2012

Collaborative referencing in traumatic brain injury

Laura Elizabeth Savicki
University of Iowa

COLLABORATIVE REFERENCING IN TRAUMATIC BRAIN INJURY

by

Laura Elizabeth Savicki

A thesis submitted in partial fulfillment
of the requirements for the Master of
Arts degree in Speech Pathology and Audiology
in the Graduate College of
The University of Iowa

May 2012

Thesis Supervisor: Assistant Professor Melissa Duff

Graduate College
The University of Iowa
Iowa City, Iowa

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

Laura Elizabeth Savicki

has been approved by the Examining Committee for the thesis requirement for the Master of Arts degree in Speech Pathology and Audiology at the May 2012 graduation.

Thesis Committee: ___________________________
Melissa Duff, Thesis Supervisor

____
Jean Gordon

____
Patricia Zebrowski

ABSTRACT

Traumatic brain injury (TBI) is a global health epidemic that has deleterious consequences for the individuals with the brain injury, their families, and society. The development and validation of effective treatments is imperative. The current study was inspired by Ylvisaker's collaborative intervention approach with individuals with TBI and draws on a line of work by Duff and colleagues (e.g., Duff et al., 2006; Gupta et al., 2011) documenting patterns of spared and impaired learning abilities in individuals with various types focal brain damage (e.g., hippocampus) and selective neuropsychological impairment (e.g., declarative memory) using a collaborative referencing paradigm. This study extends this line of work by examining the ability of individuals with mild to moderate traumatic brain injury to develop and use referential labels for novel picture cards across repeated interactions with a familiar partner as they complete a collaborative referencing task. Five TBI participant pairs (an individuals with TBI and their partner) and five healthy comparison pairs completed 24 trials (6 trials in each of 4 sessions) of the collaborative referencing task across two days. As a group, the performance of four of the five TBI pairs did not differ from healthy comparison pairs on the primary dependent variables of card placement accuracy, time to complete each trial, and reduction in communicative resources across trials. That is, despite having TBI, these individuals were able to develop and use unique and concise labels to reference the novel cards in collaboration with a familiar partner. The fifth TBI participant pair (3591) differed from the other TBI and healthy comparison pair on both quantitative and qualitative measures. Speculating that 3591's husband may have contributed to their poor performance, a follow-up study was conducted whereby 3591 was brought back to lab several months later and she complete one session of the collaborative referencing task with a new partner. The results of the follow-up study were striking. 3591 and her new partner were as successful as other pairs on all measures of learning in the study.

Given the complex nature of cognitive, neurological, behavioral, personality, and communicative impairments associated with TBI, the findings here, that all participants with TBI were successful in the task, are surprising and provides further evidence that these interactive sessions are potent learning environments. The results of the study support the idea that use of a social and collaborative interaction paradigm facilitates learning in adults at least one year time post injury with mild to moderate brain injuries. Aspects of the collaborative referencing task that exemplify Ylvisaker's contextualized invention approach are completion of a goal-directed task, working with a partner who was relevant to the participant's everyday life, supports were provided by the partner as needed, the task was repeated many times in order to increase chances of the pair's success, and skills were taught through collaboration rather than explicit instruction. Although this was not an intervention study, these findings provide further evidence supporting the use of Ylvisaker's social, interactive, and collaborative approach for individuals with TBI. This study is the first to our knowledge to investigate learning during a collaborative referencing task with individuals with TBI and the positive results obtained here suggest that this may be a fruitful way to deploy Ylvisaker's contextualized intervention approach in more controlled research settings.

TABLE OF CONTENTS

LIST OF TABLES

Table

LIST OF FIGURES

Figure

CHAPTER I

REVIEW OF THE LITERATURE

Traumatic brain injury (TBI) is a significant public health issue around the world. In the United States alone, 1.7 million individuals experience a TBI per year, accounting for 1.3 million emergency room visits, 275,000 hospitalizations, and 52,000 deaths (Faul, Wald, & Coronado, 2010). An estimated 5.3 million Americans live with a disability related to TBI (Langlois, Rutland-Brown, & Wald, 2006). TBI commonly results in debilitating and lifelong impairments in cognition, behavior, and emotion. The impact of TBI also extends beyond the individual. Caregivers and spouses of individuals with TBI have been found to undergo significant stress. According to Kreutzer and colleagues (Kreutzer, Gervasio, & Camplair, 1994), these caregivers "report more symptoms of psychological distress than the normal population and other types of medical patients" (p. 208). TBI is prevalent and costly. It is estimated that the annual cost of TBI in the US is $60 billion (Langlois et al., 2006). This figure includes losses in productivity and medical costs associated with the lifelong treatment and rehabilitation of individuals with TBI. Individuals with TBI are at a greater disadvantage compared to those with physical disabilities because their cognitive impairments are often perceived to be "invisible" (Langlois et al., 2006). In a study of the personal experience of individuals with TBI, Chamberlain (2006) found that family, friends, and even healthcare professionals are insensitive to the cognitive disabilities (which are invisible to others) exhibited by individuals with TBI particularly when compared to physical disabilities. Anecdotally, many individuals with TBI report that they wish they had a physical disability (if they don't) so that others could see that they are not the same as they were before the injury. Because of the high prevalence and incidence of TBI, in addition to its deleterious effects, lack of a cure, and burden on society, it is imperative that effective treatments be developed and validated.

Definition of TBI

TBI is defined as an injury to the brain due to external forces and results in a variety of temporary or permanent physical, cognitive, emotional, and behavioral impairments (Brain Injury Association of America, 2011). TBI can be caused by either an open head injury (penetrating head injury) or by a closed head injury (nonpenetrating head injury). In open head injury, the skull is fractured, the dural lining and the brain are penetrated resulting in focal damage and isolated cognitive impairment (Murray & Clark, 2005; Ylvisaker & Feeney, 1998). The terms TBI and closed head injury (CHI) are used synonymously. Compared to open head injury, TBI is characterized by diffuse brain damage and a constellation of cognitive impairments (Murray & Clark, 2005) and the dura matter are not penetrated by external forces (Ylvisaker & Feeney, 1998).

Pathophysiological disruptions associated with TBI occur during two main stages: primary and secondary injury. The primary stage of injury consists of focal contusions (i.e., direct tissue damage), lacerations, intracranial hemorrhages, and diffuse axonal injury. Damage as a result of primary injury occurs at the moment of impact with the external force and is the primary insult. The focal contusions of TBI result from the compression of brain tissue against the skull at the site of the blow (coup) and the opposite side of the brain (contrecoup) (Ylvisaker & Feeney, 1998). The frontal lobe is at particular risk for damage in TBI. Portions of the prefrontal lobes and anterior or posterior temporal lobes are often pushed into the bony pertuberances of the skull during impact (Adams, Graham, Scott, Parker, & Doyle, 1980; Toyama, Kobayashi, Nishiyama, Satoh, Ohkawa, et al., 2005). Diffuse axonal injury (DAI), is considered to be the most common and important pathologic feature of CHI (Smith, Meaney, & Shull, 2003). During DAI axons located throughout the brain undergo the forces of rotational acceleration and inertia. This results in shearing, twisting, tearing, and breakage of axons (Ylvisaker & Feeney, 1998). According to Smith and colleagues (2003), the brain stretches and recovers easily under the normal conditions of everyday life. However, when strain is rapidly applied to the brain (e.g., automobile accidents) it becomes stiff and brittle resulting in "tensile elongation" of the axons and damage to the axonal cytoskeleton. Thus, the extent of axonal injury is dependent on the magnitude and rate of strain on the brain. The severity of DAI is hypothesized to correlate with the impairments, prognoses, and recovery from TBI.

Secondary injury in TBI occurs after primary impact and is characterized by a set of biochemical reactions and cascades that may take several hours to days to manifest (Granacher, 2008). Cerebral metabolism (e.g., oxygen and glucose consumption) is frequently reduced after TBI. Brain injury is thought to result in the massive release of excitatory amino acid neurotransmitters (e.g., glutamate) (Werner & Englehard, 2007). Increased levels of glutamate lead to neuronal excitotoxicity causing alteration of normal cellular metabolism (Walker, Harting, Baumgartner, Fletcher, Strobel, & Cos, 2009). The severity of primary injury relates to the degree of metabolic disturbance, and it has been found that outcome is worse in patients with lower metabolic rates than in those with minor or no metabolic dysfunction (Werner & Englehard, 2007). Upon primary injury, there is a series of metabolic changes in the brain similar to an ischemia-like pattern (i.e., an increase in permeability of the membrane of the brain.) The second part of the pathophysiological cascade consists of terminal membrane depolarization along with excessive release of excitatory neurotransmitters (Werner & Englehard, 2007). These events result in necrotic or programmed cell death.

Edema (swelling) can also occur as a secondary injury. Uncontrolled brain swelling and rise in intracranial pressure in patients with TBI is the most frequent cause of death (Marmarou, Fatouros, Barzo, Portella, Yoshihara, Tsuji, et al., 2000). TBI triggers immune and inflammatory cascades that contribute to secondary injury (Walker et al., 2009). The skull is an enclosed cavity that does not expand and edema increases the pressure within it. High intracranial pressure can cause further damage to the brain and even death (Ylvisaker & Feeney, 1998). Removal of portions of the skull is a common treatment for edema to prevent further brain damage.

Ischemia refers to inadequate blood flow to the brain resulting in decreased supply of glucose and oxygen to brain tissue and is another secondary injury (Brookshire, 2007). Cell death and infarction will occur if cerebral blood flow is not restored (Gillis, 1996). When the flow of oxygen to the brain is dramatically reduced, hypoxia can occur. Anoxia is a more extreme form of hypoxia, in which oxygen supply is completely cut off. In severe TBI, hypoxic-ischemic injury at some level is to be expected (Graham, Adams, & Doyle, 1978). The hippocampus, an important structure for the formation of new declarative memory, is particularly sensitive to hypoxic-ischemic injury (Bigler, 1990). Hemorrhages (e.g., extradural hemorrhage, acute subdural hemorrhage, chronic subdural hemorrhage, subarachnoid hemorrhage, and intracranial hemorrhage) are also a common type of secondary injury.

TBI can be broken down into levels of severity: mild, moderate, and severe. The Glasgow Coma Scale (GCS) and Post Traumatic Amnesia (PTA) are both used to determine the severity of TBI (Teasdale & Jennett, 1974). The GCS is a 15 point scale that assesses severity by examining eye opening, motor response, and verbal response in the injured patient. A score between 3 and 8 indicate severe head injury; scores between 9 and12 indicate moderate head injury, and scores of 13 to 15 indicate mild head injury. The PTA is the interval between injury and the return of continuous recall and is considered to be a better predictor of outcome (Brookshire, 2007; Jennett, Teasdale, & Braakman, 1998).

<u>Demographics of TBI</u>

According to Ylvisaker and Feeney (1998):

> “the classic profile of someone with a brain injury is an adolescent or young adult male who was something of a risk taker before the injury, may have overused or abused alcohol and recreational drug, may have had academic, social, or vocational difficulties before the injury, and more likely than not can be found toward the lower end of the socioeconomic spectrum” (p. 42).

The most current epidemiological data from the CDC (Faul et al., 2010) does not coincide with the stereotypic TBI profile. Prevalence and incidence data from the CDC indicate that the highest rate of TBI is actually in adults age 75 and over. While older adults may have higher rates of TBI than younger individuals, younger individuals may receive more intensive treatment, making their presence more salient and stereotypical to rehabilitation professionals. Overall, TBIs occur most commonly in children between the ages of 0 and 4, adolescents between 15 and 19, and adults 65 and over. Men have higher rates of TBI than women in each age group (Faul et al., 2010).

The leading causes of TBI are falls, motor vehicle accidents, struck by/against events (e.g. collisions), and assaults (Faul et al., 2010). Falls are the most common cause of TBI and are responsible for half of the TBIs among children 0-14 and 61% of TBIs among adults 65 years and older (Faul et al., 2010). Domestic violence and child abuse often account for TBI in these age groups as well. Adult and pediatric physical abuse can result in head trauma from violent shaking, head being hit by an object or a fist, and hypoxia induced by choking (Stern, 2004). Motor vehicle accidents are the second leading cause of TBIs and result in the largest number of TBI related deaths (Faul et al., 2010). Another major risk factor in obtaining a TBI is previous injury. Individuals who have sustained multiple brain injuries are at an increased risk of receiving another brain injury, and more specifically, those who have experienced two injuries are at risk for a third injury eightfold over the general population (Annegars, Grabow, Kurland, & Laws, 1980).

Sequelae of TBI

TBI can result in a variety of cognitive, neurological, personality, and behavioral changes. Impairments across these domains are highly individualized, which makes every individual's profile of impairment different. For example, one individual may have impairments predominantly in personality (e.g., mood swings, motivation) and behavior (e.g., aggression, irritability); and in another individual, there may be more profound neurological (e.g., fatigue, dizziness, weakness) and cognitive (e.g., judgment, planning, sequencing) deficits. Impairments in any of these domains can occur independently although often times they occur in conjunction with one another. Because of the highly interdependent nature of these domains, impairments in one are frequently associated with impairments in another. Also, impairments in some domains may mask impairments in other domains or may make it seem as though there are impairments in another domain. For example, in instances when an individual experiences fatigue and/or pain, which are both neurologically related, there are often concomitant cognitive impairments in attention and memory resulting from the neurological impairments. Because fatigue and pain alone can negatively impact cognitive performance (e.g., memory, attention) it can be difficult to determine the underlying cause of cognitive disruptions. This type of scenario contributes to the many challenges in the assessment and treatment of TBI.

Cognitive Changes

Cognitive changes associated with TBI include problems with memory, decision making, planning, sequencing, judgment, attention, communication, organization, and self-perception. Impairment in executive functioning can cause deficits in different and multiple cognitive domains. For example, one individual may have a deficit only in the area of attention and another individual, of the same severity, may have deficits in planning, sequencing, and judgment. According to Ylvisaker and DeBonis (2000), the core of disability for individuals with TBI is impairment in executive functioning. While the a precise definition of executive functioning is elusive, (Jurado & Rosselli, 2007), it is generally accepted that it is high level cognitive functioning that includes the control and regulation of all aspects of deliberate, nonautomatic, and nonroutine behavior (Ylvisaker & Feeney, 1998). More specifically, executive functioning is involved in formulating goals, planning how to achieve them, carrying out the plans, and revising those plans in response to feedback (Ylvisaker & Feeney, 1998). It also includes initiating and inhibiting behavior, monitoring and evaluating behavior, thinking strategically and flexibly, and using moral and ethical behavior. Executive functioning is thought to be at the core of "adult-like" functioning, which is considered to be appropriate and socially responsible (Jurado & Roselli, 2007). Impairment in executive functioning can cause deficits in different and multiple cognitive domains. For example, one individual may have a deficit only in the area of attention and another individual, of the same severity, may have deficits in planning, sequencing, and judgment.

Hartley (1995) explains that the frontal lobes control executive functioning through regulation of cognitive processes. The frontal lobes ensure adequate, efficient allocation and maintenance of attention in goal directed behavior. Also, they are responsible for inhibiting irrelevant sensory information and shifting attention to relevant information. Focal contusions and DAI in TBI frequently occur in this area (anterior and inferior frontal lobes), and therefore, problems with executive functioning are common. Damage to the frontal lobe and impaired executive functioning are not mutually exclusive. That is, not all patients with frontal lobe damage perform poorly on neuropsychological tests of executive functioning and vice versa (Anderson, Damasio, Jones, & Tranel, 1991).

One of the most vulnerable areas of the brain in TBI, however, is the ventromedial prefrontal cortex (VMPC). Bony pertuberances extending from the crista galli are a threat to the VMPC during the rotational forces of TBI (Body, 2007). This area is of particular interest because it is linked to both executive functioning and other higher level cognitive processes, including social cognition. VMPC damage and TBI are associated with inappropriate social behavior, including impaired processing of social emotions, lack of self-awareness, loss of insight, disinhibition, and impaired decision making (Barrash, Tranel, & Anderson, 2000). Despite socially inappropriate behavior and impaired decision-making, adults with VMPC damage have preserved intellect and maintain knowledge of social conventions (Anderson, Bechara, Damasio, Tranel, & Damasio, 1999).

Theoretically, VMPC damage is related to TBI based on the somatic marker hypothesis (Body, 2007). Grounded in the work of Damasio (1994), the somatic marker hypothesis is the idea that visceral and emotional states (somatic markers) are associated with specific stimuli or actions based on past experience (Ylvisaker & Feeney, 1998). These markers are thought to influence decision-making and rationality (Dunn, Dalgleish, & Lawrence, 2006). According to Adolphs (2001), somatic markers steer the decision making process toward advantageous outcomes for the individual, based on past experience with similar situations. The prefrontal cortex is responsible for controlling the mechanism by which the values of actions are acquired, represented, and retrieved (Adolphs, 2001). Individuals with VMPC damage show an immediate response to consequence but there is no effect over the long term (Bechara, Damasio, Damasio, & Anderson, 1994). Similarly, disinhibition and failure to learn from consequences are both hallmarks of TBI (Ylvisaker & Feeney, 1998).

Impairment in declarative memory frequently occurs in TBI. The declarative memory system is critical in memory formation of relations among different pieces of experience by accumulating of memories of facts and events and binds the inputs that converge on the hippocampal system (e.g., relational memory system) (Cohen & Banich, 2003). Declarative memory supports related representations and is accessible to different processing systems (e.g., language areas, visual areas) in the brain (Cohen & Banich, 2003). The declarative memory system supports the rapid acquisition of knowledge that can be consciously expressed, flexibly retrieved, and used in novel contexts. Declarative memory is composed of semantic and episodic memory (Tulving, 1972). Semantic memory includes vocabulary and general knowledge about the world that is context free (Brookshire, 2007; Cohen & Banich, 2003). Episodic memory, on the other hand, is memory for autobiographic events that are contextually bound (time and place) (Cohen & Banich, 2003). Declarative memory is supported by the medial temporal lobes and specifically the hippocampal system (Cohen & Banich, 2003; Squire & Zola, 1996). In relation to TBI, the hippocampus is particularly sensitive to hypoxic-ischemic injury (Bigler, 1990). Individuals with TBI frequently experience hypoxia. Chang and colleagues found that most individuals with a severe TBI experienced hypoxic episodes (Change, Youn, Benson, Mattick, Andrade, Harper, et at., 2009). The vulnerability of the hippocampus to hypoxia is related to deficits in explicit and declarative memory in individuals with TBI (Ylvisaker & Feeney, 1998).

In contrast, procedural memory, a type of non-declarative memory, is usually well preserved in TBI. Non-declarative memory refers to changes in performance (i.e., skills, speed, preferences) that directly result from experience (Cohen & Banich, 2003). An example of non-declarative memory would be the ability to ride a bike. It is easy to give directions on how to ride a bike, but this does not translate to the ability to ride a bike. It is only with repeated experience do individuals learn how to ride a bike. This type of change in performance, as with other skills or habits acquired through non-declarative (procedural) memory, is slow and incremental. Knowledge related to the skill cannot be consciously expressed (verbally stated) and is inflexible (the knowledge does not generalize). This is because procedural memories are not accessible to systems (e.g., motor or visual) that are not initially involved in the learning phase (Squire & Zola, 1996). In contrast to declarative memory, procedural learning involves tuning and modifying of processing systems and is supportive of non-related representations (Cohen & Banich, 2003). Procedural memory is also different in that it does not rely on the hippocampus. The basal ganglia, specifically the striatum, has been identified as being important for procedural memory (Cohen & Banich, 2003). Declarative and procedural memory representations are considered to be anatomically and functionally distinct and each can be impaired in isolation. Because procedural memory is intact or often less impaired than declarative memory, it has been identified as a possible asset in rehabilitation. As Ylvisaker and Feeney state, "it is possible to teach individuals with TBI procedures and routines with repeated practice even in the presence of significant explicit, deliberate, declarative memory problems" (1998, p. 61).

The amydala, part of the limbic system, aids in the acquisition and deployment of emotionally laden memories and emotional responses. In healthy, non-brain injured individuals Pavlovian fear conditioning causes the acquisition of a reflexive response after presentation of a neutral conditioned stimulus that is then paired with an aversive event (Maren, 2001). In a study by Bechara and colleagues, individuals with bilateral amygdala damage failed to produce a reflexive response to aversive stimuli, unlike healthy comparison participants, even though they had normal declarative memory and could recall facts about the conditioned stimulus (Bechara, Tranel, Damasio, Adolphs, Rockland, & Damasio, 1995). The amygdala, in conjunction with the orbitofrontal cortex (similar to the location of the VMPC), is thought to be part of a circuit that oversees emotion regulation (Adolphs, 2002) and this circuit is susceptible to damage in TBI. Impulsivity and aggression, which are two frequent behavioral manifestations of impaired emotion regulation in TBI, are thought to result from a loss of frontal lobe inhibition over the subcortical limbic structures(e.g., amygdala) (Greve, Sherwin, Stanford, Mathias, Love, & Ramzinski, 2001).

Theory of mind (TOM) is another domain of cognition that is frequently impaired after TBI. TOM is the ability to understand and predict behavior based on inferences of the mental states of others (Bibby & McDonald, 2005). TOM interacts with memory, executive functioning, and emotion. It is a critical component of social interaction and communication. Social interaction is complex and requires behaviors that are complex and flexible (Bibby & McDonald, 2005). Humans are innately social and differ from other species through the use of language, complex social interaction, and memory. According to Adolphs (1999), TOM and social cognition are used by humans for cooperativity, altruism, and other aspects of prosocial behavior. It can also be used negatively in acts of coercion, deception, and manipulation. Recognition of emotion is critical for TOM. In a study by McDonald and Flanagan (2004), it was found that 30% of individuals with severe TBI had significant problems with recognizing emotions in facial expressions and/or perceiving tone of voice of others. The frontal lobes are also thought to play a role in TOM. Lesions of the frontal lobes have been found to be associated with impaired visual perspective taking and impaired detection of deception (Stuss, Gallup, & Alexander, 2001).

