The Thesis Committee for Shayne Melissa Weinstein
Certifies that this is the approved version of the following thesis:

Communication Deficits in the Elderly after TBI as a Function of Age of Injury: A Systematic Analysis of Existing Literature and Survey of Estimates of Severity of Impairment

APPROVED BY
SUPERVISING COMMITTEE:

Supervisor:

Thomas Marquardt

Harvey Sussman

Communication Deficits in the Elderly after TBI as a Function of Age of Injury: A Systematic Analysis of Existing Literature and Survey of Estimates of Severity of Impairment

by

Shayne Melissa Weinstein, B.A.

Thesis

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

May 2014

Acknowledgements

Many thanks to my supervisor, Dr. Thomas Marquardt, for his guidance and support during the thesis process and throughout graduate school in general. He infuses education with humor, kindness, and wit, and I look up to him as an educator, mentor, and, soon, peer. Additional thanks to Dr. Harvey Sussman for his assistance with the editing process, and to Dr. Courtney Byrd for constant moral support. Finally, this thesis would not be possible without the support, laughter, and shoulders of my outstanding 2014 cohort.

Abstract

Communication Deficits in the Elderly after TBI as a Function of Age of Injury: A Systematic Analysis of Existing Literature and Survey of Estimates of Severity of Impairment

Shayne Melissa Weinstein, M.A.

The University of Texas at Austin, 2014

Supervisor: Thomas Marquardt

The elderly are a rapidly growing population in the United States and have the highest rate of TBI-related hospitalization. Across all levels of severity, elderly persons have uniformly poorer outcomes including quality of life, community integration, disability, and mortality, but there is a significant lack of published research regarding communication outcome in the elderly population. The likelihood that speech-language pathologists (SLPs) will clinically treat elderly clients with TBI is great; understanding the effects that age of injury has on communication may inform clinicians' abilities to accurately and efficiently assess, diagnose, and treat the elderly. The present study examined the relationship between age of onset of injury and severity of communication deficits following traumatic brain injury (TBI); the study included a review of published research and a survey of SLP estimates of severity of impairment. Limitations of the study and directions for further research are discussed.

Table of Contents

List of Tables

Introduction

More than 1.7 million people in the United States sustain a traumatic brain injury (TBI) annually; approximately 52,000 die and 275,000 are hospitalized (Faul, Xu, Wald, & Coronado, 2010). Elderly adults aged 75 years and older have the highest rate of TBI-related hospitalization and death (Faul et al., 2010) and represent the largest age group affected by head injury (Depreitere, Roosen, & Grandas, 2012; Cuthbert et al., 2014; Faul et al., 2010; Flanagan, Hibbard, Riordan, & Gordon, 2006). The elderly are a rapidly growing population in the United States; the U.S. Census projects that by the year 2030 the elderly population may grow to be 20% of the U.S. population (Susman et al., 2002). As the elderly population increases, so do the number of head injuries and there is an increasing need for medical care and rehabilitation for older individuals.

Most available research regarding TBI is neuropsychologically based and examines the relationship between TBI and neurogenesis, quality of life, and epidemiology. Within these topics, the majority of research investigates the pediatric and young adult populations. There is a paucity of TBI research available that includes in-depth cognitive and linguistic analysis and almost none that explore these factors within the elderly population. Research with the elderly population is difficult and "few researchers have used multiple or logistic regression, matching, or other statistical methods to control for the effects of important confounding variables, such as severity of initial injury,

comorbidities, and baseline health status, when determining the effect of chronological age on outcomes after TBI" (Thompson, McCormick, & Kagan, 2006, p. 1593). Confounding variables must be taken into account when investigating the elderly population because, as a group, they may be predisposed to medical fragility and premorbid and comorbid disorders. Communication disorders in the elderly population with TBI is a research area that warrants careful investigation.

PURPOSE

The purpose of this study is to investigate language processing deficits in TBI as a function of the age of occurrence. Examination of previous research combined with information gathered from speech-language pathologists (SLPs) may show that there are differences in communicative functioning as a function of the time of onset that may be a predictor of communicative outcome in the elderly. If assessment results differ significantly for elderly patients compared to younger adults, there are implications for clinical management of this population, including course of rehabilitation and expected functional communication outcomes. For example, if some domains of communication or areas of cognition are more impaired in the elderly, clinicians may be directed towards specific assessment tools or methods of intervention. If communication in the elderly is more severely impacted by injury, intervention may focus more on maintenance of residual communication rather than attempts to regain lost functioning.

