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2019

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Perception and Expression of Emotion in TBI: Identification of Emotion, Recognition of Emotional Ambiguity, and Emotional Verbal Fluency

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August 2019

Dedication

For Justin, who told me to keep going, allowed me to keep going, and pushed me to keep going when I was not as certain in my work. Thank you will never be enough.

I love you.

For Rett and Vera Lu, who motivated me more than they currently understand.

And for my dad, who made me promise him I would never quit.

Soli Deo Gloria

Acknowledgements

I would like to thank my advisor, Dr. Thomas Marquardt, for supporting me through an unusual and unorthodox doctoral journey, and my most recent research assistants, Noora Raad, Brooke Conway, and Laura Nagy, who were incredible during data collection, and wise beyond their years. I'd also like to thank my committee members, Drs. Sussman, Henry, and Fingerman, whose instruction and guidance were invaluable, and Dr. Byrd, who showed me that it was possible to care for students and teach them at the same time.

Drs. Megann McGill, Mirza Lugo, and Allison Myer – thank you for inspiring me to keep going, over and over.

Jenna Harland, thank you for companionship and unconditional sisterly-love.

Ellen Schmear, thank you for watching Vera Lu, editing, and letting me make that final push to the finish line.

To my students - all of them, hundreds of them. Nothing motivated me more than being in the classroom with you. Your engagement and support convinced me the classroom is where I belong. Thank you.

In memory of Chris Matyear, who confirmed that teaching was my calling.

Abstract

Perception and Expression of Emotion in TBI: Identification of Emotion, Recognition of Emotional Ambiguity, and Emotional Verbal Fluency

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Communication and social integration require effective emotional, cognitive, and language processing within the brain. Traumatic brain injury (TBI) results in impaired emotion processing in a variety of contexts including emotion encoded in facial appearance, prosody, and the linguistic content of messages. Individuals with TBI report difficulty in relationship maintenance and social integration post injury as a result of impairments in communication. Emotional communication is frequently ambiguous or incongruous in presentation and its accurate perception is vital to effective communication and interpersonal relationships. Recognition of ambiguity in emotional communication has not been investigated in individuals with TBI.

This study evaluated differences in emotion perception and expression between 12 individuals with TBI and 24 individuals without TBI. Three tasks were utilized: 1) emotion identification in 34 congruous and 66 incongruous emotional sentences, 2) identification of ambiguity in emotion in 34 congruous and 66 incongruous emotional sentences, and 3) verbal fluency with emotion category generation. Participants without brain injury demonstrated increased accuracy in emotion identification and emotional ambiguity identification. Participants without brain injury generated more responses in all verbal fluency categories. Both groups were more accurate in emotion identification of congruous sentences, and more accurate in ambiguity identification in congruous sentences. Participants with TBI showed impaired identification of emotion in sentences, impaired identification of emotional ambiguity in sentences, and a reduced number of responses in verbal fluency tasks when compared to individuals without brain injury. Results are discussed in terms of impact on effective communication for individuals with TBI. These findings support that individuals with TBI are impaired in perception of emotion, including ambiguity in emotional communication, and show reduced output in verbal fluency tasks.

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CHAPTER 1: Introduction

Effective communication requires a complex interplay of social, emotional, cognitive, and language functions within the brain. Traumatic brain injury (TBI) is a disruption of brain functions secondary to an external force applied to the head (Centers for Disease Control and Prevention, 2015; Faul & Coronado, 2015; Menon, Schwab, Wright, & Maas, 2010). The injury results in physical, cognitive, social, emotional, and communicative impairments that impair the capacity for social and occupational reintegration and reduce quality of life (Dijkers, 2004; Douglas, 2017; Flynn, Mutlu, Duff, & Turkstra, 2018; Henry, Phillips, Crawford, Theodorou, & Summers, 2005; Hoofien, Gilboa, Vakil, & Donovick, 2001; Vallat-Azouvi, Paillat, Bercovici, Morin, Paquereau, Charanton, Ghout, & Azouvi, 2018; Zupan, Neumann, Babbage, & Willer, 2009).

Individuals with TBI often present with poor recovery of social functions, difficulties maintaining relationships, and psychosocial impairments (Hoofien, Gilboa, Vakil, & Donovik, 2001; Togher, McDonald, & Code, 2013; Wood, Liossi, & Wood, 2005). Social communication disorders such as these are often cited as the most permeating impairments post injury (Spell & Frank, 2000). Impairments include deficits in interpreting prosody, humor, sarcasm, facial expressions, and linguistically encoded expressions of emotion (Croker & McDonald, 2005; McDonald & Flanagan, 2004; Myers, 1999; Watts & Douglas, 2006).

Spoken language conveys emotion through paralinguistic (facial expressions and prosody) and linguistic (words) information (see Table 1 for definitions). Sometimes these messages include ambiguous emotional information, where the linguistic information is incongruent with paralinguistic information (e.g., “I love you” spoken in an angry tone, with an angry facial expression). Individuals receiving messages must process lexical-semantic and paralinguistic components conveying emotion within the message and identify and resolve ambiguity.

Deficits in affective processing, including impairment in perception of emotion via visual modalities such as facial expression (Croker & McDonald, 2005, McDonald & Saunders, 2005; Milders, Fuchs, & Crawford, 2003; Spell & Frank, 2000), via auditory modalities reliant on paralinguistic features such as prosodic intonation and emphasis (Dimoska, McDonald, Pell, Tate, & James, 2010; Marquardt, Rios-Brown, Richburg, Seibert, & Cannito, 2001; Milders, Fuchs, & Crawford, 2003), and via lexical encoding (Czimskey & Marquardt, 2019), may be less apparent than memory deficits and are less frequently reported and treated (Myers, 1999). If not identified and provided with effective rehabilitation, individuals with affective processing deficits associated with TBI may experience a decline in their ability to communicate and may have a negative impact on the quality of their personal relationships (Godwin, Kreutzer, Arango-Lasprilla, & Lehan, 2011; Hoofien, Gilboa, Vakil, & Donovik, 2001; Vallat-Azouvi et al., 2018; Wood, Liossi, & Wood, 2005). Assessment for TBI have traditionally sought to isolate emotion modality preference and individual modality perception for individuals with TBI, but have neglected to assess whether these individuals can detect ambiguity or incongruity in paralinguistic and linguistic emotional expression.

The Current Study

The purpose of this study is to investigate the abilities of individuals with TBI to perceive and identify ambiguous and incongruous emotional communication. Previous studies have examined individual modalities, or congruous presentation of emotional expression (prosody, facial expression, lexical-semantic content), and have presented incongruous emotional messages to determine which modality individuals with TBI find preferential for interpretation, but there has not been a study observing incongruous emotion detection (i.e. the ability to identify that lexical-semantic information indicates one emotion, while prosodic information indicates a different emotion) in individuals with TBI. This study explored whether individuals with TBI perceive incongruous emotion, or a mismatch in lexical and prosodic emotional cues (e.g., "I feel wonderful" said in a sad tone) with the same accuracy as individuals without brain injury. This study analyzes emotion identification abilities and emotion ambiguity identification abilities of individuals with and without TBI when presented with congruous and incongruous emotional stimuli and investigates the performance of individuals with and without TBI on verbal fluency tasks, including emotional verbal fluency tasks.

Ambiguity in emotional expression is frequent and the ability to identify such ambiguity is crucial to effective communication (Zupan, Neumann, Babbage, & Willer, 2009). This study will contribute information about emotional expression and perception in individuals with TBI important to identifying the cognitive and language deficit patterns that characterize the disorder and that must be addressed in rehabilitation to promote effective communication.

CHAPTER 2: Review of the Literature

Emotion and Language

Language and emotion are inextricably linked. Individuals use language to describe their emotions, highlighting personal feeling and affect in various forms. Effective communication requires the interpretation of emotion integrated within lexical-semantic and paralinguistic (communication accompanying the semantic and linguistic content such as gesture, facial expression, prosodic intonation) contexts (Schwartz, Pell, & Stamatakis, 2012). Even without emotional words (or words that denote an emotion) humans may intone "neutral" language, with no apparent emotion encoded linguistically, with paralinguistic characteristics that indicate emotion or direct the communication partner to an emotional response. "Emotion," "affect," and "mood" are frequently used indiscriminately and interchangeably, though Alpert & Rosen (1990) make distinctions between the three; emotion, reflective of a feeling, is longer in duration than affect, which is an expression of feeling that may be brief or rapidly changing and can be generated by different mediums of language expression (see Table 1). "Mood" is described as a more sustained, long-term emotional state. Ekman (1973) found that emotions were tied to individual facial expressions and described six primary emotions that are "universal" or most readily identified across cultures: surprise, disgust, anger, happiness, sadness, and fear (Ekman, Levenson, & Friesen, 1983).

Table 1

Definitions for Emotion and Language Terms

Term	Definition
emotion	neurological state generated from environmental input and the biological response both voluntary and visceral (Arciniegas & Topkoff, 2000)
mood	sustained, persistent emotion (Alpert & Rosen, 1990)
affect	brief, immediate experience of emotion, embedded in symbols (Alpert & Rosen, 1990; Karow & Connors, 2003)
semantics	lexical-semantics, pertaining to word meaning and word choice
linguistics	referring to spoken or written language, typically in isolation
lexical	pertaining to words utilized, word meaning, largely interchangeable with semantics for purposes of this study
prosodic	referring specifically to the intonation or sing-song nature of natural speech which may change with emotion or meaning intended
paralinguistic	referring to features surrounding the lexical entities or words themselves, including prosody, rate, emphasis, intensity, and sometimes used to refer to gesture, facial expression and other pragmatic communication behaviors

Neuroanatomical Representation and Perception of Emotion

The neuroanatomy of emotion reflects both the multiplicity of emotions and the channels which are utilized in their expression and perception. Many neural areas and networks are involved in perceiving, processing, and communicating emotion. The two most frequently cited areas of the brain responsible for emotional perception are the prefrontal cortex (PFC), including the dorsolateral, orbitofrontal, and ventromedial PFC (Balconi, Grippa, & Vanutelli, 2015; Goel et al., 2017; Hornak et al., 2003; Morris et al., 1996; Ochsner, Bunge, Gross, & Gabrieli, 2002; Phan, Wager, Taylor & Liberzon, 2002) which is largely responsible for emotional identification and decision making, and the amygdalae (Cunningham, Van Bavel, & Johnsen, 2008; Fanselow & LeDoux, 1999; Hamann, Ely, Hoffman, & Kilts, 2002; LeDoux, 2007; Sander, Grafman, & Zalla, 2003) which have a major role in fear response but also are involved in both positive and negative emotion processing.

The brain regions supporting language are frequently recruited in emotional tasks as language may be involved in the expression of emotion. However, research indicate that the recruitment of language areas may be involved in the creation of emotion as a feeling or response, not just linguistic processing. Satpute, Nook, Narayanan, Shu, Weber, and Ochsner (2016) utilized tasks to assess whether the use of category-labeling had an impact on neural representation of emotions. They found that the act of labeling is not strictly a post-hoc behavior after an emotion has been conjured or determined. Rather, the act of labeling an emotion can further build the emotion's representation within the brain. This was demonstrated by asking participants to categorize a visual facial expression (shown digitally) as "calm" or "fearful" or along a continuum as "calm," "neutral," or "fearful." In a second task, participants were asked to categorize their own affective response as "bad" or "good" or along a continuum as "bad," "neutral," or "good." Utilizing function magnetic resonance imaging (fMRI) along with psychophysical methods, Satpute et al.'s (2016) first task indicated that individuals were more likely to perceive an emotion as affectively intense (fear) with categorical rather than continuous judgments and showed greater activation in the right amygdala during these categorical judgements. The second task showed more intense emotion (bad) during categorical rather than continuous judgements and resulted in greater activity in the right ventral anterior insula and left amygdala during categorical judgements. Categorical labeling can increase amygdala function and connectivity with the ventral medial PFC. These results are consistent with the psychological constructionist view (Barrett, 2017) and indicate that the act of labeling, a language-based task, increases activity in brain areas associated with emotion.

Network and Constructionist Emotion

Neural areas correlating with specific cognitive/emotional functions contribute to a "localizationist" account of affective perception and expression, but these areas are frequently incorporated into a more recent "network" view of cognitive processes underlying perception and expression of affect (Barrett, 2017). The network approach to the perception and expression of emotion allows for the varied functions and locations associated with emotional tasks to be viewed collectively as a dynamic and interactive network which includes language as a contributing factor to emotion perception and expression. The brain areas associated with affective processing are not active in isolation, indicating the simultaneous and communicative nature of emotional processing (Barrett, 2017; Pessoa, 2008).

Neuroimaging studies have shown that emotion and cognition (memory, attention, language, problem solving, planning) coexist in similar neurological networks. Pessoa (2008) asserted that brain regions traditionally described as encompassing "emotion" (e.g., the amygdala, ventral striatum and hypothalamus) are also involved in cognition while regions traditionally described as "cognitive" (e.g., the prefrontal and parietal cortices) are involved in emotion. Pessoa (2008) argued that cognition and emotion are integrated in the brain, working as a "dynamic coalition" rather than the separate entities that they occupy in description. This network theory of cognition and emotion is largely incorporated into the psychological constructionist theory of emotion (Barrett, 2017) which provides a framework for understanding emotional systems and organization. The psychological constructionist theory assumes basic categories of emotion but indicates that these emotions are learned and created by past experiences. In addition, the psychological constructionist theory accounts for cultural impact on emotion, arguing that the words people know and assign to different emotions and affective states serve as predictive constructs for emotions.

The impact of culture on emotion is similar to the impact on color perception and the assignment of lexical labels to color segments. The brain is not pre-wired to distinguish between colors, as they occur on a continuous spectrum, but cultures assign category labels to sections of the spectrum, which impacts an individual's cognition surrounding color and its perception (Thierry, Athanasopoulos, Wiggett, Dering, & Kuipers, 2009). If a culture does not have a word for the color “purple,” an individual within that culture will assign that color differently, most likely to a word corresponding to “blue,” “red,” or “dark.” As such, English-language users learn English “colors” and use those labels as a predictive construct for perceiving and assigning colors. Likewise, individuals construct emotions according to the language labels they interact with, the environment they experience, and their own cognitive processes. As such, the psychological constructionist view incorporates affect and language as crucial elements in the creation of emotion.

The constructionist theory of emotion provides an approach for viewing the domains of cognition, emotion, and language as synergystic rather than antagonistic. Certainly, the inclusion of cognition, language, and emotion as parts of a whole results in a more dynamic representation of communication. The widespread and diffuse neuroanatomical damage caused by TBI (Centers for Disease Control and Prevention, 2015) typically results in a variety of cognitive deficits, and means an individual with TBI would likely experience deficits in emotional processing. Depending on the severity of injury and primary locations of damage, an individual with TBI may present with a range of deficits in emotional processing and communication.

TBI Causes, Demographics, and Descriptions

TBI is a significant cause of disability within the United States. A report by Faul, Xu, Waldo, and Coronado (2010) of the National Center for Injury Prevention and Control

Division of Injury Response utilized data collected between 2002 and 2006 and indicated that an average of 1.7 million Americans sustain a TBI annually, with 275,000, approximately 16%, requiring hospitalization post injury. The same report cited TBI as accounting for 30.5% of injury-related deaths in the United States. These data do not account for individuals who did not seek medical attention, or received medical attention outside of emergency services, nor did they account for individuals treated overseas or within the military (Centers for Disease Control and Prevention, 2015).

Primary causes of TBI include falls, projectile objects, motor vehicle collisions, assaults, sports injuries, and military blasts (Centers for Disease Control and Prevention, 2015; DePalma & Hoffman, 2018; Faul & Coronado, 2015; Menon, Schwab, Wright, & Maas, 2010; Taylor, Bell, Breiding, & Xu, 2017). Children under the age of four, adolescents age 15-19, and individuals over the age of 65 are most likely to receive treatment for a TBI. Across all ages, males are more likely to sustain a TBI than females, with approximately 1.4 times as many injuries for males compared to females. Falls are the leading cause of TBI, with children under 4 and adults over 75 comprising the majority of fall-related injuries (Centers for Disease Control and Prevention, 2010). An estimated 3.2-5.3 million individuals live with TBI in the United States (Centers for Disease Control and Prevention, 2015). The number of individuals living with TBIs continues to increase as mortality rates decrease due to medical technology and surgical advancements that allow more individuals to survive injuries that previously would have resulted in death (Faul & Coronado, 2015). The rising number of individuals living with TBI in the United States makes the assessment and treatment of TBI of particular importance from an economic, social, and educational perspective.

Injury Types

TBIs typically are described as open-head or closed-head injuries. If the external force applied to the head is a projectile or force that pierces the skull, the injury is an open-head injury. When the force applied during injury does not pierce the skull, the injury is a closed-head injury. Individuals with either open or closed-head injuries can experience both focal and diffuse damage. Open-head injuries sometimes result in more localized damage to brain tissue, though laceration of brain tissue, blood loss, and edema pose a significant threat to well-being and recovery. Open-head injuries also carry a risk of infection with the introduction of foreign material to brain tissue (Kazim, Shamim, Tahir, Enam, & Waheed, 2011). Closed-head injuries typically result in three types of damage: 1) contusions, or bruising and compression, at the initial point of impact and the opposite point of impact from ricochet (coup/contrecoup injury locations), 2) lacerations, primarily in the prefrontal and inferior temporal areas of the brain secondary to location of bony protrusions of the skull that underlie these structures, and 3) widespread shearing, stretching, and tearing of axons (diffuse axonal injury) that impairs neuron function across a broad area of brain tissue (Centers for Disease Control and Prevention, 2015). Secondary effects may exacerbate the initial injury as edema and intracranial pressure may lead to ischemia and progressive cell death (Brookshire, 2007; McDonald, Togher, & Code, 2013).

