5-2022

Examination of Social Cognition Impairments in Adults with Traumatic Brain Injury through the Awareness of Social Inference Test performance

Brea Lenae Rivera

Abstract

Social cognition focuses on how people process, perceive, and apply information in social context in order to understand and infer their own behaviors and that of others. Impaired social cognition is a common, and often chronic, outcome of many neurological and psychiatric disorders, including traumatic brain injury (TBI). By lacking these social skills, there is a major disadvantage for social integration with others. In order to assess social cognition deficits in adult TBI populations, Part 1 and 3 of The Awareness of Social Inference Test (TASIT) were administered to examine social cognition impairments. A sample of 58 participants (28 TBI, 30 healthy control) were compared on their ability to accurately recognize emotions and interpret social situations. Mixed analyses of variance (MANOVA) revealed that those diagnosed with mild and severe traumatic brain injury may have difficulties with both basic aspects of social perception and more complex higher-order cognitive abilities when compared to healthy controls, showing less accuracy for both Part 1 and 3 of TASIT. These findings support previous literature that state how social perception deficits affect TBI populations, which has implications for both remediation of such impairments and for educating those who interact with people diagnosed with TBI.

Keywords: traumatic brain injury, social cognition, emotion recognition, social inferences

MONTCLAIR STATE UNIVERSITY

Examination of Social Cognition Impairments in Adults with Traumatic Brain Injury through The Awareness of Social Inference Test performance

by

Brea Lenae Rivera

A Master's Thesis

Submitted to the Faculty of Montclair State University

In Partial Fulfillment of the Requirements

For the Degree of

Master of Arts

May 2022

College of Humanities and Social Sciences

Department of Psychology

Thesis Committee:

[redacted]

Ruth E. Propper, Ph.D
Thesis Sponsor

[redacted]

Jean Lengenfelder, Ph.D

[redacted]

Erin Kang, Ph.D

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Montclair State University

Montclair, NJ

2022

Acknowledgements

Throughout this journey of completing this project, I received an overwhelming amount of support. I would like to start by thanking Dr. Jean Lengenfelder, for being my research mentor and being such an important part of my committee. Through her assistance, I have gained so much knowledge in the field of psychology, and I am forever thankful. Secondly, I would like to extend thanks to my committee chair Dr. Propper, who has given me endless opportunities to be successful. Without her support throughout my internship, none of this would even be possible! Lastly, I would like to thank Dr. Kang, who has been an awesome educator and committee member throughout my time in this program. I appreciate all the time and effort put into this project.

I would like to extend gratitude to my family for all of their support through my educational endeavors. Without my mother, father, and sister; I wouldn't be here today. It is through their love and care that I even had the strength to go forward. As the first person in my entire family to receive a master's degree; I truly hope I make them proud. They are in my heart and soul in everything that I do.

Contents

List of Tables

Examination of Social Cognition Impairments in Adults with Traumatic Brain Injury through The Awareness of Social Inference Test performance

Traumatic brain injuries (TBI) are defined as an alteration in brain function or other evidence of brain pathology caused by an external force (Azouvi et al., 2017). According to the Centers for Disease Control and Prevention (CDC), a TBI is caused by a bump, blow, or jolt to the head, or a penetrating head injury that disrupts the normal function of the brain and can occur from damage that is closed (nonpenetrating) or open (penetrating) (Centers of Disease Control and Prevention [CDC], 2014). TBIs are a serious healthcare problem, as individuals who survive TBI may suffer lifelong disability due to cognitive disorders and behavioral changes (Azouvi et al. 2017). Known as a leading cause of death and disability throughout the world, the leading causes of TBI include road traffic incidents, assault, sports-related injuries, and falls (Tiret et al., 1990). Typically, the demographic primarily affected by TBI are young adult males (15-25 years of age) after road-related incidents; but young infants and older adults are commonly affected after falls (Tiret et al., 1990).

The severity of a TBI is measured through the Glasgow Coma Scale (GCS) or by the duration of post-traumatic amnesia (PTA) (Teasdale & Bennet, 1974). By GCS standards, a score of 3-8 denotes a severe TBI, 9-12 for moderate, and 13-15 as mild (Jennett & Teasdale, 1981). As for PTA, TBI is categorized as severe if the duration is over 7 days, between 1 and 7 days for moderate, and up to 24 hours for mild (Capizzi et al., 2020). As previously noted, patients with moderate-to-severe TBI experience a wide range of deficits, including slowed information processing, impaired long-term memory, attention, working memory, executive functioning, self-awareness, and social cognition (Calvillo & Irimia, 2020). Though literature is expanding on this topic, little is known about whether TBI severity affects various aspects of

social cognitive processes such as emotion recognition (for universal emotions) and social inference.