Neurological, Personality, and Behavioral Changes

Neurological changes consist of problems with muscle movement and coordination, sleep, hearing, vision, taste, smell, touch, fatigue, weakness, balance, speech, and sexual dysfunction. Any of these physiologic changes may exacerbate impairments in cognition, personality, and behavior. Personality and behavioral changes after TBI include problems with social skills, mood swings, anger management, coping skills, self-monitoring, and motivation. Individuals with TBI also commonly experience depression, anxiety, stress, denial, frustration, irritability, agitation, and excessive laughing or crying (Brookshire, 2007). All of these neurological, personality, and behavioral changes serve as obstacles to interpersonal, academic, and vocational success. For example, psychosocial problems (e.g., depression and anxiety) are major obstacles to community re-entry for individuals with TBI (Morton & Wehman, 1995).

Communication

Each of the domains previously discussed are necessary for effective communication. The nature of brain damage and the large number of cognitive impairments associated with TBI have many implications for its impact on communication. TBI does not typically cause primary linguistic deficits, like aphasia. Only 30% of individuals with TBI also experience aphasia (Sarno, Buonaguro, & Levita, 1986). For individuals with TBI, mild to severe cognitive and communication impairments result from underlying cognitive dysfunction (Beukelman & Yorkston, 1991). Communication impairments in TBI are the result of the interactions of language, cognition, and interpersonal functioning (Body, 2007). TBI is considered to be an acquired cognitive-communication disorder. The American Speech-Language Hearing Association (ASHA) (2005) defines cognitive-communication disorders as difficulty with any aspect of verbal and/or nonverbal communication in any domain of language (e.g., phonology, morphology, syntax, semantics, pragmatics) that is affected by disrupted cognition (e.g., attention, perception, memory, organization, executive function). Common communicative deficits found in individuals with TBI include: difficulties with topic maintenance, poorly organized discourse, impaired comprehension and speaking in situations with distractions, use of rude or inappropriate remarks, immature communication style, inappropriate laughter, difficulty understanding feelings, motivations, and opinions of others, difficulty adjusting speech rate and loudness to fit context, difficulty initiating and maintaining conversation, concrete interpretation of a messages, decreased interpretation of abstract language, and poor interpersonal coordination in conversation, including deficits in facial mimicry (Hartley, 2005; Body, 2007; McDonald, Li, De Sousa, Rushby, Dimoska, James, et al., 2010). The conversations of individuals with TBI have described as less interesting, less appropriate, less rewarding, and more effortful than individuals without TBI (Bond & Godfrey, 1997).

Collectively, these communicative impairments can lead to impaired social competence and social isolation for individuals with TBI (Bibby & McDonald, 2005).

Social Consequences

Deficits across various domains (i.e., cognitive, neurological, personality, and behavioral) collectively cause problems with interpersonal relationships and functioning in daily life. Individuals with TBI face severe consequences related to their disabilities, including unemployment and financial struggle, inadequate academic achievement, loss of pre-injury roles, loss of independence, difficulties in maintaining interpersonal relationships, and marital breakdown (Morton & Wehman, 1995; Temkin, Corrigan, Dikmen, & Machamer, 2009). A meta-analysis by Temkin, Corrigan, Dikmen, and Machamer (2009) concludes that there is sufficient evidence supporting the connection between moderate and severe TBI and adverse long-term outcomes for employment and social relationships. Even more significant is the correlation between brain injury and criminal behavior. In a study by Sarapata, Herrmann, Johnson, and Aycock (1998), it was found that 50% of non-violent crimes (i.e., non-violent felonies and misdemeanors) had a prior history of head injury and current impaired cognitive and emotional functioning. Freedman and Hemenway (2000) reported that 12 out of 16 death row inmates had a history of brain damage, some with multiple injuries. Not only does TBI have an impact on the areas of employment, academic achievement, and social relationships, but it also has very serious social implications for society.

Intervention

Because of the high incidence and prevalence of TBI, large monetary costs, and its detrimental impact on aspects of quality of life, it is crucial that TBI be properly assessed, diagnosed, managed, and prevented (ASHA, 2005). Speech-language pathologists play a critical role in the assessment, intervention, counseling, and advocacy for individuals with TBI. First and foremost, effective intervention techniques need to be developed in order to begin to alleviate this public health crisis.

Due to the complex nature of cognitive, neurological, behavioral, personality, and communicative impairments associated with TBI and the individualized profiles of impairment among individuals with TBI, it is a difficult population to assess and treat. Not only is this population notoriously challenging to work with in regards to assessment and intervention, but also, the practices in the area of cognitive rehabilitation are somewhat controversial. The American Speech-Language Hearing Association's *Technical Report of Cognitive-Communication Disorders After Brain Injury* (2003) says that there is no clear professional "home" for brain injury rehabilitation and that there are currently no generally agreed-on standards of clinical practice for brain injury. It is also noted that treatment efficacy studies in this area are often methodologically weak and have ambiguous results (ASHA, 2003). It is not uncommon for treatments to include indefensible practices provided by inadequately trained practitioners. This further demonstrates the need for research and development of clinically relevant and effective intervention techniques for TBI.

The World Health Organization has developed a framework for systematically analyzing illness, which is known as the International Classification of Functioning (WHO ICF). This classification is broken down into body structure/function limitations, activity limitations/disability, and participation limitations/handicap limitations. Body structure/function limitations, formerly referred to as impairment, is a disease or disorder (e.g., traumatic brain injury, aphasia). Activity limitation, or disability, is the interaction between an individual and the physical environment. Following a disease or disorder an individual may experience reduced ability to perform certain functions (e.g., attention deficits, memory deficits). Participation limitations, formerly referred to as handicap, are an individual's functioning in the social environment. A disruption in body structure or function may create limitations in participation in society (e.g., inability to maintain employment) (WHO, 2001). These three classifications are important to understanding intervention techniques in cognitive and communication rehabilitation as different interventions target different aspects of this framework. Another framework for TBI intervention was proposed by Ylvisaker and colleagues who propose that there are two main paradigms associated with cognitive and communicative rehabilitation of TBI: traditional and contextualized (described below) (Ylvisaker & Feeney, 2000; Ylvisaker, Hanks, & Johnson-Greene, 2003).

Traditional Intervention

Traditional cognitive rehabilitation focuses on deficits in body structure/function and is specifically designed to reduce primary neurological impairment. The goal of traditional intervention for individuals with TBI is to reduce activity and participation limitations by targeting underlying structure and function deficits (Ylvisaker & Feeney, 1998). Traditional intervention for TBI works to change impaired cognitive functioning. Furthermore, this approach is curative and restorative (Ylvisaker, Hanks, & Johnson-Greene, 2003). It is considered to be ideal because it aims to reduce underlying deficits thereby reducing activity and participation limitations in every situation (Ylvisaker & Feeney, 1998).

In the ASHA *Technical Report Rehabilitation of Children and Adults with Cognitive-Communication Disorders After Brain Injury* (2003), assessment and treatment within the traditional paradigm is explained. Traditional assessment of cognitive-communication disorders, including TBI, utilizes standardized neuropsychological and language measures for diagnostic, treatment, and outcome purposes (Ylvisaker et al., 2003). Traditional intervention consists of cognitive exercises used to restore cognitive processes or skill and/or acquisition of compensatory cognitive behaviors. Decontextualized exercises are initially used in intervention to restore cognitive processes and skills, and commonly in this approach, patients use computer activities with these exercises for practice (Ylvisaker et al., 2003). Exercises are made to target various cognitive areas like attention, memory, and visual perception, in isolation (Ylvisaker et al., 2003). Hierarchies are important to the structure of traditional intervention. First, a skill is mastered in a given task and then generalized to other tasks. Once this is mastered, body structure/function limitations are targeted and then activity and participation limitations.

An example of a common intervention in the traditional paradigm is errorless learning; a technique used for targeting memory deficits in individuals with TBI. This intervention is a systematic type of instructional method that capitalizes on a patient’s preserved procedural memory (Ehlhardt, Sohlberg, Kennedy, Coehlo, Ylvisaker, Turkstra, et al., 2008). As previously mentioned, memory deficits in TBI are frequently related to impaired explicit or declarative memory while implicit or procedural memory is intact. Training involves eliminating errors while learning by breaking tasks down into small steps, using modeling before the performance of a task, dissuading guessing, immediately correcting errors, and fading prompts (Sohlberg, Ehlhardt, & Kennedy, 2005). The theory behind errorless learning is that performance on memory tasks may be influenced by earlier exposure to information despite no conscious awareness of exposure (Ylvisaker & Feeney, 1998). If their exposure was to a mistake, that mistake may persist with a stronger representation than a correct response. The idea is that the practicing of errors may significantly interfere with learning; therefore, it is important to remove all errors during the learning process (Ylvisaker & Feeney, 1998). In a meta-analysis of traditional instructional methods for memory impairment in individuals with neurogenic disorders (e.g., TBI, dementia), Ehlhardt and colleagues indicated that errorless learning is a generally successful technique (Ehlhardt, Sohlberg, Kennedy, Coelho, Ylvisaker, Turkstra, 2008). Consistent across interventions in the traditional paradigm, errorless learning takes place in a clinical setting, rather than naturalistic settings, with special materials and specific cognitive retraining specialists across a series of highly scripted and hierarchical sessions.

However, errorless learning has been criticized for the hyper-specificity of the training situations, the acceptance of only experimenter generated responses, and poor generalization (Duff, Hengst, Tranel, & Cohen, 2008; Stark, Stark, & Gordon, 2005). A consequence of interventions that tap implicit (non-declarative) memory, unlike declarative memory, is that the newly acquired information cannot be consciously expressed and is inflexible. Anything implicitly learned will, therefore, not generalize beyond stimuli that share features with the learned behavior (Turkstra & Bourgeois, 2005). While it is impressive that individuals with profound declarative memory impairments can acquire new information, their learning is far from normal: memory impaired individuals require many more trials to learn a fraction of what healthy participants can learn (Duff et al., 2008). In a study by Stark et al. (2005), a profoundly amnesic man was taught the names of his grandchildren through errorless learning. A picture of two of his grandchildren was presented in 2,000 trials. When presented with a set of four pictures, two of which were in the picture he had been show, the patient could not select his grandchildren. In a similar study by Bayley & Squire (2002), profoundly amnesic patient E.P. was taught sentences through errorless learning. Healthy comparison participants learned the sentences in 4 trials, whereas E.P. took 48 trials. Both of these examples highlight minimal gains in learning for extensive effort. These modest gains and poor to no generalization, across many training sessions are relatively common outcomes for interventions in the traditional paradigm and likely accounts for the generally pessimistic view of cognitive rehabilitation for individuals with TBI.

Contextualized Intervention

In stark contrast to traditional intervention is the contextualized approach. At the heart of the contextualized approach is the notion that it is more effective for individuals with TBI to practice functional tasks that are relevant to their everyday lives, rather than decontexualized exercises (Ylvisaker et al., 2003). Contextualized intervention accomplishes this by focusing on activity/participation of the WHO International Classification of Functioning (ICF) framework, with specific emphasis on the development of strategic thinking and compensatory behavior within functional contexts for individuals with chronic cognitive impairments from TBI (Ylvisaker et al., 2003). As its name implies, context is an important component of contextualized intervention. There is a clear focus on providing intervention within functional and salient contexts that are relevant to the individual's everyday life (e.g., home, work, school), modification of the environment to facilitate the success of the individual (e.g., reducing distractions, increasing familiarity), and modification of expectations and support from the people (e.g., family, co-workers, peers) in the individual's everyday life (e.g., training, problem solving, routines) (Ylvisaker et al., 2003). One of the greatest benefits of contextualized intervention is transfer to real life situations. This is in direct contrast to traditional intervention in which,

> "Behaviors and skills acquired in a laboratory or training context are unlikely to transfer to functional application contexts and be maintained over time without heroic efforts to facilitate transfer and maintenance" (Ylvisaker & Feeney, 1998; p.24).

For example, social skills training (e.g., eye contact, complimenting, greeting) in which skills are explicitly taught without respect to context has been found to rarely generalize to real-world social interaction, which is the ultimate goal of the training (McIntosh, Vaughn, & Zargoza, 1991). By targeting things like social interaction and communication, that are personally meaningful to the individual, through positive everyday routines that are set in contexts highly relevant to the individual, there is a greater likelihood of both skill acquisition and transfer to real-world settings.

Contextualized Intervention: Positive Everyday Routines

Positive everyday routines, developed by Mark Ylvisaker and Tim Feeney, are a type of contextualized intervention for TBI. Theoretically this approach is supported by Ylvisaker and Feeney's (1998) framework called the "horns of dilemma", which connects the cognitive impairments and challenges of working with TBI to rehabilitation outcomes. The first horn relates to successful behavior and decision making through the use of high reason (executive functioning). Individuals without brain injury make decisions through deliberate planning, strategic learning, and by use of declarative memory. Executive functioning is one of several domains that are frequently impaired in TBI as a result of frontal lobe damage. As explained earlier, a constellation of cognitive, neurological, personality, behavioral, and social impairments may occur after TBI. All of these deficits interfere with the ability to use high reason in TBI.

The second horn of dilemma specified by Ylvisaker and Feeney (1998) is the somatic marker hypothesis, which comes from the work of Damasio (1994). As explained earlier, this is a model for showing how emotional states are linked to activity in the body and ultimately, decision making (Dunn et al., 2006). Somatic markers can be associated with positive and negative stimuli and actions. For individuals without brain injury, decision-making is fueled by operant conditioning, and by previously experienced somatic markers from the past (e.g., rewards and punishments) (Ylvisaker & Feeney, 1998). Individuals with TBI, on the other hand, who have damage to VMPC and amygdala, have limited connections to previously stored representations and have breakdowns in creating new representations that include somatic markers for behavior regulation. Also, punishment has been found to cause an emotional effect that is not connected to modification of behavior for individuals with TBI; however, the effects of punishment are only seen immediately after it occurs.

The combination of horn one (poor high reasoning skills) and horn two (inability to learn from consequences) is a destructive mix for the success and outcome of individuals with TBI. One way to tackle these problems would be through external control, in which health care staff and family members could make all of the decisions for the individual. The risk involved with total external control, however, is learned helplessness and oppositionality, which could exacerbate problems (Ylvisaker & Feeney, 1998). Internal control, on the other hand, is a more constructive way of addressing decision making, and it can be accomplished through the use of positive everyday routines.

The horns of dilemma framework sets the stage for positive everyday routines as an appropriate and effective type of contextualized intervention for TBI. Ylvisaker and Feeney (1998) designate that this approach requires everyday people (e.g., family, friends, peers, staff) present in the lives of the individual with TBI to assist them in developing and using successful routines in the functional contexts (e.g., home, work, school) that are important to the individual. Internal representations of events are stored as scripts or Ylvisaker and Feeney's term, routines. A script/routine may include knowledge of an event's location, sequences associated with events, people that are commonly involved with the event, and the language used at the event. The components of event knowledge influence behavior (Abelson, 1981). Non brain injured adults are able to flexibly use scripts/routines to fit novel situations. The cognitive, neurological, personality, behavioral, and social changes occurring after TBI can affect the acquisition and use of scripts/routines in novel situations and environments.

According to Ylvisaker and Feeney (1998), routines are effective because they utilize the intact procedural memory system in individual with TBI. Within these positive routines, skills, strategies, and behaviors are taught through collaboration, apprenticeship, and scaffolding, rather than through explicit instruction. Skills obtained in routines are practiced until they become habit. The goal is incremental improvements in cognition, behavior, communication, and generation of an internal model. Focus is always placed on the individual's successes, no matter how small they are. Table 1 compares the focus and goals, treatment modalities and methods, organization of treatment, and setting, content, and providers of treatment from traditional intervention and contextualized intervention (Ylvisaker, Hanks, & Johnson-Green, 2003).

Collaborative Referencing

Collaborative referencing tasks, also called barrier tasks, have a long history of use in speech-language pathology and psychology (Clark & Wilkes-Gibbs, 1986; Davis & Wilcox, 1981; Krauss & Weinheimer, 1964; Yule, 1997). These tasks have been used to characterize the way speakers adjust and modify their utterances over time in response to changes in the listeners' knowledge and social roles and to document change over time. Typically, collaborative referencing tasks involve two people sitting across from one another, with their view of each other completely obscured. Each person is assigned a role (director or matcher), with the director providing verbal clues to the matcher on how to, for example, match a set of pictures to specific locations on a board. Research has documented change over repeated trials in the way speakers adjust their utterances in response to the listeners' knowledge and social roles and in how speakers and listeners collaborate on the development and use of specific references (see Clark, 1992; Yule, 1997). Studies have consistently found that referencing expressions simplify and shorten across trials.

Considered a seminal study in collaborate referencing, Clark and Wilkes-Gibbs (1986) studied eight pairs of college students complete a barrier task. An opaque screen separated the pairs, and the director was given an arranged sequence of twelve cards, each displaying a Chinese tangram figure, placed into two rows of six. The director's job was to instruct the matcher to order his or her cards in the same order. The director and matcher were allowed to talk as much as needed to complete the task. This was completed six times, for six trials. Card placements were checked at the end of each trial, and the pair was told what placements were mismatches. Each session was tape-recorded and timed (length of each trial). Overall, the error rate was 2%, and the six trials took an average of 25 minutes. Across trials, the number of words per figure declined, and number of turns declined across trials. The director and matcher became more efficient across trials and the referencing expressions became shorter and more concise as the task and trials went on. Clark and Wilkes-Gibbs (1986) used the term “common ground” to explain this pattern. Speakers and listeners share common ground, which are the beliefs, attitudes, and knowledge about communicative exchanges. Common ground helps speakers and listeners to communicate rapidly and efficiently in interaction (Clark, 1992). Clark (1992) went on to introduced a model of collaborative referencing which states that the interactive processes of collaboration or the ‘‘intricate back and forth interchange on each and every reference’’ (p. 104) contributes to the communicative pairs’ common ground, allowing them to, over time, reduce the amount of overt collaborative effort (number of words and turns) necessary to successfully establish and resolve individual references. The interaction and collaboration have been shown to be critical to the observed learning as the effects of the collaborative model cannot be attributed to repetition alone. That is, without an interlocutor present with whom to interact and collaborate, but with repeated repetition of the same referential expression, the amount of overt collaborative effort does not decrease across trials (Hupet & Chantraine, 1992).

In a line of work to investigate collaborative practices in individuals with neurogenic communication disorders, Hengst and colleagues (Hengst, 2003; Duff et al., 2006) redesigned Clark’s barrier protocol, which was already oriented to collaborative communicative practices, to align it thoroughly with Ylvisaker’s collaborative intervention approach (1998). This redesign of Clark’s barrier task included a partial barrier to allow nonverbal as well as verbal communication, a greater number of referencing opportunities, and use of familiar partners (e.g., a family member). Findings from this line of work with individuals with a range of disorders (e.g., aphasia, amnesia, Alzheimer’s disease) are summarized below.

Collaborative Referencing Tasks and Aphasia

Hengst (2003) was the first to modified Clark's (1992) barrier task protocol to investigate collaborative referencing in a neurogenic population and studied individuals with moderate to severe aphasia and their routine communication partners. The barrier task protocol used in this study closely adhered to the protocol established by Clark and Wilkes-Gibbs (1986); however, modifications were made in order to obtain more qualitative information through ethnographic and discourse analytic techniques and to increase communicative success in pairs managing aphasia (Hengst, 2003). One of the first modifications was the use of routine communication partners, rather than stranger partners and the partners switched roles each trial. The number of trials was also increased from six to 24 total (four sessions, 6 trials per session). The barrier task was introduced as a game instead of an experimental task, and controls on the task were minimal. Pairs were instructed to communicate and interact as much as they needed; however, they were also encouraged to interact in any way necessary, which included talking, gesturing, and writing. Additionally, the protocol was modified by having the pairs match photos of familiar scenes for sessions two and three, rather than Chinese tangrams. By using familiar photos, it was thought that communicative success would increase because the pairs could draw upon shared personal histories (Hengst, 2003). For the fourth session, the pairs were also allowed to decide who would be the director for each trial.

The results showed that individuals with aphasia and their routine communication partners were successful at completing the barrier task. In fact, the individuals with aphasia were able to reference novel cards in a manner typical of adults without aphasia, which was evident in the progression to simpler, more definite references, and reduced effort and collaboration across trials. The individuals with aphasia used verbal and nonverbal resources to accomplish referencing. Furthermore, this study provides evidence for tacit learning across trials. Each pair was able to develop specific referencing expressions and manage the trials. Learning is considered to be part of the evolution of common ground and it is situated in interaction (Clark, 1992).

Collaborative Referencing Tasks and Amnesia

Duff, Hengst, Tranel, and Cohen (2006) used a barrier task to assess the ability of individuals with amnesia (as a result of anoxia and damage to the hippocampus) to acquire referential labels across a series of interactive sessions with their communication partners. Clark speculated on the memory requisites of common ground and suggested that it involves the ability of speakers and listeners to track, recall, and continuously update their records of new events (Clark, 1992). Accordingly, each participant in a conversational exchange is assumed to have a model of what is in the other person's mind, a model that is built up from previous contact and is continuously updated as the exchange continues (Clark, 1992). To test this prediction, Duff et al. (2006) drew upon the barrier task protocols used by Clark and Wilkes-Gibbs (1986) and Hengst (2003). Specific aspects of the Clark and Wilkes-Gibbs (1992) protocol were maintained, such as consistent participant roles (director and matcher) and stimuli across trials, and comparison participants. This was done in order to keep experimental controls of the task. Aspects of the Hengst (2003) protocol, such as the partial barrier and familiar partners, were kept in order to preserve social interaction.

The amnesia pairs and comparison pairs completed all trials and had high card placement accuracy. Despite the severe declarative memory impairment, the patients with amnesia and their familiar partners demonstrated significant learning across trials. In fact, the amnesia pairs showed a rate of learning equal to that of healthy comparison pairs on measures of time to completion and in the reduction of communicative resources (i.e., words, turns) across trials. Just as the college-aged pairs describe by Clark and Wilkes-Gibbs (1986), across trials the amnesia pairs arrived at unique and concise labels for the cards that facilitated rapid and efficient communication. Other remarkable results showed that 30 minutes following the end of session four, all of the individuals with amnesia generated their final concise label for at least 10 of 12 cards, and six months following the study they could still produce these labels for 80% of the cards on average. One individual with amnesia was able to produce 10 of 12 labels two years after participating in the study.