Closed-head injuries are classified as “acceleration-deceleration” or “non-acceleration” injuries (Brookshire, 2007). Acceleration-deceleration injuries are initiated by physical forces rapidly accelerating the head which is then then stopped abruptly on impact (i.e. motor vehicle collision, falls). During an acceleration-deceleration injury, if the skull stops moving, the brain may continue in motion, impacting the inside of the skull; the initial point of impact with the skull is termed “coup injury” while the injury at the opposite point of impact, post ricochet, is called “countrecoup injury.” A non-acceleration injury occurs when an external force impacts a restrained or immobilized head. Typically, the primary area of impact for a non-acceleration injury is the area directly adjacent to the impacted skull. Non-acceleration injuries also may result in skull fractures and depressions, increasing the risk for nerve damage and meninges damage as well as infection.

Diffuse axonal injury (DAI) describes damage to white matter tracts within the brain due to stretching, rotational shearing, and compression during brain trauma, typically in high velocity injuries. DAI may result in spontaneous disruption of action potentials or ion channel transfer, axon enlargement, or microlesions, all of which may interfere with effective signal transmission within the brain (McDonald, Togher, & Code, 2013). DAI typically is widespread, rather than localized, and contributes to the variety of impairments seen post injury. DAI is typically associated with closed-head acceleration-deceleration injuries, though it may be seen in other injuries as well.

TBI, regardless of type or cause, results in widespread damage to cortical tissue and a multitude of impairment domains. All brain injuries are different, with varying recoveries, impairments, strengths, and impacts on the those who have sustained injuries. Despite the unique nature of individual TBIs, there are expected areas of impairment that are associated with these injuries.

General Effects of TBI

Common sequelae of TBI include impairments in cognition, emotion, and communication. Individuals with TBI frequently present with cognitive difficulties in attention, memory, executive functioning, language, and information processing in addition to other impairments (Brookshire, 2007; Dikmen, Corrigan, Levin, Machamer, Stiers, & Weisskopf, 2009; Togher, McDonald, & Code, 2013). The combined cognitive, emotional, social, communicative, and physical impairments in individuals with TBI contribute to difficulty completing activities of daily living, workforce reentry, and social reintegration, negatively impacting quality of life.

Physical Sequelae

TBI is a major cause of disability in the United States and worldwide (Centers for Disease Control and Prevention, 2015; Langlois, Rutland-Brown, & Wald, 2006). The cortical damage caused by TBI can result in physical symptoms in addition to the wide array of cognitive and communicative deficits which may present (Brookshire, 2007).

Motor deficits may include paralysis, numbness, muscle weakness, and muscle incoordination which may also lead to speech impairments, swallowing difficulties, and inability to complete activities of daily living (Iaccarino, Bhatnagar, & Zafonte, 2015). Sensory disruptions include impaired vision, smell, hearing, taste, and equilibrium, leading to sensitivity and perceptive impairments such as dizziness and light/sound sensitivity (Valente & Fisher, 2011). Physical and sensory impairments vary and correspond with areas of primary damage. These physical and sensory deficits can impact societal reintegration post injury, particularly when ability to complete activities of daily living (ADLs) are impaired. The inability to complete ADLs inhibits independent care and ability to return to work and other premorbid activities, which in turn negatively impacts societal reintegration and quality of life (Gordon, Cantor, Dams-O'Connor, & Tsaousides, 2015; Hoofien, Gilboa, Vakil, & Donovick, 2001; Schwab, Gundmudsson, & Lew, 2015).

Memory Deficits

Memory deficits are possibly the most pervasive impairment in individuals with TBI (Cristofori & Levin, 2015; Vakil, 2005; Vallat-Azouvi et al., 2018). Individuals with TBI show deficits in various memory functions when compared to individuals without brain injury (Baddeley, Harris, Sunderland, Watts, & Wilson, 1987; Vakil, 2005; Zec, Zellers, Belman, Miller, Matthews, Ferneau-Belman, & Robbs, 2001). Short term memory is usually more impaired than long term memory though some individuals experience post-traumatic amnesia (PTA) and retrograde amnesia (RA) of varying severity at initial onset

(Baddeley, 1990; Levin, O'Donnell, & Grossman, 1979; Levin, 1989). PTA and RA are typically minimal or resolve while other memory deficits are more pervasive, including deficits in episodic memory (i.e., knowing what happened in what location at what time), semantic memory (i.e., general knowledge, learned information), and autobiographical memory (i.e., knowledge of personal events and identity) (Baddeley, 1990; Cristofori & Levin, 2015; Levin, 1989). Short-term memory deficits in individuals with TBI have been demonstrated through impairment in verbal and visual recall tasks (Vakil, 2005). Individuals with TBI perform more poorly than neurotypical counterparts in tasks such as cued-recall, recall, recognition tasks (Baddeley, et al., 1987) and on memory assessment batteries assessing verbal memory, visual memory, and delayed recall (Zec et al., 2001).

Executive Functioning Deficits

Individuals with TBI present with deficits in executive functioning. Executive functioning is described as the attentional control processes underlying cognition and behavior that direct goal and purpose (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010; Togher, McDonald, Coelho, & Byom, 2013). Executive functioning deficits may include disruption in inhibition, problem solving, planning, attention, organization, and metacognition. Working memory assessments are frequently cited in the description of executive function disruption due to the role of working memory in attention (McCabe et al., 2010). Deficits in working memory are evidenced by longer reaction times and impaired performance in dual-task paradigms such as those utilized by McDowell, Whyte, and D'Esposito (1997). The dual task paradigms compared individuals with TBI and without on visual reaction times in one task while concurrently performing articulation or digit-span tasks. Reduced reaction times as well as decreased performance on concurrent tasks led McDowell et al. (1997) to conclude that working memory impairments in individuals with TBI were related to dysfunction in the central executive system.

Other manifestations of executive functioning deficits include impaired drive or control, deficits in metacognition or self-monitoring, and impaired problem-solving abilities. Impaired drive may result in severe apathy, or conversely, inflexibility (Togher, McDonald, Coelho & Byom, 2014). Individuals with TBI may show difficulty initiating action or a preference to initiate repetitive or habitual behaviors or actions. Disinhibition may result in disruptive behaviors and interfere with appropriate interactions and communication. Metacognition disruption is displayed through difficulty with evaluating self-progress toward a goal and evaluating personal abilities. Individuals with TBI may overestimate or underestimate their ability to complete a task and not perceive their own areas of deficit. Individuals with TBI and metacognition impairment display an inability to detect and correct their own errors (O'Keeffe, Dockree, Moloney, Carton, & Robertson, 2007). Problem solving impairment may present as an inability to appropriately appraise a situation and anticipate consequences. Individuals with TBI may not be able to maintain organization while planning action during problem solving activities, leading to inability to execute the needed actions with appropriate direction (Togher, McDonald, Coelho, & Byom, 2013). For example, an individual with TBI may forget an appointment, lack transportation, and decide to start walking to the appointment despite formidable distance and inclement weather rather than contacting someone to alert them to their situation, seeking transportation, and considering the impact that walking will have on arrival time and well-being.

Language and Communication Deficits

Individuals with TBI do not typically exhibit symptoms of frank aphasia, such as inability to comprehend spoken language or verbally express spoken language. However, they demonstrate communication impairment reflected in discourse (i.e. connected speech used for conversation, explanation, description, or narrative etc.) and pragmatics (i.e. appropriate use of language, including verbal and nonverbal communication, such as facial expression, eye-contact, and turn taking) including difficulty with inference, inflexible communication, impaired word retrieval, and impaired social communication (Douglas, 2017; Frencham, Fox, & Maybery, 2005). Discourse and pragmatic language impairment are more commonly attributed to underlying cognitive impairments rather than overt language deficits as individuals with TBI typically demonstrate intact content and form while usage is most readily affected (Togher, McDonald, Coelho, & Byom, 2013).

Discourse deficits typically present through decreased production, decreased cohesion, and impaired story grammar (Togher, McDonald, Coelho, & Byom, 2013). Marini et al. (2011) compared discourse narrative samples from individuals with TBI to individuals without brain injury and found that while the participants with TBI demonstrated typical grammar and lexical skills, their narratives contained more errors than participants without brain injury. Narratives were elicited by asking participants to create a story surrounding an image. The narratives of the TBI group contained more errors of coherence and cohesion, primarily a result of interruptions to flow and conversational derailments within the discourse (Marini et al., 2011). Individuals with TBI also have been shown to have impaired story grammar (Mozeiko, Le, Coelho, Krueger, & Grafman, 2011). Mozeiko et al. (2011) administered a discourse task utilizing a 16-picture panel story-retell. Individuals with TBI presented with significantly poorer story grammar than neurotypical participants, and discourse deficits were significantly correlated with executive functioning task performance. Discourse deficits in individuals with TBI have also been shown in conversational settings. Coelho, Youse, and Le (2002) utilized a conversation setting to elicit discourse from individuals with and without TBI. Two researchers acted as conversation facilitators for each participant in the study. Measures included turn-taking, appropriateness, and topic initiation. While several measures showed no significant differences between responses of the two participant groups, the more interesting finding was how the conversation facilitators responses changed. More comments and prompts were required from the facilitators for the individuals with TBI to maintain conversation flow than for the group without injury (Coelho, Youse, & Le, 2002).

MacLennan, Cornis-Pop, Picon-Nieto, and Sigford (2002) reported that as many as 86% of individuals with TBI present with pragmatic communication impairment of some type. Pragmatic impairment may present as "rudeness" or a disregard of societal norms surrounding politeness or appropriate engagement such as an inability to perceive or express indirect requests. Other pragmatic impairments will emerge from deficits in perception of indirect language such as difficulty perceiving and understanding humor and sarcasm (Togher, McDonald, Coelho, & Byom, 2013). Angeleri et al. (2008) utilized a new assessment, the Assessment Battery for Communication, to demonstrate pragmatic deficits in individuals with TBI. The assessment contained items addressing production and comprehension of a variety of different speech acts including basic speech acts such as assertions, questions, requests, and commands, and non-basic acts such as irony and deceit, in linguistic, paralinguistic, and extralinguistic contexts. Angeleri et al. (2008) found that individuals with TBI performed significantly poorer than individuals without injury in all contexts. Additionally, increasing complexity increased impairment in pragmatic communication acts for individuals with TBI while it did not increase impairment in standard communication acts.

Communication deficits for individuals with TBI also include impairments in comprehension and expression of emotion, both embedded in lexical content and in paralinguistic information such as prosody and facial features. Individuals with TBI have shown difficulty determining emotion displayed from emotion facial expression (Croker & McDonald, 2005; McDonald & Saunders, 2005; Milders, Fuchs, & Crawford, 2003; Spell & Frank, 2000) as well as impairment in labeling of visually presented emotion and matching emotion. Similar deficits are shown in perception of emotion expressed vocally through prosodic intonation. Individuals with TBI show impairment in emotional labeling and matching when presented with emotion encoded in intonation (Dimoska, McDonald, Pell, Tate, & James, 2010; Marquardt, Rios-Brown, Richburg, Seibert, & Cannito, 2001; Milders, Fuchs, & Crawford, 2003). These social, emotional, and pragmatic impairments interfere with the ability of individuals with TBI to reintegrate socially because they impede effective communication (Douglas, 2017; Flynn, Mutlu, Duff, & Turkstra, 2018; Milders, Fuchs, & Crawford, 2003).

Emotional Processing and Language

Emotion can be conveyed through a variety of language related functions: semantics (word choice, linguistic content), prosody (the melodic intonation of speech), facial expression, and non-verbal pragmatic functions (gesture and body language) (Schwartz, Pell, & Stamatakis, 2012). Both hemispheres of the brain contribute to the expression and processing of emotional information. The right hemisphere has a leading role in processing facial features and prosodically intoned information while the left hemisphere has a primary processing role in interpreting and expressing lexically encoded information (Myers, 1999). A breakdown in any part of this complex interpretation and expression can result in communication failure and over time lead to a relationship failure as effective emotional communication is the basis of a healthy, or maintained, relationship (Godwin, Kreutzer, Arango-Lasprilla, & Lehan, 2011; Hoofien, Gilboa, Vakil, & Donovik, 2001; Vallat-Azouvi et al., 2018; Wood, Liossi, & Wood, 2005).

Joukamaa, Saarijärvi, Muuriaisniemi, and Salokangas (1996) reported that individuals with impairment in expression and perception of emotion reported lower quality of health and life. Similarly, Carton, Kessler, and Pape (1999) found that difficulty distinguishing emotion in facial emotion and vocal prosody correlated with higher levels of depression and less well-being in relationships. Emotional expression in relationships is positively correlated with relationship satisfaction (King, 1993). Mongrain and Vettese (2003) found that conflict in emotional expression resulted in less congruency and less positivity in communication. Conflict in emotional expression can lead to dissatisfaction in interpersonal relationships. Effective emotional perception is not only critical to effective communication but to relationship satisfaction and well-being (Schwartz, Pell, & Stamatakis, 2012).

Emotion is Ambiguous

The multi-factorial nature of emotional communication is frequently portrayed as a multi-pronged approach to communicating a singular construct. However, emotion is not always singularly communicated; it can be ambiguous both in expression and perception (Hirsch & Matthews, 2000; Kempe, Rookes, & Swarbrigg, 2013). Frequently, emotion is communicated tentatively and with ambiguous expression. The most common example of this is demonstrated in how an individual answer the question "How are you?" An exasperated facial expression and angrily intoned "fine," is not indicative of a day that was satisfactory. Similarly, sarcasm relies on the incongruous expression of paralinguistic and linguistic factors.

There are different “channels” for emotional communication: facial expression, prosody, and linguistic content. While these channels are often congruent (i.e. prosodic and semantic content match) during communication, frequently there is incongruency and ambiguity in emotional expression (Ben-David et al., 2016). As a result, communication involving affect or emotion is frequently incongruous or ambiguous (Kempe, Rookes, & Swarbrigg, 2013). This ambiguous and incongruous communication of affect requires the message receiver to first perceive, then resolve the ambiguity to maintain effective communication.

The Separate Effects of Prosody and Lexical Semantics

The multi-modal nature of emotional communication allows different channels to convey different affects. Prosody and lexical semantic content, though both spoken, can have separate effects during communication of emotion. Pell, Jaywant, Monetta, and Kotz (2011) showed that prosodic cues and semantic cues could independently prime judgments of facial expression in individuals without brain injury and at similar rates. Pell et al. (2011) showed that when prosodic and semantic cues were congruent with the facial expression shown, judgements regarding emotion were significantly faster in individuals without brain injuries. Ben-David, Multani, Shakuf, Rudcicz, and van Lieshout (2016) utilized a new tool, the Test for Rating Emotions in Speech (T-RES), in which individuals without brain injuries rated emotional and neutral sentences, some with congruent prosodic and semantic cues and some with incongruent prosodic and semantic cues based on overall emotion, prosodic cues, or semantic cues as directed. Ben-David et al. (2016) found a supremacy for congruency of emotion when rating sentences, and that while prosody and semantics were separate, they were not entirely separable, as participants seemed unable to completely ignore one in favor of the other. In incongruent sentences, Ben-David et al. (2016) found a preference for prosodic cues in judging the conveyed emotion.

The prosodic cue preference (over semantics, specifically) found by Ben-David et al. (2016) is somewhat controversial as there is no clear evidence for prosodic dominance. Rather, various outcomes have been indicated regarding preferential cues in emotional perception. Difficulties in identifying emotion from verbal communication typically stem from impairment in perceiving or identifying emotion in either semantic or prosodic cues. Early evidence for prosodic dominance in perceiving emotional content was reported by Mehrabian and Wiener (1967). In this study, participants (without brain injury) were asked to listen to sentences with positive, neutral, and negative emotional valence semantically, said with either, positive, neutral, or negative valence prosodically. Sentences were sometimes congruous between semantic and prosodic valence and sometimes incongruous. Participants were asked to make judgements on the valence (positive or negative) of the emotion by marking on a scale where one anchor was “positive” and the other anchor was “negative” and were given instructions as to whether they should pay attention to the words (semantics), tone (prosody), or both. Results indicated that prosody had more influence on perception of emotional valence than semantics when participants were instructed to make judgements based on both modalities. Similarly, when making judgements based on one modality, prosody was more likely to influence valence perception than semantics indicating the supremacy of prosody.

Several studies show similar findings regarding prosodic and semantic perception, though sometimes less directly. Morton and Trehub (2001) showed that adults rely on paralinguistic cues when making judgements on ambiguous emotional sentences while children aged six years and under rely more heavily on semantic content to disambiguate the same sentences. Twenty sentences with sad or happy semantic content were recorded with both happy and sad prosodic paralinguistic cues to create 40 total utterances. When looking at responses to utterances with conflicting semantic and prosodic information, all 20 adult participants showed preference for paralinguistic cues over semantic. Children from ages four to 10 were scored on the task, with younger children showing preference for semantic material, and slowly moving toward more reliance on paralinguistic material by age 10 years.