Social Cognition and TBI

Social interaction is a foundational element of human behavior developed through the processing of complex stimuli. Interpreting social stimuli requires the ability to perceive, recognize, process and respond to social cues that can be subtle, multiple, contradictory, or changing (Beaudoin & Beauchamp, 2020). Known as "social cognition," adaptive social interactions depend on core cognitive functioning and mental abilities such as perception, language, memory, attention, and executive function. Social cognition is defined as "the ability to recognize, manipulate and behave with respect to socially relevant information (…and) requires neural systems that process perception of social signals and that connect such perception to motivation, emotion, and adaptive behavior" (Adolphs, 2001). There are several critical mechanisms within social cognition that facilitate this innate ability to connect and respond to one another. These include the ability to detect an emotion based on a facial expression, as well as more complex assessments such as having the ability to understand the internal state of another person, which is known as theory of mind (ToM) (Schingler, 2009). Furthermore, social cognition entails the ability to create representations of another person's mental state, such as their beliefs, intentions, feelings, and experiences, in order to flexibly guide social behavior (Adolphs, 2001). These mechanisms make it possible to recognize the emotional state of others, see a situation from someone else's perspective, demonstrate empathy, and be able to gauge the intentions of another's actions (McDonald, 2013).

As is the case with many areas of cognition, social capabilities can be impaired in a number of ways. Impaired social cognition is a common and often chronic outcome of many

neurological and psychiatric disorders, including TBI (Ubukata et al., 2014). Impaired social cognition has been reported in up to one-half of individuals with severe TBI, many of whom exhibit specific impairments in the ability to recognize emotions in faces and voices, self-reported difficulties in emotional empathy, and theory of mind (Honan et al., 2016). Poor social cognition is a deficit in patients with TBI, commonly characterized by: immature or inappropriate humor, self-focused conversations with a lack of interest in others, frequent conversation interruptions or topic shifts, blunt manner, inappropriate levels of self-disclosure, disinhibited remarks, and slowed comprehension of social information (McDonald et al., 2003). By lacking these social skills, there is a disadvantage for social integration with others that can lead to poor self-esteem or strained relationships. Adults with TBI experience various social perception deficits, such as the ability to accurately recognize facial emotions or infer emotional states based on someone's tone of voice (Jackson & Moffat, 1987). Furthermore, there are difficulties in higher-level facets, such as pragmatic inference or viewing a situation from another person's point of view (Dennis & Barnes, 1990; 2000). At yet another level of social perception, adults with TBI have been found to have difficulty inferring the intended meanings of verbal and nonverbal behavior when placed in context. Thus, people with TBI have been found to have difficulty recognizing faux pas and interpreting ambiguous advertisements, sarcastic remarks, and the nature of interpersonal relationships (Milders et al., 2003; Pearce et al., 1998).

Emotion Recognition and TBI

Social cognition includes a number of processes, including the ability to recognize emotions. The ability to produce and recognize facial expressions of emotion can be a vital component of interpersonal communication (Mancini et al., 2018). The universal emotions

include happiness, sadness, anger, fear, disgust, surprise, and contempt (Kohler et al., 2004), each with their own characteristics and appearance. These emotions are considered to be universally understood, as theorists have found consistent evidence for recognizing their expression within any population and culture (Ekman, 1970). Additionally, there are other emotions such as guilt, shame, arrogance, admiration, regret, interest, jealousy, and hatred. These are considered social emotions because they are culture-specific and spoken in some societies, but not in others (Dursun et al., 2010). Basic universal emotions can be distinguished as either positive or negative, considering that individuals may either want to avoid or experience specific emotions. Happiness and surprise are often classified as positive emotions, while sadness, anger, fear, and disgust are classified as negative (Dursun et al., 2010). As previously noted, the reduced ability to recognize others' emotions is a typical impairment in TBI patients. Facial expressions convey emotional cues, and accurate recognition of these cues aids in the subsequent application of appropriate social skills (Collins & Nowicki, 2001). It has been suggested that several domains of social cognition, including facial affect recognition, contribute to effective social competence (Addington et al., 2008).

Because facial expressions offer essential information in social interactions, it is helpful to know the extent to which individuals with TBIs experience impairments in this area. Babbage et al. (2011) conducted a meta-analysis that included 13 studies to determine the magnitude and frequency of emotion recognition impairments (specifically facial expression recognition) in adults with TBI. It was determined that 39% of people who sustained a moderate-to-severe TBI had significant difficulties recognizing facial expressions (Babbage et al., 2011). These findings make it clear that this is not a rare occurrence in adults with TBI and imply the importance of understanding the extent and repercussions of these cognitive limitations.

While impairments in emotion recognition have been found in TBI participants across varying severities (Ietswaart et al., 2008), it has also been noted that TBI severity is associated with an increased deficit in facial expression recognition performance. Rosenberg et al. (2015) assessed facial emotion recognition in individuals with moderate-to-severe TBI through the emotion recognition task (ERT). This measure incorporates a series of morphed facial expressions of gradually increasing intensity. Consistent evidence was noted between emotion recognition impairment and injury severity with a positive correlation, such that those with severe TBI demonstrated significantly poorer recognition performance compared with participants with moderate or mild TBI. The TBI group was worse overall in emotion recognition performance when compared to matched controls (Rosenberg et al., 2015).