These findings challenged Clark's notion of the requisite memory demands for common ground and suggested that non-declarative forms of memory can support at least some aspects of common ground. Consistent with many of the tenets of Ylvisaker and Feeney's positive routines, the performance of individuals with profound impairments in memory and learning suggest that these interactive communication sessions are potent learning environments and have significant implications for memory intervention. However, not all aspects of performance on this task are normal. In subsequent analyses, Duff and colleagues have reported consistent differences and disruptions in the interactional discourse of the amnesia pairs including differences in the proportion of turns dedicated to task management or non-task talk (Duff, Hengst, Tranel, & Cohen, 2008); reduced episodes of verbal play (Duff, Hengst, Tranel, & Cohen, 2009), and marked disruptions in the use of definite references (Duff, Gupta, Hengst, Tranel, & Cohen, 2011). These findings suggest an interesting pattern of spared and impaired abilities and point to the complex orchestration of memory (and other cognitive systems) necessary for success.

Collaborative Referencing Tasks and Dementia

Feyereisen, Berrewaerts, and Hupet (2007) used a barrier task with individuals in the early stages of dementia of the Alzheimer's type (DAT) to assess communication breakdowns. The protocol used in this study closely followed Clark and Wilkes-Gibbs (1986); however, the participants with dementia completed the task with an examiner as a partner, used sets of six cards, and completed only three trials of the task. Examiners were instructed to maintain a neutral attitude and used specific prompts to elicit a label. Like individuals with amnesia, those with DAT present with similar memory deficits. Feyerseisen et al. (2007) found that participants with DAT produced more words than comparison participants and required more turns in order to achieve agreement with their partner (an examiner). The participants with DAT did not use any definite references and almost never used labels in the second and third trials, in comparison to normal participants who used an average of one label in the third trial.

Duff and colleagues have also examined collaborative referencing in individuals with Alzheimer's disease (AD) using a modified protocol of that described above. While the basic aspects of the protocol remained the same (e.g., partial barrier, familiar partners) pilot testing indicated that 24 trials across two days was too fatiguing for the AD participants so the protocol was shortened to 12 trials (Duff, Gallegos, Cohen, & Tranel, in preparation). Five patients with very mild AD, each interacting with a familiar partner, and five comparison pairs completed the modified protocol. Given that the AD participants were very early in the disease process they were remarkably similar to the participants with hippocampal amnesia (e.g., predominate impairments in declarative memory). Like patients with hippocampal amnesia, the AD patients became increasingly economical in their communication, with increased accuracy and decreased time to complete trials in a manner indistinguishable from healthy comparison pairs.

Collaborative Referencing Tasks and Amygdala Damage

Gupta, Duff, and Tranel (2011) used the same barrier task protocol as Duff and colleagues (Duff et al., 2006) to study collaborative referencing in an individual with focal bilateral damage to the amygdala. As previously mentioned the amygdala is important for processing emotion and enhances declarative memories that are highly emotional or salient (Cohen & Banich, 2003). Patient SM, who has focal and complete bilateral damage to the amygdala, has well documented deficits in the processing social and emotional information in social communication (e.g., eye contact, recognizing facial expressions, use of social and emotional cues, personal space, and forming social judgment (Spezio, Huang, Castelli, & Adolphs, 2007; Adolphs, Baron-Cohen, & Tranel, 2002; Kennedy, Glascher, Tyszka, & Adolphs, 2009; Adolphs, Tranel, Damasio, 1998). Communication, social and emotional information are important for acquiring and using common ground in social interaction (Krauss & Fussell, 1996). Indeed, Duff and colleagues have speculated that the individuals with amnesia and AD were so successful on this task, in part, due to their preserved social and emotional communication abilities. In order to understand the role of social and emotional processing deficits, stemming from amygdala damage, on the development of collaborative referencing and its impact on common ground, Gupta et al. (2011) had SM complete the barrier task with a familiar partner. In addition to healthy comparison pairs, this study also examined brain-damaged comparison subjects in order to better match SM on standardized measures of intelligence.

Results revealed that like comparison pairs, SM and her partner were able to create concise card labels, decrease overall trial times, and place cards with accuracy (Gupta et al., 2011). However, there were also striking differences between SM and her partner and the other pairs. SM and her partner did not show the same rate of decrease in trial times across sessions. Healthy comparison pairs and brain damage comparison participants show a typical pattern of performance across trials; these pairs show a decrease in the number of total words across trials for the initial description of cards, which is a result of the development of direct, concise card labels. SM did not display this common feature, in that there was essentially no reduction in words used for description across trials (Gupta et al., 2011). In fact, she used fewer words to initially describe the cards on the first trial. She shows a different, slower rate of reduction in words from comparison directors between trials one and six. Compared to the individuals with amnesia (Duff et al., 2006), SM shows impaired learning on the barrier task (Gupta et al., 2011). Her declarative memory system is intact, unlike the individuals with amnesia who had rates of learning similar to comparison participants (Duff et al., 2006). Conversely, the individuals with amnesia do not have the social and emotional deficits that SM displays. Gupta et al. (2011) accounts for SM's inflexible card descriptions as a possible consequence of over-reliance on her intact declarative memory. She may be unable to tailor her card description based on social and emotional cues of the interaction and therefore, relies on a previously successful reference. Because of SM's impairments in social interaction and memory, she may not be able to utilize her partner's feedback to update common ground (Gupta et al., 2011). This may contribute to SM's poor performance on the barrier task compared to the individuals with amnesia. This study shows that learning through collaborative referencing may be limited without intact social and emotional processing.

Collaborative Referencing Tasks and VMPC Damage

Duff and colleagues (Gupta, Tranel, & Duff, 2012) continued their work on collaborative referencing and the role of social and emotional processing by looking at the performance of in individuals with VMPC damage. The protocol used in this study replicated Duff and colleagues' (2006) study of collaborative learning in individuals with amnesia. It was found that individuals with VMPC damage show performance similar to normal comparison participants. Specifically, they developed concise and simplified card labels across trials, and thus, the number of words, turns, and time decreased across trials. Despite normal performance and evidence of in-tact learning, the quality of interaction between the VMPC participant and partner were found to be qualitatively different from normal comparison pairs. Analyses indicate that VMPC pair interactions were rated to be less efficient, and raters were less likely to want to complete the barrier task in the future with the VMPC directors than the comparison directors. VMPC damage seems to play a more important role in the quality of the social interactions rather than the acquisition and use of common ground (Gupta et al., 2012).

Summary of the Literature Review

TBI is a major public health issue that impacts the lives of almost 2 million American's yearly (Faul et al., 2010). A variety of cognitive, neurological, personality, behavioral, and communicative changes can occur from TBI as a result of both focal and diffuse damage. In addition, individuals with TBI are likely to be unemployed, have financial struggle, inadequate academic achievement, loss of pre-injury roles, loss of independence, difficulties in maintaining interpersonal relationships, and marital breakdown (Temkin, Corrigan, Dikmen, & Machamer, 2009; Morton & Wehman, 1995). Overall, TBI has a high prevalence, is financially burdensome to society, and can be detrimental to all aspects of quality of life for those affected. It is critical that TBI be properly assessed and managed (ASHA, 2005).

Rehabilitation of individuals with TBI is notoriously challenging and complex. Ylvisaker has developed a model called the "horns of dilemma" to explain the challenges associated with TBI intervention (Ylvisaker & Feeney, 1998). A traditional approach to intervention is the typical approach used to target cognitive and communication impairments in individuals with TBI. This type of intervention is characterized by training using structured hierarchically organized tasks outside of naturalistic contexts and treating particular domains of cognition in isolation. More importantly, it has been shown that traditional intervention does not lead to particularly significant or meaningful gains, which is apparent in training techniques like errorless learning. Ylvisaker argues for contextualized intervention as a more sound approach to increase success in individuals with TBI. Contextualized intervention involves positive everyday routines that are relevant to an individual's life and needs as a means of facilitating positive behavior and improvement in communication. This type of intervention is executed through the use of relevant activities, settings, and participant of individuals (e.g., family members, supervisors, peers) that are meaningful to the individual (Ylvisaker & Feeney, 1998). Tasks situated in social interaction are believed to be the optimal condition for learning for individuals with TBI (Ylvisaker & Feeney, 1998). Empirical data supports the use of this approach for individuals with TBI.

The Current Study

The current study is inspired by Ylvisaker's collaborative intervention approach with individuals with TBI. Barrier tasks are a commonly used clinical intervention tool in the field of speech-language pathology. The barrier task protocol used in the line of work by Duff and colleagues and for the current study has the experimental constraints necessary for documenting and measuring learning in a valid and reliable way yet provides an opportunity to see Ylvisaker's collaborative and contextualized model in action. In the current study, TBI and healthy comparison participants completed the "game-like" barrier task with a familiar partner, given as much time as needed to complete the task, were encouraged to communicate in any way (e.g., gestures, facial expressions) and work together to complete the task, given many opportunities (24 trials) to complete and be successful at the task, and the experimenter served as the facilitator of the task rather than a participant.

The line of work from Duff and colleagues (e.g., Duff et al., 2006; Duff et al., in preparation; Duff et al., 2008; Gupta et al., 2011; Gupta et al., 2012) using the barrier task has documented striking patterns of spared and impaired learning abilities in individuals with various types focal brain damage (e.g., hippocampal, amygdala, VMPC) and selective neuropsychological impairment (e.g., declarative memory, social and emotional processing) as they complete a collaborative referencing task with a familiar partner. Of course, complex behavior such as communication is the product of the interaction of multiple cognitive systems working in concert. The current study examines the consequences of damage to multiple cognitive systems as a result of TBI for successful performance in the collaborative referencing task. Here, we explore the ability of individuals with TBI to develop and use referential labels for novel picture cards across repeated interactions with a familiar partner.

The primary question to be addressed is:

> Does the utilization of a social and collaborative interaction paradigm facilitate learning in individuals with traumatic brain injury, permitting them to learn to collaboratively generate responses that bring about increasing efficient communication about novel semantic information?

Given the remarkable learning observed in patients with amnesia and that patients with TBI can have a similar memory profile (i.e., deficits in declarative memory while procedural memory is relatively intact), one might predict that the individuals with TBI may perform similarly (e.g., dramatic decreases in the time and number of words to complete the task; development and use of unique labels for the cards). On the other hand, hippocampus, amygdala, and VMPC are all vulnerable to damage following TBI and impairments in declarative memory and social and emotional processing are well documented. It stands to reason that damage to multiple cognitive systems that have been shown to play a critical role in various aspects of performance and learning in the collaborative referencing task would significantly undermine the success of communication pairs managing TBI. The current study of individuals with TBI affords a unique glimpse into the interaction and orchestration of cognitive domains, as well as of communication practices evident in collaborative social interaction in TBI.

Table 1. Comparison of traditional and contextualized intervention

Traditional Intervention	Contextualized Intervention
Focus and Goals	
The goal is to restore cognitive functioning.	The primary goal is to help individuals achieve real-world objectives and participate in their chosen real-world activities.
Treatment Modalities and Methods	
Uses cognitive exercises to restore cognitive processes or skills.	Flexible combination of cognitive exercises (if indicated), intervention for strategic thinking and compensatory behavior in functional contexts, and environmental modifications (including changes in the support behavior of others).
Organization of Treatment	
Hierarchically structured and highly specific tasks.	Generalization is promoted from the beginning. Context limitations can be addressed first by enabling participation with environmental supports, activity/participation limitation, and then reduced with compensatory behaviors. Structure/function limitations finally reduced with internalization of strategies.
Setting, Content, Providers	
Clinical setting with special equipment. Cognitive retraining specialists provide the intervention.	Possibly clinical settings using personally relevant content (materials and tasks) or personally relevant settings. Intervention is provided by specialists who also recruit the support of people in everyday life.

CHAPTER II

METHODS

Participants

Twenty individuals participated in the study: 5 individuals with traumatic brain injury, 5 healthy comparison participants (matched pair wise to the participants with TBI on age, sex, and education), and 10 familiar communication partners. Participants with TBI were recruited from the Iowa Traumatic Brain Injury Registry. Healthy comparison participants were drawn from the community for a previous study.

Participants with Traumatic Brain Injury

The five participants with TBI (three males) were between the ages of 22-76 years (M = 53.8; SD = 23.45). Four participants were right handed and one had mixed handedness. Handedness was determined using the Edinburgh Handedness Scale (Oldfield, 1971). The participants' years of education ranged from 11 to 15 years (M = 12.6; SD = 1.51 years). All participants with TBI had normal or corrected hearing and vision; negative premorbid history neurological or psychiatric disease, or language or learning disability per self-report; English as a primary language; were all at least one year post injury. At the time of the injury, the participants were, on average, 42.0 years old (SD = 17.6; range 21-68). The demographic information for the participants with TBI is presented in Table 2.

The etiologies for the participants with TBI include a baseball accident, two unhelmeted bicycle/motorcycle accidents, and two falls. Of the four participants on whom neuroimaging data are available (acute or chronic), all four had positive findings for bifrontal lesion or contusions (1424, 3591, 3622), or temporal lesion (2894). Initial Glasgow Coma Scale (GCS) scores were available from the medical records of three participants indicting mild (GCS = 13) and moderate (GCS = 10; 12) brain injuries. Examination of medical reports also revealed that all participants experienced posttraumatic amnesia (range 2 days to 6 weeks). Table 3 lists specific information about the etiology and severity (i.e., GCS cores, duration of retrograde amnesia, duration of posttraumatic amnesia) of the participants' TBIs.

All participants with TBI also completed (or were in the process of completing) a battery of neuropsychological tests (see Tranel, 2008) covering the areas of: (1) intellectual and achievement abilities, (2) memory, (3) speech and language, (4) perception and attention, (5) visuoconstructional ability, (6) psychomotor and psychosensory functions, (7) executive functions, (8) personality and affect, and (9) premorbid status. The test battery is in Appendix A. Scores for neuropsychological testing is presented in Table 4. As a group, their chronic neuropsychological profiles are grossly within the normal range. Thus, while their brain injuries were classified as mild to moderate according to GCS and other indices, their current functioning would be classified as mild or within normal limits on standardized neuropsychological tests. Consistent with the TBI population more broadly, there is heterogeneity in the group and pockets of disrupted cognition within individuals.

The Weschler Adult Intelligence Scale (WAIS-FIQ) is a measure of intelligence. The participants' scores were all in the normal range (M= 107.5; SD = 13.89). Intelligence scores were not available for participant 3625. The participants completed a battery of memory assessments, including the Wechsler Memory Scale-III/IV (WMS), Galveston Orientation and Amnesia Test (GOAT), Auditory Verbal Learning Test (AVLT), and Complex Figure Test (CFT (delay)). Scores for the WMS and CFT were not available for participant 3625. As a group, the scores on the memory tests were within normal limits and none of the participants had post-traumatic amnesia at the time of this study (GOAT, M = 99; SD = 2.23). Scores on the WMS ranged from 107-134 (M= 122.75; SD = 12.68). AVLT scores ranged from 5 to 14 (M = 12.4; SD =4.15) for trial 5 and the delayed recall scores ranged from 8 to 14 (M = 11.6; SD = 2.30). The participants' scores on the CFT ranged from 6-27 (M=18.25; SD = 9.71). Closer inspection of individuals' scores, however, reveals that participant 3591 deviates from the group and has significant lower scores in memory suggesting a moderate to severe anterograde declarative memory impairment.

To assess visuospatial abilities, participants completed the copy portion of Complex Figure Test (CFT). A score on this measure was not available for participant 3625. Scores on the CFT (copy) ranged from 26-34 (M= 30.75; SD = 3.59), which is within normal limits. The Wisconsin Card Sorting Test (WCS) was administered as a measure of executive functioning. Scores for participant 3622 and 3625 were not available. Scores ranged from 0-6 for categories (M = 2.3; SD = 3.21) and 12-94 (M = 49.6; SD = 41.4) for perseverative errors. Only 2894 had a score within normal limits while 1424 and 3591 were impaired.

A certified speech-language pathologist determined that all participants were free of dysarthria. The Boston Naming Test (BNT), Token Test (TT), and Western Aphasia Battery (WAB) were used assess language and rule out aphasia. Scores on the BNT ranged from 53-59 (M = 55.8; SD = 2.16). Participant 3625's score for the TT was not available. Each of the four other participants was at ceiling on the TT. All participants were free of aphasia as determined by WAB scores above 93.8. (range 99-100; M=99.6; SD =0.54).

The Beck Depression Inventory (BDI) was used to assess the participants' level/severity of depression. Scores ranged from 0 (minimal depression) to 14 (mild depression) (M= 7.4; SD =6.07).

However, the mild or within normal limits on the neuropsychological testing should not be taken to mean that the participants do not experience consequences from their injuries. Three of the five TBI participants retired (1424, 3591) or are on disability (3625) because of their injury. Participant 3622 has returned to college but struggles to maintain passing grades and manage his finances independently.

Comparison Participants

Five healthy comparison participants were matched pairwise to the TBI participants based on demographic variables such as age, sex, and years of education. Table 5 displays the demographic information for the comparison participants.

Comparison participants had normal or corrected to normal hearing and vision; no neurological or psychiatric history or language or learning disability per self-report; spoke English as a primary language. The comparison participant group was 3 males and 2 females. All 5 comparison participants were right handed and ranged between the ages of 24-74 (M = 53.4; SD = 21.79). Comparison participants had 12-16 years of education (M =12.8; SD = 1.6). The TBI group (5 TBI participants) was similar in terms of age and years of education, with a mean age of 53.8 years (SD = 23.45) and 12.6 (SD = 1.51) years of education.

Familiar Communication Partners

The five participants with TBI and five comparison participants each completed the collaborative referencing task with a familiar communication partner. Familiar communication partners were friends, siblings, and spouses with whom they had been in regular contact (e.g., monthly) with for at least five years. Each of the partners had normal or corrected to normal hearing and vision; no neurological or psychiatric history or language or learning disability per self-report; spoke English as a primary language. Table 6 displays the demographics of the familiar communication partners.

Procedure

The current study used a collaborative referencing task, in which individuals with TBI and a familiar communication partner worked together to develop and use references for a set of tangram cards. The procedures for the collaborative referencing task used are identical to Duff and colleagues (Duff et al., 2006).

To complete the collaborative referencing task, participant pairs (e.g., individual with TBI and a familiar communication partner) sat at a table across from one another. Identical boards with 12 numbered spaces, with numbers 1-6 on the top row and 7-12 on the bottom row (See Figure 1) were placed in front of each participant. A low barrier separated the participants to obscure their view of the stimulus cards, but still allowed them to view their partner's face, postures, gestures, and movements above the level of the barrier.

Identical sets of Chinese tangram cards were provided to each participant in the pair. The tangram figures provided in Figure 2 were selected from Elffers (1976) and were 2x3 inches in size and on 3.5x5 inch laminated cards. Tangrams have a long history of use in collaborative referencing tasks (Clark & Wilkes-Gibbs, 1986; Clark, 1992; Hengst, 2003) and are well suited to examine the development of shared referential labels as the figures because they can resemble people, animals, or objects, but have no pre-established label.

Each member of a pair was assigned the role of either director or matcher. For all trials of the collaborative referencing task, the participants with TBI (and the comparison participants) were the directors and their familiar communication partners were the matchers. The collaborative referencing task began with the director's 12 cards in a unique order predetermined by the investigator for each trial. The goal of each trial was to have the director communicate to the matcher how to arrange his or her board using the cards so that at the end of the trial the two boards have card placements in the same order. The matcher began the task with his or her cards placed around the board so that they were easy to view and reach. Rather than treating the collaborative referencing task as an experiment, it was presented as a game to the pairs. Each pair was encouraged by the examiner to have fun while completing the task and to communicate as much as needed and in any way necessary (e.g., talking, gestures) in order to successfully complete the game.

The participant pairs were instructed at the beginning of each session to not move the barrier or stand up to look at the order of the cards on the other participant's board. Each pair completed four sessions composed of six trials. The sessions were conducted over a span of two days with two sessions per day. Sessions occurring within the same day were separated by a 30-minute interval at minimum. Over the course of two days, each pair completed 24 trials resulting in 288 card placements. The full protocol and instructions to participants are provided in Appendix B.

The participants with TBI completed an interview conducted by the examiner after a 30 minute break after the last session on day two. The purpose of the interview was to assess the memory for the cards and labels developed during the sessions. The participants with TBI and comparison participants were first shown the cards used in the barrier task interspersed with 12 foils and then asked if each card was familiar and if they had ever used the cards. They were required to provide a label for each card. The total number of cards identified as new and old and the number of correct card labels given was reported as a percentage correct. A label that was used consistently for a particular card on more than 80% of the trials was considered to be a correct response. Healthy comparison participants were drawn from the community for a previous study and at that time, follow-up interviews were not conducted with these participants. A direct comparison is not possible; however, we will broadly compare performance of the TBI participants on this measure with other healthy comparison participants from other studies.

The length of each trial was recorded in seconds. Participants were instructed at the beginning of the task that the time it took to complete the trial was not important even though it was recorded. The examiner left the room during each trial so as not to interfere with the communication or become a part of the exchanges. Prior to starting each session the participant pairs were instructed to notify the examiner when each trial was complete at which time the investigator came back into the room. When the examiner re-entered the room she checked the cards to determine how many cards had the correct placement on the matcher's board. A stopwatch was used to measure the time required to complete each trial. The examiner always marked the beginning of each trial with, "Begin when you are ready and have fun" and timing commenced. A trial ended when the participant pair verbally indicated that they completed the trial. The pairs were told at the end of each trial how many cards were correctly placed but not which cards were incorrect. Between trials the examiner helped the director place the cards into a new predetermined sequence for the following trial. At this time the matcher was instructed to remove the cards from his or her board and place them into view around the outside of the board.

Each barrier task session was video-recorded onto mini dv cassettes. The camera was placed approximately five feet from the table in order to capture both the profile of each participant and a view of their workspace.

Data Analysis

Basic performance measures and a set of discourse measures were used to measure learning. Basic performance measures included time, number of correct cards placed, and retention scores. Discourse measures were taken from the prepared transcripts (see below) and included total numbers of turns and words.