Nygaard and Lunders (2002) found that individuals without brain injury utilize prosodic cues to disambiguate ambiguous lexical material, specifically homophones (i.e. pain vs. pane), when one of the homophones was happy/sad while the other was neutral. In trials blocked by prosodic presentation and randomized trials, results indicated that sad prosodic cues facilitated more access to the sad homophone as opposed to the neutral homophone, while happy prosodic cues facilitated more access to the happy homophone as opposed to the neutral homophone. Arguably, these studies show that adults use prosody preferentially to disambiguate meaning but may not point to “prosodic dominance” where prosodic cues are utilized to the exclusion of lexical cues.

Other evidence indicates that semantic cues are more dominant in discerning message intent. Ishii, Reyes, and Kitayama (2003) devised a Stroop task aimed at determining whether semantics or prosodic content had more impact on classifying sentences. English-speakers showed greater difficulty ignoring semantic content than ignoring prosodic content when classifying sentences as pleasant, unpleasant, or neutral, indicating a preference for semantic information.

The supremacy of congruency in perceiving emotion is almost certain though the debate over prosodic or semantic dominance is unresolved. Studies have shown that when emotion is congruent across channels of emotional communication, messages are processed more quickly, with increased accuracy, and with greater impact than when one channel is neutral or incongruent with another. Ishii et al. (2003) reported faster categorization for utterances with congruent semantics and prosody regardless of whether the participant was instructed to focus on a single channel. Pell et al. (2011) found similar results with processing speeds with congruent priming and categorizing tasks. The same task saw increased accuracy across sad targets when the prime and target were congruent. Ben-David et al. (2016) showed an increase in perceived emotional effect when prosodic and semantic cues matched as opposed to incongruent or semi-neutral cues.

There is evidence that emotional valence has potential to impact emotional processing in addition to the facilitation effect of congruency. Sass et al. (2012) suggested that emotionally intoned information can impact semantic association networks and processing, including evidence for a positivity bias. Sass et al. (2012) found that when participants were primed with positively valanced words it facilitated speed in detection of other positively valanced words while priming participants with negatively valanced words did not have the same effect for detecting negatively valanced words. Ashby, Isen, and Turken (1999) suggested that positive affect increases dopamine levels within the brain leading to possible improved performance on cognitive tasks, including language related tasks. Other studies report similar positivity bias in language related tasks such as Kuchinke, Jacobs, Grubich, Võ, Conrad, and Herrmann (2005) who demonstrated positivity bias utilizing a lexical decision task. Kuchinke et al. (2005) provided evidence that participants had faster reaction times in decision making tasks pertaining to positive stimuli when compared with neutral and emotional stimuli. These studies collectively indicate that positively valanced emotion may aid in semantic or cognitive processing of emotion for individuals without brain injury.

The multimodal structure of affective communication combined with the ambiguous and incongruous presentation of affective messaging creates a variety of possible difficulties for individuals with TBI. While evidence suggests that neurotypical individuals utilize prosody to disambiguate incongruous messages, and that congruous affective messages are easier to perceive and categorize than incongruous messages attentional, executive functioning, and social communication impairments present in TBI may prohibit effective perception and expression of affective information.

TBI and Emotion

Research has demonstrated that TBI can result in impairment of emotion identification, perception, and expression. Emotional perception in individuals with TBI is often assessed via accuracy of identification of emotional faces and affective prosody. Individuals with TBI have been found to have impairment in identification of emotion via prosodic tone and/or facial expression in a variety of studies.

TBI and Facial Expression of Emotion

Prigatano and Pribram (1982) compared individuals with and without documented brain lesions on perception and recall of emotional facial expressions utilizing photograph images. Results indicated that individuals with brain lesions performed less accurately than matched neurotypical participants on both accuracy of labeling of emotional expressions and recall of emotional facial expressions when subjects were asked to determine what expression an image-subject displayed in a previous viewing. Croker and McDonald (2005) utilized multiple tasks to show that individuals with severe TBI present with difficulty in identification and matching of emotion with facial expression, though performance could be improved with increased context. The first task utilized black and white photographs of facial expressions; participants were asked to label each photograph with either happiness, sadness, anger, fear, surprise, disgust, or neutral. The second task utilized similar photographs, but rather than asking the participants to label the emotion presented, they were asked to choose which of four presented photographs presented the same emotion. A third task presented the participants with verbal scenarios that would elicit an emotion and asked the participant what emotion the situation would make them feel. A fourth task asked participants to select an appropriate facial expression for a given scenario, while a fifth task asked them to select a lexical label for the facial expression they previously chose to match the contextual scenario. Participants with TBI were less accurate than participants without brain injury in both the labeling and matching facial expression tasks. There were no significant differences in the third task, ascribing an emotional label to a scenario, though when asked to choose a facial expression for a given scenario, the TBI group again performed less accurately than the group without injury. When asked to label the facial emotion they chose, the TBI group was more likely to label the facial expression according to the given context than the expression they labeled than the group without injury. Watts and Douglas (2006) showed that individuals with severe TBI showed reduced accuracy in naming and recognition of facially expressed emotion in video recorded vignettes where actors portrayed emotion and correlated this finding with a reduction in perceived communicative effectiveness as evaluated by a close friend or family member. In the naming task, participants were asked to verbalize what emotion the actor in the vignette displayed, while in the recognition task, the participants were asked to choose what emotion was displayed from a typed list of six emotions (happy, sad, angry, surprise, disgusted, scared). In both tasks, individuals with TBI performed significantly less accurately than the neurotypical group. The performance of the TBI group on emotion expression tasks was significantly correlated with communication competence as rated by a close-other while it was not correlated with their own scores of communication competence (Watts & Douglas, 2006).

Knox and Douglas (2009) showed that in addition to having difficulty matching emotional expression to a social situation, individuals with severe TBI have reduced social participation. In their study, individuals with TBI were compared to individuals with no brain injury on several facial expression perception tasks and social participation via self-reported assessments of occupation and social integration. Knox and Douglas (2009) reported that individuals with TBI performed less accurately than the neurotypical group on both ascribing an emotion to a videoed emotional scene and labeling static, affective facial expressions. The key finding in this study was that performance of individuals with TBI on emotional perception tasks was significantly correlated with scores on the occupational and social integration assessment, indicating a link between emotional perception and social integration (Knox & Douglas, 2009). Similarly, a recent study by Rigon, Turkstra, Multu, and Duff (2018) correlated facial expression recognition abilities in individuals with moderate to severe TBI with communication effectiveness scores as rated by communication partners. Rigon et al. (2018) asserted that social communication of individuals with TBI is negatively impacted with increased impairment in facial expression recognition, indicating a link between emotional perception and effective social communication and relationships. This reduction in social communicative effectiveness may contribute to decreased social integration and relationship failure in individuals with TBI.

TBI and Prosodic Expression of Emotion

Individuals with TBI demonstrate impairment in identification of emotion via spoken language perceived auditorily (Blonder, Bowers, & Heilman, 1991, Marquardt et al., 2001; McDonald & Pearce, 1996; Milders, Fuchs, & Crawford, 2003; Spell & Frank, 2000). Spell and Frank (2000) utilized a prosodic recognition task and a functional communication assessment to draw conclusions about prosodic perception and its impact on functional communication. Both participants with and without TBI were presented linguistically neutral sentences portrayed in a variety of emotional prosodic tones (happy, angry, sad, fearful). In addition to individuals with TBI performing significantly less accurately than the neurotypical group, a significant correlation was found between the ability to interpret prosody and functional communication scores. Marquardt et al. (2001) found similar results when asking individuals with and without TBI to label emotions when viewing videos. Participants were shown videos of sentences in which the facial and prosodic affect contrasted with the linguistic content (e.g. "I hate you" said with happy intonation and a smile) as well as videos of linguistically neutral sentences with emotional prosody and facial expressions. The individuals with TBI were significantly less accurate than the group without TBI for labeling all sentences. In addition, results indicated that individuals with TBI relied more heavily on linguistic or semantic content than individuals without brain injury for emotion labeling (Marquardt et al., 2001). Dimoska, McDonald, Pell, Tate, & James (2010) also demonstrated that individuals with TBI utilize or prefer semantic information compared to prosodic information in spoken sentences to determine emotion.

Brain Injury and Ambiguous Emotional Messages

Few studies have addressed perception of ambiguity in emotional messages in individuals with brain injury and no studies have directly evaluated ambiguity detection in emotion communication. Marquardt, Cannito, and Sherrard (1992) compared individuals with and without brain injuries on emotional identification in ambiguous messages, focusing on whether participant groups indicated preference for paralinguistic content or linguistic content. Marquardt et al. (1992) found that individuals with brain injury (left hemisphere, right hemisphere, and bilateral) relied more heavily on linguistic cues to disambiguate emotional messages than individuals without brain injury.

Studies of individuals with isolated lesions secondary to stroke have indicated that individuals with left hemispheric lesions present with more impairment in emotion identification at the linguistic level, while individuals with right hemispheric lesions present with more impairment in discerning affective prosody and facial expression (Karow, Marquardt, & Marshall, 2001). However, a similar study by Karow, Marquardt, and Levitt (2013) compared individuals with left and right cortical and subcortical lesions on perception of emotion in ambiguous emotional messages where paralinguistic information matched (prosody and facial expression) when presented together, but paralinguistic and linguistic content did not match. Karow et al. found that individuals without brain injury and individuals with left cortical lesions preferred paralinguistic content for identifying ambiguous messages in all contexts. Individuals with right cortical lesions preferred paralinguistic information when facial expressions were present but this preference decreased when prosody was utilized in isolation. The group with left subcortical lesions demonstrated no pattern for linguistic or paralinguistic content while prosody was present, but demonstrated a preference for facial expression cues over linguistic content in disambiguation. Though all groups demonstrated a preference for facial expression cues over prosodic cues, the participants with right subcortical lesions demonstrated a significantly weaker preference. Karow et al. concluded that all cortical and subcortical lesions, regardless of location, impair processes for emotion perception. The use of ambiguous emotional messages as stimuli revealed more information about perception and impairment in individuals with brain injuries in these studies.

TBI, Cognition, and Emotion

TBI can interfere with emotional communication outside of prosody and facial modalities through additional cognitive deficits that impact emotional perception. Individuals with TBI experience impairment in recognition of social and emotional cues and show an inability to respond appropriately to these cues (Milders, Fuchs, & Crawford, 2003). McDonald and Flanagan (2004) utilized a video-based conversation task to determine if individuals with TBI could perceive the perspectives of other individuals using theory of mind (taking the perspective of other individuals and perceiving that different individuals have different awareness and knowledge sets). McDonald and Flanagan found that compared to age-matched participants without brain injury, individuals with TBI showed impairment in social perception and theory of mind (2004). Czimskey and Marquardt (2019) compared recall of emotional and neutral paragraphs and words (all presented auditorily and in neutral prosody) between individuals with and without brain injury. The discrepancy in recall abilities between the two groups was anticipated (individuals without TBI recalled more words from word lists and units from paragraphs). However, Czimskey and Marquardt (2019) also found that individuals without brain injury showed increased recall for emotional words and paragraphs while the individuals with TBI showed increased recall only for emotional words. The "emotional advantage" was not observed for individuals with TBI at the paragraph level. A similar study by Turkstra, Duff, Politis, and Mutlu (2019) utilized written stimuli to show that individuals with TBI were less sensitive to social communication cues communicated via text. Individuals with and without TBI were asked to read pairs of statements by two text-based speakers. The statements contained social cues and participants were asked to make judgments about how the speakers felt based on their text statements. Results indicated that individuals with TBI were less sensitive to immediacy cues indicating preference and less sensitive to perceiving preference of the speakers than individuals without TBI (Turkstra et al., 2019).

Critically, the impairments secondary to TBI in emotion, cognition, and language are largely inseparable, as impaired language can lead to impaired emotion, just as impaired emotional functions can impair effective communication. Cognition, language, and emotion are intertwined. Emotion and semantic information may be inseparable, as emotional and semantic information are frequently associated (Ben-David, 2016). Kuchinke et al. (2005) utilized fMRI to show that emotional and neutral words were stored not only in semantic networks of literal meanings but also in emotional networks. A semantic development study by Skrandies (2011) showed similar results via semantic word ratings.

Impairment to language can also disrupt emotional function (Lindquist, Satpute, & Gendron, 2015), though individuals with TBI may have damage to areas of the brain directly associated with emotion perception and processing (such as the amygdala and PFC). Lindquist, Barrett, Bliss-Moreau, and Russell (2006) have shown this language-emotion connection in studies utilizing neurotypical individuals with temporarily disrupted language. Using a semantic satiation method (repetition of a word until it temporarily loses its meaning), participants were asked to repeat an emotion word (such as "anger") either 30 times (semantic satiation) or three times (priming), then asked to make judgements on emotional faces. Lindquist et al. (2006) found that participants were both slower and less accurate in making judgements about emotional faces over three separate studies. In their first study, participants repeated an emotional word (i.e. angry) and then were asked to determine if images of facial expressions matched the spoken word. Individuals assigned to the satiation group were significantly slower in administering judgements. In a second study, the participants were asked to repeat the emotional word and then determine if two facial expressions presented matched each other. If one or both facial expressions presented matched the word repeated, the participants in the satiation group performed slower than other participants. A third study looked at accuracy of judgements by utilizing a similar task to the second study but imposed a time limit to force quick reaction times. Individuals assigned to the satiation group performed less accurately on the task than other participants. A follow-up study by Gendron et al. (2012) sought to eliminate the possible conflict with an emotional judgement and emotional word satiation and asked participants to make an arbitrary perceptual judgement (such as how far apart the eyes were) about an emotional face. Again, emotional word satiation interfered with perceptual judgements on emotional faces indicating that language deficits can interrupt emotional processing unrelated to language. These results reiterate that emotion and language should be studied together for naturalistic stimuli and assessment purposes.

TBI and Verbal Fluency

The assessment of expressive communication post TBI usually addresses narratives, confrontation naming, and verbal fluency, but emotional expression is not often a specific area of study. Verbal fluency tasks specifically (i.e. generative naming tasks) are utilized as a measure of language ability and executive function (Kavé, Heled, Vakil, & Agranov, 2011). Verbal fluency tasks include controlled word association and category naming and are related to expressive abilities (Shao, Janse, Visser, & Meyer, 2014). Subjects participating in a verbal fluency task are given one minute to produce all of the words related to the prompt which typically has a semantic or phonemic theme (e.g. animals, words that begin with /s/). There is contradictory data regarding whether phonemic or semantic verbal fluency tasks are more impaired or more difficult for individuals with TBI. Some investigators claim that phonemic verbal fluency tasks are more impacted by frontal lobe brain injury while semantic tasks are more impacted by temporal brain injury (Kavé et al., 2011). Despite contradictory data, evidence suggests these impairments are more related to executive functioning deficits than word finding deficits, as individuals with TBI demonstrate impairment in verbal fluency tasks in the absence of word finding difficulties (Bittner & Crowe, 2006).

Emotional verbal fluency, asking a participant to generate words they associate with an emotion, is a more recent task (Sass, Fetz, Oetken, Habel, & Heim, 2013). Sass et al. (2013) asserted after their initial study that emotion has the potential to influence performance on cognitive and linguistic tasks, particularly in special populations, despite the lack of differences between sematic and emotional category performance in individuals without brain injury. While the initial study looked at performance by neurotypical individuals, the task was later adapted by Wauters and Marquardt (2018) and administered to bilingual individuals with TBI. Wauters and Marquardt (2018) found that emotional verbal fluency tasks were not significantly correlated with language profiles, indicating that emotional processing abilities may be more of the driving force behind performance on the task. The emotional verbal fluency task shows potential as a tool for evaluating expressive emotional abilities in individuals with TBI, as impaired emotion perception may lead to impaired emotional production (Lindquist, Barrett, Bliss-Moreau, Russell, 2006).

Conclusions

Individuals rely on accurate emotional perception and expression to communicate effectively and maintain relationships. TBI causes difficulties in emotional perception and communication that negatively impact relationships and quality of life (Cattran, Oddy, & Wood, 2011; Godwin, Kreutzer, Arango-Lasprilla, & Lehan, 2011; Hoofien, Gilboa, Vakil, & Donovik, 2001; Vallat-Azouvi et al., 2018; Wood, Liossi, & Wood, 2005). TBI poses an interesting conundrum for both the study and rehabilitation of language and emotional processing given the potential for diffuse and widespread damage affecting multiple cognitive domains. While individual neuroanatomical areas of damage may not be identifiable in an individual with TBI, assorted impairments involving communication and language may produce impairment in emotional processing and vice versa. Individuals with TBI struggle with emotional perception in various contexts, and ambiguity of emotion and multi-channel delivery of emotion may compound these impairments.

Language and emotional impairments in TBI typically have been investigated as separate entities, though research suggests that this may be an inadequate approach to these impairments given the intertwined nature of language and emotion (Barrett, 2017; Gendron et al., 2012; Lindquist et al., 2006; Lindquist, Satpute, & Gendron, 2015; Pessoa, 2008).

Linguistic stimuli are frequently avoided in assessing emotional perception to avoid detecting linguistic impairments masquerading as emotional impairments. Individuals with TBI often demonstrate impairment in perception and identification of emotion in the absence of linguistic stimuli via prosodic and visual channels. While these affective deficits have been well-documented, the role of ambiguity in affective expression and perception has largely been addressed only with respect to semantic or prosodic preference. Though individuals with TBI appear to utilize semantics to resolve ambiguity more than individuals without TBI, the ability for individuals with TBI to identify the presence of emotional ambiguity or incongruity has not been directly assessed.