Furthermore, it has been found across several studies that accuracy in emotion recognition can depend on the category of the emotion. Williams and Wood (2010) assessed the ability to accurately recognize facial expressions through the Emotion Evaluation Test (EET) and Ekman 60 Faces Test (E-60-FT). It was found that the TBI group was significantly impaired compared to the control group when recognizing emotions on both tests. In terms of specific emotions, TBI participants did not have any impairments in identifying positive facial expressions when compared to healthy control populations. In contrast, deficits were observed when identifying negative emotions such as anger, fear, and disgust. This may be attributable to negative emotions requiring more elaborate processing, as they share more distinctive features. Consequently, if head trauma affects emotional processing, recognition accuracy may be more difficult compared to positive emotions (Williams & Wood, 2010). These previous studies show that TBI groups experience emotion recognition deficits when compared to healthy control populations. Still, it is not entirely clear if these complications are dependent on TBI severity.

Additionally, there are conflicting findings on how emotion categories contribute to recognition deficits, especially when detecting negative emotions. The current study addresses these drawbacks by assessing emotion recognition abilities in a TBI sample with mild and severe diagnoses with all emotion categories.

TASIT (The Awareness of Social Inference Test)

It would not be possible to understand social cognition and its mechanisms without psychometrically validated measures. A measure that explores one of these mechanisms is The Awareness of Social Inference Test (TASIT). This is a clinically sensitive, ecologically valid measure of basic emotion perception and social cognition (Honan et al., 2016). This test assesses social cognition through videotaped vignettes that mimic everyday interactions (McDonald et al., 2004). Similar to real-world situations, TASIT uses audio-visual recordings of everyday conversations to assess aspects of social cognition in a single measure, such as emotion perception and theory of mind assessments. Consisting of three parts, TASIT examines the ability to interpret emotional expression from nonverbal information, as well as interpret social inference through exchanges and interactions (McDonald et al., 2003). Part 1, the Emotion Evaluation Test (EET), is used to assess a subject's ability to recognize the six basic emotions: happiness, sadness, anger, fear, disgust, surprise (and neutral) (Ekman, 1973). It consists of 28 video vignettes lasting 15-60 seconds each that depict actors enacting scripts that illustrate the six basic emotions.

Parts 2 and 3 of TASIT assess theory of mind (ToM) by aiming to understand more complex aspects of social cognition, such as evaluating the beliefs and intentions of the speaker or understanding the meaning of conversational exchanges. Part 2, The Social Inference-Minimal Test (SI-M), tests the ability to understand sincere or sarcastic exchanges. After viewing each

vignette of a social interaction, participants were required to answer questions about the speaker's feelings, beliefs, intentions, and meaning (later referred to as feel, think, intend, and mean questions, respectively) (McDonald et al., 2003).

Part 3, the Social Inference-Enriched Test (SI-E), is a more complex version of Part 2, consisting of 16 vignettes (between 15-60 seconds each) that present conversational exchanges in which all vignettes contain messages that are literally not true, presenting as either sarcasm or lies. Similar to SI-M, half the scenes are sarcastic exchanges, while the remainder depict a speaker who is lying (usually kindly) such that they intend the literal message to be accepted, although it is contrary to what they believe (Honan et al., 2016). Part 3 contains additional cues to assist in the comprehension process, providing additional information on the protagonist's beliefs and knowledge of the situation (McDonald et al., 2003). The contextual clues were either visual edits to indicate the actual state of affairs or a prologue that reveals the speaker's true thoughts. Similar to SI-M, comprehension for SI-E is tested by answering questions about the speakers' feelings, beliefs, intentions, and the meaning of their statement. This test is administered to assess social inference (Honan et al., 2016). To sum, TASIT offers valuable insight into an individual's abilities to perceive both basic and more complex emotions.

TASIT AND TBI

As previously discussed, the occurrence of social cognition deficits in TBI populations is critical and using TASIT to assess social perception following a TBI can be beneficial in a variety of ways. Through this test, there is a basis for understanding the probable coexistence of the relationship between emotion processing, ToM deficits, and social reasoning in TBI populations. McDonald & Flanagan (2004) tested 34 adults with severe TBI on parts 1, 2, and 3 of TASIT. For Part 1 (EET), TBI participants demonstrated significantly decreased performance

in comparison to control participants, as TBI participants were less accurate in identifying every emotion (happiness, sadness, anger, fear, disgust, surprise). Similar patterns were seen in performance on Parts 2 and 3, the social inference tests. The TBI participants performed less well than the control participants, especially in Part 3. This study revealed that social perception deficits exist in a significant proportion of people with severe TBI, including deficits in understanding basic emotions, subtle emotions, speakers' beliefs and intentions, and the meaning of conversational inference (McDonald & Flanagan, 2004). As most studies focus on moderate to severe TBI, research conducted by Theadom et al. (2019) examined social cognition deficits in populations with mild TBI four years post-injury. A sample of 121 TBI participants was assessed. To enable the comparison of social cognition skills with people without TBI, norms were selected from the normative database of TASIT. Each control was age-matched to an individual in the TBI sample within a 5-year age range (Theodom et al., 2019). One in five people with mild TBI experienced social inference difficulties 4-years post-injury. Scores on the SI-E, Part 3 of TASIT, denoted lower scores for the TBI sample compared to age-matched norms with a small effect size (Theadom et al., 2019). It is evident that there is a significant difference in social cognition capabilities and facial emotion recognition in TBI populations compared to healthy control subjects. A setback of these previous studies includes the limited TBI populations, as most do not test groups that consist of varying severities and instead choose to focus on one (mild, moderate, or severe). Furthermore, previous work by Theodem et al. (2019) utilized normative data from a database instead of testing a healthy control population. Additionally, this study only completed a TASIT assessment four years post-injury of a mild TBI, so it remains unclear as to when social cognition deficits emerge following mTBI and

whether they improve, decline, or remain stable over time. The current study addressed these drawbacks by testing a chronic TBI group that varied in severity and length of injury.