SLPs are charged with the task of rehabilitation of cognition and language after neurological events such as TBI. SLPs use evidence-based research to make assessment, diagnostic, intervention, and prognostic decisions for their clients. Ensuring that SLPs

have adequate information will ensure that the elderly receive the most efficient treatment and rehabilitation care possible. This study aims to add to the literature by determining what research is currently available regarding communication and the elderly with TBI and recommending future directions of research.

Definition of Traumatic Brain Injury

Traumatic brain injury results from trauma from an external force or event. Individuals with TBI present with a common group of symptoms, generally associated with frontal lobe pathology, and can include deficits in cognition (attention, categorization, memory, and executive function), language, speech, and motor coordination. Due to the external sources of injury, TBI is differentiated from other forms of brain injury including stroke, tumor, anoxia, dementia, and degenerative diseases.

Pathophysiology

Traumatic events to the brain can result in closed head injuries (CHIs) and open head injuries (OHIs). CHIs do not break the skull or penetrate the cerebral meninges. They are categorized into acceleration-deceleration injuries and impact-based injuries. Acceleration-deceleration injuries result from an individual moving at an accelerated pace and then abruptly coming to a halt, causing the brain to collide against the inside of the skull. A typical result from this type of impact is known as coup-contrecoup injury in which the brain bounces back and forth within the skull due to inertial forces, generating multiple lesions and diffuse injury.

Rotational forces of the body and head during the injury event cause damage to neuronal connections (diffuse axonal shearing), the predominant pattern of injury for TBI (Bigler, 1990) characterized by small lesions in white matter tracts (Maas, Stocchetti, & Bullock, 2008). Generally, acceleration-deceleration TBI occurs as a result of motor-vehicle accidents, sports-related injuries, and falls.

Impact-based CHI, is caused by an individual's head being struck by a moving object or the individual's head striking against a surface. Examples are falls or violent assaults or blows caused by accidents such as falling debris. Impact-based injury may result in depression of the skull at the site of injury, which bruises and tears the underlying tissue and causes focal damage.

OHIs result from penetration of the skull by a foreign object and often occur as a result of assault, falls, or ballistic trauma. The extent of injury is often determined by the nature of the impact. For example, a bullet passing through the head will tear tissue throughout its path, whereas injury from a fall may produce a more distinct, focal lesion. Focal lesions may include cerebral contusions, lacerations, localized hemorrhages, and focal ischemic lesions.

Elderly individuals are particularly susceptible to more severe pathophysiological changes associated with TBI. Brain mass is decreased with age causing enlargement of subdural space; the brain is more likely to shift during traumatic events and the chance of diffuse and focal lesions is increased. Additionally, bridging veins in the elderly brain are more atrophied and susceptible to shearing forces, increasing the likelihood of subdural hematomas (Flanagan, Hibbard, & Gordon, 2005). Last, the elderly have

increased chance of secondary injury due to concomitant or premorbid systemic disorders, adversely affecting outcomes.

MANAGEMENT

Initial stages of management of TBI may include pre-hospital care to prevent hypoxia and hypotension, admission care to stabilize, diagnose, and operate if necessary, acute care, inpatient care, and finally outpatient care once the patient can be released from the hospital. Approximately 85% of recovery occurs in the 6-month period post-TBI injury (Maas et al., 2008). Good outcomes are achievable for elderly patients, but the elderly tend to require longer hospitalizations and are less likely to be able to care for themselves at home in the post-injury period (Naugle, 1990). This often means higher costs for insurance companies and caregivers and raises issues regarding the care provided to elderly persons, making accurate diagnosis and efficient treatment essential.