Basic Performance Measures

The two basic performance measures calculated were length of the trial and card placement accuracy. The examiner recorded the length of each session using a stopwatch and time was recorded in minutes and seconds. Timing of each trial began when the examiner stated, "Begin when you are ready and have fun" and ended when the participant pair indicated verbally that they were finished. Card placement accuracy refers to the total number of cards (max 12) in the correct place on the matcher's board at the end of each trial. Each of the TBI participants completed a card recognition and labeling task during the follow-up interview, which was completed 30 minutes after the final trial. The participants were shown a total of 24 tangram cards (12 used in study, 12 foils). First, participants identified the cards as familiar and unfamiliar and a retention score was generated (number correctly identified as familiar). The participants were also asked to provide a label for each card.

Transcribing the Collaborative Referencing Task

All four sessions of the collaborative referencing task were recorded and then transcribed. Session one for TBI pair 3591 was not audio recorded due to equipment failure. The recordings yielded approximately 17 hours and 32 minutes of tape that was transcribed. Transcription conventions for transcription of the sessions followed procedures outlined by Hengst, 2003 and Duff (2006; 2008). The transcription system is unique because it is similar to reading a musical score. Rather than highlighting one line in only the oral/auditory modality, which is a common procedure in traditional transcription protocols, this system accounts for all communicative resources (e.g., linguistic communication, non-linguistic communication, gestures, back channel), and it is temporally organized. This allowed card placement to be visualized concurrently with communication and reflects the temporal organization of discourse. Appendix C contains the transcription conventions.

Preparation of the transcripts occurred in three stages. The first two stages of preparation involved the audio and video portions of the transcripts. Research assistants in the Communication and Memory Lab within the Department of Communication Sciences and Disorders at the University of Iowa were the original transcribers. Each student received formal training in transcription and application of transcription conventions. All utterances, audible sounds, and pause times were transcribed from the audio portion of DVD recordings. XXX will was used to mark inaudible or unintelligible utterances in the transcripts. The four collaborative referencing sessions for each participant pair were entirely transcribed, which included task instruction, all of the trials, the discourse between the examiner and the participants while setting up for the proceeding trial. The second stage of transcription required the audio and video portions of the session recordings. At this point, the original transcribers added gestures, card placement sequences, and any necessary corrections to the transcript. During the third stage, the final version of the transcript (consensus transcript) was completed. The consensus transcriber (the investigator) and the original transcriber sat together to review and discuss the video and transcript. Any necessary corrections and additions to transcript were made at this time through discussion and consensus between the transcribers. Consensus was made on all transcripts. When consensus was reached, the transcript was finalized and ready for coding and analysis.

Discourse Measures

The discourse measures included the total number of words and turns for each participant pair in order to delineate the amount of communicative resources used during the experimental portion of the task.

The total number of words for each pair used in each of the 24 trials was counted. A total word count for each participant for each session was also obtained. Consistent with the protocol used in Duff et al. (2006; 2008), words were broadly defined and there was little emphasis on morphological and syntactic structure of words. Instead, words were counted as a way to capture verbal space and effort. False starts and place holders were each counted as one word (e.g., “and the he’s the he’s facing the opposite direction” = 9 words; “Five uh small arrow chimney” = 5 words). Contractions were counted as one word (e.g., “can’t” = 1 word). Initial sound and part-word repetitions were each counted once (e.g., “f- feet and knees” = 4 words; “a man sitting he- heels on the floor” = 8 words). Words with multiple initial sound repetitions were only counted once (e.g., “t- t- triangle” = 2 words). Across four sessions of the task and the ten pairs (i.e., five TBI pairs, five comparison pairs), 68,043 words were coded.

Consistent with the procedures in Duff et al. (2006), turns were defined as utterances produced by one individual and included both verbal and nonverbal resources. Turn boundaries were marked by a change in speaker. For turns that were jointly constructed, in situations where one individual begins an utterance that was completed by another individual, they were counted as two turns. When two individuals spoke simultaneously they were both given credit for individual turns. Instances of back-channeling (e.g., “uhuh”, “mhm”) were also counted as turns. Some turns contained gestures or consisted of a gesture alone. In instances where turns are not attended to or utilized by participants, they were accounted for and coded. Across four sessions of the task and the ten pairs (i.e., five TBI pairs, five comparison pairs), 9,680 turns were coded.

Discourse Measure: Initiating Noun Phrase

In order to track the stabilization and learning of card labels, the number of words of the initial description, or the initiating noun phrase (INP), of each card in all 24 trials was recorded. The INP word count only included words related to the card description and was the first attempt at describing or labeling the card without any input from the other pair member. Words not directly related to the labels or referencing of the card were not included (e.g., “um”, “uh”). Unlike the total word counts, the INP does not include contributions from both the director and matcher and does not include talk not directly related to card referencing (e.g., task management, conversation). This analysis is important for documenting learning because it shows the amount of effort used to describe the cards separate from other talk that occurs during the task.

Reliability

Inter-and intrajudge reliability ratings were estimated for the number of words and turns from approximately 30 of the 240 (12%) transcripts. Three trials per participant pair were randomly selected from three sections within the transcript: the beginning (i.e., trials 1- 8), the middle (i.e., trials 9-16, and the end (i.e., trials 17-24). Reliability ratings were accomplished by dividing the category totals of the reliability coding by the original coding. The investigator performed intrajudge reliability and a trained research assistant performed interjudge reliability.

Interjudge agreement for the total number of words and turns for each of the 30 trials was .99 (5950/5947) and .99 (775/777) respectively. Intrajudge agreement for the total number of words and turns for each of the 30 trials was .99 (5921/5947) and .98 (768/777) respectively. For INP coding, interjudge agreement for number of words was .98 (3023/3058), and intrajudge agreement was .99 (3023/3047).

Statistical Analysis

The main dependent variables used to assess the development and use of common ground were the rate of reduction in time and the rate of reduction in words in the initial description of the cards across trials. The rate of reduction is the critical index of learning; hence, the slopes of the rate of reduction will be compared using one-tailed t-tests (to test our hypothesis that TBI pairs will be impaired compared to normal comparison pairs).

Table 2. Demographics of participants with TBI

Participant	Sex	Hand	Education (Years)	Age at Testing (Years)	Chronicity (Years)	Employment Status / History
1424	M	R	13	76	27	Retired/ Railroad clerk
2894	F	M	12	66	29	Employed/ Wedding Planner
3591	F	R	12	69	1	Retired/ Telemarketer
3622	M	R	15	22	1	Student
3625	M	R	11	36	1	Disability / Truck driver
Mean			12.6	53.8	11.8	
Standard Deviation			1.51	23.45	14.8	

Note: M = male; F = female; Hand = handedness; R = right; M = mixed

Table 3. TBI etiology and severity

Participant	Etiology	Neuroimaging results	Glasgow Coma Scale	Length of retrograde amnesia*	Duration of posttraumatic amnesia
1424	Baseball accident	Chronic MRI shows bifrontal lesions	n/a	None	2 weeks
2894	Unhelmeted bicycle accident	Chronic MRI shows left temporal lesion	n/a	None	3 days
3591	Fell on ice	Chronic MRI shows bifrontal lesions	12	30 minutes	22 days
3622	Fell down stairs	Acute head CT showed bifrontal contusions	10	None	2 days
3625	Unhelmeted motorcycle accident	n/a	13	None	6 weeks

Note: * via patient report; MRI = magnetic resonance imaging; CT = computed tomography

Table 4. Performance on neuropsychological measures for participants with TBI

		1424	2894	3591	3622	3625	Mean (SD)
Intelligence	WAIS-III FIQ	111	115	87*	117*	n/a	107.5 (13.89)
Memory	WMS-III GMI	118	134	107	132	n/a	122.75 (12.68)
	GOAT	100	100	100	100	95	99 (2.23)
	AVLT (TR5/DR)	14/13	14/14	**5/8**	15/12	14/11	12.4/11.6 (4.15/2.30)
	CFT (DR)	25	15	**6**	27	n/a	18.25 (9.71)
Language	BNT	59	56	56	55	53	55.8 (2.16)
	TT	44	44	44	44	n/a	44 (0)
	WAB	99	100	100	100	99	99.6 (0.54)
Visuospatial	CFT (copy)	34	30	26	33	n/a	30.75 (3.59)
Executive Function	WCS (cat/PE)	1/43	6/12	**0/94**	n/a	n/a	2.3/49.6 (3.21/41.4)
Mood	BDI	10	0	8	14	5	7.4 (6.07)
General	SCATBI (score/ interpretation)	12 (mild)	17 (normal)	11 (mild)	15 (borderline normal)	17 (normal)	14.4 (2.79)

Note: WAIS = Wechsler Adult Intelligence Scale; WMS = Wechsler Memory Scale-III; GOAT = Galveston Orientation and Amnesia Test; AVLT = Auditory Verbal Learning Test; CFT (DR) = Complex Figure Test; BNT = Boston Naming Test; TT = Token Test; WAB = Western Aphasia Battery; CFT (copy) = Complex Figure Test; WCS (cat/PE) = Wisconsin Card Sorting; BDI = Beck Depression Inventory; * denotes WAIS-IV score. Bold scores indicate a deficit.

Table 5. Comparison participant demographics

Comparison Participant Number	Sex	Handedness	Education (Years)	Age at Testing (Years)
1424C	M	R	12	71
2894C	F	R	12	70
3591C	F	R	12	74
3622C	M	R	12	24
3625C	M	R	16	31
Mean			12.8	53.4
Standard Deviation			1.6	21.79

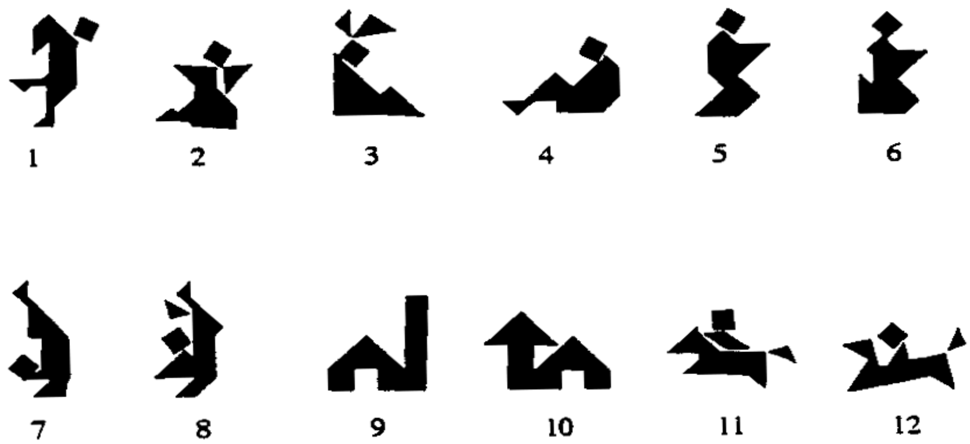
Note: M = male; F = female; L = left; R = right

Table 6. Familiar communication partner demographics

TBI Participant	Relationship	Age (Years)	Education (Years)	Comparison Participant	Relationship	Age (Years)	Education (Years)
1424	Wife	74	12	1424C	Wife	66	16
2894	Husband	67	14	2894C	Sister	76	12
3591	Husband	68	12	3591C	Friend	77	14
3622	Brother	22	15	3622C	Wife	26	20
3625	Wife	51	16	3625C	Wife	24	14
Mean		56.4	13.8	Mean		53.8	15.2
Standard Deviation		21.03	1.78	Standard Deviation		23.8	2.71

Figure 1. Table set up with barrier, playing boards, and cards for barrier tasks

Figure 2. Tangram figures used in the collaborative referencing task



CHAPTER III

RESULTS

Results from four participant pairs (1424, 2894, 3622, 3625) and their matched healthy comparison pairs are reported as a group analysis in this chapter. These pairs were classified as being "successful" (i.e., showed learning) on the collaborative referencing task. The fifth TBI participant pair (3591) differed across quantitative and qualitative measures and is presented separately as a case study later in the chapter.

Documenting Learning

The current study investigated the ability of individuals with TBI to acquire referential labels for novel tangram cards in collaboration with a familiar communication partner. Specifically, the primary question addressed was: 1.) Does the utilization of a social and collaborative interaction paradigm facilitate learning in individuals with traumatic brain injury, permitting them to learn to collaboratively generate responses that bring about increasing efficient communication about novel semantic information? The primary measures of learning include changes across trials in the accuracy of card placements, completion times for each trial, communicative resources (e.g., words, turns) used to complete the task, and retention of card labels after a 30 minute delay.

Results of the Four Successful TBI Participant Pairs

Card Placement Accuracy

Each pair placed 12 cards per trial and the total number of correct cards placed was recorded. TBI and comparison pairs had an overall card placement accuracy of 99% and 98%, respectively. Card placement accuracy on the first trial for the TBI and comparison pairs was 89% and 81%, respectively.

Time to Completion

Across trials, both within and across sessions, TBI and comparison pairs displayed significant reductions in time to complete each trial. Mean time to completion for the set of 12 cards dropped from 9:29 (min:sec) and 10:32 on trial 1, for TBI and comparison pairs, respectively, to just 0:55 and 0:41 on the final trial. Figure 3 shows the time to completion across trials and sessions for the TBI and comparison participant pairs.

The time to completion for both the TBI and participant pairs decreased across trials and session. However, TBI participants take longer to complete the first trial of each session (i.e., trials 1, 7, 12, 18).

Figure 4 shows the observed means for time across trials for the two groups (plotted with session-by-session linear trends). The time to complete each trial was similar for TBI and comparison pairs. The learning slopes of the groups' rate of reduction in time across all 24 trials did not differ significantly (TBI mean slope = -14.2 (SD = 5.2); comparison mean slope = -10.3 (SD=5.1); p=0.33).

Reduction in Overt Collaborative Effort for Referencing

Previous research with healthy participants shows that, over time and with repeated experience and interaction, there is a reduction in the overt collaborative effort needed for successful referencing (i.e., across trials pairs use fewer words and turns to refer to the cards) (Clark, 1986). The number of words and turns were totaled across trials in order to determine if the participants with TBI demonstrated a reduction in collaborative effort to across trials in referencing the cards. Consistent with Clark's (1986) collaborative referencing model, both the TBI and comparison pairs displayed the reduction in collaborative effort indicated by a reduction in the number of words and turns used to complete the task across trials. Total number of words dropped from 4419 and 5443 on trial one for TBI and comparison pairs, respectively, to just 344 and 328 on the final trial. For total number of turns, TBI and comparison pairs dropped from 446 and 481, respectively, on trial 1 to 91 and 101 on the final trial. The total number of resources used by the TBI and comparison pairs per trial is shown in Table 7. The total number of resources reflects totals for the director and matcher together. Figure 5 displays the decrease in number of words across trials and sessions for the TBI and comparison pairs. Figures 5 and 6 shows the similarity in the number of words and turns used across trials and sessions.

Quantitative and Qualitative Analysis of the Initiating Noun Phrase

The TBI and comparison pairs generated unique labels for each card that shortened and stabilized over time. Rapid and efficient communication occurred as the participant pairs developed succinct and shortened card labels. The card labels were tracked across trials and sessions by extracting the initiating noun phrase (INP), which was the director's first attempt at describing or labeling the card without any input from the matcher. The INP differs from total word count because it contains only talk related to the cards and excludes input from the matcher. It looks specifically at what the participant with TBI is doing. Figure 7 displays the decrease in number of words used in the INP across trials and sessions by the participants with TBI.

The number of words in the INP across trials was similar for TBI and comparison pairs. While, TBI pairs produced more words overall, the learning slopes of the groups' rate of reduction in words across all 24 trials did not differ significantly (TBI mean slope = -4.9 (SD = 1.5); comparison mean slope= -4.5 (SD = 24); p=0.81). An example of the pairs' efficient communication is displayed in table 8, which shows the INP for each of TBI participant 3625's card placements from session 1, trial 1 and session 4, trial 6.

Table 8 shows that TBI participant 3625 used shortened and concise card labels across the task. Card labels ranged from 2 to 59 words compared for session 1, trial 1, which is greater than session 4, trial 6, in which the participant with TBI used labels ranging from 0 to 6 words in length. Shortened and concise labels helped pair 3625 complete the task faster. For session 4, trial 6, the pair completed the task in 27 seconds compared to 6 minutes and 7 seconds in session 1, trial 1. Each of the successful TBI pairs (1424, 2894, 3622, 3625) demonstrated decreased INP length across sessions and trials. Table 9 shows the description of one card across four sessions by TBI pair 2894. This example shows the rapid and large decrease in communicative resources across sessions and trials. TBI participant 2894 first described this card in session 1, trial 1 using a total of 43 words. By session 1, trial 4 only two words were used to successfully describe the card to her partner. The language of the label is simplified to "the pitcher" or "pitcher" and the label stabilized for the remainder of the sessions and trials. All of the pairs showed simplification and stabilization of cards labels across trials and sessions.

Retention of Card Labels

A follow-up interview was conducted with each TBI participant 30 minutes after the end of the final trial. During the interview, TBI participants completed a card recognition and labeling task. Each TBI participant was shown a total of 24 tangram cards (12 used in study, 12 foils). First, the participants were asked to identify the cards as familiar and unfamiliar and to provide a card label for each. TBI participants 2894, 3622, and 3625 correctly identified all 12 cards used in the study as familiar with no false positive answers. TBI participant 1424 correctly identified all 12 cards used in the study as familiar and falsely identified one card as familiar. On average, the TBI participants generated 9 (range 2-12) (75%) of the same card labels used by his or her participant pair during the barrier task. TBI participant 1424 generated only 2 of the same concise card labels, while the other 3 TBI participants generated at least 10 (83.3%). Retention data for the comparison participants was not collected for the current study; however, in the study by Duff et al. (2006), healthy comparison participants (n=4) produced 83.3% of their final concise label. Overall, TBI participants 2894, 3622, and 3625 perform similar to healthy comparison participants in their retention of the card labels whereas 1424 deviated from the group and could only remember 2 labels.

Case Study: TBI Participant Pair 3591

Participant pair 3591 is presented as a case study. This pair deviated significantly from the other TBI and healthy comparison participant pairs by not demonstrating learning across trials of the collaborative referencing task on quantitative and qualitative measures. After presenting the primary data, possible explanations for the poor performance of this pair are considered including the neuropsychological profile of 3591, which also deviates from the group, and the role of the matcher. More specifically, because we speculated that 3591's husband may have contributed to their poor performance a follow-up study was conducted whereby we brought 3591 back to lab several months later and had her complete one session of the collaborative referencing task with a new partner. Results from that session are also presented below along with an interim discussion.

Card Placement Accuracy

TBI participant pair 3591 placed 12 cards per trial and the total number of correct cards placed was recorded. Pair 3591 and a demographically matched comparison pair had an overall card placement accuracy of 74% and 100%, respectively. Not only was pair 3591's overall card placement accuracy much lower than the matched comparison participant but was also much lower than the four successful TBI pairs who, as a group, had 99% card placement accuracy. Pair 3591 also different from all other pairs (TBI and comparison) by having highly variable card placement accuracy. Pair 3591 achieved 100% card placement accuracy in 4 out of 24 trials (trials 1, 14, 20, 21) (only 16% of trials), whereas 3591's matched comparison pair achieved 100% card placement accuracy for all trials. The other TBI pairs reached ceiling by trial 5. Pair 3591 did not show learning on this measure.

Time to Completion

Pair 3591 did not display a consistent or significant reduction across trials in the time taken to complete each trial. In fact, in striking contrast to all other pairs in the study, this pair was actually slower on the final trial (24th trial) than on the first trial. For trial 1, pair 3591 completed the task in 6:09 (min:sec) and for trial 24, completed the task in 6:24. 3591's matched comparison pair took slightly longer to complete trial 1, 7:21; however, time to completion dropped to 1:09 in trial 24. For the successful TBI pairs, mean time to completion dropped from 9:29 on trial 1 to just 0:55 on the final trial. Pair 3591 was also highly variable in the time to completion for each trial. Figure 8 shows the time to completion for pair 3591 and their matched comparison pair.

Reduction in Overt Collaborative Effort for Referencing

The number of words and turns were calculated across trials to determine if pair 3591 demonstrated a reduction in collaborative effort in the development and use of the referential labels. The total number of resources (i.e., director and matcher combined) used by pair 3591 and their matched comparison pair per trial is shown in Table 10. Session one of the initial testing (with her husband) was not recorded due to technical difficulty.

As can be seen in the table 10, pair 3591 used twice as many turns and words, overall, to complete the task as their matched comparison, and this is without the data from the first session. The number of words used by pair 3591 was variable within and across sessions. For example, in session 3, pair 3591 used 1179, 1367, 1407, 560, and 838 across the 6 trials (range of 847 words). Pair 3591 had a spike in the number of words used in session 4, jumping from 722 words in session 4, trial 2 to 1194 words in session 4, trial 3. The number of words then decreased for session 4, trial 5 to only 438 words.

Quantitative and Qualitative Analysis of Initiating Noun Phrase

The card labels used by pair 3591 were tracked across trials and sessions by coding the initiating noun phrase (INP). The number of words in the INP was coded to get a purer measure of the communicative effort dedicated exclusively to referencing cards. The INP is the director's first attempt at describing or labeling the card without any input from the matcher (RS) and to exclude any talk unrelated to the card labels (e.g., reviewing the procedures of the task; small talk).

Like the other pairs in the study (TBI pairs and healthy comparison pairs), the demographically matched comparison pair for pair 3591 showed a reduction in the INP across trials; Tr 1 = 192 words, Tr 24 = 82 words. In striking contrast, pair 3591 did not show this same reduction. Similar to performance on other measures (i.e., words, turns, INP), pair 3591 was highly variable across trials. INP data is not available for session 1 due to recording failure. For trial 7 (session 2, trial 1), the INP contained 150 words and on the final trial (trial 24) contained 234 words. The number of words in the INP ranged from 94 (trial 17) to 241 words (trial 14). On average, the successful TBI participants showed a reduction in the INP across trials; Tr 1 = 236 words, Tr 24 = 54 words. Figure 9 displays the total number of words in the INP for each of the 12 cards in each trial for 3591. The data points for 3591 trials 1-6 are at 0 because of missing data following recording failure. Also, the data point for the comparison pair on trial 17 is at 0 because INP data could not be calculated due to a missing piece of transcript. Based on the Figure 9, it is clear that pair 3591 did not display the typical pattern of shortened card labels across trials and sessions like the matched comparison pair or the successful TBI participants.