Current Study

In the current study, findings from previous literature on social cognition following TBI were extended through the use of TASIT. This study addressed the limitations of earlier studies and offers novel contributions to the topic of social cognition in TBI populations. This was done by testing a TBI group consisting of severe and mild participants, as opposed to focusing on only one population. In addition, this study compared a TBI group directly to a healthy control population that was matched for age and education as opposed to normative TASIT data. Lastly, the current research included a chronic TBI sample with a wide range of months since the injury. By testing this TBI group, social cognition is assessed across different TBI severities with varying months post-injury; which further fills the gap in understanding various populations of TBI patients and their impairments. In order to evaluate all of these proposals, two hypotheses were tested:

H1. When compared to a healthy control group; individuals with TBI would be less accurate in their ability to recognize emotions displayed by actors in Part 1 of TASIT (happiness, sadness, anger, fear, disgust, surprise).

H2. Individuals with TBI would be less accurate in their ability to interpret questions about the feelings, beliefs, intentions, and meanings of the actors' exchanges in Part 3 of TASIT when compared to a healthy control group.

Method

Participants

A total of 58 participants (13 females, 45 males) between the ages of 20 and 65 (*M* = 39.62, *SD* = 14.01) participated in this study. There were 28 individuals with TBI (4 females, 24 males) and 30 healthy control participants (9 females, 21 males). The education in years ranged from 11 to 20 (*M* = 15.05, *SD* = 1.97). This was a sample of chronic TBI participants whose months since injury ranged from 7 to 412. The average amount of months post-injury was 125.43, which is around 10 years (*SD* = 102.50). Recruitment of participants occurred via the Kessler Foundation between December 2019 and December 2020. To be eligible for this study, participants had to be between the ages of 18-65, have a confirmed diagnosis of mild or severe TBI, and could read and speak English fluently. Diagnoses were confirmed by medical records obtained through Kessler Foundation. Exclusion criteria included having a prior stroke or neurological disease, having a history of a significant psychiatric illness, or having a significant alcohol or drug abuse history. All participants completed a consent form prior to testing. This data is a subset from a larger randomized controlled trial that examined the effects of an emotional processing training program in persons with TBI. All subject information had been de-identified, and this research was IRB approved via the Kessler Foundation.

Materials

This study utilized a desktop computer in a standardized format, with all subjects using the same desktop computer in a testing room provided via the Kessler Foundation. Vignettes directly from TASIT (parts 1 and 3) were viewed on a computer screen with the examiner in the room. Each participant was tested individually. Part 1 consisted of the Emotion Evaluation test, which included 28 vignettes between 15-60 seconds each in order to assess recognition of the six basic emotions: happiness, sadness, anger, anxiety (fear), revolt (disgust), surprise, and neutral (Ekman, 1973). There were four vignettes each for the seven emotions that were being assessed.

Participants were required to decide which emotion was represented after watching the vignette once.

Part 3 consisted of the Social Inference-Enriched Test (SI-E), which included 16 vignettes between 15-60 seconds, each showing conversational exchanges. All vignettes contained messages that were literally not true and contained either sarcasm or a lie. Similar to Part 1, the vignettes were viewed on a computer screen with the examiner in the room. Participants were tested using Form B of TASIT (see Appendices A, B, and C).

Procedure

All participants were tested individually. Standardized instructions from the TASIT were read that explained to the participant that he or she would be shown a video of people interacting and that they would be asked questions about these interactions. After each vignette, the video was paused, and verbal responses from the participant were collected and recorded by the examiner. For Part 1, participants had to choose the emotional expression that was presented in the vignette. For Part 3, after viewing each vignette, participants were required to answer four questions that assessed the target actor's feelings, beliefs, intentions, and meaning (referred to as feel, think, do, and say questions). The responses to these questions could either be yes, no, or "I don't know." Part 3 included vignettes depicting actors lying, while others contained sarcastic exchanges. Additionally, vignettes that presented lies were accompanied by some type of contextual clue (prologues or visual edits) to provide more information to the scene. The questions for each vignette were carefully worded, and pilot tested (McDonald et al., 2003) to be simple to understand (see Appendix B).