SEVERITY

Severity is determined using standardized scales and by examining structural damage to the brain upon hospital admission using computed tomography (CT) scans and magnetic resonance imaging (MRI). Severity scales classify patients with TBI into varying levels upon a spectrum, ranging from mild (generally including concussion) to moderate to severe. Severity of injury is a determining factor for hospital admission, prognosis for recovery, and course of diagnosis and treatment. The severity of brain injury at onset is a good prognostic indicator of neuropsychological outcome and extent of recovery in TBI, and an indicator of persistence of symptoms and deficits- the lower

the severity the higher the chances are for positive functional outcome (Serino et al., 2006). Severity is also an indicator of social and economic ramifications for the individual; in 2004, the unemployment rate was calculated as 69% for survivors of moderate to severe head injury (Papathanasiou, Coppens, & Potagas, 2011). During the course of rehabilitation, clinicians may use severity level as a predictor of outcome to have realistic expectations of the individual's ability to return to work or community activities.

Mild TBI (mTBI) may include a brief change in mental status or transient loss of consciousness, Glascow Coma Scale (GCS; Teasdale & Jennett, 1974) stage of 13-15, loss of consciousness 30 minutes or less, and post-traumatic amnesia not greater than 24 hours (Green, Stevens, & Wolfe, 1997). Most patients with mild TBI (mTBI) do not go to trauma centers and are not seen by neurosurgeons (Flanagan et al., 2006; Shukla & Devi, 2010). There may be significant under-diagnoses and underestimation of incidence rates for individuals with mTBI across age groups.

Moderate TBI is classified as a rating of 9-13 and usually includes diffuse axonal damage throughout the brain and brainstem, damaged brain tissue, and focal lesions (Maas et al., 2008; Brookshire, 2007). Complications may include lacerations and contusions on the brain surface and at the level of blood vessels. Despite this damage, patients with moderate TBI will usually see moderate amounts of physiologic recovery due to neuroplasticity (Brookshire, 2007). However, since the elderly are thought to have more limited regenerative capacity and reduced neuroplasticity, they may not see levels of recovery equal to younger patients.

Moderate-to-severe TBI includes more significant loss of consciousness or amnesia lasting more than 24 hours (Papathanasiou et al., 2011). Following severe injury, the individual may experience secondary sequelae including cell death, diffuse axonal injury throughout the brain and brain stem, brain swelling, anoxia, seizures, vascular changes, and other complications (Brookshire, 2007; Papathanasiou et al., 2011). With such extensive damage, neuroplasticity generally does not contribute significantly to recovery at any age group.

Information regarding severity levels for the elderly following TBI should be interpreted with caution, since there are many confounding factors that warrant consideration. Premorbid functioning and comorbid conditions are important considerations for the elderly population and may affect severity and outcome. For example, despite lower GCS ratings at admission, the elderly tend to have lower discharge scores than younger patients (Susman et al., 2002). Low hospital admission rates and under-diagnosis of mTBI may mean that incidence data for elderly patients is not known as well as in the larger population and underestimates the numbers of elderly patients with TBI in general. Additionally, expected recovery due to neuroplasticity at moderate severity levels in younger patients may not be expected in the elderly, as neuroplasticity is thought to decrease as the brain ages.

AGE EFFECTS

Age is an important predictor of outcome following head injury. The elderly have increased risk for injury, higher mortality rates across severity levels than younger patients, differing etiologies of injury, slower recovery rates, poorer functional outcomes,

and are more likely to exhibit longer-persisting deficits (Brookshire, 2007). Age groups vary in susceptibility to head injury; young adults and males are the most frequently injured (Naugle, 1990) and TBI is the leading cause of disability in adults younger than 34 years in the U.S. (Papathanasiou et al., 2011). While there is a period of relatively low risk in the middle adult years, the risk increases substantially from 65-70 years of age (Rapoport & Feinstein, 2000). The elderly account for 38.2% of non-concussion TBI and 32.6% of ICU admissions, making this population the largest age group represented (Depreitere et al., 2012).

EPIDEMIOLOGY

Cause of injury differs depending on the age of the individual. Motor vehicle accidents (MVAs) and gunshot wounds account for the majority of head injuries in young adults (mid-adolescence to the mid-twenties). MVAs are reported to be a leading cause of TBI-related mortality in the elderly population due to risk factors including poorer vision, slower reflexes, and reduced bone density. Falls are the second leading cause of trauma overall, and account for the majority of injuries in the very young and the elderly (Naugle, 1990). The elderly are particularly susceptible to trauma from falls because a history of a single fall increases the risk for subsequent falls and repetitive injuries (Thompson et al., 2006).