Table 11 shows that TBI participant 3591 used shortened and concise card labels for some cards across the task but for others the labels actually increased. For example, the card labeled as “He's squatted leaning to the right with the square being the head there's a triangle underneath it one big one beneath that first triangle” in session 2, trial 1 became known as “The Z” in session 2, trial 3. The card label “The Z” was then used in 13 out of the remaining 15 trials. RS provided the label “The Z” three times (trials 15, 22, 24). Many of the INP card labels used by pair 3591 are lengthy and often ambiguous. For example, 3591 uses the following INP (37 words) label during trial 22 (session 4, trial 4) to describe a card,

> “On an angle like this where to the right there's two triangles pointed outward and there's a square up on an angle above his mid-section and a triangle loosely up to the right and one pointed down”.

This performance differs from 3591’s matched comparison as well as the successful TBI participants who were not producing such lengthy and ambiguous labels this late in the task. By session 4, trial 6, TBI participant 3591 used card labels ranging from 2 to 44 words in length, which is greater than her matched comparison who used card labels ranging from 1 to 14 words in length. Additionally, successful TBI participant 3625 used labels ranging from only 1 to 6 words in session 4, trial 6. Each of the successful TBI pairs (1424, 2894, 3622, 3625) demonstrated decreased INP length across sessions and trials.

Also different from other pairs was the fact that RS (the matcher) produced a portion of the labels during the task. RS produced 14% (30/216) of the card labels, whereas for the other TBI pairs the director generated the labels for all cards (100%). The number of INP labels provided by the matcher increased from 1 label in session 2, trial 1 to 8 labels in session 4, trial 4. It was my impression that RS increased the number of labels he produced across the task because he was frustrated with 3591 and their poor performance and as a way to take more control of their performance. The role of RS is considered in more detail below.

Retention of Card Labels

A follow-up interview was conducted 30-minutes after the end of the final trial with TBI participant 3591. Similar to the other TBI participants in the study, 3591 completed a card recognition and labeling task. She was shown a total of 24 tangram cards (the 12 used in this study, 12 foils) in a randomized order. 3591 correctly identified all 12 cards used in the study as familiar with no false positives and generated 6 out of 12 of the same card labels used with her partner during the barrier task. The successful TBI participants on average generated 9 out of 12 (range 2-12) of the same card labels using during the task, which makes 3591's performance below average.

Interim Discussion

The results show that TBI participant 3591 was impaired on the collaborative referencing task and did not demonstrate learning on the selected variables of time, words, turns, and INP. Compared to the successful TBI pairs, pair 3591 demonstrated low card placement accuracy and extended time to completion. 3591's card labels were lengthy and ambiguous across trials and sessions, and she demonstrated poor memory for the labels during the follow-up interview. To further investigate pair 3591's strikingly different performance, her neuropsychological data and the pattern of interaction with her familiar communication partner are examined in the sections below.

3591's Neuropsychological Profile

3591's TBI was characterized as mild to moderate like the other TBI participants in the study. Her injury resulted in bifrontal contusions, which is similar to participants 1424 and 3622 who demonstrated learning and success during the collaborative referencing task. However, her neuropsychological profile indicates weaknesses in intelligence, memory, visuospatial skills, and executive function that are not evident in the other TBI participants. 3591 performed lower on many of the neuropsychological tests than the other TBI participants (presented here as the group mean of the other four

TBI participants): Wechsler Adult Intelligence Scale (intelligence measurement) (3591 = 87; TBI M = 107.5); Wechsler Memory Scale-II (memory measurement) (3591 = 107; TBI M = 122.75); Auditory Verbal Learning Test (memory measurement); (3591 = 5/8; TBI M = 12.4/11.6); Complex Figure Test (memory measurement) (3591 = 6; TBI M = 18.25); Complex Figure Test (visuospatial measurement) (3591 = 26; TBI M = 30.75); and Wisconsin Card Sorting Test (executive function measurement) (3591 = 0/94 (categories/perseverative errors)) (M = 2.3/49.6). Refer to page 46 for scores on all neuropsychological measures for all TBI participants.

Does 3591's neuropsychological profile account for her poor performance on the collaborative referencing task? Memory impairment alone would not account for her poor performance. Duff, Hengst, Tranel, and Cohen (2006) who used an identical version of the collaborative referencing task used here in the current study to assess the ability of individuals with severe declarative memory impairments to acquire referential labels with familiar communication partners. They found that the amnesia individuals demonstrated intact learning across the same measures examined here. That is, the amnesia pairs had high card placement accuracy (94%), demonstrated significant learning across trials on measures of time to completion and in the reduction of communicative resources (i.e., words, turns) across trials, and developed unique and concise labels for the cards. In fact, like the successful TBI pairs here, the learning did not differ from healthy comparison participants. Thus, 3591's poor performance is likely not related to a deficit in declarative memory.

Additionally, frontal lobe damage and related deficits alone would also not account for such poor performance. Gupta, Tranel, and Duff (2011) studied individuals with damage to the ventromedial prefrontal cortex damage and who had deficits in social and emotional processing on a collaborative referencing task identical to the current study. As previously mentioned, the VMPC is a vulnerable area in TBI and individuals with damage to this area often show impaired executive functioning in everyday life but it seldom shows on neuropsychological testing (Anderson, Damasio, Jones, & Tranel,1991).

The VMPC patients studied by Gupta et al. (2011) demonstrated performance equivalent to healthy comparison participants and demonstrated learning (e.g., high card placement accuracy, decreased time to complete the task, shortened and succinct card labels, decrease in communicative resources). Additionally, successful TBI participant 1424, demonstrated impairments primarily in executive functioning indicated by poor performance on the Wisconsin Card Sorting Test (1/43). 1424 and his partner successfully completed the collaborative referencing task with high card placement accuracy, decreased time to complete the task across trials and sessions, decreased communicative resources across trials and sessions, and simplified and shortened card labels suggesting that poor performance on the Wisconsin Card Sorting Test is not predictive of poor performance on the collaborative referencing task.

Based on the results of Duff et al. (2006) and Gupta et al. (2011), impaired memory or executive functioning in isolation would not result in poor performance on the barrier task. In the case of 3591, perhaps the interaction of deficits in multiple cognitive domains (i.e., intelligence, memory, visuospatial skills, executive functioning) created a cumulative effect and was enough to undermine her success at the task. That is, it is possible that even minor deficits in 2 or more cognitive domains are sufficient to disrupt the orchestration of cognitive resources necessary to support complex behavior. It is also possible that 3591 has deficits in procedural memory that may have contributed to her poor learning. Duff and colleagues (2006) suggested that the amnesic participants were successful in the collaborative referencing task, in part, because of their intact procedural memory. Although declarative memory is typically more impaired in TBI than is procedural memory, we cannot rule out a procedural memory deficit in 3591. A deficit in procedural memory, in concert with the other cognitive impairments, is a possible explanation that warrants further exploration.

Role of 3591's Familiar Communication Partner

3591 completed the barrier task with her husband (RS). RS was a 68 year old male with 12 years of education. 3591 and her husband had a communication history dating back 40 years. The interaction between 3591 and RS during the collaborative referencing task is qualitatively different than the interactions occurring between the successful TBI participants and their familiar communication partners. In contrast to the patterns of interaction in the other pairs, 3591's partner frequently and overtly criticized 3591 and there was more negative affect in these sessions than in the other participant pairs in this study. That is, although a formal analysis of extra-linguistic features was not completed, pair 3591 did not demonstrate the kind of laughing, smiling, joking, or teasing that was ubiquitous in the other TBI and comparison pairs across the 24 trials.

Figures 10 through 12 are all excerpts from the transcripts of the interaction between 3591 and her husband. 3591 (MS) is the top line of the transcript and her partner (RS) is the bottom line. The transcript is read like a musical score and preserves the temporal aspects of the interaction. The asterisks designate either card placements/snaps (CP and/or CS) or gestures. See appendix C for specific transcript conventions. Figure 10 and figure 11 both highlight the negative affect present throughout the collaborative referencing task trials. In Figure 10, RS comments on 3591's rate of card description/labeling and attempts to correct her perspective of the card. At this point, the pair's frustration escalates, which is indicated by their facial expressions, tone of voice, and gestures. This pattern of interaction is typical of this pair throughout the task. RS often commented and criticized the time it took 3591 to produce the labels saying things like, "come on", "keep going", and "took you that long to figure that out". The nonverbal (e.g., angry face, shakes head) and other extralinguistic features (e.g., sighing), which are documented in figure 11, further illustrates the negative pattern of interaction between the pair. In figure 11, RS's demeanor in this interaction is demeaning and disrespectful (i.e., cursing) and further fuels the frustration between the pair. Throughout the sessions it appeared that RS wanted to assume the role of the director. Figure 12 is a typical example showing RS taking the speaking floor from 3591 and assuming the role of director.

These are just a few examples that highlight the tense and often hostile interaction between RS and 3591 that were present in all trials and sessions. The successful TBI participants and their familiar partners had different patterns of interaction compared to 3591 and RS. These pairs would frequently laugh, smile, use playful gestures, and tease one another typical of verbal play reported in these collaborative sessions (Duff et al., 2008; Hengst, 2006; Shune & Duff, 2012). The experimenter who worked with 3591 and RS was shocked while watching the videos of the pair. She reported that RS was very friendly and pleasant and that these aspects of the interaction between the pair were completely unexpected and not present when the experimenter was in the room between trials to set the cards up. Overall, the qualitative differences between the successful TBI participant pairs and pair 3591 lead us to further investigate the role of the partner in successfully completing the collaborative referencing task.

Follow-up Study with TBI Participant Pair 3591

A follow-up study with TBI participant 3591 and a new interactive partner was completed to examine more closely the role of the partner during the collaborative referencing task. The new interactional partner was RH, a hospital employee in her 50s. RH has a long history in working in our laboratory with patients with acquired brain injury and has had at least yearly contact with 3591 for more than a decade. RH has never participated in this task before and did not have any information about 3591's performance in the task with her husband. The procedure for this follow up study was exactly the same although only one session of 6 trials was completed. A different set of tangram cards, shown in figure 13, from the initial study were used. To be consistent with the original study, 3591 was the director for all trials.

Card Placement Accuracy

3591 and RH placed 12 cards per trial across a total of 6 trials and had an overall card placement accuracy of 94% (68/72). This is an improvement from the card placement accuracy in the first session with her husband, which was only 66% (48/72). 3591 and RH's performance is similar to that of session 1 for the successful TBI participant pairs, who had an average card placement accuracy of 96% (279/288) on the first 6 trials of the task. On the final trial (trial 24) with partner RS, the pair had an overall card placement accuracy of 75% (9/12). On the first trial with partner RH, the pair had an overall card placement of 66% (8/12), only one less card in the correct place than what 3591 and her husband RS had after completing the task 24 times. For each of the following 5 trials, 3591 and RH achieved 100% (12/12) card placement accuracy.

Time to Completion

3591 and RH demonstrated a reduction in the time to completion across trials. In Figure 14 the time to completion for the follow-up study is compared with session 1 of 3591 and her husband RS. 3591 and her husband completed trial 1 in 6:09 (min:sec) and trial 24 in 6:24. 3591 and RH completed trial 1 in 6:53 and trial 6 in 1:23.

Overt Collaborative Resources

The number of words and turns were calculated across the six trials to determine if 3591 and RH demonstrated a reduction in collaborative effort to develop and use referential labels. Due to recording failure, we cannot make a direct comparison of total resources (i.e., words, turns) between session 1 with 3591 and RS and the follow-up study. However, by looking at the change in the number of words and turns across a single session (session 2 with partner RS, and session 1 of the follow-up study with RH) striking differences are apparent. The number of turns used by 3591 and RS for trial 7 (session 2, trial 1) was 122 and for trial 13 (session 2, trial 6) was 102. This represents a slight decrease of only 16 percent. Similarly, the number of words used by 3591 and RS was 919 for trial 7 (session 2, trial 1) 919 and for trial 13 (session 2, trial 6) was 788, indicating a slight decrease of 14 percent. In the follow-up study, 3591 and RH used 655 words for trial 1 and 169 words for trial 6, which was a 74 percent decrease. The number of turns used by 3591 and RH decreased from 91 in trial 1 to 42 in trial 6, which was a decrease of 53 percent.

Contribution of the Matcher

To determine the amount of contribution by the matcher in the completion of the collaborative referencing task, the number of words was totaled for 3591 and RH separately. In the first two trials RH and 3591 had reciprocal communication and roughly even contributions as measured by words. RH used 379 words in trial 1 and 271 words in trial 2, whereas, 3591 used 276 and 264 respectively. By trial 3, 3591 used more words than RH for the remainder of the session (trials 3-6). The number of words RH used decreased from 379 in trial 1 to just 35 in trial 6. The number of words used by 3591 dropped from 276 in trial 1 to 134 in trial 6. Perhaps the initial support by RH in the beginning helped facilitate the pair’s success (high card placement accuracy, decreased time to completion, decrease in overt collaborative resources) in future trials.

Conclusion to the Follow-up Study

3591’s performance with partner RH is in sharp contrast with her original performance with her husband, RS. Critically, in her interactions with RH 3591 does not appear impaired on the task indicated by normal card placement accuracy (94%) on 6 trials, decreased time to completion of the task across trials, and decreased overt collaborative resources with her partner. Qualitatively, the interaction between 3591 and RH is different than with her husband. 3591’s interaction with RH included laughter, smiling, and joking, which were not present in any of the 24 trials with RS.

Table 7. Total resources used by TBI and comparison pairs

	TBI Pairs		Comparison Pairs	
	Turns	**Words**	**Turns**	**Words**
Session 1				
Trial 1	**446**	4419	**481**	5443
Trial 2	**411**	3776	**304**	2866
Trial 3	**282**	1962	**169**	1278
Trial 4	**201**	1384	**178**	1276
Trial 5	**227**	1519	**114**	742
Trial 6	**134**	676	**118**	595
Session 2				
Trial 1	**173**	1347	**146**	1004
Trial 2	**191**	1201	**117**	626
Trial 3	**121**	626	**117**	637
Trial 4	**111**	550	**98**	385
Trial 5	**113**	513	**121**	536
Trial 6	**118**	518	**116**	534
Session 3				
Trial 1	**150**	1018	**114**	525
Trial 2	**125**	770	**126**	471
Trial 3	**106**	551	**105**	473
Trial 4	**110**	516	**105**	364
Trial 5	**103**	474	**118**	480
Trial 6	**102**	478	**N/A**	N/A
Session 4				
Trial 1	**110**	559	**95**	405
Trial 2	**131**	642	**90**	355
Trial 3	**106**	467	**105**	363
Trial 4	**93**	404	**102**	386
Trial 5	**90**	374	**95**	332
Trial 6	**91**	344	**101**	328
Total	**3845**	**25088**	**3235**	**20404**

Table 8. Card labels provided by the TBI participant 3625 session 1, trial 1 vs. session 4, trial 6

Card	Card Label (INP) Session 1 Trial 1	Length of Card Label	Card Label (INP) Session 4 Trial 6	Length of Card Label
1	There's feet in the back goin' up	7 words	Squatting man head attached	4 words
2	The triangle that is not connected	6 words	Handstand dog	2 words
3	A guy almost slouching over his feet are out in front of him	13 words	Dude sleeping	2 words
4	A boot and the point of the boot looking at very bottom of it looks like a boot would be pointing to the left amongst this blob that's going up still down on the lower part is a square and if you move up the body again the very top of it looks like a triangle attached to it	59 words	Boot	1 word
5	A little man kicking his leg up and then he's got a square at the back of his neck	19 words	Dude dancing	2 words
6	A very small messed up step with a square touching it off to the top right then there's two triangles above the square	23 words	Whatever the hell it is	5 words
7	The YMCA with the square angle	6 words	YMCA	1 word
8	A pointed doggie with something on its back	8 words	Jumping dog with the rectangle square	6 words
9	Another dog	2 words	Dorsal fin	2 words
10	The house	2 words	Short chimney	2 words
11	The house with the very long chimney with no point	10 words	Silo	1 word
12	A messed up "s" with the square on the very top	11 words		0 words (no description but card correctly placed)
Trial length	6 minutes, 7 seconds		27 seconds	
Card placement accuracy	100%		100%	

Table 9. A card description by TBI participant 2894

Session:Trial	**Card Label Across Sessions and Trials**
1:1	It's flat on the top it's not a very big one it's flat on the top and flat on the bottom it has a diamond up at the right corner and then on the corner of that diamond it has a triangle attached **(43 words)**
1:2	It has a diamond at the top triangle attached to that and an anvil or something (16 words)
1:3	A short one the pitcher (5 words)
1:4	The pitcher **(2 words)**
1:5	The pitcher (2 words)
1:6	The pitcher (2 words)
2:6	Pitcher (1 word)
3:6	The pitcher (1 word)
4:6	The pitcher (2 words)

Table 10. Total resources used by TBI participant pair 3591 and matched comparison pair

		TBI Pair 3591		Comparison Pair	
		Turns	**Words**	**Turns**	**Words**
Session 1					
	Trial 1	N/A	N/A	**104**	1069
	Trial 2	N/A	N/A	**52**	748
	Trial 3	N/A	N/A	**43**	419
	Trial 4	N/A	N/A	**32**	298
	Trial 5	N/A	N/A	**34**	332
	Trial 6	N/A	N/A	**43**	354
Session 2					
	Trial 1	**122**	919	**52**	376
	Trial 2	**101**	744	**38**	371
	Trial 3	**71**	525	**33**	359
	Trial 4	**84**	717	**24**	226
	Trial 5	**53**	511	**44**	337
	Trial 6	**102**	788	**26**	210
Session 3					
	Trial 1	**127**	1179	**33**	268
	Trial 2	**102**	1367	**25**	221
	Trial 3	**113**	1407	**32**	262
	Trial 4	**98**	1069	**26**	179
	Trial 5	**70**	560	**34**	224
	Trial 6	**86**	838	**24**	156
Session 4					
	Trial 1	**98**	702	**25**	176
	Trial 2	**105**	722	**27**	123
	Trial 3	**132**	1194	**24**	127
	Trial 4	**56**	438	**26**	128
	Trial 5	**74**	581	**24**	113
	Trial 6	**60**	641	**31**	165
Total		**1654**	**14902**	**856**	**7261**

Table 11. INP labels for pair 3591 session 2, trial 1 vs. session 4 trial 6

Card Placement	**Card Label (INP) Session 2 Trial 1**	**Length of Card Label**	**Card Label (INP) Session 4 Trial 6**	**Length of Card Label**
1	He's standin' on one foot	5 words (3591)	The guy standing on one leg	6 words (3591)
2	The head which is a square at the top to the right of that square is a triangle the left of that square is another triangle	26 words (3591)	He's got another triangle in front of the face with a little triangle to the back of his shoulder and a big triangle sticking out down toward the bottom where that square is slightly attached to and the legs are slanted to the left	44 words **(RS)**
3	Two triangles on top above the head he's sitting down	10 words (3591)	The flag above the head	5 words (3591)
4	He's laying in the recliner	5 words (3591)	The one in the recliner	5 words (3591)
5	He's squatted leaning to the right with the square being the head there's a triangle underneath it one big one beneath that first triangle	25 words (3591)	The Z	2 words **(RS)**
6	A head	2 words (3591)	A head on top of a square to the right of that square is a large triangle	17 words (3591)
7	A witch there's a head which is a square and it looks like he's layin' down with his feet up	20 words (3591)	The head which is turned like a diamond to the right of that far right of that on top is a triangle like his feet are elevated laying on his back	31 words (3591)
8	It's kinda half way layin' down with his feet up	10 words (3591)	A head which is a square which is a diamond to the left of that is a triangle big one to the right of that is a detached triangle and to the right of that triangle is a triangle with a point pointed up	44 words (3591)
9	The garage with the silo on the right hand side	10 words (3591)	The barn with the silo on the right	8 words (3591)
10	The arrow going to the left	6 words (3591)	The one with the arrow on the left	8 words (3591)
11	A head which is the top which is connected to a rectangle to the left of that rectangle are two triangles	21 words (3591)	The horse	2 words **(RS)**
12	A head with a triangle below it	7 words (3591)	A chunk the head is a square or appears that's the head being a square that's string attached the head is not square with the world and on the right lower side of that is a triangle and the triangle is pointed seated down at the lower right and his feet are slightly up a little bit from the extreme bottom left	62 words **(RS)**
Trial length	10 minutes, 0 seconds		6 minutes, 24 seconds	
Card placement accuracy	50%		75%	

Figure 3. Time to completion across trials and sessions for TBI and comparison pairs

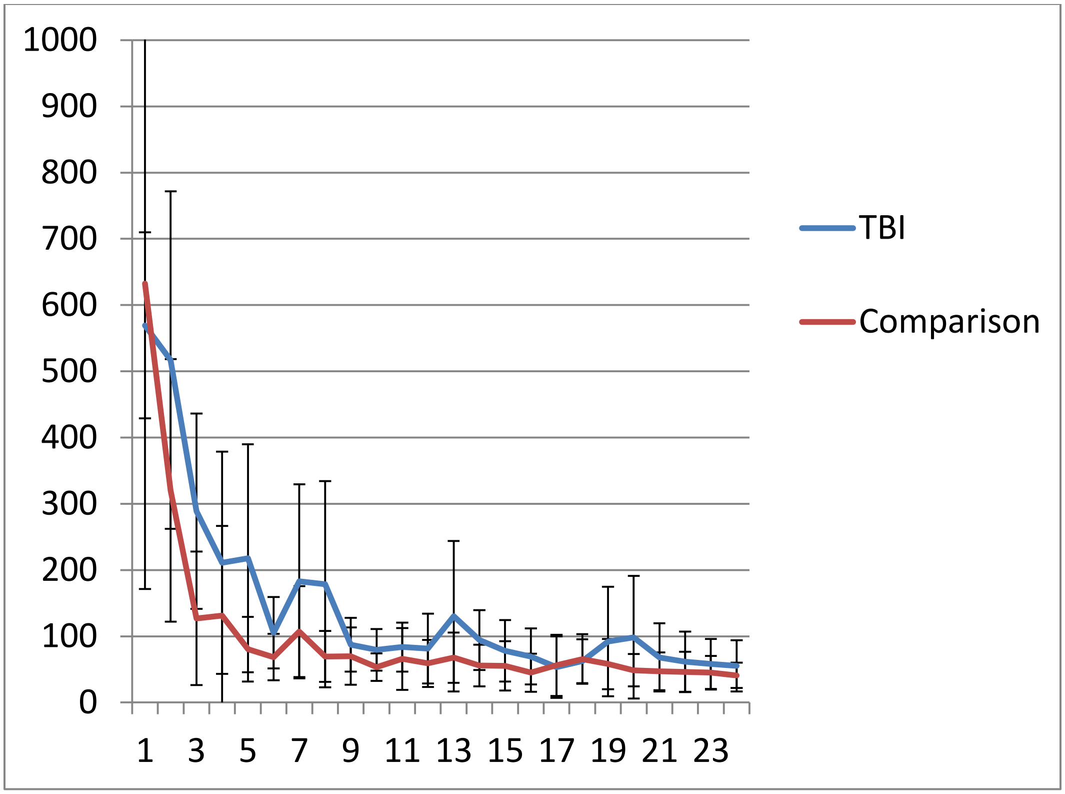


Figure 4. Observed means for time across trials for TBI and comparison pairs (shown with session-by-session linear trends)