Results

Part 1: Emotion Evaluation Test

To determine group differences in emotion perception between TBI participants and healthy control participants, a 2 (Group: TBI vs. Healthy Control) x 7 (Emotion: Happiness vs. Sadness vs. Fear vs. Anger, vs. Disgust vs. Surprise vs. Neutral) mixed analysis of variance (MANOVA) was conducted. For Part 1, "happy," and "surprised" were considered positive emotions and "sad," "angry," "anxious" and "revolted" were considered negative emotions. Overall, for all emotions tested in Part 1, there was a difference between groups and their ability to accurately identify emotions (Total Correct: $F(1, 56) = 13.430$, $p = .001$). In examining performance on positive or negative emotions, there was a significant difference between TBI and HC on their ability to correctly identify positive emotions $F(1, 56) = 6.409$, $p = .014$. Additionally, there was also a significant difference between TBI and HC on their ability to correctly identify negative emotions, $F(1, 56) = 12.323$, $p = .002$. When examining performance on each of the six emotions and the neutral condition, a significant difference between TBI participants and healthy controls when identifying five of the six emotions was found (happy, surprised, sad, anxious and revolted; see Table 1). Differences between groups when identifying angry facial emotions approached significance, and there was no significant difference between groups when identifying neutral expressions. Denoted by the means, TBI participants identified fewer correct emotions in a positive direction in comparison to HC (see Table 1).

Part 3: Social Inference-Enriched Test (SI-E)

To determine group differences between TBI participants and healthy control participants in their abilities to detect both lies and sarcasm in Part 3 of TASIT, a 2 (Group: TBI vs. Healthy Control) x 2 (Vignette: Lies vs. Sarcasm) within factors analysis of variance (ANOVA) with 4 factors (do, say, think, and feel) was conducted. Overall, there was a difference between the

groups and their ability to accurately answer questions about lies (Total Correct: $F(1, 56) = 7.916$, $p = .007$) and sarcasm (Total Correct: $F(1, 56) = 9.135$, $p = .004$.) When examining performance on each of the 4 questions when vignettes displayed lies, a significant difference was found between TBI participants and healthy controls when accurately identifying the speaker's feelings (feel). There was no significant difference between groups when identifying the speaker's intentions (do), meaning (say), and beliefs (think). When examining performance on each of the 4 questions when vignettes displayed sarcasm, a significant difference was found between TBI participants and healthy controls when accurately identifying the speaker's intentions (do), meaning (say), and feelings (feel) were found. There was no significant difference between groups when identifying the speaker's beliefs (think). Denoted by the means, TBI participants identified fewer correct questions in the positive direction in comparison to HC (see Table 2).

Discussion

The goal of this study was to further the existing body of work on social cognition deficits in individuals with mild and severe TBI. This was done by utilizing the clinical assessment tool known as TASIT, The Awareness of Social Inference Test. Previous to this study, there were several gaps in the literature in terms of participant and TBI characteristics. First, it addressed the need for research on social cognition in TBI populations that tested groups of both severe and mild cases of TBI simultaneously. Second, it added further insight by comparing these groups directly to a healthy control group that was matched for age and education instead of comparing them to normative TASIT data. Finally, it addressed the need for research on TBI patients with a wide range of severities and duration since the onset of TBI symptoms. To do all of this, two hypotheses were tested:

H1: When compared to healthy controls, individuals with TBI would be less accurate in their ability to recognize emotions displayed by actors in Part 1 of TASIT.

H2: Individuals with TBI would be less accurate in their ability to interpret questions about the feelings, beliefs, intentions, and meanings of the actors' exchanges in Part 3 of TASIT when compared to a healthy control group.

Hypothesis 1 was supported by the results of this study. In the emotion recognition tasks in Part 1, the results depict differences in groups for both positive and negative emotions. Those with TBI had difficulty recognizing all emotion categories compared to the healthy control group except for anger and neutral, as both of these expressions did not yield significant differences between groups. Previous literature has found that those diagnosed with moderate-to-severe brain injury may have difficulties with both basic and more complex higher-order social cognitive abilities (Honan et al., 2016). These findings support previous literature. However, the finding that those with TBI did not differ significantly from control in their ability to recognize anger and neutral differed from previous reports that found particular impairments in negative emotions such as fear, anger, and sadness (Hopkins et al., 2002; Jackson & Moffat, 1987; McDonald et al., 2003). Having the ability to accurately identify angry emotions may be due to negative recognition bias, as angry faces can be universally interpreted as signals of threat or danger in our environment (Surcinelli et al., 2006). These findings offer clinical implications that those with TBI may benefit from emotion recognition interventions to improve their abilities to detect and interpret emotions, such as facial affect recognition or emotional prosody tasks.

The results from Part 3 confirmed hypothesis 2. When compared to healthy control subjects, the TBI group had a difficult time accurately understanding someone else's feelings, beliefs, intentions, and meaning in certain interactions when the other person was using sarcasm

meant to amplify the truth or using a lie to conceal or minimize the truth. The findings from Part 3 reveal that the individuals with TBI are worse in their ability to judge a speaker's feelings when interactions consist of either lies or sarcasm in comparison to healthy control subjects. More specifically, TBI participants had a more difficult time determining the speaker's intentions, meaning and feelings when they were being sarcastic as opposed to them lying when compared to healthy controls. This might indicate in broader TBI populations that lies are easier to detect than sarcasm, considering that the vignettes depicting lies were presented with a contextual clue that provided the participant with extra information. When answering questions about vignettes that show lies, TBI participants may have had more understanding of what is explicitly true due to the contextual clues, whereas the vignettes that depict sarcasm did not have these clues added. Having context might play a role in the ability to understand certain conversations since providing information about another person's intentions can have a direct effect on comprehending their actual meaning. To accurately interpret certain comments, it is imperative that one can gauge the speaker's beliefs, mood, and attitude (McDonald & Flanagan, 2004). Consistent with previous findings, there was a lack of difficulty when answering "think" questions for both sarcasm and lies when compared to healthy controls. As noted, this may reflect the fact that additional cues (prologues or visual edits) provide explicit information of what the speaker knows (McDonald & Flanagan, 2004), aiding in accuracy when answering these questions. These findings offer clinical implications that those with TBI may need support through interventions that have a strong focus on higher cognitive skills in social inference so that a conversation including more complex intentions (such as jokes, faux pas, lies, sarcasm, etc) can be more easily understood.