MORTALITY RATES

Overall mortality rates for TBI declined in the 1990s, but remained the highest for the elderly population. This is not attributable to severity level because the elderly maintain

higher mortality rates even when admitted with lower injury severity scores and higher mean GCS scores (Susman et al., 2002; Thompson et al., 2006). Age-related factors contributing to poorer outcomes include motor deficits, general deconditioning, and cognitive impairments (Roosen, Vandenbussche, & Depreitere, 2013). High mortality rates in the elderly population mean that finding elderly patients to study when investigating TBI is difficult; existing studies usually have small participant numbers and results vary widely.

ETIOLOGY OF INJURY

Etiology of injury differs for the elderly than younger populations, partially attributable to physiologic changes due to aging. Normal aging changes may include decreased brain mass, creating more space for the brain to move around in the event of trauma, adherence of the dura mater to the skull, and cerebrovascular atherosclerosis (Thompson et al., 2006). Additionally, elderly people often receive anticoagulant drugs as part of routine management, increasing the likelihood of diffuse cerebral bleeding. The elderly are more vulnerable to subdural hemorrhages (SDH) than the younger population because bridging veins are more susceptible to the shearing forces resulting from trauma due to natural atrophy from age (Flanagan et al., 2006). SDH may occur in the elderly after trivial injury and after falls during which there is no direct head trauma and resulting hemorrhages are likely to be larger (Brookshire, 2007). Diffuse axonal injury following SDH may result in changes in cognition and behavior, but often does not show up on standard CT and MRI scans, leading to poor detection of this common type of injury in the elderly and complicating accurate diagnoses. The likelihood that brain trauma will

result in TBI is higher for the elderly and may result in longer hospital stays, greater need for post-injury rehabilitation, and decreased functional independence.

GENDER EFFECTS

Gender effects on incidence vary by age. Males have a higher incidence of TBI in older adults and young adults between 15 and 25 years old (Brookshire, 2007) and are at greatest risk across all etiologies, but women are more likely to be hospitalized after injury in the elderly population (Thompson et al., 2006). Harvey and Close (2012) examined trends in older TBI patients in New South Wales, Australia and found that males accounted for a higher rate of TBI in patients aged 55-79, but not ages 80 and older. This could be because women tend to live longer than men. Shukla & Devi (2010) argued that gender as a predictor of outcome is more controversial and that outcome is more related to age.

The elderly are at high risk for TBI and older age is a predictor of poorer functional outcome. Older age has effects on severity level, mortality rate, incidence, and etiology of injury. Less is known, however, about the effects of age of TBI onset on severity of language processing deficits.

COGNITIVE AND COMMUNICATION DEFICITS

TBI may be the result of focal or diffuse injury. Focal versus diffuse injury causes differing patterns of deficits ranging from specific to global and mild to severe, and has an impact on resulting cognitive and communication deficits. Depending on the affected area(s) of the brain, an individual may experience disruptions to primary areas of

executive functioning important for cognition and/or centers important for auditory comprehension and expressive language.

Due to the positioning of the brain inside the skull, the inferior frontal lobes and anterior portion of the temporal lobes are particularly predisposed to injury during TBI (Flanagan et al., 2006). The frontal lobe is involved in executive functions including planning, judgment, decision-making, attention, and inhibition. The temporal lobe is important for processing of auditory information and association areas in the left temporal lobe are important for language processes involving semantics and syntax. Communication deficits present following all levels of injury severity and, due to the heterogeneous nature of injury, may occur at any level of the communication process including cognition, speech, pragmatics, and expressive and receptive language.

Communication deficits resulting from TBI differ from those in patients with vascular infarct because they are not generally linguistically based; they are hypothesized to be reflections of underlying executive function impairments, and not the linguistic system itself (Brookshire, 2007). Specific language impairments often include difficulties with word retrieval, discourse, pragmatics, auditory comprehension, and articulation. Deficits vary depending on the severity of injury, stage of recovery, and factors intrinsic to the individual; however, even with a diagnosis of mild injury, communication deficits may have a profound impact on the functional abilities of the individual.