This Study and Impact

Naturalistic stimuli representative of emotional communication require linguistic and emotional content to be presented concurrently. Tasks aimed at assessing linguistic and emotional processes concurrently are being utilized more frequently and via novel methods such as emotional verbal fluency (Sass et al., 2013) and T-RES (Ben-David et al., 2016), though these methods have not been fully explored in the TBI population. The impact of TBI on language and cognition has been investigated extensively, while the effects on emotion have been addressed in isolation and often separated from cognitive and language impairment. Including assessment of emotional perception and its inherent ambiguity is imperative in improving social and emotional outcomes for individuals with

TBI, as these deficits appear to negatively impact quality of life and cannot be treated appropriately without careful assessment.

This study has three aims:

- **Aim 1: Compare the ability to identify emotions and neutrality in emotionally ambiguous (incongruous) and congruous sentences in individuals with TBI and with no brain injury (NBI).**
    - Prediction: Individuals with brain injury will show increased difficulty with identification of emotion when compared to individuals with NBI. Individuals with TBI will perform less accurately on emotion identification tasks in both congruent and incongruent presentations (interaction anticipated)
- **Aim 2: Compare the ability to identify ambiguity in emotionally incongruous and congruous sentences in individuals with TBI and NBI.**
    - Prediction: Individuals with TBI will show decreased accuracy in identifying incongruity of emotion when compared to individuals with NBI (interaction anticipated).
- **Aim 3: Compare verbal fluency responses in emotional and non-emotional categories in individuals with TBI and NBI.**
    - Prediction: Individuals with TBI will produce fewer responses than individuals with NBI, and fewer responses in the emotional categories than in the non-emotional categories (interaction anticipated).

CHAPTER 3: Method

Participants

The University of Texas at Austin Institutional Review Board approved this study. Participants were recruited through contacts with the University of Texas Speech and Hearing Clinic and included 12 adults (8 male, 5 female; mean age= 33.58 years; range 19-50 years) with TBI (see Table 2) and 24 individuals without a history of neurological, psychiatric, or developmental disorders, (11 males and 13 females; mean age = 30.71 years; range 20-59 years) and no history of brain injury (see Table 3). Independent t-tests for unequal sample sizes were insignificant for age (t = .86; p = .39). All participants had completed at least 12 years of education and both reported and demonstrated normal hearing acuity based on medical history and responses to verbal instructions and questions during the administration of a medical-biographical questionnaire. Independent t-tests for unequal sample sizes were significant for year of education (t = -2.31; p = .03). Information regarding brain injury for the TBI participants was obtained from the *Ohio State University Traumatic Brain Injury Identification Method* (OSU TBI-ID) (Corrigan & Bogner, 2007), a standardized procedure for eliciting lifetime TBI events utilizing structured interview and supported by medical reports when available. The TBI participants reported they were native English speakers and at least six months post injury. TBI participants reported no history of aphasia and demonstrated necessary language skills for completion of the experimental tasks during biographical data collection and OSU TBI-ID.

All participants completed the *Beck Depression Inventory II* (BDI-II) (Beck & Steer, 1996) and a forward and backward digit span, a subtest of the *Wechsler Adult Intelligence Scale-III* (Wechsler, 1997) (See Table 2 and Table 3). In addition, participants with TBI completed the *Cognitive Linguistic Quick Test-Plus* (CLQT+) (Helm-Estabrooks, 2007) and scores are presented in Table 2. No participants with TBI required the aphasia-administration of the CLQT+ confirming necessary language function for the experimental tasks.

The CLQT+ is a screening tool that assesses five cognitive domains: attention, memory, language, executive functions, and visuospatial skills. The test provides an estimate of post brain trauma cognitive functioning. Criterion-referenced cut-off scores and severity ratings based on clinical and nonclinical subject distributions are provided for the measure. The mean CLQT+ score for the TBI participants was 3.33 (range 1.8-4.00); six participants scored within normal limits, three were mild and three were moderately impaired.

The BDI-II is a 21-item multiple choice self-report inventory designed to measure depression severity. A score of 0 to 3 is assigned to each question and the total score is compared to established cut off scores reflecting depression severity. Scores 9 or less indicate minimal depression, 10-18 mild depression, 19-29 moderate depression and >30 severe depression. The BDI-II score range for the TBI participants was 3-28 (mean 16, see Table 2). Scores were within minimal depression range for three TBI participants, mild for four, and moderate for five. The scores reflect expected mild to moderate clinical depression for the participants with brain trauma. The NBI participants reported minimal or mild clinical depression; only one reported moderate depression (See Table 3). As anticipated, a t-test for independent samples (t = 3.25; p < .01) found a significant difference in the reported clinical depression for the two groups, indicating the TBI group exhibited more depressive symptoms than the NBI group.

Table 2

Descriptions of Participants With Traumatic Brain Injury (TBI)

					CLQT+ Scores							Digit Span		
Participant	Age	Sex	Years Edu	Months Post Injury	Att	Mem	EF	Lang	VS	RATE	Total	Forward	Back.	BDI-II
TBI 1	28	F	14	28	4	4	4	4	4	wnl	4	10	7	8
TBI 2	27	M	12	32	4	3	4	4	4	wnl	3.8	11	4	16
TBI 3	44	F	14	55	4	4	3	3	4	wnl	3.6	12	6	16
TBI 4	27	M	16	39	4	4	4	4	4	wnl	4	11	6	11
TBI 5	28	F	12	125	3	2	4	2	4	mild	3	2	2	3
TBI 6	19	F	12	21	4	4	3	4	3	wnl	3.6	5	4	20
TBI 7	42	F	13	18	3	2	2	4	3	mod	2.8	8	6	25
TBI 8	50	M	13	240	3	2	4	3	4	mild	3.2	6	5	26
TBI 9	29	M	12	74	2	1	3	2	1	mod	1.8	7	2	25
TBI 10	40	M	13	42	3	4	1	4	3	mild	2.8	11	6	28
TBI 11	34	M	13	133	2	2	2	2	2	mod	2	6	4	4
TBI 12	35	M	16	86	4	4	4	4	4	wnl	4	8	8	10
Mean	33.58	-	13.33	74.42	3.33	3.00	3.17	3.33	3.33	mild	3.22	8.08	5.00	16.00

Note. CLQT+ scores presented as severity scores (4 = within normal limits, 3 = mild, 2 = moderate, 1 = severe). BDI -II scores presented as raw scores. CLQT+ = Cognitive Linguistic Quick test; Att = attention; Mem = memory; EF = executive function; Lang = language; VS = visuospatial skills; RATE = severity rating; wnl = within normal limits; Years Edu = years of formal education; BDI-II = Beck Depression Inventory II.

Table 3

Descriptions of Participants Without Brain Injury (NBI)

Participant	Age	Sex	Years Edu	Digit Span Forward	Digit Span Backward	BDI-II
NBI 1	20	M	13	11	8	2
NBI 2	59	F	16	9	7	7
NBI 3	20	F	14	9	6	10
NBI 4	20	F	14	7	5	7
NBI 5	21	F	15	11	11	2
NBI 6	21	F	15	12	8	11
NBI 7	35	F	13	10	5	7
NBI 8	37	M	13	10	4	0
NBI 9	34	M	13	14	13	13
NBI 10	24	F	16	9	7	19
NBI 11	23	F	13	11	6	12
NBI 12	25	F	16	10	7	22
NBI 13	28	M	13	8	6	14
NBI 14	27	F	16	16	7	18
NBI 15	23	F	15	11	5	5
NBI 16	32	M	16	10	6	4
NBI 17	35	F	12	11	6	0
NBI 18	44	F	14	14	11	9
NBI 19	40	M	16	15	11	7
NBI 20	22	M	14	8	5	3
NBI 21	33	M	18	11	10	6
NBI 22	40	M	13	8	5	2
NBI 23	36	M	16	14	4	6
NBI 24	38	M	15	12	6	4
Mean	30.71	-	14.54	10.88	7.04	7.92

Note. Years Edu = years of formal education; BDI-II = Beck Depression Inventory II.

The digit span task was comprised of pairs of number series from 2 to 9 digits presented forward and from 2 to 8 digits presented backwards (Wechsler, 1997). The digits were presented at the rate of 1 per second with the shortest sequences presented first. One point was assigned for repetition of each correctly recalled sequence to give a digit span score for both forward and backward recalled sequences. The score was not indicative of the actual "span" or the maximum number of correctly called digits forward or backward. The mean score was 8.08 forward and 5.00 backwards for participants with TBI (mean span of 4.58 forward and 3.33 backward), compared to 10.88 and 7.04 for the participants with NBI (mean span of 5.92 forward, and 4.33 backward). Independent t-tests for unequal sample sizes were significant for both forward score (t = -3.04; p <.01) and backward score (t = -2.53; p = .02), as well as forward span (t = -2.87; p < .01) and backward span (t = -2.13; p = .04), indicating that individuals with TBI presented with impaired attention and working memory.

In summary, the TBI participants were typical of mildly impaired individuals with injury secondary to motor vehicle accidents. As a group, they demonstrated significantly reduced cognitive processing ability, reduced digit span recall, and increased clinical depression.

Experimental Stimuli

The stimuli used for the study included 105 sentences (five for example purposes) of various emotional content. Thirty-four of the sentences used were congruent (prosodic and lexical emotional content matched), 17 were "neutralized" (prosody was neutral, lexical content was emotional), and 49 were incongruous (prosodic and lexical content were different emotions, mismatched) (See Table 4 and Appendix). Sentence stimuli were constructed to measure the impact of prosodic and lexical semantic content on the perception of emotion. Fifty of the 105 sentences were described by Ben-David, Lieshout, and Leszcz (2011), and Ben-David, Thayapararajah, and Van Lieshout (2013). The remaining sentences were similar in form, developed by the same research group and provided via personal communication by the author. The affective categories chosen for study were Anger, Happiness, Fear, Sadness, and Neutral. These emotions are frequently studied (Zupan, Neumann, Babbage, & Willer, 2009) and are easily distinguishable prosodically based on emotion-specific acoustic characteristics (Juslin & Laukka, 2003). The same sentence set was used for the sentence emotion identification task and the sentence emotional ambiguity identification task.

The verbal fluency task utilized phonemic and semantic category prompts frequently used in research and assessment (Helm-Estabrooks, 2001; Kavé, Heled, Vakil, & Agranov, 2011; Shao, Janse, Visser, & Meyer, 2014; Wauters & Marquardt, 2018), while the emotional categories were based on recent literature exploring emotional verbal fluency (Sass et al., 2013; Wauters & Marquardt, 2018). An additional abstract category prompt, "intelligence," was included as a comparator for emotional fluency and a buffer between emotional trials.

Sentence Stimuli Development

Ben-David et al. (2011) developed 500 sentences (lexical only) from emotional word ratings by young adults. Subsequently, the number of sentences was reduced to a set of 125, 25 for each emotional category from ratings by 40 young adults who rated the semantic emotional content (Anger, Happy, Fear, Sadness) on a six-point Likert scales. Sentences were presented in written form and were assigned to an emotional category based on high mean rating in one category (i.e. happy) and low mean rating on the other three emotions. Sentences were assigned to a Neutral category if they had low mean ratings on all four emotional scales. Utilizing sentences with low standard deviations confirmed agreement among raters. Statistical evaluation revealed no significant differences between emotional category sentence sets on the basis of number of syllables, frequency of use, or phonological neighborhood (Ben-David, Van Lieshout, & Leszcz, 2011).

Ben-David, Thayapararajah, and Van Lieshout (2013) investigated the sentences from Ben-David, Van Lieshout, and Leszcz (2011) in an auditory format. The sentences were recorded by a trained, professional female actor (native English speaker). Sentences were recorded three times in each of the five affective prosodies (four emotional, one neutral) regardless of lexical semantic emotional content, to generate a set of sentences. The digital files were equated in mean-square amplitude and delexicalized via filtering, effectively allowing participants to hear the prosody in isolation. The delexicalized sentences were presented to raters who were asked to evaluate a sentence's perceived emotional connotation based on prosodic information without any semantic content. The researchers reported that the delexicalized sentences were accurately attributed to each of the intended emotional categories and that no emotion was attributed to the neutral category sentences indicating the prosody was appropriately representative of the intended emotion (Ben-David, Thayapararajah, Van Lieshout, 2013).

Table 4

Experimental Sentence Stimuli by Prosodic and Lexical Content

	Prosodic Content				
Lexical Content	Angry	Happy	Sad	Fear	Neutral
Angry	8	2	3	3	4
Happy	3	7	3	2	5
Sad	3	3	7	2	4
Fear	3	3	3	8	4
Neutral	4	4	4	4	4

Note. Numbers represent quantity of sentences within each content category. Cells in gray indicate congruent sentences.

Sentence Emotion Identification Task

Procedures: The sentences were presented via *Sennheiser* headphones using a Dell Inspiron 13 7000 Series 2-in-1 computer. Administration of the experimental sentences tasks was preceded by presentation of a practice sentence list (five sentences) selected from the sentence list that were not included in the experimental task. The emotion identification task was always presented prior to the ambiguity identification task, since the ambiguity task required the participant to make evaluations regarding emotion. Participants received the sentences in one of three randomized presentations but did not receive the same order presentation for both the emotion identification and emotional ambiguity identification tasks. Participants were informed that some of the sentences were emotional or conveyed an emotion and some of the sentences were not emotional (neutral). They were instructed to point to the pictogram (see Figure 1) that communicated what feeling or emotion was being communicated (Schwartz, 2013). They also were informed that sometimes more than one emotion was being communicated and that they should select the emotion that they believed was most dominant. The first five stimulus examples were presented for identification and the participant was asked if they had any questions about the task. Questions were answered before presentation of the experimental stimuli.

Scoring: Each item had one or two possible correct responses. Sentences that were congruent for lexical semantic and prosodic content had one possible answer (the emotion encoded in both prosodic and lexical content). Incongruent or neutralized sentences had two possible correct answers, the lexically encoded emotion or the prosodically encoded emotion. For example, if a sentence had neutral lexical content and angry prosodic content, a response of neutral or angry was counted as correct. Responses were counted as correct if participants chose either the lexical or prosodic designation as the emotion for the sentence. If the participant chose one of the correct answers for an incongruous sentence, the prosodic or lexical semantic option was recorded to determine if the participant demonstrated a preference for the lexical semantic or prosodic content in sentence perception.

Reliability: Two scorers recorded responses from the participants with TBI and NBI. Interscorer reliability was determined by dividing the number of agreed upon responses by the total number of responses. The mean percent agreement for the all participants was 100% for all the emotional identification task.

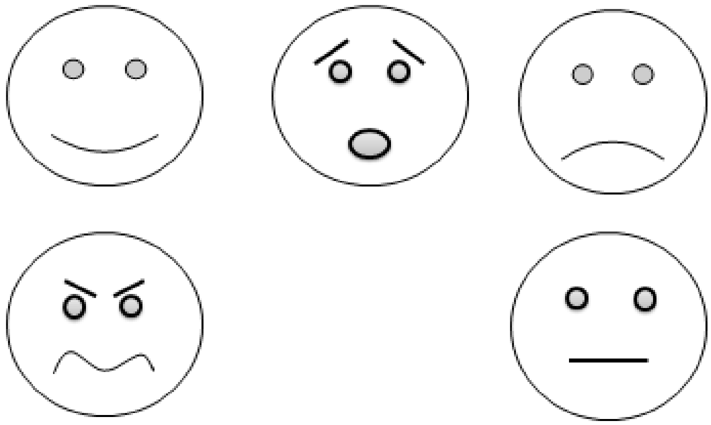

Figure 1. Response form for sentence emotion identification task. Pictograms representative of emotion conveyed in sentence tasks. Top row from left to right: happy, fear, sad; bottom row left to right: angry, neutral. Adapted from Schwartz, 2013.

Sentence Emotional Ambiguity Identification Task

Procedures: Participants were unaware they would be hearing the sentences a second time for the administration of the emotional ambiguity identification task. The digit span and BDI-II were administered in between sentence tasks. Participants were informed that they would hear sentences one at a time; some of the sentences were emotional or conveyed an emotion while some of the sentences were neutral. They were instructed to decide if the words of the sentence matched the emotion or tone of the voice. They were instructed to utilize the response sheet and point to the check mark if the words matched the tone or to point to the X mark if the words and inflection did not match (see Figure 2). The first five sentences were provided as examples to ensure understanding of the task.

Scoring: For the identification task, there was only one correct answer for each item. The participant was asked "does the tone or inflection of the voice match the words being said in the sentence?" in response to the auditory presentation of the sentences.

Participants responded by pointing to the one of the dichotomously displayed options, a check mark if the prosodic and lexical emotional cues match, or the X mark if the prosodic and lexical cues did not match (see Figure 2). The response form included written reminders of "matches" and "does not match" with the symbols. Responses were recorded for each participant from the two groups.

Reliability: Two scorers recorded responses from the participants with TBI and NBI. Interscorer reliability was determined by dividing the number of agreed upon responses by the total number of responses. The mean percent agreement for the all participants was 100% for the emotional ambiguity identification task.