An additional dynamic to consider is the way that TASIT is administered and structured, as this may have had an effect on performance. Previous findings state that individuals with TBI

show more pronounced impairment compared to healthy controls when stimuli is presented in a multi-modal format (Binder et al., 2019). As TASIT consists of video vignettes, participants were able to draw conclusions about the interactions based on both facial and vocal expressions from the actors. The findings in this present study supported the idea that by adding greater sensory details, there may be an inability to process such details effectively following a TBI (Binder et al., 2019), as Parts 1 and 3 consisted of a combination of sensory details such as audio and visuals.

Limitations and Future Directions

This study's findings support previous literature that state how social cognition deficits affect populations with mild and severe TBI. The difficulties have been found in various aspects of social cognition; such as recognizing basic emotions, understanding someone else's beliefs and intentions, being aware of inferences made through conversation and identifying more subtle aspects of emotions. Shortcomings of this study include not testing participants on part 2 of TASIT, as this may provide more information on TBI population's abilities to understand the beliefs and intentions of others without contextual cues. Furthermore, TASIT is a set of stimuli found in New Zealand, which may lead to less understanding due to cultural nuances that are specific to New Zealand and aren't easily understood in the United States. Future research in this field is essential, considering there is very little research that examines the relationship between emotion processing, theory of mind deficits, and social reasoning in the TBI population, despite their probable coexistence. This is a shortcoming because there is reason to believe that both emotion processing and mentalization are part and parcel of understanding social inference (McDonald et al, 2003). In practicality, deficits in social cognition can lead to difficulties in forming and keeping interpersonal relationships.

Additionally, understanding lies and sarcasm is not often taught in rehabilitation programs for TBI populations, even though this higher-level abstract capability is essential in social interactions. To further assist TBI patients, it could be beneficial to assess social cognition through TASIT and other clinical tools when in rehabilitation. If scores are low, it could be useful to examine the interpersonal and social relationships they share with others, considering this may be an indicator of poor relationships. Future studies could include self-reports of social behaviors, as well as surveys completed by close friends, family and caretakers compared to TASIT results. This could aid in enhancing one's personal or professional life experience after a TBI. Additionally, in the future, it would be ideal to compare TASIT results to written tests to determine if visual models like TASIT are better tools for assessing social cognition deficits. Furthermore, TASIT results could be compared with other high-level aspects of neuropsychology such as decision making or concept acquisition to see if there is a correlation between social cognition deficits and other cognitive processes.

Table 1. TBI and HC performance for Part 1 by emotion.

	TBI	HC	F	p
Happy	3.39 ± .956	3.83 ± .461	5.10	.028
Surprised	3.46 ± .576	3.77 ± .430	5.18	.027
Sad	2.82 ± .983	3.50 ± .682	9.43	.003
Anxious	3.04 ± 1.23	3.63 ± .615	5.59	.022
Anger	3.04 ± 1.17	3.47 ± .730	2.87	.096
Revolted	3.14 ± 1.11	3.83 ± .379	10.29	.002
Neutral	2.50 ± 1.20	2.80 ± .925	1.14	.289

Table 2. TBI and HC performance on Part 3.

	TBI	HC	F	p
Lie				
Do	6.89 ± .956	7.30 ± .702	3.449	.069
Say	6.39 ± 1.59	7.03 ± 1.40	2.648	.109
Think	6.29 ± 1.33	6.77 ± .817	2.797	.100
Feel	6.07 ± 1.92	7.33 ± .802	10.896	.002
Sarcasm				
Do	5.14 ± 1.99	6.40 ± 1.30	8.183	.006
Say	5.29 ± 1.70	6.13 ± 1.41	4.310	.042
Think	6.89 ± 1.20	7.37 ± .808	3.159	.081
Feel	5.92 ± 1.25	6.67 ± 1.06	5.929	.018

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Appendix A (TASIT Form B: Part 1 Summary Sheet)

TVTC Thames Valley Test Company

TASIT B:

PART 1 ~

EMOTION EVALUATION TEST

SUMMARY SHEET

Name: M/F: D.O.B.: Date:

Item no.	Two-person Scene prompt "Focus on the..."	ACTORS* Target actor in bold	Happy (i)	Surprised (ii)	Neutral (iii)	Sad (iv)	Angry (v)	Anxious (vi)	Revolted (vii)
Practice		**Ruth**							
1 (sad)		**Mick**							
2 (hap)		**Zika**							
3 (neu)		**Zika**							
4 (ang)		**Mick**							
5 (sur)		**Ruth**							
6 (anx)		**Michael**							
7 (rev)	Woman	**Ruth**, Mick							
8 (neu)		**Ruth**							
9 (anx)	Man	**Mick**, Olivia							
10 (sur)		**Mick**							
11 (hap)	Dark-haired man (on right)	**Michael**, Gary							
12 (sad)		**Zika**							
13 (ang)		**Kirsty**							
14 (rev)		**Mick**							
15 (anx)		**Kirsty**							
16 (sur)		**Olivia**							
17 (hap)		**Michael**							
18 (neu)		**Gary**							
19 (sad)	Woman	**Olivia**, Mick							
20 (rev)		**Ruth**							
21 (neu)	Man of Asian origin (on left)	**Keith**, Mick							
22 (hap)		**Gary**							
23 (ang)	Man	**Michael**, Zika							
24 (anx)		**Ruth**							
25 (rev)		**Tanya**							
26 (sad)		**Michael**							
27 (sur)	Man	**Mick**, Zika							
28 (ang)		**Olivia**							
No. items correct for each emotion:									
No. of positive vs negative emotion items correct:			Positive emotions : (i) + (ii) + (iii) =			Negative emotions: (iv) + (v) + (vi) + (vii) =			
TOTAL No. OF ITEMS CORRECT:			Positive + Negative emotions =						

APPENDIX B (TASIT Form B: Part 3 Response Form)

Thames Valley Test Company

TASIT B:

PART 3 ~

SOCIAL INFERENCE (Enriched) -

RESPONSE FORM

PRACTICE ITEM

A.	Is Ruth trying to pressure Gary into helping her?	Y	N	DK
B.	Is she trying to say it's OK if he doesn't help her?	Y	N	DK
C.	Does she think he should stop what he is doing and help her?	Y	N	DK
D.	Is she annoyed with him?	Y	N	DK

1. SCRIBBLING

A.	Is Gary hiding the fact that Rosie scribbled in his book?	Y	N	DK
B.	Is he trying to say Rosie needs another lesson in how to treat books?	Y	N	DK
C.	Does Ruth know that Rosie scribbled in the book?	Y	N	DK
D.	Is Gary openly annoyed about the scribbles in the book?	Y	N	DK

2. MOVING

A.	Is Rowan trying to make Tanya believe he's happy to help her?	Y	N	DK
B.	Is he trying to tell her his back hurts?	Y	N	DK
C.	Does he think he should continue carrying boxes?	Y	N	DK
D.	Is he openly concerned for her feelings?	Y	N	DK

3. FAT

When Ruth is talking to Gary in the fitting room...

A.	Is she trying to make him believe he hasn't put on weight?	Y	N	DK
B.	Is she trying to say he has put on weight?	Y	N	DK
C.	Does she think he's put on weight?	Y	N	DK
D.	Does he seem happy with her?	Y	N	DK

4. CD

A.	Is Jane pretending she is happy with Billie?	Y	N	DK
B.	Is she trying to say she'd worry about lending her CDs to Billie again?	Y	N	DK
C.	Does she believe Billie returned her CDs in good order?	Y	N	DK
D.	Is she openly annoyed with Billie?	Y	N	DK

5. ENOUGH TO EAT

A.	Is Gary joking with Angela about having enough to eat?	Y	N	DK
B.	Is he trying to say he's still hungry?	Y	N	DK
C.	Does she think he's joking with her?	Y	N	DK
D.	Is he openly showing concern for her feelings?	Y	N	DK

6. HOT WATER BOTTLE

A.	Is Michael trying to make Olivia believe he'll pack the hot-water bottle?	Y	N	DK
B.	Is he trying to say it's a silly idea to take the hot-water bottle?	Y	N	DK
C.	Does he believe it's a good idea to take the hot-water bottle?	Y	N	DK
D.	Is he openly playing with her?	Y	N	DK

7. SMASHED CAR

After Frank enters...

A.	Is Ruth trying to make Frank worry less about smashing the car?	Y	N	DK
B.	Is she trying to say it's not as bad as it seems?	Y	N	DK
C.	Does she believe the boss will understand?	Y	N	DK
D.	Is she showing concern for Frank?	Y	N	DK