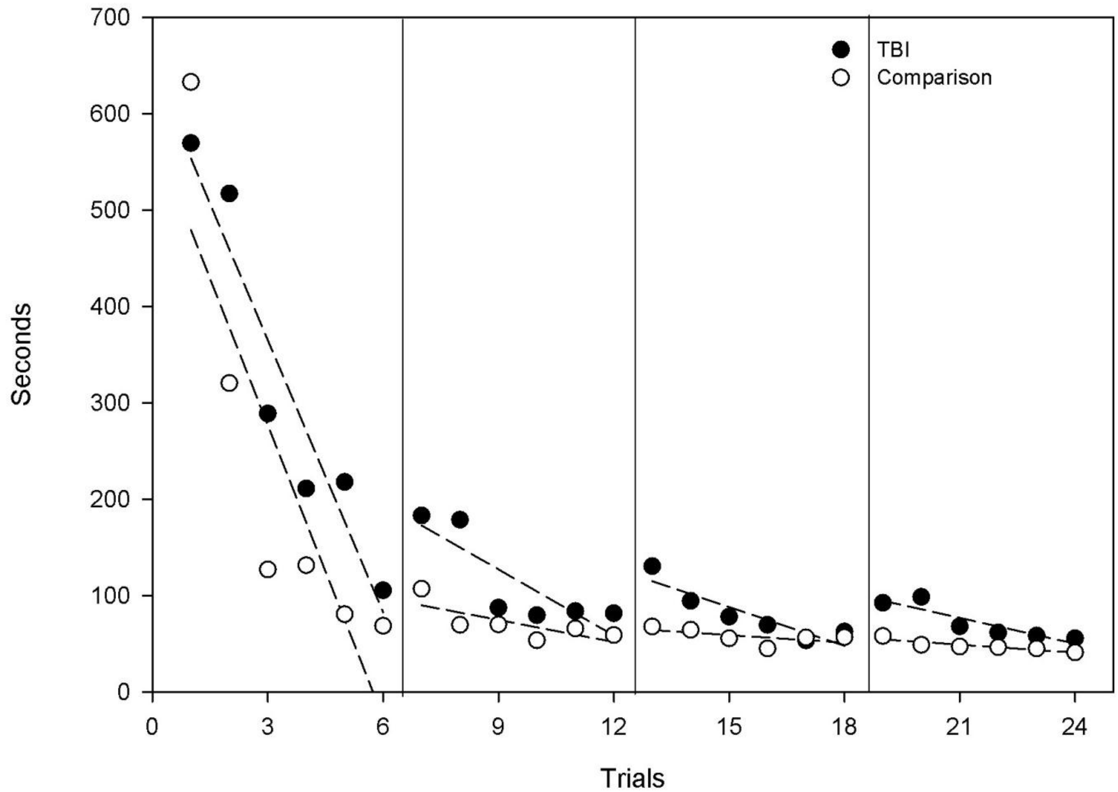


Figure 5. Total number of words for TBI and comparison pairs across trials and sessions

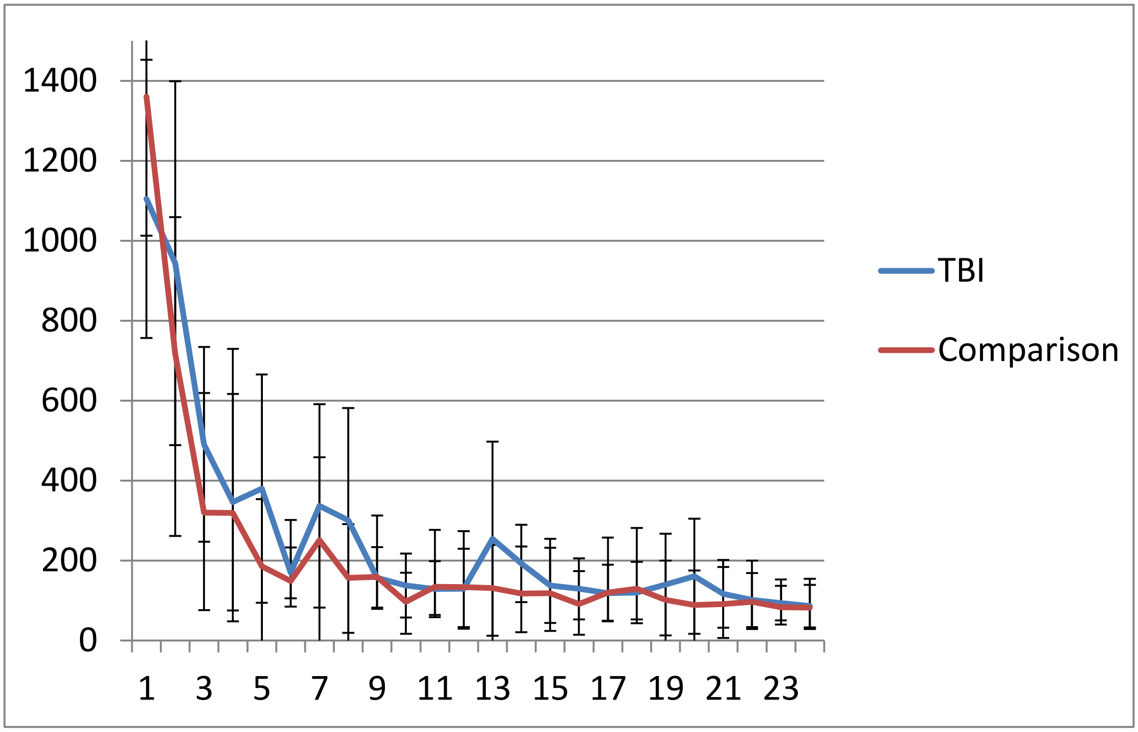


Figure 6. Total number of turns for TBI and comparison pairs across trials and sessions

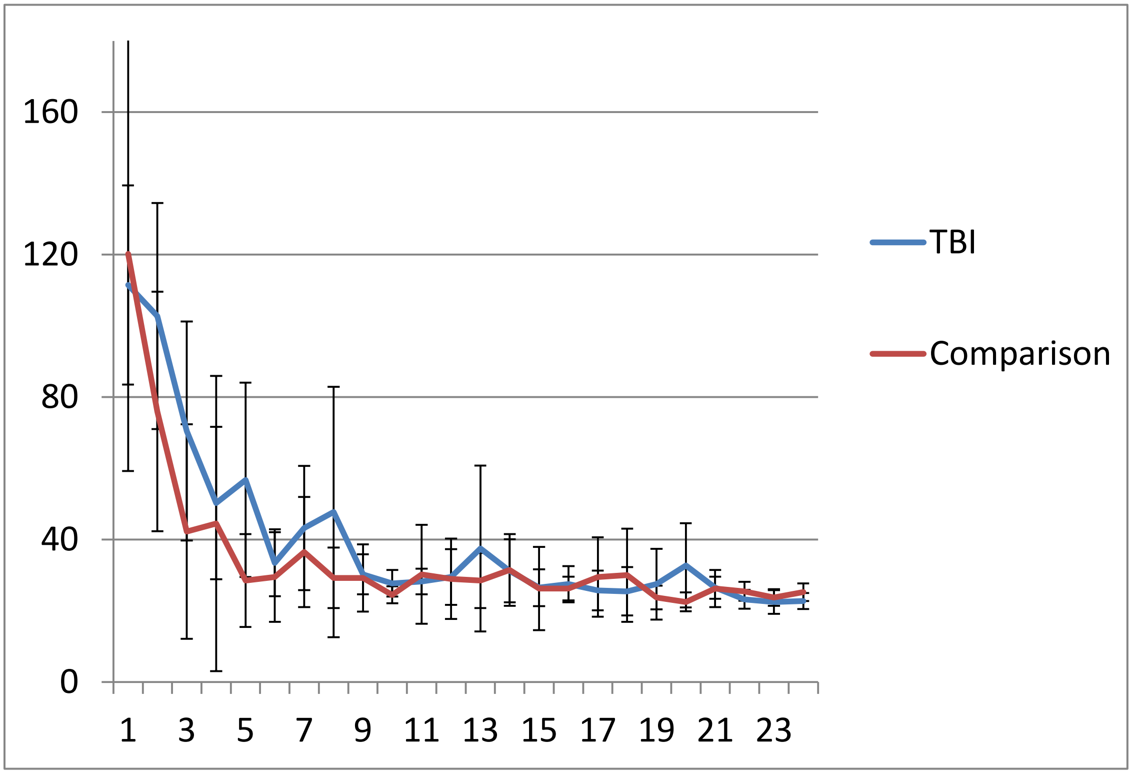


Figure 7. Initiating noun phrase length across trials and sessions (shown with session-by-session linear trends)

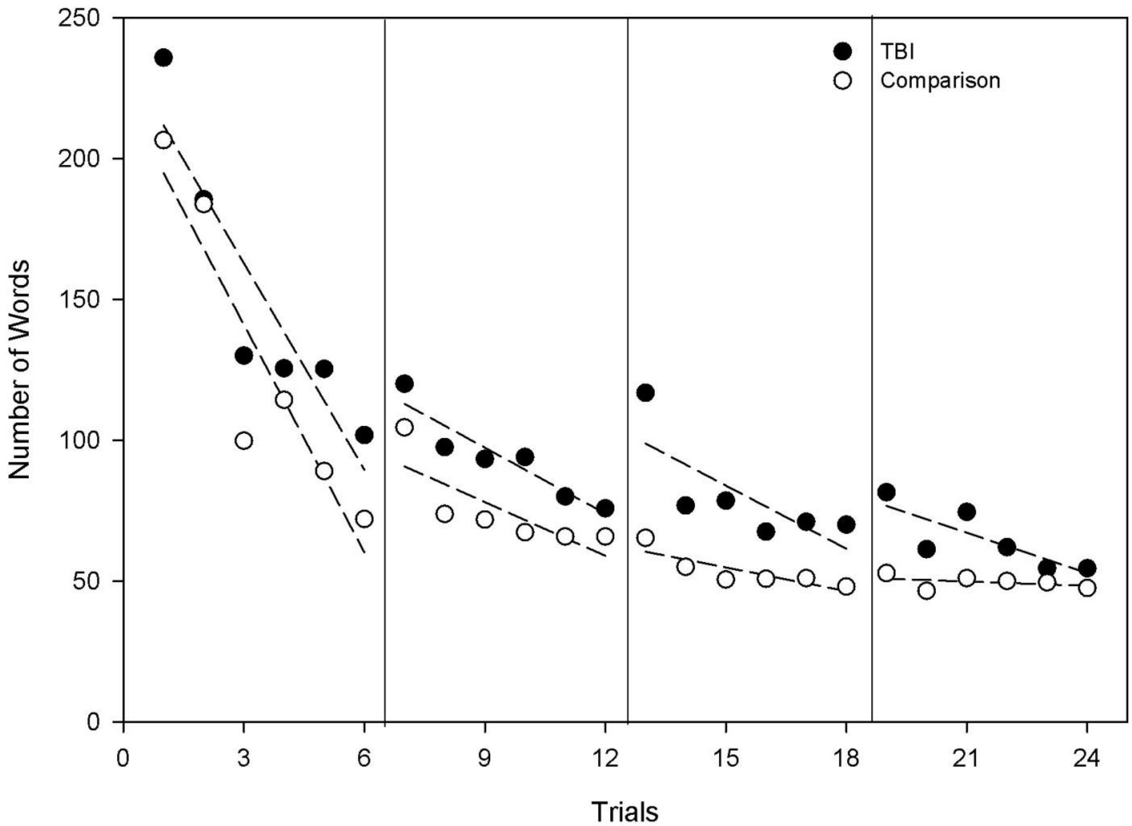


Figure 8. Time to completion for TBI participant pair 3591 and matched comparison pair

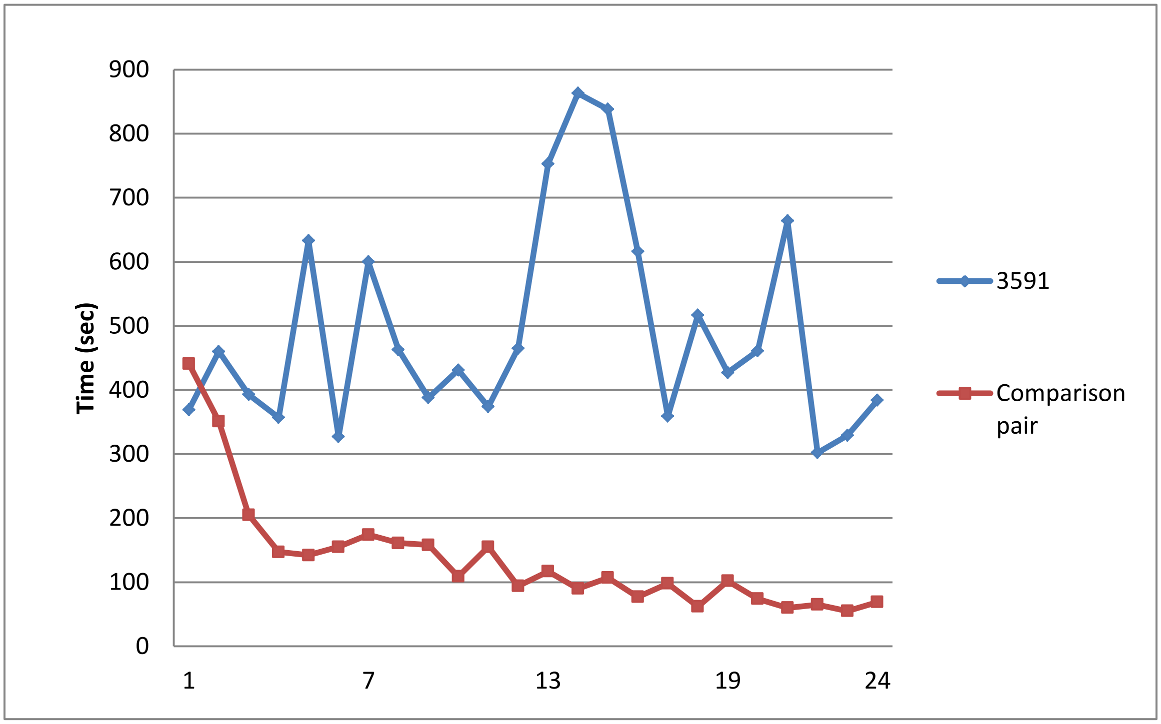


Figure 9. Number of words in the INP across trials and sessions

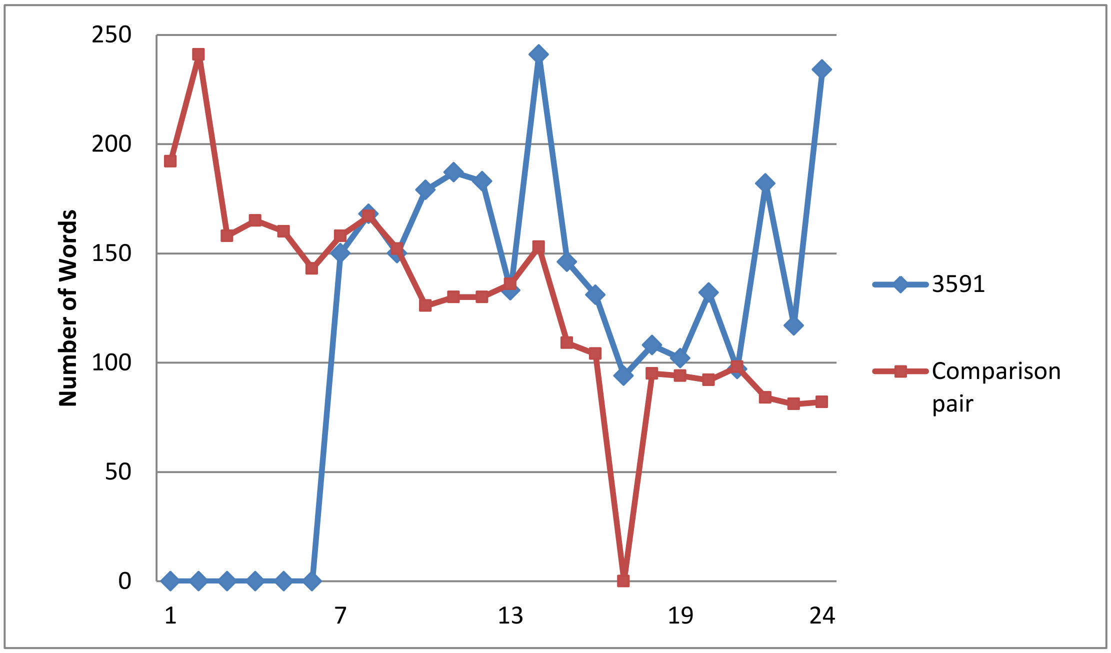


Figure 10. Transcript example- Partner's focus on 3591's deficits

MS:		^^h His head connected to a rectangle, to the
RS:	*Okay now read me nine ..2.. *CS/CP	
MS:	left of the rectangle is its	
RS:		Marianne do you realize the head's gotta be on one end
MS:		*It's in the top of the middle ….4….
RS:	of the body and not in the middle?	*[sighs] Come ahead
		*angry face *shakes head

Note: Excerpt from session 2, trial 2

Figure 11. Transcript example- Frustration

MS: Got him? Okay Number six is two
RS: ‘Kay Yup Now I got three and six ..2..

MS: triangles on top above the head ..2.. he’s sitting down ….4….
RS: ‘Kay *Come on keep
*nods

MS: And that’s about it The square is the head
RS: going Well there’s a square

MS: ..2.. *What ^^h ….4….
RS: God damnit Marianne
*angry face

Note: Excerpt from session 2, Trial 1

Figure 12. Transcript example- Partner takes control of task

MS: [tongue click] Twelve has a square
RS: Okay what's number twelve? ..2..

MS: which is *cockeyed to it's not *square Yes
RS: It looks like he's crouched down?
*arm up *draws square

MS: That's correct and below that square is a triangle to
RS: His feet go out to the left *
*CP

MS: the left kinda like and on the right hand side is a triangle
RS: *'Kay I ain't gonna
*lifts fingers

MS:
RS: talk anymore about that one 'kay now what's number two or five ..2.. I've got
-

MS:
RS: two left and they're kinda standin' … one looks like standin' on one leg and … to

---

MS:
RS: the left … angled to the left, right above that's a big triangle and above that

---

MS:
RS: there's a square partially attached and way up at the top there's a triangle

---

MS:
RS: attached to the other and below that air bed is another loose triangle …10…

Note: Excerpt from session 3, trial 3

Figure 13. Tangram figures used in the follow-up study

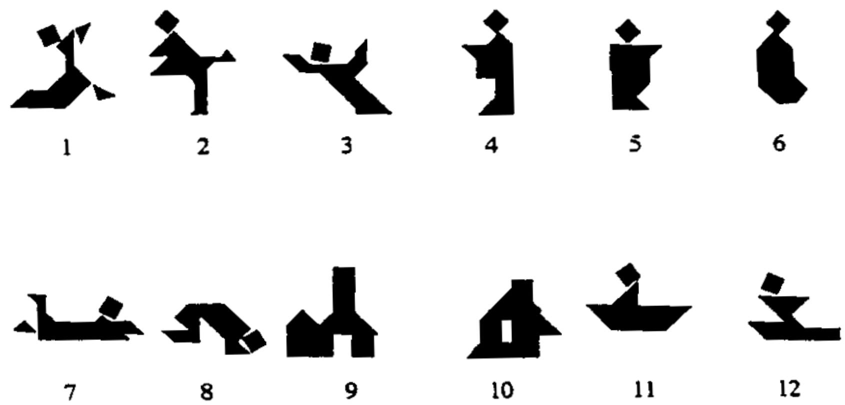
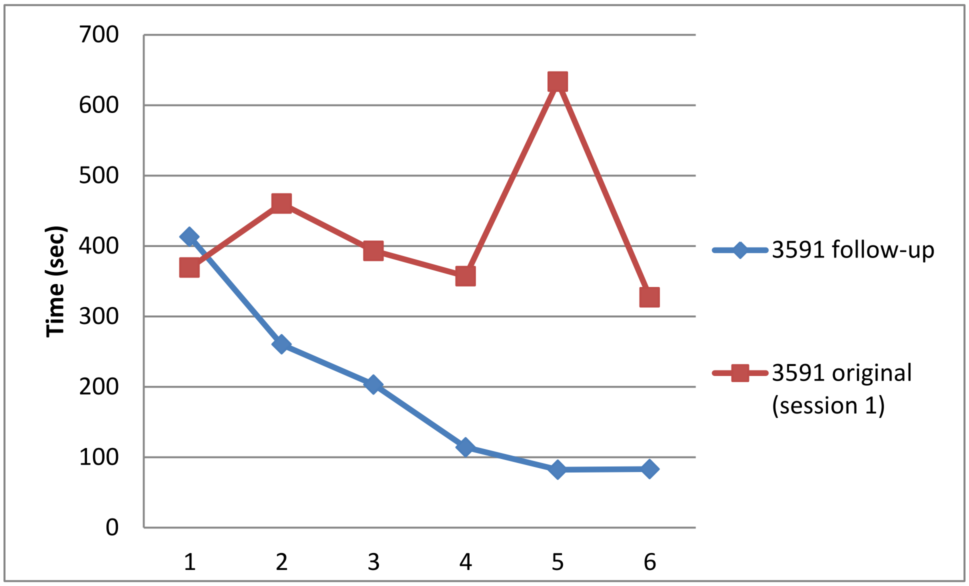


Figure 14. Time to completion: A comparison of 3591 and partner RS (original study) versus partner RH (follow-up study)



CHAPTER IV

DISCUSSION

Summary

The current study brings together Ylvisaker's collaborative intervention approach for individuals with TBI and a line of empirical work from Duff and colleagues (e.g., Duff et al., 2006; 2008; in preparation; Gupta et al., 2011; 2012) using a collaborative referencing task to explore new learning following acquired brain injury. The current study examined the ability of individuals with TBI to acquire referential labels in a collaborative and interactive task. The primary question of interest was:

> Does the utilization of a social and collaborative interaction paradigm facilitate learning in individuals with traumatic brain injury, permitting them to learn to collaboratively generate responses that bring about increasing efficient communication about novel semantic information?