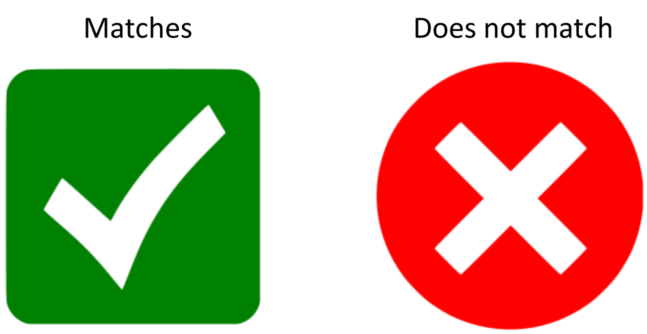

Figure 2. Response form for emotional ambiguity identification task. Green check box indicates the prosodic and lexical content of presented sentence are the same. Red "x" circle indicates that prosodic and lexical content of presented sentence are different.

Verbal Fluency Tasks

Categories: Categories were chosen based on previous studies of verbal fluency that included emotion (Sass et al., 2013; Wauters & Marquardt, 2018). Included were phonemic (/s/ words), semantic (animals), emotion (happy, angry), and abstract (intelligence) tasks. The phonemic and semantic fluency tasks were administered first, with the emotional prompts administered in counterbalanced order, with the abstract, non-emotional prompt "intelligence" used as a buffer between the emotion trials. The administration order was either /s/ words, animals, angry, intelligence, happy, or, /s/ words, animals, happy, intelligence, angry.

Instructions: Participants were instructed to name as many items as possible in one minute for each category. Instructions were presented as "name all the animals you can in one minute. Ready? Begin." Abstract category instructions were presented as "tell me words you associate with happiness or feeling happy." If a participant indicated they had a question before responding to the instructions for the task, they were clarified or reinstructed.

Scoring: Responses were transcribed and scored by the researcher and a trained research assistant. Each response was counted as one if it represented the target category and was not a repetition. In the event that the participant produced a superordinate category (such as "fish") in conjunction with specific exemplars (such as "salmon" and "tuna"), only the specific exemplars were counted as unique items. Proper nouns were not included in the total number of correct responses for words that begin with /s/, however they were counted as responses in emotion and abstract categories when they were judged to be content relevant by the scorers.

Reliability: Two scorers recorded responses from the participants with TBI and NBI. Interscorer reliability was determined by dividing the number of agreed upon responses per emotional and neutral category by the total number of responses. The mean percent agreement for the TBI participants was 100% for all tasks. Mean percent agreement for NBI participants was 99%.

General Procedures

Participants were tested in a speech and hearing center treatment room or a quiet setting of the participant's choosing. The clinical assessment measures for the TBI participants were administered by individuals trained in speech, language, and cognitive assessment. Data was collected by research assistants trained to the tasks.

Prior to administration of the experimental tasks, participants completed necessary consent forms as well as biographical information forms. Individuals with TBI also completed the OSU TBI-ID (see Table 5). A confirmatory task was administered prior to experimental tasks to ensure that participants were capable of perceiving and expressing basic emotion. All participants were required to demonstrate adequate knowledge of emotions included in the task by observing each emotion depicted on the pictogram answer sheet (see Figure 1) and describing an event or reason that would make them feel that emotion. The administrator asked the participant, "What is something that would make you feel this emotion?" while pointing to one of the five pictograms depicting an emotion in the experimental task. The question was asked in relation to each of the five possible emotions (happy, sad, angry, fear, neutral) included on the answer sheet. The verbal fluency task and sentence tasks were presented in counterbalanced order for each participant. The participant received either the verbal fluency/category generation task or the sentences task first. Participants received one of three randomly ordered sentence lists and received the fluency prompts with /s/ and animal prompts first (for task execution) then received the experimental prompts in either "Happy, Intelligence, Angry" or "Angry, Intelligence, Happy" order. Responses were scored on-line. Participants were recorded via digital video camera (Sony Vixia) for later analysis and for coding and reliability purposes. Order of administration was counterbalanced within each participant group to minimize order effects.

Statistical Analyses

Statistical analyses were computed using IBM SPSS. Analyses for Task 1, sentence emotion identification, were completed via three one-way ANOVAs, one for congruent items, one for incongruent items, and one for prosodic preference in correctly identified incongruent items. Separate ANOVAs were required due to different correct hit-rates for congruent (20% correct hit-rate) and incongruent (40% correct hit-rate) items. Analyses for task 2, sentence emotional ambiguity identification, utilized a mixed-model ANOVA comparing groups and item type (congruent/incongruent). Post-hoc t-tests were utilized where appropriate. The verbal fluency task was analyzed via MANOVA with post-hoc pairwise comparisons.

Table 5

Task Presentation Orders

	TBI Participants	NBI Participants
Order 1	TBI Consent Form	NBI Consent Form
	Biographical Data	Biographical Data
	OSU TBI ID*	Task 1: Emotional ID
	Task 1: Emotional ID	Beck Depression Inventory - II
	Beck Depression Inventory - II	Digit Span
	Digit Span	Task 2: Ambiguity ID
	Task 2: Ambiguity ID	Task 3: Verbal Fluency
	Task 3: Verbal Fluency	
	CLQT+*	
Order 2	TBI Consent Form x2	NBI Consent Form x2
(counterbalanced)	Biographical Data	Biographical Data
	OSU TBI ID*	Task 3: Verbal Fluency
	Task 3: Verbal Fluency	Task 1: Emotional ID
	Task 1: Emotional ID	Beck Depression Inventory - II
	Beck Depression Inventory - II	Digit Span
	Digit Span	Task 2: Ambiguity ID
	Task 2: Ambiguity ID	
	CLQT+*	

Note. TBI = traumatic brain injury; NBI = no brain injury; OSU TBI ID = Ohio State University Traumatic Brain Injury Identification Method; * = tasks administered to TBI group only

CHAPTER 4: Results

Tasks were administered to investigate the ability of participants with traumatic brain injury (TBI) and participants with no brain injury (NBI) to identify the emotion encoded in sentences that included congruous (same emotion encoded in words and in prosody) and ambiguous (different emotions encoded in prosody compared to words) sentences. Using the identical sentence task, the study also examined the ability of both groups of participants to detect sentences in which the semantic and prosodic emotion did not agree.

Sentence Emotion Identification Task

Performance on the emotion identification task for participants in the TBI and NBI groups is shown in Tables 6 and 7, and mean group performances in Figure 3. The mean ratio of correct responses for the NBI group (M = .93, SD = .05) was greater than the mean ratio of correct responses for TBI participants (M = .84, SD = .10). For congruent stimuli (lexical semantic content matched prosodic content) individuals with NBI chose the correct emotion more frequently (M = .96, SD = .07) than the TBI participants (M = .86, SD = .17). Incongruent stimuli yielded 92% correct responses for NBI participants (M = .92, SD = .05), but only 82% for TBI participants (M = .82, SD = .08).

One way ANOVA comparisons of differences in the percent of total correct responses between the two groups were significant for both congruent (F(1, 34) = 5.59, p

= .02) and incongruent (*F*(1, 34) = 19.98, *p* < .01) stimuli. Homogeneity of variance assumption was violated for congruent items (Levene's test, *F*(1, 34) = 7.99, *p* < .01), but non-parametric test confirmed the robustness of the findings (Kruskal-Wallis *h* = .016). Given the robustness of ANOVA in samples of this size and the nonparametric confirmation of significance analysis continued via ANOVA. All assumptions were met for incongruent item comparison via ANOVA. Comparison of performance within the two groups was not completed because probabilities for a correct response were greater for incongruous (40%) than congruous (20%) stimuli.

NBI participants identified the prosodic emotion as dominant more often than the semantic (*M* = .72, *SD* = .25) in emotion identification of the incongruous stimuli. In comparison, participants with TBI chose the prosodic emotion in 58% of incongruous trials *(M* = .58, *SD* = .31). All assumptions were met for prosodic preference comparison via ANOVA. The difference in selection bias was not significant between he to participant groups (*F*(1, 34) = 2.22, *p* = .15).

Table 6

Emotion Identification Task Ratio Correct Responses by Sentence Type for NBI Participants

Participant	Overall	Congruent	Incongruent	Prosodic
NBI 1	0.88	0.94	0.85	0.75
NBI 2	0.85	0.91	0.82	0.89
NBI 3	0.92	1.00	0.88	0.38
NBI 4	0.93	0.94	0.92	0.89
NBI 5	0.96	1.00	0.94	0.82
NBI 6	0.93	1.00	0.89	0.80
NBI 7	0.94	1.00	0.91	0.93
NBI 8	0.97	1.00	0.95	0.86
NBI 9	0.97	0.97	0.97	0.61
NBI 10	1.00	1.00	1.00	0.92
NBI 11	0.92	1.00	0.88	0.74
NBI 12	0.93	0.94	0.92	0.79
NBI 13	0.76	0.65	0.82	0.22
NBI 14	0.92	0.94	0.91	0.83
NBI 15	0.95	0.94	0.95	0.90
NBI 16	0.94	1.00	0.91	0.88
NBI 17	0.94	1.00	0.91	0.88
NBI 18	0.94	0.91	0.95	0.05
NBI 19	0.98	1.00	0.97	0.25
NBI 20	0.91	0.97	0.88	0.90
NBI 21	0.99	1.00	0.98	0.57
NBI 22	0.94	0.94	0.94	0.74
NBI 23	0.93	0.94	0.92	0.93
NBI 24	0.97	0.97	0.97	0.86
M	0.93	0.96	0.92	0.72
SD	*0.05*	*0.07*	*0.05*	*0.25*

Note. NBI = no brain injury; Overall = all sentences combined; Prosodic = in correctly identified incongruent sentences, the ratio of prosodic content chosen as emotion over all correctly identified incongruent sentences

Table 7

Emotion Identification Task Ratio Correct Responses by Sentence Type for TBI Participants

Participant	Overall	Congruent	Incongruent	Prosodic
TBI 1	0.85	0.88	0.83	0.95
TBI 2	0.93	0.91	0.91	0.93
TBI 3	0.85	0.91	0.82	0.57
TBI 4	0.77	0.94	0.68	0.71
TBI 5	0.93	1.00	0.89	0.09
TBI 6	0.80	0.82	0.79	0.71
TBI 7	0.93	1.00	0.89	0.25
TBI 8	0.85	0.91	0.82	0.69
TBI 9	0.72	0.53	0.82	0.19
TBI 10	0.88	0.97	0.83	0.63
TBI 11	0.60	0.50	0.65	0.30
TBI 12	0.94	0.97	0.92	0.97
M	0.84	0.86	0.82	0.58
SD	*0.10*	*0.17*	*0.08*	*0.31*

Note. TBI = traumatic brain injury; Overall = all sentences combined; Prosodic = in correctly identified incongruent sentences, the ratio of prosodic content chosen as emotion over all correctly identified incongruent sentences

These results indicated that individuals with NBI were more accurate at emotional sentence identification for both congruous and incongruous sentences. When assessing groups for prosodic/semantic preference in incongruent sentences, no significant difference was found.

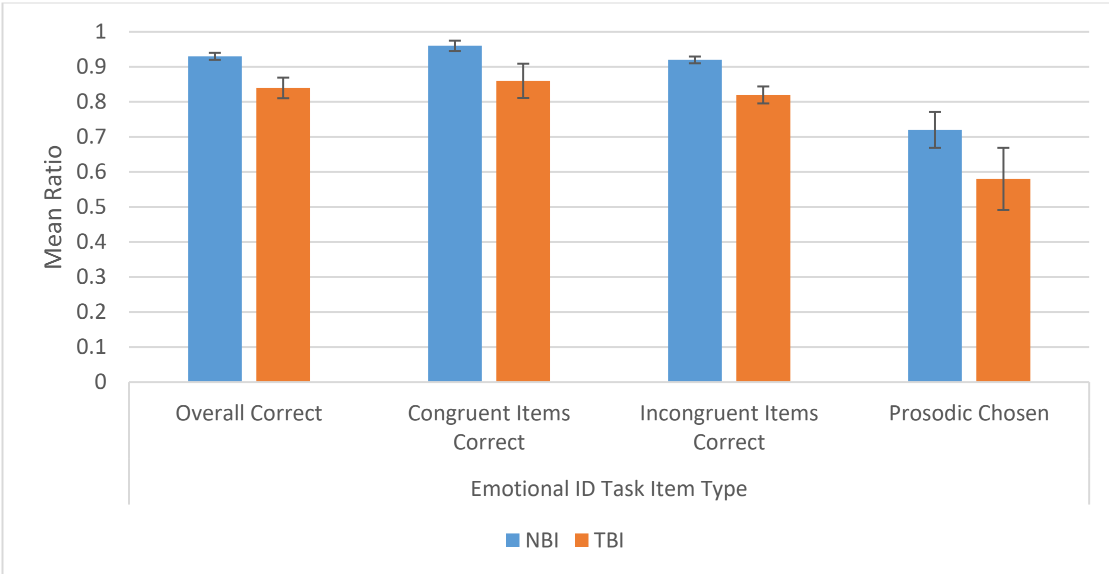

Figure 3. Mean ratio correct scores for emotion identification task. NBI = individuals with no brain injury; TBI = individuals with traumatic brain injury; Prosodic Chosen = in correctly identified incongruent sentences, the ratio of prosodic emotion chosen as emotion over all correctly identified incongruent sentences

Sentence Emotional Ambiguity Identification Task

Individual participant performance on emotional ambiguity identification tasks is shown in Tables 8 and 9, and mean group performances in Figure 4. For the emotional ambiguity identification task, individuals with NBI chose the correct response in 85% of trials (*M* = .85, *SD* = .06), while individuals with TBI chose the correct response on 69% of trials (*M* = .69, *SD* = .15). In congruent sentence trials individuals with NBI identified congruent trials correctly more frequently (*M* = .94, *SD* = .05) than TBI participants (*M* = .87, *SD* = .15). Performance on incongruent sentence trials was lower with 80% correct identification for NBI compared to 61% (*M* = .61, *SD* = .24) for TBI participants.

Table 8

Emotional Ambiguity Identification Task Ratio Correct Responses by Sentence Type for NBI Participants

Participant	Overall	Congruent	Incongruent
NBI 1	0.74	0.94	0.64
NBI 2	0.86	0.91	0.83
NBI 3	0.85	0.94	0.80
NBI 4	0.91	1.00	0.86
NBI 5	0.82	0.88	0.79
NBI 6	0.79	0.88	0.74
NBI 7	0.89	1.00	0.83
NBI 8	0.86	1.00	0.79
NBI 9	0.93	0.97	0.91
NBI 10	0.92	1.00	0.88
NBI 11	0.83	0.97	0.76
NBI 12	0.80	0.94	0.72
NBI 13	0.80	0.91	0.74
NBI 14	0.91	0.88	0.92
NBI 15	0.86	0.91	0.83
NBI 16	0.88	0.94	0.85
NBI 17	0.85	1.00	0.77
NBI 18	0.88	0.94	0.85
NBI 19	0.78	0.97	0.67
NBI 20	0.79	0.79	0.79
NBI 21	0.90	1.00	0.85
NBI 22	0.75	0.91	0.67
NBI 23	0.90	0.97	0.86
NBI 24	0.77	0.97	0.67
M	*0.84*	*0.94*	*0.79*
SD	*0.06*	*0.05*	*0.08*

Note. NBI = no brain injury; Overall = all sentences combined.

A mixed-model ANOVA was used to investigate the effects of groups and sentence type on correct responses. The effects of groups ($F(1, 34) = 34.52$, $p < .01$) and tasks ($F(1, 34) = 22.41$, $p < .01$) were significant. Homogeneity of variance assumption was violated for (Levene's test, $F(1, 34) = 28.63$, $p < .01$), but non-parametric tests confirmed the robustness of the findings (Kruskal-Wallis, all items Chi-Square = 9.56, $h < .01$;

incongruent items Chi-Square = 4.78, *h* = .03; congruent items, Chi-Square = 5.06, *h* = .03). Given the robustness of ANOVA in samples of this size and the nonparametric confirmation of significance, analysis continued via ANOVA. The interaction of groups and trials was not significant ($F(1, 34) = 2.40$, $p = .13$). Post hoc t-tests comparing within group performance on incongruent and congruent trials revealed a significant difference for NBI ($t(23) = 8.19$, $p < .01$) and TBI groups ($t(11) = 2.79$, $p = .02$). Post hoc t-test also found significant group differences on congruent trials, ($t(34) = 2.26$, $p = .03$) and incongruent trials ($t(34) = 3.50$, $p < .01$).

Table 9

Emotional Ambiguity Identification Task Ratio Correct Responses by Sentence Type for TBI Participants

Participant	Overall	Congruent	Incongruent
TBI 1	0.81	0.97	0.73
TBI 2	0.88	0.94	0.85
TBI 3	0.82	0.94	0.76
TBI 4	0.76	0.91	0.68
TBI 5	0.57	0.88	0.59
TBI 6	0.54	0.85	0.38
TBI 7	0.62	0.94	0.46
TBI 8	0.63	0.82	0.53
TBI 9	0.41	0.88	0.17
TBI 10	0.56	0.97	0.35
TBI 11	0.75	0.41	0.92
TBI 12	0.88	0.88	0.88
M	*0.69*	*0.87*	*0.61*
SD	*0.15*	*0.15*	*0.24*

Note. TBI = traumatic brain injury; Overall = all sentences combined.