8. PIZZA				
B.	Is Kevin covering up how little money there is in the jar?	Y	N	DK
B.	Is he trying to say there's plenty of money in the jar?	Y	N	DK
C.	Does Olivia think he's teasing her?	Y	N	DK
D.	Is he openly concerned for her feelings?	Y	N	DK
9. CROSSWORD				
A.	Is Michael trying to make Keith believe he's completed the crossword?	Y	N	DK
B.	Is he trying to say he found it easy?	Y	N	DK
C.	*By end of scene,* does Keith think Michael did well on the crossword?	Y	N	DK
D.	Is Michael openly annoyed at Keith?	Y	N	DK
10. PARTY				
A.	Is Tanya genuinely trying to make Jane feel better about her party?	Y	N	DK
B.	Is she trying to say it wasn't Jane's fault?	Y	N	DK
C.	Does Tanya think the party was a success?	Y	N	DK
D.	Is Tanya openly sympathetic and caring towards Jane?	Y	N	DK
11. CUP OF TEA				
A.	Is Kirsty trying to hide the fact that there's hardly any tea left?	Y	N	DK
B.	Is she trying to say she'd like some more?	Y	N	DK
C.	Does she think there's plenty of tea left?	Y	N	DK
D.	Is she openly annoyed with him?	Y	N	DK
12. ICE CREAM				
A.	Is Tanya trying to hide the fact that Cal didn't eat all his dinner?	Y	N	DK
B.	Is she trying to say Cal obeyed Michael?	Y	N	DK
C.	Does Michael think Cal has eaten all his dinner?	Y	N	DK
D.	Is Tanya openly annoyed?	Y	N	DK
13. BABYSITTER				
A.	Is Michael seriously trying to make Tanya believe he wants to go out?	Y	N	DK
B.	Is he trying to say he's disappointed about staying home?	Y	N	DK
C.	Does she think he'd rather stay home?	Y	N	DK
D.	Is he pleased about staying home?	Y	N	DK
14. OUTFIT				
A.	Is Ruth teasing Keith about how the outfit looks?	Y	N	DK
B.	Is she trying to say it isn't so bad?	Y	N	DK
C.	Does she think it looks awful?	Y	N	DK
D.	Is she openly sympathetic?	Y	N	DK
15. BOYFRIEND				
A.	Is Jane trying to reassure Annie that she likes her new boyfriend?	Y	N	DK
B.	Is she trying to say she thinks Annie's boyfriend is great?	Y	N	DK
C.	Does Annie believe Jane likes her new boyfriend?	Y	N	DK
D.	Does Jane dislike Annie's new boyfriend?	Y	N	DK
16. FAREWELL				
A.	Is Michael trying to make Olivia feel OK about asking for $20?	Y	N	DK
B.	Is he trying to say he's got plenty of money for lunch?	Y	N	DK
C.	Does he believe he's got enough money for lunch?	Y	N	DK
D.	Is he openly annoyed?	Y	N	DK

APPENDIX C (TASIT Form B: Part 3 Summary Sheet)

Thames Valley Test Company

TASIT B:

PART 3 ~

SOCIAL INFERENCE (Enriched)

SUMMARY SHEET

Item no.	ACTORS* Target actor in bold	DO	SAY	THINK	FEEL	TOTAL CORRECT Visual Cue	TOTAL CORRECT Text Cue
Practice Item	**Ruth** Gary	**Y** N DK	Y **N** DK	**Y** N DK	**Y** N DK	N/A	N/A
1 (lie)	*(Scribbling)* **Gary** Ruth	**Y** N DK	Y **N** DK	Y **N** DK	Y **N** DK		
2 (sar)	*(Moving)* **Rowan** Tanya Jane	Y **N** DK	**Y** N DK	Y **N** DK	Y **N** DK		
3 (lie)	*(Fat)* **Ruth** Keith Gary	**Y** N DK	Y **N** DK	**Y** N DK	**Y** N DK		
4 (sar)	*(CD)* **Jane** Rowan	Y **N** DK	**Y** N DK	Y **N** DK	**Y** N DK		
5 (sar)	*(Enough to eat)* **Angela** Gary	**Y** N DK	**Y** N DK	Y **N** DK	Y **N** DK		
6 (lie)	*(Hot water bottle)* **Mick** Olivia	**Y** N DK	Y - **N** DK	Y **N** DK	Y **N** DK		
7 (sar)	*(Smashed car)* **Ruth** Keith Gary	Y **N** DK	Y **N** DK	Y **N** DK	Y **N** DK		
8 (lie)	*(Pizza)* **Keith** Olivia	**Y** N DK	**Y** N DK	Y **N** DK	**Y** N DK		
9 (sar)	*(Crossword)* **Mick** Keith	Y **N** DK	Y **N** DK	Y **N** DK	**Y** N DK		
10 (lie)	*(Party)* **Tanya** Rowan Jane	**Y** N DK	**Y** N DK	Y **N** DK	**Y** N DK		
11 (sar)	*(Cup of tea)* **Kirsty** Gary	Y **N** DK	**Y** N DK	Y **N** DK	**Y** N DK		
12 (sar)	*(Icecream)* **Tanya** Keith	Y **N** DK	Y **N** DK	Y **N** DK	**Y** N DK		
13 (lie)	*(Babysitter)* **Mick** Tanya	**Y** N DK	**Y** N DK	Y **N** DK	**Y** N DK		
14 (lie)	*(Outfit)* **Ruth** Keith	Y **N** DK	**Y** N DK	**Y** N DK	**Y** N DK		
15 (sar)	*(Boyfriend)* **Jane** Johnno Tanya	Y **N** DK	Y **N** DK	Y **N** DK	**Y** N DK		
16 (lie)	*(Farewell)* **Michael** Olivia	**Y** N DK	**Y** N DK	Y **N** DK	Y **N** DK		
	Total no. of Lie items (lie) correct:						
	Totel No. of Sarcastic items (sar) correct						
	TOTAL No. OF ITEMS CORRECT:						

CORRECT RESPONSES ARE INDICATED IN BOLD TYPE