The results of the study showed that four of the five TBI participant pairs demonstrated learning on the collaborative referencing task with a familiar partner of their choice and that the fifth TBI participant demonstrated learning when paired with a different familiar partner. The performance of the TBI participants, as a group, did not differ from healthy comparison participants on measures card placement accuracy, time to completion across trials and sessions, and the development of unique and succinct card labels. Given the complex nature of cognitive, neurological, behavioral, personality, and communicative impairments associated with TBI, the findings here, that all participants with TBI were successful in the task, are surprising and provides further evidence that these interactive sessions are potent learning environments (see Duff et al., 2008).

The heterogeneity of the TBI population makes it a difficult population to assess, treat, and research (Ylvisaker & Feeney, 1998; Kennedy, 2002; ASHA, 2003). Intervention studies are particularly challenging because it is difficult to create a large group of individuals with TBI who are similar in terms of demographic (e.g., age, sex, time post-injury), neuropsychological (e.g., range and severity of impairments) and neuroanatomical variables (e.g., Kennedy, Coelho, Turkstra, Ylvisaker, Sohlberg, Yorkston, Chiou, & Kan, 2008). Furthermore, the TBI population is diverse with regards to outcome and the impact of the injury on their daily lives. The participants in the current study highlight some of this variability. While all participants were similar in that they sustained mild to moderate brain injuries, participants were heterogeneous in terms of age (range 21-76 years), time post injury (range 1-29 years), neuropsychological profiles (e.g., 1424 impaired on a measure of executive functioning; 3591 impaired across multiple domains), and outcome (e.g., 2894 maintained career as wedding planner post injury; 3622 continued as a student after his injury but, per participant report, was struggling academically; 3625 is unable to work and on disability). With these factors in mind, the results of this study are particularly striking. That is, despite the variability all participants were successful and demonstrated learning.

The results of the study support the idea that use of a social and collaborative interaction paradigm may facilitate learning in adults at least one year time post injury with mild to moderate brain injuries. Aspects of the collaborative referencing or barrier task (terms are used interchangeably) that exemplify Ylvisaker’s contextualized invention approach are completion of a goal-directed task, working with a partner who was relevant to the participant’s everyday life, supports were provided by the partner as needed, the task was repeated many times in order to increase chances of the pair’s success, and skills were taught through collaboration rather than explicit instruction. Although this was not an intervention study, these findings provide further evidence supporting the use of Ylvisaker’s social, interactive, and collaborative approach for individuals with TBI. Our study did not include a control task; therefore, we are unable to say that the collaborative referencing task is superior to other methods. Given that the participants did not have profound deficits in declarative memory, it stands to reason that these participants would succeed in other learning paradigms. However, this study is the first to our knowledge to investigate learning during a collaborative referencing task with individuals with TBI and the positive results obtained here suggest that this may be a fruitful way to deploy Ylvisaker's contextualized intervention approach in more controlled research settings. A direct comparison of this approach with other approaches used more frequently in the literature is also needed.

Errorless learning is a common intervention technique used with individuals with TBI to promote new learning. Research has shown that errorless learning produces modest gains but is often described as painfully slow (taking hundreds of trials) with poor to no generalization of skills to other contexts (e.g., Ehlhardt et al., 2008; Turkstra & Bourgeois, 2005). In contrast, the participants with TBI in the current study demonstrated learning at a rate equal to that of healthy comparison participants and showed generalization outside of the task. On the card retention task completed 30 minutes following the final session, the TBI participants generated an average of 9 (range 2-12) (75%) of the same card labels used by during the collaborative referencing task. TBI participant 1424 generated only 2 of the same concise card labels, while the other 3 TBI participants generated at least 10 (83.3%). Retention data for the comparison participants was not collected for the current study; however, in the study by Duff et al. (2006), healthy comparison participants (n=4) produced 83.3% of their final concise label. These data suggest that the TBI participants generalized the use of the card labels to other contexts, with 4 participants achieving levels comparable to that of healthy comparison participants.

The strongest evidence supporting Ylvisaker's approach is evident with TBI participant 3591, who had the worst neuropsychological profile of the participants and whose performance varied depending on the partner. 3591 was successful when completing the collaborative referencing task with a more collaborative and interactive partner. The collaboration and cooperation combined with shared perspective and positive interaction may have facilitated 3591's success at the task and is consistent with the "ingredients" of Ylvisaker's positive everyday routines (Ylvisaker, Hanks, & Johnson-Green, 2003).

Role of the Partner

The everyday people involved in the lives of individuals with TBI play a critical role in their success and outcome. While this point has been emphasized extensively in the writings of Mark Ylvisaker, the difference in the performance of participant 3591 with two different communication partners highlights the role of the partner in everyday communication. 3591 and her husband performed poorly on the collaborative referencing task. Pair 3591differed from the other TBI participants and matched comparison participant on qualitative (e.g., simplification and stabilization of card labels) and quantitative measures (e.g., card placement accuracy, time to completion, use of overt collaborative resources, INP labels). Through video observation, it was observed that the pattern of interaction between 3591 was negative, and at times hostile, while the interaction between 3591 and the research assistant was described as more positive and collaborative. 3591 and the research assistant were also more successful on the collaborative referencing task than 3591 and her husband.

While 3591 deviates from the TBI group in terms of her neuropsychological profile (e.g., weaknesses in intelligence, memory, visuospatial skills, executive functioning) the difference in her performance across communication partners is particularly interesting and has significant implications for clinical practice. One explanation for 3591's improved performance was the different patterns of interaction with her new partner.

Characterizing specific behaviors that mark positive interaction is challenging. Indeed, in the areas of basic sociolinguistic work, discourse studies, and clinical studies of partner training it is the case that not a single behavior or even a set of behaviors has emerged as contributing significantly to positive or successful interaction. Ylvisaker's approach does not explicitly state a list of positive behaviors but rather a set of principles (e.g., scaffolding, apprenticeship). The current study faces the same challenges. I acknowledge the terms "supportive" and "positive" are broad and not clearly defined. Despite the ambiguity of these terms, there were striking differences in performance by TBI participant 3591 when working with a different partner. Consistent with Ylvisaker's positive everyday routines and collaborative intervention approach, perhaps 3591 required greater support, positive interaction, and a partner who was willing to work together in order to be successful at the task. 3591's negative interaction with her husband was characterized by outward frustration (e.g., cursing, sighing, angry gestures). 3591 appeared to be emotionally distressed, indicated by gestures, facial expressions, and tone of voice, in the video recordings of the task with her husband. When completing the task with a new partner, 3591 was observed to be frequently smiling, laughing, and joking.

3591's husband, conversely, used a much more direct communication style during the task. He addressed 3591 in more direct ways (e.g., "God damnit Marianne") and often told her how to describe the cards. Also, emphasis appeared to be placed more on 3591's successes in the follow-up study with a less familiar partner (research assistant) rather than her areas of impairment or deficit (e.g., words of encouragement, agreement), like in the interactions with her husband. It is unclear exactly which positive behaviors and aspects of the interaction with the research assistant that facilitated 3591's success and this is an area that warrants further investigation.

Everyday people (e.g., family, friends, peers, staff) who are present in the individual's life are a critical component of Ylvisaker's model. When intervention services are no longer available, it is the everyday people who are with the patient. Being an everyday partner alone, however, does not equate a positive experience, which is evident in 3591's case. Her performance on the collaborative referencing task with her husband, whose communication history spans 40 years, was worse than when playing with a research assistant. Individuals with TBI vary not only in terms of cognitive, neurological, behavioral, personality, and communicative impairments but also in regards to support in their environment. The amount of support provided in the individual's environment has a profound impact on outcome and recovery (Kreutzer, Marwitz, & Kepler, 1992; Morton & Wehman, 1995; Ylvisaker & Feeney, 1998; Hibbard, Cantor, Charatz, Rosenthal, Ashman, Gunderson, Ireland-Knight et al., 2002).

One approach to characterizing and quantifying positive interaction is by looking at repeated engagement. Hengst, Duff, and Dettmer (2010) argue that repeated engagement in meaningful goal-directed activities and in social interaction facilitates learning and communicative success. Repetition alone does not necessarily improve performance, but rather being engaged cognitively and socially contributes to learning (Hengst et al., 2010). Engagement can be displayed in a number of ways although the work by Duff and Hengst has drawn heavily on Deborah Tannen's (1989) writing on involvement strategies. Tannen, a sociolinguist, argues that involvement is displayed in language through the use of tropes, verbal play, reported speech, repetition, and other discursive features. Of particular interest here is the lack of verbal play in the sessions with 3591 and her husband and the presence of it in the session with the research assistant and all the other participant pairs in the study. While the exact relationship between verbal play (and the use of involvement strategies) and communication and learning in the collaborative referencing task awaits further study, it should be considered one marker of the presence of engagement in these interactions and may be related to the improved performance of 3591 with a different partner.

Partner Training

In the area of neurogenic communication disorders, there has been increased interest in the role of the communication partner, specifically in the areas of partner education and training as part of aphasia intervention. Conversation training programs have proven to be an effective way to increase communicative access and success, and reduce psychosocial consequences of aphasia (Turner & Whitworth, 2006). Supported Conversation for Adults with Aphasia (SCA; Kagan, 1998) is an intervention approach that involves training conversation partners to provide communication opportunities with appropriate supports necessary for people with aphasia (Kagan, 1998). Another type of conversational training program for aphasia is called Conversation Coaching (Hopper, Holland, & Rewega, 2002), which targets both the conversation partner and the person with aphasia's conversational skills in context. This method is more structured and involves the clinician selecting particular conversation strategies (e.g., topic starters, verbal and visual cues, drawing, writing), following a hierarchy, and coaching the partners during communication scenarios (Hopper, Holland, & Rewega, 2002; Turner & Whitworth, 2006).

Communication partner education and training programs have also been developed as intervention with individuals with dementia. The FOCUSED program (Ripich, Wykle, & Niles, 1995) is an acronym standing for face-to-face, orientation, continuity, unsticking, structure, exchanges, and direct. With these principles in mind, it is designed to provide caregivers of individuals with Alzheimer's disease with information regarding communicative breakdowns. It has been shown that interpersonal relations between the caregiver and individual with Alzheimer's disease improves when there is understanding of the linguistic and intellectual impairments experienced by the patient (Bayles, 1986). In a review of education of caregivers and communication training for dementia it was determined that partner training regarding communication strategies, amount of encouragement/criticism to provide to the patient, behavior management was beneficial to both professional and family caregivers of individuals with dementia and helped changed patterns of interaction and communication patterns (Zientz, Rackley, Chapman, Hopper, Mahendra, Kim, & Cleary, 2007).

Much less work has been done in the area of partner training for individuals with TBI. Togher, McDonald, Code, and Grant (2004) developed a training program designed to improve communication between individuals with TBI and police officers during routine service encounters via telephone. Police officers completed a 6-week training program, consisting of 6 2-hour sessions of communication strategies training, which included training modules regarding the demographics and nature of TBI (e.g., differentiating TBI from mental illness, video case studies), information about communication (e.g., features of communication situations, the role of a police officer), information on the type and structure of telephone inquiries (e.g., typical features of service encounters with individuals with TBI), strategies for communicating during telephone inquiries (e.g., closure elements, question-asking strategies) practice communication with individuals with TBI (e.g., practicing communication strategies during an interview with an individual with TBI), and revision and role-plays (e.g., small group activities) (Togher et al., 2004). The results of the study show that the officers in the training group learned strategies that resulted in more efficient and focused interactions with the TBI participants. Partner training is considered to be a type of "environmental modification" within Ylvisaker's collaborative intervention paradigm (Ylvisaker et al., 2003). This may include training or coaching of communication partners (e.g., family, friends, work supervisors, coworkers) regarding types of supports, how to provide supports, and ways to reduce supports as the individual regains function (Ylvisaker et al., 2003).

Partner education and training has been a successful method of intervention for other neurogenic communication disorders and is a potentially valuable area of intervention for TBI. The results of the current study demonstrate the impact the partner can have on communication. Although we do not know the patterns of interaction between 3591 and her husband prior to the study, we suggest training communication partners, like 3591's husband, as a way of facilitating everyday communicative success. Training programs for familiar communication partners may incorporate both TBI education (e.g., basic facts about brain injury, symptoms to expect) and training of specific communication and interactional strategies (e.g., providing supports, strategies for redirection, using nonverbal communication) and practice implementing these strategies (e.g., barrier task, everyday activities).

Limitations of the Study

The small sample size (5 participants) in addition to the large range of ages and varying lengths of time post injury of the participants make it difficult to generalize the results of the current study. TBI can result from a number of etiologies and lead to diffuse damage of the brain impacting many structures. This can cause a variety of cognitive, neurological, personality, and behavioral changes that is highly individualized, making each individual's profile of impairment very different. All of the TBI participants in the current study sustained mild to moderate TBIs. Therefore, it is unclear how individuals with severe TBI would perform in a collaborative referencing task. The collaborative referencing task targeted interaction between familiar communication partners. TBI participant 3591 completed a follow-up study with a less familiar partner and performed much more similar to her matched healthy comparison than when completing the task with her husband. It is unknown how other TBI participants would perform with unfamiliar partners who provided differing levels of support during the task.

Another limitation to the study is that we did not have all of the neuropsychological measurements for all of the TBI participants. Without this, we do not have details regarding all areas of their neuropsychological profile. At the time of the study, we were unable to obtain neuroimaging for each TBI participant and therefore, were unable to match participants by lesion sites.

Future Research

Future research should include replication of the results with a larger and more homogeneous group of TBI participants (e.g., age, gender), perhaps doing cohorts of young versus old participants with TBI. It would be interesting to investigate how individuals with more severe brain injuries and pronounced neuropsychological impairments manage an identical collaborative referencing task with a familiar partner. Based on the current study, it is clear that the partner plays a critical role in the completion and success of TBI pairs during a collaborative referencing task. In the case of individuals with severe TBIs and significant cognitive deficits in a number of domains, perhaps implementing a training program for the partners about positive interactions, supports, and before completion of the task, may facilitate improved performance on the collaborative referencing task. Also, future studies using collaborative referencing tasks with individuals with TBI should include a control task in order to make the case that this approach is better than other learning paradigms.

APPENDIX A

Traumatic Brain Injury Registry Neuropsychological Battery

1. Intellectual and achievement abilities
    a. Wechsler Adult Intelligence Scale-IV (Wechsler, 2008)
    b. Wide Range Achievement Test-4: Reading, Spelling and Arithmetic Subtests (Wilkinson, 1993)

2. Memory
    a. Benton Laboratory Orientation Questionnaire (Benton Laboratory, 1976)
    b. Wechsler Memory Scale-III (Wechsler, 1997)
    c. Auditory-Verbal Learning Test: standard administration, 24-hour delayed recall and recognition trials (Rey, 1964)
    d. Benton Visual Retention Test (Administration A) (Sivan, 1991)
    e. Complex Figure Test - delayed recall (standard) and 24-hour delayed recall (Knight & Kaplan, 2004)
    f. Brief Visual Memory Test-Revised (Benedict, 1997)
    g. Recognition Memory Test (Warrington, 1984)
    h. Rotor Pursuit (Corkin, 1968)
    i. Mirror Tracing Test (Milner, 1962)
    j. Bead Memory Subtest from the Stanford-Binet IV Intelligence Scales (Thorndike et al.,1986)
    k. Iowa Autobiographical Memory Questionnaire (Tranel & Jones, 2005)
    l. Iowa Famous Faces Test (Tranel, 2006)
    m. Boston Remote Memory Battery (Albert et al., 1979): Multiple Choice Questionnaire; and Recall Questionnaire

3. Speech and Language
    a. Multilingual Aphasia Examination (Benton & Hamsher, 1978)
    b. Boston Diagnostic Aphasia Examination, Third Edition (Goodglass et al., 2000)
    c. Boston Naming Test (Goodglass et al., 2000)
    d. Assessment of Writing (Benton Laboratory)
    e. Iowa-Chapman Reading Test (Manzel & Tranel, 1999)
    f. Clinical Speech Ratings (Benton Laboratory, BDAE)
    g. Clinical Elicitation of Singing (Benton Laboratory)
    h. Assessment of Gestural & Buccofacial Praxis (Benton Laboratory)
    i. Category Fluency Test (Benton Laboratory)

4. Perception and Attention
    a. Facial Recognition Test (Benton et al., 1983)

b. Judgment of Line Orientation Test (Benton et al., 1983
c. Hooper Visual Organization Test (Hooper, 1983)
d. Agnosia Screening Evaluation (Benton Laboratory)
e. Screening evaluation for visual, auditory, and tactile neglect (Benton Laboratory)
f. Useful Field of View Test (Ball & Owsley, 1993)

5. Visuoconstruction
a. Complex Figure Test-Copy (Knight & Kaplan, 2004)
b. Drawing of a clock, a house, and a bicycle (Lezak et al., 2004)
c. Three Dimensional Block Construction (Benton et al., 1983)
d. Psychomotor and psychosensory functions
e. Purdue Grooved Pegboard Test (Lafayette Instruments)
f. Right-Left Discrimination (Benton et al., 1983)
g. Finger Localization/Recognition (Benton et al., 1983)
h. Dichotic Listening (adapted from Kimura, 1967; Damasio & Damasio, 1979)
i. Line Cancellation Test (Benton et al., 1993)
j. Smell Identification Test (Sensonics, Inc.)

6. Executive functions
a. Trail-making Test (Reitan & Wolfson, 1985)
b. Wisconsin Card Sorting Test (Heaton et al., 1993)
c. Stroop Color and Word Test (Golden, 1978)
d. Visual Image (Nonverbal) Fluency (Anderson, 1989)
e. Category Test (Halstead, 1947; DeFilippis, McCampbell, & Rogers, 1979)
f. Tower of London Test (Shallice, 1982)
g. Tower of Hanoi Test (Glosser & Goodglass, 1990)
h. Proverbs Test (Gorham, 1956)

7. Personality and affect:
a. Behavior Check List - Current Function (Patient, Relative, and Examiner Versions) (Benton Laboratory)
b. Beck Depression Inventory (Beck et al., 1961)
c. Beck Anxiety Inventory (Beck, 1993)
d. Minnesota Multiphasic Personality Inventory-2 (MMPI-2) (Hathaway & McKinley, 1951, 1989)
e. Iowa Scales of Personality Change (Barrash et al., 2000)

8. Premorbid status
a. Geschwind-Oldfield Handedness Questionnaire (Oldfield, 1971)
b. Patient Biography Form-Patient Version (Benton Laboratory)
c. Patient Biography Form-Relative Version (Benton Laboratory)
d. National Adult Reading Test (NART; Nelson & Willison, 1991)

APPENDIX B

General Protocol for Barrier Game

Four Tangram Sessions

- The game is played six times each session
- The matcher/director roles stay constant for all four sessions within a condition. Calculate correct number

****

Barrier Game Instructions

Set-up and Materials: Participants are sitting at a table, facing each other.

Researcher is on the side. Cameras are in a fixed location on each side of the table so as to make both the participants' faces and the matcher's board visible. Playing boards, cards, and barrier are not in place.

Instructions:

1. Game Instructions:

"I want you to play this matching game. Each session you will play the game six times. And, I will record you playing the game together. It should be fun, kind of like Solitaire or a puzzle. Do you like games?" (pause for answer) "Today, I will teach you how to play, but it is very easy and there are very few rules."

2. Playing Boards:

"You each have a playing board in front of you." (Place board in front of each player) The two boards are identical. They each have 12 spots on them, 6 in the first row and 6 in the second row. Each spot is numbered 1 though 12 (count out all 12 while pointing to each spot on the board in front of the individual with TBI).

3. Playing Cards:

"You each have a set of 12 picture cards. Both sets are identical." (fan out the two sets of cards but don't allow for discussion of pictures) "See how there is just enough room for all 12 cards (Pick up cards again to decrease likelihood of discussion of the pictures). Ask patient first then partner, "Do these look familiar?, Have you ever seen these before?") These questions will be asked at the beginning of each session.

4. Director and Matcher:

"To play this game, one person is the director and one person is the matcher. The director starts with his picture cards already on the playing board. Then the director tells the matcher which picture card to put in each numbered spot, starting with spot one (point to each spot as mentioned) then spot 2, spot 3, through spot 12. At the end, we check to see if the matcher's board looks like the director's board."

5. Barrier

"However, to make sure that the matcher doesn't just look at the order of cards on the director's board, I will put this barrier between you." (place barrier) "Now, can you see each other okay?"

6. Full Communication

"There is only one rule in this game and that is that you can't move or look around the barrier. Other than that, anything goes! Be creative! You can use the cards in any way that you want to. You can use gestures, facial expressions, and you can both talk as much as you want to. The only thing you can't do is move the barrier and look at the order of the cards on the director's playing board."

7. Assigning Roles and Setting Up Cards:

"Each time we play X will be the director and Y you will be the matcher. So, Y, we will set up your cards so that you can easily see all of them." (Stand cards up against barrier in one long row, above the playing board). "Can you reach all of these?" "X, we are going to set your cards on the playing board in this order" (show X the master sheet and start placing cards on playing board. Encourage X to help if he shows any inclination to do so, saying things like thank you, yep that's right, let's check, etc.)