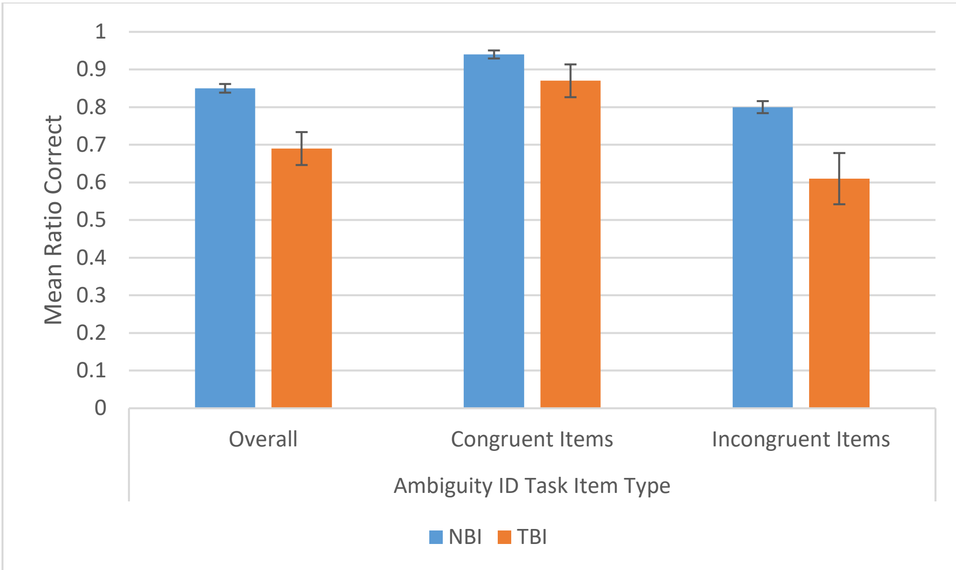

Figure 4. Mean ratio correct scores for emotional ambiguity identification task. NBI = individuals with no brain injury; TBI = individuals with traumatic brain injury

These results indicated that individuals with NBI were significantly more accurate at emotional ambiguity identification overall. Both groups were more accurate with correct identification of congruent sentences than incongruent sentences, and individuals with NBI were more accurate than individuals with TBI in identifying both congruent and incongruent sentences correctly.

Verbal Fluency Tasks

Individuals with NBI generated more responses than individuals with TBI in all five verbal fluency prompts (see Figure 5 and Tables 10 and 11). For the phonological prompt, /s/, individuals with NBI generated a mean of 16.29 responses (*SD* = 4.54) while individuals with TBI generated a mean of 9.33 responses (*SD* = 4.60). Given the semantic category prompt of “animals,” individuals with NBI generated a mean of 23.29 responses (*SD* = 5.88) while individuals with TBI generated a mean of 16.58 responses (*SD* = 5.11). The emotional prompt of “anger” yielded a mean of 10.58 responses from individuals with NBI (*SD* = 3.54) and a mean of 5.17 responses from individuals with TBI (sd = 2.04). The remaining emotional prompt of “happy” elicited a mean of 13.71 responses from individuals with NBI (*SD* = 4.98) and a mean of 8.00 responses from individuals with TBI (*SD* = 4.35). The abstract, non-emotional category of “intelligence” resulted in a mean of 11.46 responses from individuals with NBI (*SD* = 3.90) and a mean of 7.50 responses from individuals with TBI (*SD* = 4.91).

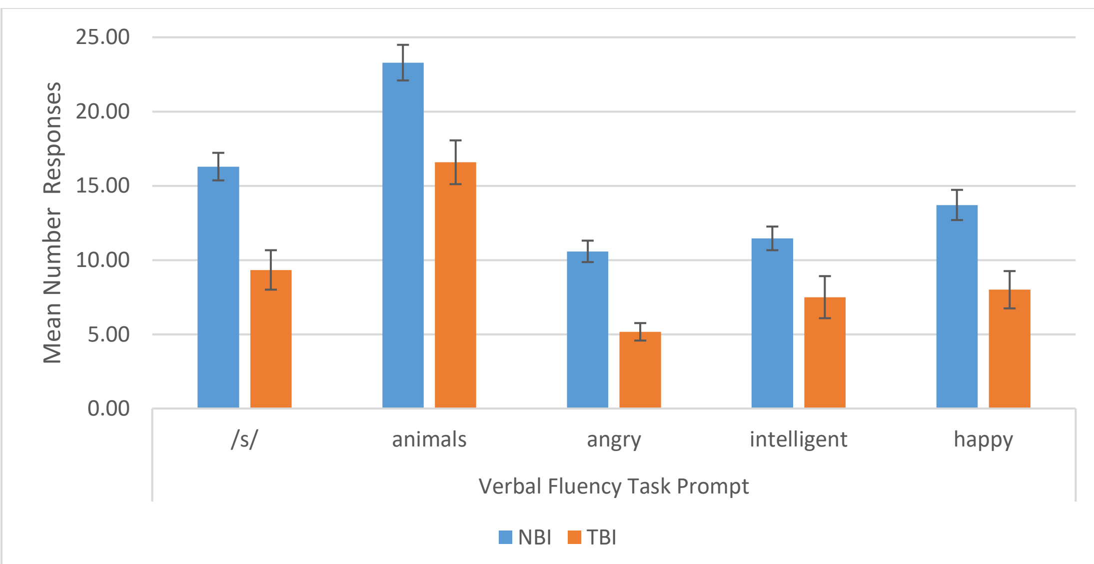

Figure 5. Mean number responses generated for verbal fluency tasks by prompt. NBI = individuals with no brain injury; TBI = individuals with traumatic brain injury

Table 10

Number of Responses for Verbal Fluency Prompts for Individuals with NBI

Participant	/s/	Animals	Angry	Intelligence	Happy
NBI 1	15	24	11	10	14
NBI 2	20	30	13	14	27
NBI 3	11	23	12	11	14
NBI 4	16	28	14	18	13
NBI 5	22	25	11	9	17
NBI 6	17	18	8	9	10
NBI 7	11	26	9	18	10
NBI 8	13	24	5	14	15
NBI 9	12	24	13	10	16
NBI 10	20	17	9	7	15
NBI 11	19	24	14	14	9
NBI 12	18	20	9	14	13
NBI 13	21	17	10	9	9
NBI 14	14	18	14	18	24
NBI 15	19	23	16	14	12
NBI 16	16	23	11	7	15
NBI 17	17	31	11	7	7
NBI 18	20	24	8	13	15
NBI 19	13	32	13	17	16
NBI 20	6	10	4	4	5
NBI 21	25	35	9	11	10
NBI 22	9	19	4	9	11
NBI 23	21	29	18	9	20
NBI 24	16	15	8	9	12
M	*16.29*	*23.29*	*10.58*	*11.46*	*13.71*
SD	*4.54*	*5.88*	*3.54*	*3.9*	*4.98*

Note. NBI = no brain injury

A MANOVA for comparing performance on the verbal fluency tasks revealed a main effect for groups, ($F(1, 34) = 26.73$, $p<.01$; observed power = .99, no significant interaction), and a main effect for category prompt ($F(4, 31) = 49.90$, $p < .01$; observed power = 1.00, no significant interaction). All assumptions were met for comparisons. Overall pairwise comparison on category prompts revealed significant differences ($p < .05$) in performance between all prompts with the exception of "happy" and "intelligence," ($p = .15$) (see Table 12).

These results indicated that individuals with NBI generated significantly more responses overall. No significant interactions were observed by measure, and pairwise comparisons indicate that prompts elicited significantly different numbers of responses overall with the exception of "happy" and "intelligence."

Table 11

Number of Responses for Verbal Fluency Prompts for Individuals with TBI

Participant	/s/	Animals	Angry	Intelligence	Happy
TBI 1	16	23	9	11	17
TBI 2	15	13	6	8	12
TBI 3	8	15	4	16	11
TBI 4	9	16	7	7	10
TBI 5	0	12	3	3	3
TBI 6	7	17	6	5	9
TBI 7	5	17	4	3	4
TBI 8	10	22	5	17	2
TBI 9	8	14	5	4	5
TBI 10	13	14	6	7	9
TBI 11	7	9	1	2	5
TBI 12	14	27	6	7	9
M	*9.33*	*16.58*	*5.17*	*7.5*	*8*
SD	*4.6*	*5.11*	*2.04*	*4.91*	*4.35*

Note. TBI = traumatic brain injury

Correlations

Several correlations were of interest within the TBI participant group. While no significant correlation was found for CLQT+ performance and emotion identification (r = .54, p = .07), a significant correlation was found for CLQT+ performance and ambiguity identification (r = .66, p = .02). CLQT+ scores also correlated significantly with TBI verbal fluency performance on the prompts of "angry" (r = .67, p = .02), and "happy" (r = .65, p = .02), but were not significantly correlated with the abstract category of "intelligence" (r = .47, p = .13). BDI-II scores were not significantly correlated with emotional identification or emotional ambiguity scores for either participant group indicating that level of depression did not impact emotion or ambiguity identification abilities.

Table 12

Pairwise comparisons for verbal fluency prompts using adjusted means for multiple comparisons.

Comparison	Mean Difference	*SE*	*p*
/s/ vs. Animals	-7.13	0.98	<.01
/s/ vs. Angry	4.94	0.75	<.01
/s/ vs. Happy	1.96	0.94	0.05
/s/ vs. Intelligence	3.33	1.01	<.01
Animals vs. Angry	12.06	0.87	<.01
Animals vs. Happy	9.08	1.13	<.01
Animals vs. Intelligence	10.46	0.98	<.01
Angry vs. Happy	-2.98	0.74	<.01
Angry vs. Intelligence	-1.6	0.77	0.05
Happy vs. Intelligence	1.38	0.93	0.15

CHAPTER 5: Discussion

This study evaluated performance of individuals with TBI and NBI on emotion identification, emotional ambiguity identification, and emotional verbal fluency. Individuals with NBI demonstrated significantly more accurate identification of emotion than their TBI peers regardless of emotionally incongruent or congruent sentence presentation. While visual inspection of the data would indicate a difference between groups in semantic/prosodic choice in incongruent sentence presentations, large variances reduced the ability to determine a main effect difference between the groups. Additionally, individuals with NBI demonstrated significantly more accurate identification of ambiguity than TBI participants regardless of whether emotional sentence presentation was congruent or incongruent. In the verbal fluency tasks, individuals with NBI generated significantly more responses across all categories.

Task 1: Emotion Identification

Aim 1: Compare TBI and NBI participant identification of emotions and neutrality in emotionally ambiguous (incongruous) and congruous emotional and neutral sentences.

Individuals with TBI identified emotion less accurately than individuals with NBI. The results of this task support previous studies indicating that individuals with TBI show impairment in identification of emotion through various modalities (Blonder, Bowers, &

Heilman, 1991, Croker & McDonald, 2005; Marquardt et al., 2001; McDonald & Pearce, 1996; Milders et al., 2003; Spell & Frank, 2000; Watts & Douglas, 2006). Critically, this study provides new insight, indicating that individuals with TBI show impairment in identification of emotion both in the face of congruous and incongruous presentation. One-way ANOVAs were utilized for assessing these tasks separately due to the different hit rates for a correct response in the tasks; for congruous sentence emotional identification the chance of guessing correctly is 20% (one out of five emotions presented is a correct choice), while for incongruous sentence emotional identification the chance of guessing a correct emotion is 40% (two out of five emotions presented are correct choices). Given the lack of increased correct identification with higher percentage chance correct per item, inference would allow the conclusion that the incongruous emotional identification was a more difficult task than congruous identification for both groups. If the tasks were of equal difficulty, increased hit rate would yield increased correct identification.

When evaluating incongruous emotion trials where the participant correctly identified one of the presented emotions, visual inspection of the means would indicate that individuals with NBI preferred prosodic cues in identifying emotion more than individuals with TBI. However, this difference was not found to be significant due to large variances in both groups. Individual inspection of participant performance would indicate that there are individuals with TBI and NBI who preferred semantic cues rather than prosodic cues, though these individuals were in the minority for both groups; 33% of participants with TBI chose the semantically encoded emotion in 70% or more of correct incongruous emotional identifications while 12.5% of individuals with NBI chose the semantically encoded emotion in 70% or more of correct incongruous emotional identifications. It is possible that individuals with TBI utilize semantic cues more than individuals with NBI, which would support Marquardt et al.'s (2001) findings that individuals with TBI rely on prosodic cues less heavily than individuals with NBI.

Task 2: Emotional Ambiguity Identification

Aim 2: Compare TBI and NBI participant identification of emotional ambiguity in emotionally incongruous and congruous emotional and neutral sentences.

Individuals with TBI demonstrated increased impairment in the ability to recognize ambiguity of emotion presented lexically and prosodically when compared with participants with NBI. Both participant groups were significantly more accurate in correctly identifying congruent sentences as congruent than correctly identifying incongruent sentences as incongruent. This task was the most novel of the identification tasks, as no direct information existed on whether individuals with TBI can identify incongruous emotion. Previous studies addressed modality preference for identification of emotion when presented incongruously but not whether the individuals with TBI could identify that incongruity was present in the given task (Dimoska et al., 2010; Marquardt et al., 2001). The decreased overall performance of individuals with TBI when compared to those with NBI, combined with the decreased performance across both groups when assessing incongruous sentences, resulted in a lower identification rate (61%) for incongruity in individuals with TBI (79% for individuals with NBI). Ability to identify that emotion is presented ambiguously may be just as vital as the ability to identify emotion portrayed given the various connotations and variety of implications that incongruous emotional presentation may provide. Sarcasm, passive aggressive behavior, humor, and other complex relational interactions are dependent on effective portrayal and perception of incongruous emotion. The inability to perceive incongruous emotion may result in a similar communication breakdown to an incorrect identification of emotion. While Ben-David et al. (2016) indicated the inability of NBI participants to completely ignore one modality of emotion while rating another in incongruous emotion presentation, the results of the current study indicate that incongruous emotional presentation can go unidentified or misidentified by both individuals with NBI or TBI. As such, the inability to ignore one emotion modality may be present (Ben-David et al., 2016), but not enough to ensure accurate identification of ambiguity.

Large standard deviations were observed for the TBI group in the ambiguity identification tasks. Considering the variability between individuals, utilizing these tasks as descriptive for individual preferences and abilities in emotional ambiguity identification may be beneficial for individuals with TBI. Descriptive information about ambiguity identification may not only be beneficial for the individual with TBI but also for any communication partners. Allowing a communication partner with NBI to complete the same identification task as the partner with TBI, then allowing the partners to view any discrepancies with how the task was perceived may shed light on the potential communication breakdowns occurring within communication partners.

Task 3: Emotional Verbal Fluency

Aim 3: Evaluate verbal fluency in emotion and non-emotion categories in TBI and NBI participants to investigate differences in number of responses.

In the verbal fluency task, individuals with TBI produced fewer responses in all categories when compared to individuals with NBI. No interactions were observed, meaning there was not a different response pattern between the two groups with regards to type of verbal fluency prompt. There was an overall effect for prompt type, while pairwise comparisons revealed significant differences between all prompts with the exception of "happy" and "intelligent." The positively valanced emotion of "happy" was also least impaired, or most robust, in the emotional verbal fluency study conducted by Sass et al. (2013). The lack of differentiation in "happy" as compared to "intelligence" may be attributed to positivity bias, since "angry" produced fewer responses, though positivity bias has been shown to increase performance of positive stimuli (such as "happy") over neutral stimuli (such as "intelligence") (Kuchinke et al., 2005; Sass et al., 2012). Previous studies addressed positivity bias in perception rather than production, though Ashby, Isen and Turken (1999) postulated that positivity bias could increase performance in a variety of cognitive and language tasks.

Reduced verbal fluency output from individuals with TBI compared to individuals with NBI was anticipated. The lack of significant interactions between groups and tasks indicates that individuals with TBI do not inherently display more impairment with emotional output than individuals with NBI as measured via verbal fluency. It is possible that this emotional verbal fluency task was not sensitive to individuals with mild cognitive impairment post TBI. However, because emotional prompts yielded significantly less output than the phonetic and semantic prompts, and individuals with TBI demonstrated reduced output compared to individuals with NBI, impairment in emotional verbal fluency, and thus emotional expression, may be more apparent in individuals with TBI.

Limitations

Participants with TBI produced large variances and standard deviations in several tasks. The participants with TBI were also mildly impaired and exhibited cognition within normal limits to moderately impaired based on CLQT+ performance. The addition of more severely impaired participants and an age and gender matched NBI group may provide a more representative estimate of overall emotional deficits in individuals with TBI. The scores of the participants with TBI suggest that the CLQT+ may have limited sensitivity to emotional language processing deficits present in individuals with mild cognitive impairment. Individuals with more severe impairment might be expected to show more robust impairment in the experimental tasks. While the lack of interaction in emotional ambiguity identification is possibly attributed to large variances and limited number of participants, another possibility is that stimuli was misinterpreted by the individuals with NBI with plausible presentations of incongruent sentences identified as "congruent" rather than "incongruent." For example, if a sentence said "I really love nature" (lexically happy), with angry prosody, an individual with NBI may have thought that was a plausible presentation if the person relaying the message was being sarcastic and decided that if sarcasm was the intention the sentence was "congruent." Additional instruction prior to the task may eliminate the potential confusion, or post-test interview would allow explanation of answer choices.

