilaria et al., (61) indicated that patients with TBI were impaired in cognitive but not affective ToM. Such studies show that ToM impairments in TBI might be selective.

Moreover, some ToM tasks have two parts: mental state/ mentalistic/ mental inferences, non-mental/ physical inferences in cartoon test (58), strange stories (62), and stories ending with human actions or control physical events rather than sarcastic or sincere remarks (63), faux pas stories and no faux pas stories in faux pas recognition test (10), and intention attribution and logical conditions in character intention task (64). According to the studies, individuals with TBI were impaired in mentalistic inferences and faux pas stories (4, 31, 33, 35, 50, 63, 65). In some studies, TBI persons were not impaired in the non-mental/physical/logical inferences, no faux pas stories, and logical stories (4, 27, 33, 57, 63). On the other hand, individuals with TBI were impaired in the non-mental/physical inferences and no faux pas stories (27, 36, 50, 66). Impairments of persons with TBI in the mental and non-mental inferences indicated that these individuals were not just impaired in ToM, but in inferring ability (36). Further experiments and studies, using a broader range of tests to assess ToM skill could shed more light on problems that patients with TBI are dealing with. Further studies should focus on:

- 1, distinguishing between cognitive and affective ToM can be effective in explaining the behavioral deficits in persons with brain injury (67). By studying cognitive and affective components of ToM, it might be easier to figure out the patients' difficulties. Therefore, a therapist can focus on the impaired aspect and provide the appropriate treatment plans for it. This type of time-saving treatment is economical and can be used for the intact component of ToM in persons with TBI for the rehabilitation purposes;
- 2, paying more attention to reaction time in ToM tasks;
- 3, conversation as a social activity in which ToM skill might play an important role. Since conversation is one type of non-laboratory tasks and requires inferences about beliefs, intentions, and emotions of addressee, it is an ideal task to evaluate ToM in the clinical populations such as TBI (39). Therefore, it is suggested that many studies be conducted by conversational tasks to assess ToM in individuals with TBI besides laboratory tasks of ToM;
- 4, further studies could be conducted on evaluating functional dif-

ferences between male and female adults with TBI in performing ToM tasks; 5, the impairment differs in different severity levels in TBI. Therefore, studies could be conducted to investigate functional differences and the impairment in ToM between individuals with mild, moderate, and severe TBI.

7.1. Conclusion

Patients with TBI were impaired in mental tasks (ToM) and non-mental tasks (more in non-mental verbal tasks compared to non-verbal ones), which indicated that persons with TBI had no especial impairment in ToM skill, regarding the impairments of ToM related to TBI. Therefore, recognition of TBI impairments in ToM is valuable for clinicians, families of the patients with TBI and even the patients themselves. Therefore, it is necessary to pay more attention to ToM in clinical management of patients with TBI. In other words, cognitive competence has impact on the ability to process social information and social behavior. Hence, impairment in ToM among individuals with TBI might lead to impairment in social behavior. Focusing on ToM and eliminating or reducing its negative outcomes due to impairments in individuals with TBI would provide opportunities for this clinical population to find a job, get back to work, have a successful performance at home, work, and school, create new relationships with the others, and return to social activities.

Footnotes

Authors' Contribution: Seyyedeh Maryam Fazaeli contributed to reading the examined studies, designing and writing the primary draft of the manuscript. Seyed Amir Amin Yazdi and Davood Sobhani-Rad read the primary draft, revised it and then, approved the final version. Shahla Sharifi & Mohammad Reza Ehsaei read and approved the final version.

Conflict of Interest: The authors declared no conflict of interests.

Funding/Support: The study received no funding.

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