8. Reviewing the Rules:

"Remember there are only three rules." (This will be stated before each session.) "First, the matcher must put the cards on the grid where the director tells you to. The director will start with the spot number one, then spot two, then three, and so on until all 12 are done."

"Second, you can talk together as much as you want to and use any gestures you want to."

"Third, you cannot look at the order of the cards on each other's boards, so you cannot remove the barrier."

"I will be using this stopwatch to see how long it takes you to complete each trial but the time is not important."

9. Scoring:

"Tell me when you are done and I will count how many cards the matcher put in the right spots." (Count without moving the barrier and simply report the number correct.)

10. Interview:

An interview regarding the task will take place at least 30 minutes following the end of the fourth session. These questions will be directed to the individual with TBI and include the following: "Have you seen these cards before?" "Have you ever used these cards before?" If you had to come up with a name for each of these cards what would it be?" Individuals with TBI will be forced/encouraged to generate some kind of a label.

APPENDIX C

Transcription Conventions

BOLD	Loud or marked voice for emphasis
(what)	Questionable transcription (sounds, including vocalizations, are in grey)
XXXXX	Unintelligible sequence, each X roughly one syllable length
…3…	Number of seconds of relative silence
…	Notes a pause in speech of less than one second
^ ^h	Audible inhalations and exhalations (or sighs)
[cough]	Description of nonspeech sounds
We- well-	Word cut off short or abandoned
O:::kay	Indicates prolonged sound or syllable
Hey dad,	Voice spoken with decreased intensity
<u>Whistle</u> <u>Okay</u>	Words cross speakers with closely matched intonational pattern
/gin/	Phonetic transcription using International Phonetic Alphabet
HEY	Shout or loud voice relative to surrounding speech
s l o w	Stretched out or slower rate relative to surrounding speech
hurry up	Rapid rate relative to surrounding speech
[unintelligible conv…..10….]	Long stretch of unintelligible vocalization
Okay.	Period (.) indicates end of turn intonation
A dog,	Comma (,) indicates questioning intonation pattern
S K I	Speaker is saying the names of letters, as if spelling out loud

*flapping arms	Activity note in black, correlates temporally to * in line of speech produced by that person. Used here primarily to record iconic gestures
S+/2	At that point temporally in transcript, matcher correctly selected card number 2
S-/9	At that point temporally in transcript, matcher incorrectly selected card number 9
P+/4	At that point temporally in transcript, matcher correctly placed selected card on number 4
P-/7	At that point in transcript, matcher incorrectly placed selected card on number 7
M[2]	Matcher or director, the initial refers to the participant's initial, holds the card up over the barrier for their partner to see
~S 5/3	Director flips card number 5 over on place number 3
~S 5/H	Director removes card number 5 from place number 1 and holds the hard in his/her hand
~S 5/B	Director removes card number 5 and places it somewhere off the board
M:[P4]	Matcher or director, the initial refers to the participant's initial, looks under a card at place 4 to see the number
M:[2]	Matcher or director, the initial refers to the participant's initial, picks up the card
Pc2/4	Matcher places card 2 from hand to place 4
^	Indicates that a participant gestured above the barrier for the communication partner to see
*	Indicates that a participant gestured below the barrier and the communication partner could not see it
m hm	Nasal agreement
uh huh	Oral agreement
m m	Nasal disagreement

uh uh	Oral disagreement

REFERENCES

Abelson, R.P. (1981). Psychological status of the script concept. *American Psychologist*, 36, 715-729.

Adams, J.H., Graham, D.I., Scott, G., Doyle, D. (1980). Brain damage in fatal non-missile head injury. *Journal of Clinical Pathology*, 33, 1132-1145.

Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Neuroscience*, 3(12), 469-479.

Adolphs, R. (2001). The neurobiology of social cognition. *Current Opinion in Neurobiology*, 11, 231-239.

Adolphs, R. (2002). Neural systems for recognizing emotion. *Current Opinion in Neurobiology*, 12, 169-177.

Adolphs, R., Baron-Cohen, & Tranel, D. (2002). Impaired recognition of social emotions following amygdala damage. Journal of Cognitive Neuroscience, 14, 1264-1274.

Adolphs, R., Tranel, D., & Damasio, A.R. (1998). The human amygdala in social judgment. Nature, 393, 470-474.

American Speech-Language Hearing Association. (2005). *Roles of Speech-Language Pathologists in the Identification, Diagnosis, and Treatment of Individuals with Cognitive-Communication Disorders: Position Statement* [Position Statement]. Available from www.asha.org/policy.

Anderson, S.W., Bechara, A., Damasio, H., Tranel, D., & Damasio, A.R. (1999). Impairment of social and moral behavior related to early damage in human prefrontal cortex. *Nature Neuroscience*, 2, 1032-1037.

Anderson, S., Damasio, H., Jones, R.D., & Tranel, D. (1991). Wisconsin Card Sorting Test performance as a measure of frontal lobe damage. *Journal of Clinical and Experimental Neuropsychology*, 13, 909-922.

Annegers, J.F., Grabow, J.D., & Kurland, L.T. (1980). The incidence, causes, and secular trends of head trauma in Olmsted County, Minnesota. *Neurology*, 30, 912-919.

Barrash, J., Tranel, D., & Anderson, S.W. (2000). Acquired personality disturbances associated with bilateral damage to the ventromedial prefrontal region. *Developmental Neuropsychology*, 18, 355-381.

Bayles, K.A. (1986). Management of neurogenic communication disorders associated with dementia. In R. Chapey (Ed.), *Language intervention strategies in adult aphasia*, *2nd edition* (pp. 462-473). Baltimore: Williams & Wilkins.

Bayley, P. J., & Squire, L. R. (2002). Medial temporal lobe amnesia: Gradual acquisition of factual information by nondeclarative memory. *Journal of Neuroscience*, 22, 5741-5748.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, 50, 7-15.

Bechara, A., Tranel, D., Damasio, H., Adolphs, R., Rockland, C., & Damasio, A.R. (1995). Double dissociation of conditioning and declarative knowledge relative to the amygdale and hippocampus in humans. *Science*, 269, 1115-1118.

Beukelman, D.R., & Yorkston, K.M. (1991). *Communication disorders following traumatic brain injury: Management of cognitive, language, and memory impairments*. Austin: Pro-ed.

Bibby, H., & McDonald, S. (2005). Theory of mind after traumatic brain injury. *Neuropsychologia*, 43, 99-114.

Bigler, E.D. (1990). Neuropathology of traumatic brain injury. In E.D. Bigler (Ed.), *Traumatic brain injury* (pp. 13–49).Austin,TX: Pro-ed.

Body, R. (2007). Decision making and somatic markers in conversation after traumatic brain injury. *Aphasiology*, 21, 394-408.

Bond, F., & Godfrey, H. P. (1997). Conversation with traumatically brain-injured individuals: A controlled study of behavioural changes and their impact. *Brain Injury*, 11, 319–329.

Brain Injury Association of America. (2011). *About brain injury.* Retrieved from: http://www.biausa.org/about-brain-injury.htm.

Brookshire, R.H. (2007). *Introduction to neurogenic communication disorders* (7th ed.). St. Louis: Mosby Elsevier.Chamberlain, D.J. (2006). The experience of surviving traumatic brain injury. *Journal of Advanced Nursing*, 54, 401-417.

Chang, J.J., Youn, T. S., Benson, D., Mattick, H., Andrade, N., Harper, C.R., Moore, C. B., Madden, C. J., & Diaz-Arrastia, R. R.(2009). Physiologic and functional outcome correlates of brain tissue hypoxia in traumatic brain injury. *Critical Care Medicine*, 37, 283-290.

Clark, H.H. (1992). *Arenas of language use*. Chicago: University of Chicago Press.

Clark, H.H., & Wilkes-Gibbs, D. (1986). Referring as a collaborative process. *Cognition*, 22, 1-39.

Cohen, N.J., & Banich, M.T. (2003). Chapter 10: Memory. In *Cognitive neuroscience and neuropsychology*, 2nd Edition. New York: Houghton Mifflin Company, pp. 322-364.

Damasio, A.R. (1994). *Descartes' error*. New York: Avon Books.

Davis, G.A. & Wilcox, M.J. (1981). Incorporating parameters of natural conversation in aphasia treatment. In R. Chapey (Ed.), *Language intervention strategies in adult aphasia*. Baltimore, MD: William and Wilkins.

Duff, M.C., Gallegos, D., Cohen, N.J., & Tranel, D. (in preparation). Learning in Alzheimer's disease is faciliatated by social interaction and common ground.

Duff, M.C., Gupta, R., Hengst, J.A., Tranel, D., & Cohen, N.J. (2011). The use of definite references signals declarative memory. *Psychological Science*, 22, 1574-1582.

Duff, M.C., Hengst, J.A., Tranel, D., Cohen, N.J. (2006). Development of shared information in communication despite hippocampal amnesia. *Nature Neuroscience*, 9, 140-146.

Duff, M.C., Hengst, J.A., Tranel, D., & Cohen, N.J. (2007). Talking across time: Using reported speech as a communicative resource in amnesia. *Aphasiology*, 21, 702-716.

Duff, M.C., Hengst, J.A., Tranel, D., & Cohen, N.J. (2008). Collaborative discourse facilitates efficient communication and new learning in amnesia. *Brain and Language*, 106, 41-54.

Dunn, B.D., Dalgleish, T., & Lawrence, A.D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience and Biobehavioral Reviews*, 20, 239-271.

Ehlhardt, L.A., Sohlberg, M.M., Kennedy, M.R., Coelho, C., Ylvisaker, M., Turkstra, L.S., & Yorkston, K. (2008). Evidence-based practice guidelines for instructing individuals with acquired memory impairments: What have we learned in the past 20 years? *Neuropsychological Rehabilitation*, 18, 300-342.

Elffers, J. (1976). *Tangram: The ancient Chinese shapes game*. New York: McGraw-Hill.

Faul, M., Xu, L., Wald, M.M., & Coronado V.G. (2010). *Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control.

Feyereisen, P., Berrewaerts, J., & Hupet, M. (2007). Pragmatic skills in the early stages of Alzheimer's disease: An analysis by means of a referential communication task. *International Journal of Language and Communication Disorders*, 42, 1-17.

Freedman, D., & Hemenway, D. (2000). Precursors to lethal violence: A death row sample. *Social Science & Medicine*, 50, 1757-1770.

Gillis, R.J. (1996). *Traumatic brain injury rehabilitation for speech-language pathologists*. Boston: Butterworth-Heinman.

Graham, D.I., Adams, J.H., & Doyle, D. (1978). Ischaemic brain damage in fatal non-missile head injuries. *Journal of the Neurological Sciences*, 39, 213-234.

Grancher, R.P. (2008). *Traumatic brain injury: Methods for clinical and forensic neuropsychiatric assessment* (2nd ed.). Boca Raton: Taylor & Francis Group, LLC.

Greve, K.W., Sherwin, E., Stanford, M.S., Mathias, C., Love, J., & Ramzinski, P. (2001). Personality and neurocognitive correlates of impulsive aggression in long-term survivors of severe traumatic brain injury. *Brain Injury*, 15, 255-262.

Gupta, R., Duff, M.C., Tranel, D. (2011). Bilateral amygdala damage impairs the acquisition and use of common ground in social interaction. *Neuropsychology*, 25, 137-146.

Gupta, R., Duff, M.C., Tranel, D. (2010). Effects of ventromedial prefrontal cortex damage to social interaction in a collaborative referencing task. *Society for Neuroscience Abstracts* 97.4.

Gupta, R., Duff, M.C., & Tranel, N.J (2012). Ventromedial prefrontal cortex damage does not impair the development and use of common ground in social interaction: Implications for cognitive theory of mind. *Neuropsychologia*, 50, 145-152.

Hartley, L.L. (1995). *Cognitive-communicative abilities following brain injury: A functional approach*. San Diego: Singular Publishing Group, Inc.

Hengst, J.A. (2001).*Collaborating on reference: A study of discourse and aphasia*. Unpublished doctoral dissertation, University of Illinois, Urbana.

Hengst, J.A. (2003). Collaborative referencing between individuals with aphasia and routine communication partners. *Journal of Speech, Language, and Hearing Research*, 46, 831-848.

Hengst, J. (2006). That mea:n dog: Linguistic mischief and verbal play as a communicative resource in aphasia. *Aphasiology* 1, 312–326.

Hengst, J.A., Duff, M.C., & Dettmer, A. (2010). Rethinking repetition in therapy: Repeated engagement as the social ground of learning. *Aphasiology*, 24, 887-901.

Hibbard, M.R., Cantor, J., Charatz, H., Rosenthal, R., Ashman, T., Gunderson, N., Ireland-Knight, L., Gordon, W., Avner, J., & Gartner, A. (2002). Peer support in the community: Initial findings of a mentoring program for individuals with traumatic brain injury and their families. *Journal of Head Trauma Rehabilitation*, 17, 112-131.

Hopper, T., Holland, A., & Rewega, M. (2002). Conversational coaching: Treatment outcomes and future directions. *Aphasiology*, 16, 745-761.

Hupet, M., & Chantraine, Y. (1992). Changes in repeated references- Collaboration or repetition effects. *Journal of Psycholinguistic Research*, 21, 485-496.

Jurado, M.B., & Rosselli, M. (2007). The elusive nature of executive functions: A review of our current understanding. *Neuropsychological Review*, 17, 213-233.

Kagan, A. (1998). Supported conversation for adults with aphasia: Methods and resources for training conversation partners. *Aphasiology*, 12, 816-830.

Kennedy, M.R.T. (2002). Cognitive-communication rehabilitation for individuals with traumatic brain injury. In M.R.T. Kennedy (Editor). *ASHA SID2*, *Perspectives on Neurophysiology and Neurogenic Speech and Language Disorders*, 12 (3). Rockville, MD: ASHA.

Kennedy, M.R.T., Coelho, C., Turkstra, L., Ylvisaker, M., Sohlber, M.M., Yorkston, K., Chiou, H.H., & Kan, P.F. (2008). Intervention for executive functions after traumatic brain injury: A systematic review, Meta-analysis and clinical recommendations. *Neuropsychological Rehabilitation*, 18, 257-299.

Kennedy, D.P., Glascher, J., Tyszka, J.M., & Adolphs, R. (2009). Personal space regulation by the human amygdala. *Nature Neuroscience*, 12, 1226-1227.

Kertesz, A. (1982). *Western aphasia battery*. New York: Grune & Stratton.

Krauss, R.M., & Fussell, S.R. (1996). Social psychological approaches to the study of communication. In E. T. Higgins & A. Kruglanski (Eds.), *Social psychology: Handbook of basic principles*. New York: Guilford Press.

Krauss, R. M., & Weinheimer, S. (1964). Changes in reference phrases as a function of frequency of usage in social interactions. *Psychonomic Science*, 1, 113-114.

Kreutzer, J.S., Gervasio, A.H., & Camplair, P.S. (1994). Primary caregivers' psychological status and family functioning after traumatic brain injury. *Brain Injury*, 8, 197-210.

Kreutzer, J.S., Marwitz, J.H., & Kepler, K. (1992). Traumatic brain injury: Family response and outcome. *Archives of Physical Medicine and Rehabilitation*, 73, 771-778.

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

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 Disease*, 167, 675-684.

Maren, S. (2001). Neurobiology of Pavlovian fear conditioning. *Annual Review of Neuroscience*, 24, 897-931.

Marmarou, A., Fatouros, P. P., Barzo, P., Portella, G., Yoshihara, M., Tsuji, O., Yamamoto, T., Laine, F., Signoretti, S., Ward, J. D., Bullock, M.R., & Young, H. F. (2000). Contribution of edema and cerebral blood volume to traumatic brain swelling in head-injured patients. *Journal of Neurosurgery*, 93, 183-193.

McDonald, S., & Flanagan, S. (2004). Social perception deficits after traumatic brain injury: Interaction between emotion recognition, mentalizing ability, and social communication. *Neuropsychology*, 18, 572-579.

McDonald, S., Li, S., De Sousa, A., Rushby, J., Dimoska, A., James, C., & Tate, R. L. (2011). Impaired mimicry response to angry faces following severe traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, 33, 17-29.

McIntosh, S., Vaughn, S., & Zargoza, N. (1991). A review of social interventions for students with learning disabilities. *Journal of Learning Disabilities*, 24, 451-458.

Morton, M.V., & Wehman, P. (1995). Psychosocial and emotional sequelae of individuals with traumatic brain injury: A literature review and recommendations. *Brain Injury*, 9, 81-92.

Murray, L.L., & Clark, H.M. (2005). *Neurogenic disorders of language: Theory driven clinical practice*. Clifton Park, NY: Thomson Delmar Learning.

Ripich, D.N., Wykle, M., & Niles, S. (1995). Alzheimer's disease caregivers: The FOCUSED program: A communication skills training program helps nursing assistants to give better care to patients with Alzheimer's disease. *Geriatric Nursing*, 16, 15-19.

Sarapata, M., Herrmann, D., Johnson, T., & Aycock. (1998). The role of head injury in cognitive functioning, emotional adjustment and criminal behavior. *Brain Injury*, 12, 821-842.

Sarno, M. T., Buonaguro, A., & Levita, E. (1986). Characteristic of verbal impairment in closed head injured patients. *Archives of Physical Medicine and Rehabilitation*, 67, 400-405.

Shamay-Tsoory, S.G., Tomer, R., Goldsher, D., Berger, B.D., & Aharon-Peretz. J. (2004). Impairment in cognitive and affective empathy in patients with brain lesions: Anatomic and cognitive correlates. *Journal of Clinical and Experimental Neuropsychology*, 26, 1113-1127.

Shune, S. & Duff, M.C. (2012). Verbal play as an interactional discourse resource in early stage Alzheimer's disease. *Aphasiology*, 1, 1-15.

Simmons-Mackie, N., Elman, R.J., Halland, A.L., & Damico, J.S. (2007). Management of discourse in group therapy for aphasia. *Topics in Language Disorders*, 27, 5-23.

Smith, D.H., Meaney, D.F., & Shull, W.H. (2003). Diffuse axonal injury in head trauma. *Journal of Head Trauma Rehabilitation*, 18, 307-316.

Sohlberg, M. M., Ehlhardt, L., & Kennedy, M. (2005). Instructional techniques in cognitive rehabilitation: A preliminary report. *Seminars in Speech and Language*, 26, 268-279.

Spezio, M.L., Huang, P.Y., Castelli, F., & Adolphs, R. (2007). Amygdala damage impairs eye contact during conversations with real people. *Journal of Neuroscience*, 27, 3994-3997.

Squire, L.R., & Zola, S.M. (1996). Structure and function of declarative and nondeclarative memory systems. *Proceedings of the National Academy of Sciences of the United States of America*, 93, 13515-13522.

Stark, C., Stark, S., & Gordon, B. (2005). New semantic learning and generalization in a patient with amnesia. *Neuropsychology*, 19, 139 -151.

Stern, J.M. (2004). Traumatic brain injury: an effect and cause of domestic violence and child abuse. *Current Neurology and Neuroscience Reports*, 4, 179-181.

Stuss, D.T., Gallup, G.G., & Alexander, M.P. (2001). The frontal lobes are necessary for ‘theory of mind’. *Brain*, 124, 279-286.

Tannen, D. (1989). *Talking voices: Repetition, dialogue and imagery in conversational discourse.* Cambridge: Cambridge University Press.

Teasdale, G., & Jennett, B. (1974). Assessment of coma and impaired consciousness. *Lancet,* 2, 81-84.

Temkin, N.R., Corrigan, J.D., Dikmen, S.S., & Machamer, J. (2009). Social functioning after traumatic brain injury. *Journal of Head Trauma Rehabilitation*, 24, 460-467.

Togher, L., McDonald, S., Code, C., & Grant, S. (2004). Training communication partners of people with traumatic brain injury: A randomized controlled trial. *Aphasiology*, 18, 313-335.

Toyama, Y., Kobayashi, T., Nishiyama, Y., Satoh, K., Ohkawa, M., & Seki, K. (2005). CT for acute stage of closed head injury. *Radiation Medicine*, 23, 309-316.

Tranel, D. (2009). The Iowa-Benton school of neuropsychological assessment. In Grant, & Adams, K.M. (Eds.), *Neuropsychological assessment of neuropsychiatric and neuromedical disorders* (3rd ed.) (pp. 66-83). New York: Oxford University Press.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory,* (pp. 381–403). New York: Academic Press.

Turner, S. & Whitworth, A. (2006). Conversational partner training programmes in aphasia: A review of key themes and participants' roles. *Aphasiology*, 20, 483-510.

Turkstra, L. S., &Bourgeois, M. (2005). Intervention for a modern day HM: Errorless learning of practical goals. *Journal of Medical Speech-Language Pathology*, 13, 205-212.

Walker, P.A., Harting, M.T., Baumgartner, J.E., Fletcher, S., Strobel, N., &Cos, C.S. (2009). Modern approaches to pediatric brain injury therapy. *Journal of Trauma*, 67, 120-127.

Werner, C., & Englehard, K. (2007). Pathophysiology of traumatic brain injury. *British Journal of Anaesthesia*, 99, 4-9.

World Health Organization. (2001). *International classification of functioning, disability and health (ICF)*. Geneva: Author.

Ylvisaker, M., & DeBonis, D. (2000). Executive function impairment in adolescence: TBI and ADHD. *Topics in Language Disorders,* 20, 29–57.

Ylvisaker, M., & Feeney, T.J. (1998). *Collaborative brain injury intervention: Positive everyday routines*. San Diego: Singular Publishing Group, Inc.

Ylvisaker, M., Hanks, R., & Johnson-Greene, D. (2003). Rehabilitation of children and adults with cognitive-communication disorders after brain injury. *ASHA Supplement,23*, 59–72.

Yule, G. (1997). *Referential communication tasks*. Mahwah, NJ: Lawrence Erlbaum Associates.

Zientz, J., Rackley, A., Chapman, S.B., Hopper, T., Mahendra, N., Kim, E.S., & Cleary, S. (2007). Evidence-based practice recommendations for dementia: Educating caregivers on Alzheimer's disease and training communication strategies. *ANCDS Bulletin Board*, 15, 55-64.