Considerations

Differences in performance between groups on all three tasks were significant despite the mild presentation of symptoms in participants with TBI, indicating that even with mild cognitive impairment, individuals with TBI show signs of impaired emotional processing. While no interactions were detected in any of the three tasks, the value of these experimental tasks may be in individual administration and performance evaluation, as separate participants showed different tendencies, trends, and impairments across tasks. For example, TBI participant 9 showed preference for prosody in 19% of trials and identified incongruent sentences correctly in 17% of trials which may indicate that this participant is not perceiving prosody as readily as their NBI counterparts. TBI manifestation and symptomology varies across individuals, which means some individuals with TBI may show impairment in emotional identification and disambiguation more than others.

Participants with NBI were more likely to comment on and identify the difficulty of the identification tasks after completion and recognize their own breakdown in communication (50% of NBI participants made unsolicited comments on the difficulty of either the emotional identification or ambiguity identification task). Of the TBI group, one participant noted the difficulty or identified their own struggle with the task at hand. It is possible that even with the difficulty NBI participants expressed with the ambiguity ID task, the ability to self-identify the struggle is helpful in self-remediation of communication while individuals with TBI may be less aware, though this would require further inquiry.

Clinical Application and Impact

Individuals with TBI demonstrate impairment in perceiving ambiguity in emotional communication. The emotional ambiguity identification task is unique. No other tasks have been utilized to directly measure awareness of individuals with TBI for ambiguous affective communication. This task is useful because it provides insight to an individual's emotional perception abilities. Individual administration of the tasks presented in this study may highlight areas of strength or impairment in emotional identification, emotional ambiguity identification, and emotional expression for individuals with TBI. Isolating areas of impairment within emotional communication can provide insight for the treatment provider, the individual with TBI, and to communication partners as to where emotional communication breakdowns may be occurring for an individual with TBI. Lexical and pencil-and-paper tasks frequently fail to capture the nuance of emotion impairment in individuals with mild TBI. More naturalistic stimuli and assessment can provide more qualitative data for analysis. Additionally, identifying more specific areas of emotion-based impairment may allow the interventionist (i.e. speech-language pathologist, counselor, psychologist, etc.) to directly target areas in need of further assessment or remediation. Ideally, the interventionist would be able to utilize a similar emotion identification and emotional ambiguity identification task to evaluate and demonstrate to the individual and their communication partner where perceptual differences exist to promote understanding on behalf of both parties and improve communication awareness. Identifying perceptual differences in emotional communication may promote patience and understanding between communication partners, allow more specific communication goals to be targeted in therapy, increase relationship quality, decrease the number of failed relationships, and increase social integration.

Accurate interpretation and expression of emotion is required for effective communication. Individuals with TBI exhibit impairment in emotional perception and expression which negatively impacts their communication and social functioning (Knox & Douglass, 2009; Spell & Frank, 2000; Watts & Douglas, 2006). Impairment in emotion perception is correlated with impairment in social integration (Knox & Douglas, 2009; Rigon, Turkstra, Mutlu, & Duff, 2018) and individuals with TBI exhibit difficulty in maintenance of relationships (Godwin, Kreutzer, Arango-Lasprilla, & Lehan, 2011;

Hoofien, Gilboa, Vakil, & Donovik, 2001; Vallat-Azouvi, Paillat, Bercovici, Morin, Paquereau, Charanton, Ghout, & Azouvi, 2018). Flynn, Mutlu, Duff, and Turkstra (2018) have shown that in addition to reduced social participation and loss of relationships, relationship quality is also negatively impacted. Individuals with TBI report more frequent anxiety and depression and a decrease in overall quality of life in addition to impairments in expression and perception of emotion (Dijkers, 2004). Henry, Phillips, Crawford, Theodorou, and Summers (2005) found that with depression and anxiety controlled, difficulty in identifying emotion was associated with poorer quality of life in individuals with TBI, indicating that quality of life measures in individuals with TBI are dependent on perceptive and expressive emotional abilities in addition to internal emotional state. By inference, individuals with impairments in emotional expression would display deficits in emotional communication and thus, relationship maintenance, leading to reduced social integration and lower quality of life (Dijkers, 2004; Henry et al., 2005; Knox & Douglas, 2009; Rigon, Turkstra, Mutlu, & Duff, 2018.

Future Directions

A case-study series analysis or utilization of derived measures at the group level may provide more insight on individual differences and performance on the emotion identification and ambiguity identification tasks. These analyses may reveal more information about individual performance and group differences, which may increase sensitivity or make visible the difference in response to ambiguity between the groups.

Future studies may directly assess emotional ambiguity identification, social/relationship satisfaction, and communication partner perception to allow for direct correlations between emotional ambiguity identification and its social impact. Establishing the daily impact of inability to identify incongruous emotional messaging is crucial to communicating the importance of this domain and supporting the need for intervention. Utilizing the Ben-David et al. (2016) T-RES task in its original form may further identify individuals with TBI processing impairment of ambiguous or incongruent emotional messages. Allowing individuals with TBI to rate and assign multiple emotions within an incongruent emotional message may allow more insight into incongruous perception. Future studies may also study the impact of valence or emotion type on group performance and on individual performance as well. It is possible that individuals with TBI perform differently in response to different emotional stimuli. Visual, paragraph length, and comparison of differently valanced emotional stimuli may provide further information on affective processing and identification of emotional ambiguity in individuals with TBI. Finally, including imaging as a component of analysis may highlight patterns of performance based on primary areas of cortical damage.

Continued study and analysis of emotional ambiguity perception and identification in individuals with TBI is critical to improving relationships and quality of life for individuals post injury. The use of novel tasks and naturalistic stimuli is imperative to isolating differences in perception and expression in individuals with TBI. Qualitative methods may be necessary for accurately demonstrating the subtle differences and impairments that individuals with mild TBI present. Survey, interview, and observation of individuals with TBI may prove useful for highlighting the roles of emotion identification and ambiguity identification in effective communication and impact on daily life.

APPENDIX

Experimental Stimuli Sentences

Emotion Conveyed		Sentence	
Lexical	Prosodic		
Angry	Angry	Do not push your luck	
Angry	Angry	You disgust me.	
Angry	Angry	Get dressed now.	
Angry	Angry	I wasn't talking to you.	
Angry	Angry	You need to grow up.	
Angry	Angry	You're just jealous of me.	
Angry	Angry	This is not your concern.	
Angry	Angry	I hate you so much right now.	
Angry	Fear	I am very angry.	
Angry	Fear	I'm sick of you being late	
Angry	Fear	You over charged me for that.	
Angry	Happy	Get out of my room.	
Angry	Happy	That's double what I paid for it	(trial)
Angry	Happy	Stop what you're doing and listen to me.	
Angry	Neutral	Some people are way too loud.	
Angry	Neutral	You think you know everything.	
Angry	Neutral	Stop wasting my time.	
Angry	Neutral	Go to hell.	
Angry	Sad	Do not waste my time.	
Angry	Sad	Quiet, this is a library.	
Angry	Sad	This is infuriating.	
Fear	Angry	Watch out for that tiger.	
Fear	Angry	I can hear footsteps in the night.	
Fear	Angry	I hear a sharp scream from behind.	
Fear	Fear	You're starting to scare me.	
Fear	Fear	I'm so scared.	
Fear	Fear	Help me, I can't swim.	
Fear	Fear	I'm choking.	
Fear	Fear	Something is creeping up my leg.	
Fear	Fear	She needs to get to a hospital.	
Fear	Fear	This place is creeping me out.	
Fear	Fear	The cobra's on the loose.	
Fear	Happy	Watch out, he's got a gun.	
Fear	Happy	Someone is following me.	

Fear	Happy	That man terrifies me.	
Fear	Neutral	The fire is spreading to the gas pipe.	
Fear	Neutral	I can't see the bear but I can hear it.	
Fear	Neutral	I smell gas leaking from the stove.	
Fear	Neutral	Look out there's a car coming.	
Fear	Sad	It's about to explode.	
Fear	Sad	He has a knife.	
Fear	Sad	Run for your life.	
Happy	Angry	I really love nature.	
Happy	Angry	I feel wonderful today.	
Happy	Angry	I won an award.	
Happy	Fear	I'm graduating today.	
Happy	Fear	I'm marrying the one I love.	
Happy	Fear	Thanks for the present.	(trial)
Happy	Happy	Good job, the crowd really loved you.	
Happy	Happy	It's a beautiful day outside.	
Happy	Happy	The clouds are pretty today.	
Happy	Happy	This food tastes very good.	
Happy	Happy	Your kids are so cute.	
Happy	Happy	His words make me smile.	
Happy	Happy	I'm going on vacation.	
Happy	Neutral	I feel wonderful today.	
Happy	Neutral	I got promoted in my job.	
Happy	Neutral	This is the happiest day of my life.	
Happy	Neutral	Congratulations, you're hired.	
Happy	Neutral	This is my favorite song.	
Happy	Sad	I love you so much.	
Happy	Sad	I won the lottery.	
Happy	Sad	Great, you got first place.	
Neutral	Angry	Red pipes are metallic.	
Neutral	Angry	Digital clocks are common.	
Neutral	Angry	Our body's made of water.	
Neutral	Angry	His glasses are on the table.	
Neutral	Fear	My desk is in the corner.	
Neutral	Fear	The earth is round.	
Neutral	Fear	This table is brown.	
Neutral	Fear	Lots of bins are in the room.	
Neutral	Fear	This is a garbage can.	(trial)
Neutral	Happy	He stands on the deck.	
Neutral	Happy	The bag is in the room.	

Neutral	Happy	I see a rug on the floor.	
Neutral	Happy	Containers have a blue lid.	
Neutral	Neutral	Her camera is in the bag.	
Neutral	Neutral	There are magnets on the fridge.	
Neutral	Neutral	Your music sheets are on the stand.	
Neutral	Neutral	One towel is folded.	
Neutral	Sad	Some tablecloths are in the basket.	
Neutral	Sad	Four drawers are in the cabinet.	
Neutral	Sad	Her book is under her bed.	
Neutral	Sad	My spoon is on the table.	
Sad	Angry	I'm going to a funeral.	
Sad	Angry	This is a sad moment.	(trial)
Sad	Angry	My best friend is moving away.	
Sad	Angry	My dog was hit by a car.	
Sad	Fear	Gray clouds make me feel gloomy	
Sad	Fear	My pet died today.	(trial)
Sad	Fear	This song make me cry.	
Sad	Happy	I am so lonely.	
Sad	Happy	I've been crying all day.	
Sad	Happy	This scene makes me feel blue.	
Sad	Neutral	The orphans never saw their father.	
Sad	Neutral	I have no friends.	
Sad	Neutral	My son is miserable.	
Sad	Neutral	She said she wants a divorce.	
Sad	Sad	The weather is depressing.	
Sad	Sad	I think we should see other people.	
Sad	Sad	She is filled with despair.	
Sad	Sad	No one sat beside me at lunch.	
Sad	Sad	She lost her whole family.	
Sad	Sad	Your baby died at birth.	
Sad	Sad	I'm so very sorry.	

REFERENCES

Alpert, M., & Rosen, A. (1990). A semantic analysis of the various ways that the terms “affect,” “emotion,” and “mood” are used. *Journal of Communication Disorders*, *23*(4–5), 237–246.

Angeleri, R., Bosco, F. M., Zettin, M., Sacco, K., Colle, L., & Bara, B. G. (2008). Communicative impairment in traumatic brain injury: A complete pragmatic assessment. *Brain and Language*, *107*(3), 229–245.

Arciniegas, D. B., & Topkoff, J. (2000). The neuropsychiatry of pathologic affect: an approach to evaluation and treatment. *Seminars in Clinical Neuropsychiatry*, *5*(4), 290–306.

Ashby, F. G., Isen, A. M., & Turken, A. U. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review*, *106*(3), 529–550.

Baddeley, A., Harris, J., Sunderland, A., Watts, K., & Wilson, B. A. (1987). Closed head injury and memory. In H. S. Levin, J. Grafman, & H. M. Eisenberg (Eds.), *Neurobehavioral Recovery from Head Injury.* (pp. 295-317). New York: Oxford University Press.

Baddeley, A. (1990). *Human Memory. Theory and Practice*. Hove and London: Lawrence Erlbaum Associates.

Balconi, M., Grippa, E., & Vanutelli, M. E. (2015). Resting lateralized activity predicts the cortical response and appraisal of emotions: an fNIRS study. *Social Cognitive & Affective Neuroscience*, *10*(12), 1607–1614.

Barrett, L. F. (2017). The theory of constructed emotion: an active inference account of interoception and categorization. *Social Cognitive & Affective Neuroscience*, *12*(1), 1–23.

Beck, A., & Steer, R. (1996). Beck Depression Inventory -- II. *Behavioral Measurement Letter*, 3(2), 3-5.

Ben-David, B. M., van Lieshout, P. H. H. M., & Leszcz, T. (2011). A resource of validated affective and neutral sentences to assess identification of emotion in spoken language after a brain injury. *Brain Injury*, *25*(2), 206–220.

Ben-David, B. M., Thayapararajah, A., & van Lieshout, P. H. H. M. (2013). A resource of validated digital audio recordings to assess identification of emotion in spoken language after a brain injury. *Brain Injury, 27*(2), 248–250.

Ben-David, B. M., Multani, N., Shakuf, V., Rudzicz, F., & van Lieshout, P. H. H. M. (2016). Prosody and semantics are separate but not separable channels in the perception of emotional speech: Test for rating of emotions in speech. *Journal of Speech, Language & Hearing Research, 59*(1), 72-89.

Blonder, L. X., Bowers, D., & Heilman, K. M. (1991). The role of the right hemisphere in emotional communication. *Brain: A Journal of Neurology, 114*(Pt 3), 1115–1127.

Brookshire, R. H. (2007). Traumatic brain injury. *Brookshire RH, Introduction to neurogenic communication disorders*, 445-530.

Carton, J. S., Kessler, E. A., & Pape, C. L. (1999). Nonverbal decoding skills and relationship well-being in adults. *Journal of Nonverbal Behavior, 23*(1), 91–100.

Cattran, C., Oddy, M., & Wood, R. (2011). The development of a measure of emotional regulation following acquired brain injury. *Journal of Clinical & Experimental Neuropsychology, 33*(6), 672-679

Centers for Disease Control and Prevention. (2010). *Traumatic brain injury in the United States: Emergency department visits, hospitalizations, and deaths 2002-2006*. Atlanta, GA: National Center for Injury Prevention and Control; Division of Injury Response.

Centers for Disease Control and Prevention. (2015). *Report to Congress on traumatic brain injury in the United States: Epidemiology and rehabilitation*. Atlanta, GA: National Center for Injury Prevention and Control; Division of Unintentional Injury Prevention.

Coelho, C. A., Youse, K. M., & Le, K. N. (2002). Conversational discourse in closed-head-injured and non-brain-injured adults. *Aphasiology*, *16*(4–6), 659–672.

Corrigan, J. D., & Bogner, J. (2007). Initial reliability and validity of the Ohio State University TBI Identification Method. *The Journal of Head Trauma Rehabilitation, 22*(6), 318–329.

Cristofori, I. & Levin, H. S. (2015) Traumatic brain injury and cognition. *Handbook of Clinical Neurology*, *127*, 579-611.

Croker, V., & McDonald, S. (2005). Recognition of emotion from facial expression following traumatic brain injury. *Brain Injury*, *19*(10), 787-799.

Cunningham, W. A., Van Bavel, J. J., & Johnsen, I. R. (2008). Affective flexibility: Evaluative processing goals shape amygdala activity. *Psychological Science (0956-7976), 19*(2), 152–160.

Czimskey, N., & Marquardt, T. P. (2019). Recall of emotional and neutral words and paragraphs in traumatic brain injury. *Aphasiology*, *33*(8), 1019–1034.

DePalma, R. G., & Hoffman, S. W. (2018). Combat blast related traumatic brain injury (TBI): Decade of recognition; promise of progress. *Behavioural Brain Research*, 340, 102–105.

Dijkers, M. P. (2004). Quality of life after traumatic brain injury: a review of research approaches and findings. *Archives of Physical Medicine & Rehabilitation, 85*(4), S21-35.

Dikmen, S. S., Corrigan, J. D., Levin, H. S., Machamer, J., Stiers, W., & Weisskopf, M. G. (2009). Cognitive outcome following traumatic brain injury. *The Journal of Head Trauma Rehabilitation, 24*(6), 430–438

Dimoska, A. A., McDonald, S. S., Pell, M. C., Tate, R. L., & James, C. M. (2010). Recognizing vocal expressions of emotion in patients with social skills deficits following traumatic brain injury. *Journal of the International Neuropsychological Society*, *16*(2), 369-382.

Douglas, J. M. (2017). “So that’s the way it is for me — always being left out.” Acquired pragmatic language impairment and social functioning following traumatic brain injury. *Brain Impairment*, *18*(3), 321–331.

Doyle, S. T., Perrin, P. B., Díaz Sosa, D. M., Espinosa Jove, I. G., Lee, G. K., & Arango-Lasprilla, J. C. (2013). Connecting family needs and TBI caregiver mental health in Mexico City, Mexico. *Brain Injury*, *27*(12), 1441–1449.

Dunning, D. L., Westgate, B., & Adlam, A.-L. R. (2016). A meta-analysis of working memory impairments in survivors of moderate-to-severe traumatic brain injury. *Neuropsychology, 30*(7), 811–819.

Ekman, P. (1973). Universal facial expressions in emotion. *Studia Psychologica, 15*(2), 140.

Ekman, P., Levenson, R., & Friesen, W. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221*(4616), 1208-1210.

Fanselow, M. S., & LeDoux, J. E. (1999). Why we think plasticity underlying Pavlovian fear conditioning occurs in the basolateral amygdala. *Neuron, 23*(2), 229–232.

Faul, M., & Coronado, V. (2015). Epidemiology of traumatic brain injury. *Handbook of Clinical Neurology*, *127*, 3–13.

Flynn, M. A., Mutlu, B., Duff, M. C., & Turkstra, L. S. (2018). Friendship quality, friendship quantity, and social participation in adults with traumatic brain injury. *Seminars in Speech & Language, 39*(5), 416–426.

Frencham, K. A. R., Fox, A. M., & Maybery, M. T. (2005). Neuropsychological studies of mild traumatic brain injury: A meta-analytic review of research since 1995. *Journal of Clinical & Experimental Neuropsychology, 27*(3), 334–351.

Gendron, M., Lindquist, K. A., Barsalou, L., & Barrett, L. F. (2012). Emotion words shape emotion percepts. *Emotion, 12*(2), 314–325.

Godwin, E. E., Kreutzer, J. S., Arango-Lasprilla, J. C., & Lehan, T. J. (2011). Marriage after brain injury: Review, analysis, and research recommendations. *The Journal of Head Trauma Rehabilitation*, *26*(1), 43–55.

Goel, V., Lam, E., Smith, K. W., Goel, A., Raymont, V., Krueger, F., & Grafman, J. (2017). Lesions to polar/orbital prefrontal cortex selectively impair reasoning about emotional material. *Neuropsychologia*, *99*, 236–245.

Gordon, W. A., Cantor, J., Dams-O'Connor, K. & Tsaousides, T. (2015) Long-term social integration and community support. *Handbook of Clinical Neurology*, *127*, 423-431.

Hamann, S. B., Ely, T. D., Hoffman, J. M., & Kilts, C. D. (2002). Ecstasy and agony: Activation of the human amygdala in positive and negative emotion. *Psychological Science (0956-7976), 13*(2), 135.

Helm-Estabrooks, N. (2007). *Cognitive Linguistic Quick Test-Plus (CLQT+).* San Antonio, TX: Psychological Corporation.

Henry, J. D., Phillips, L. H., Crawford, J. R., Theodorou, G., & Summers, F. (2006). Cognitive and psychosocial correlates of alexithymia following traumatic brain injury. *Neuropsychologia*, *44*(1), 62–72.

Hirsch, C.R., & Mathews, A. (2000). Impaired positive inferential bias in social phobia. *Journal of Abnormal Psychology*, 109, 705-712.

Hoofien, D., Gilboa, A., Vakil, E., & Donovick, P. J. (2001). Traumatic brain injury (TBI) 10–20 years later: A comprehensive outcome study of psychiatric symptomatology, cognitive abilities and psychosocial functioning. *Brain Injury*, *15*(3), 189–209.

Hornak, J., Bramham, J., Rolls, E. T., Morris, R. G., O'Doherty, J., Bullock, P. R., & Polkey, C. E. (2003). Changes in emotion after circumscribed surgical lesions of the orbitofrontal and cingulate cortices. *Brain: A Journal of Neurology*, *126*(Pt 7), 1691–1712.

Iaccarino, M.A., Bhatnagar, S., & Zafonte, R. (2015). Rehabilitation after traumatic brain injury. *Handbook of Clinical Neurology*, *127*, 411-422.

Ishii, K., Reyes, J. A., & Kitayama, S. (2003). Spontaneous attention to word content versus emotional tone: Differences among three cultures. *Psychological Science (0956-7976)*, *14*(1), 39.

Joukamaa, M., Saarijärvi, S., Muuriaisniemi, M. L., & Salokangas, R. K. (1996). Alexithymia in a normal elderly population. *Comprehensive Psychiatry*, *37*(2), 144–147.

Juslin, P. N., & Laukka, P. (2003). Communication of emotions in vocal expression and music performance: Different channels, same code?. *Psychological Bulletin*, *129*(5), 770–814.

Karow, C. M., Marquardt, T. P., & Marshall, R. C. (2001). Affective processing in left and right hemisphere brain-damaged subjects with and without subcortical involvement. *Aphasiology*, *15*(8), 715–729.

Karow, C. M., & Connors, E. C. (2003). Affective communication in normal and brain-damaged adults: an overview. *Seminars in Speech & Language*, *24*(2), 69–91.

Karow, C., Marquardt, T., & Levitt, S. (2013). Processing of ambiguous emotional messages in brain injured patients with and without subcortical lesions. *Aphasiology*, *27*(3), 344–363.

Kavé, G., Heled, E., Vakil, E., & Agranov, E. (2011). Which verbal fluency measure is most useful in demonstrating executive deficits after traumatic brain injury? *Journal of Clinical & Experimental Neuropsychology, 33*(3), 358–365.

Kazim, S., Shamim, M., Tahir, M., Enam, S., & Waheed, S. (2011). Management of penetrating brain injury. *Journal of Emergencies, Trauma, and Shock*, *4*(3), 395.

Kempe, V., Rookes, M., & Swarbrigg, L. (2013). Speaker emotion can affect ambiguity production. *Language & Cognitive Processes*, *28*(10), 1579–1590.

King, L. A. (1993). Emotional expression, ambivalence over expression, and marital satisfaction. *Journal of Social and Personal Relationships*, *10*(4), 601–607.

Knox, L., & Douglas, J. (2009). Long-term ability to interpret facial expression after traumatic brain injury and its relation to social integration. *Brain & Cognition*, *69*(2), 442–449.

Kuchinke, L., Jacobs, A. M., Grubich, C., Võ, M. L.-H., Conrad, M., & Herrmann, M. (2005). Incidental effects of emotional valence in single word processing: An fMRI study. *NeuroImage, 28*(4), 1022–1032.

Langlois, J. A., Rutland-Brown, W., & Wald, M. M. (2006). The epidemiology and impact of traumatic brain injury: A brief overview. *The Journal of Head Trauma Rehabilitation*, *21*(5), 375–378.

LeDoux, J. (2007). The amygdala. *Current Biology, 17*(20), R868–R874.

Levin, H. S., O'Donnell, V. M., & Grossman, R. G. (1979). The Galveston Orientation and Amnesia Test: A practical scale to assess cognition after head injury. *Journal of Nervous and Mental Disorders, 167*,675–684.

Levin, H. S. (1989). Memory deficit after closed-head injury. *Journal of Clinical and Experimental Neuropsychology, 12*, 129-153.

Lindquist, K. A., Satpute, A. B., & Gendron, M. (2015). Does language do more than communicate emotion?. *Current Directions in Psychological Science, 24*(2), 99–108.

Lindquist, K. A., Barrett, L. F., Bliss-Moreau, E., & Russell, J. A. (2006). Language and the perception of emotion. *Emotion, 6*(1), 125–138.

MacLennan, D., Cornis-Pop, M., Picon-Nieto, L., & Sigford, B. (2002). The prevalence of pragmatic communication impairments in traumatic brain injury. *Premier Outlook*, *3*(4), 38-45.

Marini, A., Galetto, V., Zampieri, E., Vorano, L., Zettin, M., & Carlomagno, S. (2011). Narrative language in traumatic brain injury. *Neuropsychologia*, *49*(10), 2904–2910.

Marquardt, T. P., Cannito, M. P., & Sherrard, K. (1992). Resolution of ambiguous emotional messages: Age, gender, and brain lesion effects. *Clinical Aphasiology*, *21*, 235–248.

Marquardt, T. P., Rios-Brown, M., Richburg, T., Seibert, L. K., & Cannito, M. P. (2001). Comprehension and expression of affective sentences in traumatic brain injury. *Aphasiology*, *15*(10/11), 1091-1101.

McCabe, D. P., Roediger, H. L., III, McDaniel, M. A., Balota, D. A., & Hambrick, D. Z. (2010). The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology*, *24*(2), 222–243.

McDonald, S., & Pearce, S. (1996). Clinical insights into pragmatic theory: Frontal lobe deficits and sarcasm. *Brain & Language*, *53*(1), 81-104.

McDonald, S., & Flanagan, S. (2004). Social Perception Deficits After Traumatic Brain Injury: Interaction Between Emotion Recognition, Mentalizing Ability, and Social Communication. *Neuropsychology*, *18*(3), 572-579.

McDonald, S., & Saunders, J. C. (2005). Differential impairment in recognition of emotion across different media in people with severe traumatic brain injury. *Journal of the International Neuropsychological Society*, *11*(4), 392–399.

McDonald, S., Togher, L., & Code, C. (2013) Traumatic brain injury: basic features. In McDonald, S., Togher, L., & Code, C. (Eds.), *Brain, behaviour and cognition. Social and communication disorders following traumatic brain injury* (26-47). New York, NY, US: Psychology Press.

McDowell, S., Whyte, J., & D'Esposito, M. (1997). Working memory impairments in traumatic brain injury: evidence from a dual-task paradigm. *Neuropsychologia*, *35*(10), 1341–1353.

Mehrabian, A., & Wiener, M. (1967). Decoding of inconsistent communications. *Journal of Personality and Social Psychology, 6*(1), 109–114.

Menon, D. K., Schwab, K., Wright, D. W., & Maas, A. I. (2010). Position statement: Definition of traumatic brain injury. *Archives of Physical Medicine and Rehabilitation*, *91*(11), 1637–1640.

Milders, M., Fuchs, S., & Crawford, J. R. (2003). Neuropsychological impairments and changes in emotional and social behaviour following severe traumatic brain injury. *Journal of Clinical & Experimental Neuropsychology, 25*(2), 157-172.

Mongrain, M., & Vettese, L. C. (2003). Conflict over emotional expression: Implications for interpersonal communication. *Personality and Social Psychology Bulletin, 29*(4), 545–555.

Morris, P. L., Robinson, R. G., de Carvalho, M. L., Albert, P., Wells, J. C., Samuels, J. F., Eden-Fetzer, D., & Price, T. R. (1996). Lesion characteristics and depressed mood in the stroke data bank study. *The Journal of Neuropsychiatry And Clinical Neurosciences, 8*(2), 153–159.

Morton, J. B., & Trehub, S. E. (2001). Children's understanding of emotion in speech. *Child Development, 72*(3), 834.

Mozeiko, J., Le, K., Coelho, C., Krueger, F., & Grafman, J. (2011). The relationship of story grammar and executive function following TBI. *Aphasiology*, *25*(6/7), 826–835.

Myers, P. S. (1999). *Right hemisphere damage: Disorders of communication and cognition.* San Diego, CA: Singular Publishing Group.

Nygaard, L. C., & Lunders, E. R. (2002). Resolution of lexical ambiguity by emotional tone of voice. *Memory & Cognition, 30*(4), 583.

O'Keeffe, F. M., Dockree, P. M., Moloney, P., Carton, S., & Robertson, I. H. (2007). Characterising error-awareness of attentional lapses and inhibitory control failures in patients with traumatic brain injury. *Experimental Brain Research*, *180*(1), 59–67.

Ochsner, K. N., Bunge, S. A., Gross, J. J., & Gabrieli, J. D. E. (2002). Rethinking feelings: An fMRI study of the cognitive regulation of emotion*. Journal of Cognitive Neuroscience, 14*(8), 1215–1229.

Pell, M., Jaywant, A., Monetta, L., & Kotz, S. (2011). Emotional speech processing: Disentangling the effects of prosody and semantic cues. *Cognition & Emotion, 25*(5), 834–853.

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience, 9*(2), 148–158.

Phan, K. L., Wager, T., Taylor, S. F., & Liberzon, I. (2002). Functional neuroanatomy of emotion: a meta-analysis of emotion activation studies in PET and fMRI. *Neuroimage, 16*(2), 331–348.

Prigatano, G. P., & Pribram, K. H. (1982). Perception and memory of facial affect following brain injury. *Perceptual & Motor Skills*, *54*, 859–869.

Rigon, A., Turkstra, L. S., Mutlu, B., & Duff, M. C. (2018). Facial-affect recognition deficit as a predictor of different aspects of social-communication impairment in traumatic brain injury. *Neuropsychology*, *32*(4), 476–483.

Sander, D., Grafman, J., & Zalla, T. (2003). The human amygdala: an evolved system for relevance detection. *Reviews In The Neurosciences, 14*(4), 303–316.

Sass, K., Habel, U., Sachs, O., Huber, W., Gauggel, S., & Kircher, T. (2012). The influence of emotional associations on the neural correlates of semantic priming. *Human Brain Mapping*, *33*(3), 676–694.

Sass, K., Fetz, K., Oetken, S., Habel, U., & Heim, S. (2013). Emotional Verbal Fluency: A New Task on Emotion and Executive Function Interaction. *Behavioral Sciences (2076-328X), 3*(3), 372–387.

Satpute, A. B., Nook, E. C., Narayanan, S., Shu, J., Weber, J., & Ochsner, K. N. (2016). Emotions in “black and white” or shades of gray? How we think about emotion shapes our perception and neural representation of emotion. *Psychological Science (0956-7976), 27*(11), 1428–1442.

Schwab, K. A., Gundmudsson, L. S., & Lew, H. L. (2015). Long-term functional outcomes of traumatic brain injury. *Handbook of Clinical Neurology*, *128*, 649–659.

Schwartz, L. (2013). *Identification of sentence emotional content in individuals with traumatic brain injury* (Master’s thesis). Retrieved from UT Electronic Theses and Dissertations.

Schwartz, R., Pell, M. D., & Stamatakis, E. A. (2012). Emotional speech processing at the intersection of prosody and semantics. *Plos ONE*, *7*(10), 1-9.

Shao, Z., Janse, E., Visser, K., & Meyer, A. S. (2014). What do verbal fluency tasks measure? Predictors of verbal fluency performance in older adults. *Frontiers In Psychology*, 5, 772.

Skrandies, W. (2011). The structure of semantic meaning: A developmental study. *Japanese Psychological Research*, *53*(1), 65–76.

Spell, L. A., & Frank, E. (2000). Recognition of nonverbal communication of affect following traumatic brain injury. *Journal of Nonverbal Behavior*, *24*(4), 285-300.

Taylor, C. A., Bell, J. M., Breiding, M. J., & Xu, L. (2017). Traumatic brain injury-related emergency department visits, hospitalizations, and deaths - United States, 2007 and 2013. *Morbidity and Mortality Weekly Report. Surveillance Summaries (Washington, D.C.: 2002)*, *66*(9), 1–16.

Thierry, G., Athanasopoulos, P., Wiggett, A., Dering, B., & Kuipers, J. (2009). Unconscious effects of language-specific terminology on preattentive color perception. *Proceedings of the National Academy of Sciences of The United States of America*, *106*(11), 4567-4570.

Togher, L., McDonald, S., & Code, C. (2013) Social and communication disorders following traumatic brain injury. In McDonald, S., Togher, L., & Code, C. (Eds.), *Brain, behaviour and cognition. Social and communication disorders following traumatic brain injury* (1-25). New York, NY, US: Psychology Press.

Togher, L., McDonald, S., & Coelho, C. A., & Byom, L. (2013) Cognitive communication disability following TBI: Examining discourse, pragmatics, behavior, and executive function. In McDonald, S., Togher, L., & Code, C. (Eds.), *Brain, behaviour and cognition. Social and communication disorders following traumatic brain injury* (89-118). New York, NY, US: Psychology Press.

Vakil, E. (2005). The effect of moderate to severe traumatic brain injury (TBI) on different aspects of memory: A selective review. *Journal of Clinical & Experimental Neuropsychology*, *27*(8), 977–1021.

Valente, S., & Fisher, D. (2011). Traumatic brain injury. *The Journal for Nurse Practitioners. 7*(10), 863-870.

Vallat-Azouvi, C., Paillat, C., Bercovici, S., Morin, B., Paquereau, J., Charanton, J., Ghout, I., & Azouvi, P. (2018). Subjective complaints after acquired brain injury: presentation of the Brain Injury Complaint Questionnaire (BICoQ). *Journal of Neuroscience Research*, *96*(4), 601–611.

Watts, A., & Douglas, J. (2006). Interpreting facial expression and communication competence following severe traumatic brain injury. *Aphasiology*, *20*(8), 707-722.

Wauters, L., & Marquardt, T. P. (2018). Category, letter, and emotional verbal fluency in Spanish-English bilingual speakers: A preliminary report. *Archives of Clinical Neuropsychology, 33*(4), 444–457.

Wechsler, D.A. (1997). Wechsler Adult Intelligence Scale (3rd ed.). San Antonio, TX: The Psychological Corporation.

Wood, R. L., Liossi, C., & Wood, L. (2005). The impact of head injury neurobehavioural sequelae on personal relationships: Preliminary findings. *Brain Injury*, *19*(10), 845–851.

Zec, R. F., Zellers, D., Belman, J., Miller, J., Matthews, J., Ferneau-Belman, D., & Robbs, R. (2001). Long-term consequences of severe closed head injury on episodic memory. *Journal of Clinical & Experimental Neuropsychology, 23*(5), 671.

Zupan, B., Neumann, D., Babbage, D. R., & Willer, B. (2009). The importance of vocal affect to bimodal processing of emotion: Implications for individuals with traumatic brain injury. *Journal of Communication Disorders*, *42*(1), 1–17.

Vita

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