Expressive language impairments

Focal lesions and diffuse damage affecting the language dominant hemisphere may produce expressive language impairments similar to those seen in patients with vascular

damage. Individuals with TBI are often appropriately termed aphasic; anomic aphasia and Wernicke's aphasia have been cited as the two most frequently occurring syndromes after diffuse closed-head injury (King, Hough, Walker, Rastatter, & Holbert, 2006; Marquardt, Stoll, & Sussman, 1990). The prevailing hypothesis for reduced expressive language skills in individuals with TBI is that deficits may be related to cognitive slowing and reduced organizational skills, rather than damage to the underlying language system.

Expressive deficits may present as difficulties with word retrieval, confrontational naming, discourse, and increased response latency. A meta-analysis of 30 studies by Henry and Crawford (2004) found that overall patients with head injury performed more poorly on assessments of phonemic and semantic fluency. Studies by King et al., (2006) and Barrow et al. (2006) found that overall, participant groups with mTBI performed poorer with regards to accuracy and response latency than non-injured participants, especially with increased cognitive load such as time constraints or increase in vocabulary level. King et al., 2006 reported that participants with mTBI exhibited word retrieval deficits in confrontation naming tasks but not in an observed discourse sample and Gruen, Frankle, and Schwartz (1990) found more impaired ability for divergent naming in head-injured participants. Word fluency and naming tasks may capture isolated incidents of language impairment in individuals with TBI, but functional communication abilities after head injury also may be examined using discourse analysis.

Discourse and pragmatics

Diffuse frontal lobe damage in the traumatically injured patient may produce deficits more similar to a patient with right-hemisphere syndrome, affecting pragmatic awareness

and communication at the discourse level. Pragmatic deficits may cause problems with turn-taking, initiating and sustaining conversation, and expressive and receptive language, which limit the individual's ability to be an effective communicator (Coehlo, Le, & Mozeiko, 2011). Pragmatic awareness is important in communication for its role in discourse and "reading" social context by using more obvious linguistic and extralinguistic information to understand paralinguistic cues (Angeleri et al., 2008). The brain-injured individual may lose the ability to comprehend beyond the literal meaning of text or conversation, and studies have found patients with TBI to be significantly impaired on pragmatic tasks such as comprehension and production of affective prosody and facial expression (Marquardt, Rios-Brown, Richburg, Seibert, & Cannito, 2001). Pragmatic deficits may lead to impairment in discourse, causing the individual to have long-winded, poorly organized, and tangential or inaccurate speech.

Discourse analysis has been used to investigate the language capabilities of individuals with TBI because it allows the examination of often-subtle language deficits. As previously mentioned, expressive deficits may be due to cognitive underpinnings rather than linguistic capabilities as is seen with vascular damage. Impaired discourse is related to the disruption of executive functions required for effective communication. For example, working memory is often impaired following TBI and working memory is important for linguistic skills such as syntactic processing, which if impaired may affect discourse functioning. Additional impairments in discourse may present in the form of excessive verbalizations and decreased appropriate content (King et al., 2006). Pragmatic

or discourse impairments following TBI often affect the individual's ability to socially integrate and re-enter work and community activities.

Speech

Approximately one third of all individuals with TBI will present with dysarthria, resulting in impaired speech motor control and decreased intelligibility (Mcauliffe, Carpenter, & Moran, 2010). Depending on the neuromuscular pathways affected, dysarthria will present as flaccid, spastic, or ataxic. Dysarthria is a result of deficits of the respiratory, phonatory, articulatory, and/or resonatory systems and leads to impairments in articulatory precision, rate, intonation, stress, and/or reduced vocal intensity. The presence of dysarthria following TBI is often an ongoing impairment well after relative recovery in other areas.

In summary, the effects of TBI on various domains of communication are clear and fairly well documented in the research literature. Age of injury onset has been shown to be a factor in overall severity and functional outcome following TBI, but reaching generalized conclusions regarding age and language processing is more difficult. Few studies specifically have addressed communication deficits following TBI in the elderly, even though the elderly are at high risk for injury and impairments.

Part One: Review of Communication Deficits Associated with TBI and the Elderly

Method

Assessment results of the target populations (i.e. adults and the elderly) were analyzed and compared via an internal review of previously published literature. Electronic databases were searched regarding functional communicative abilities of the two populations in question, within various verbal domains of communication including expressive language (e.g. word retrieval, naming, discourse), pragmatics, dysarthria, and receptive language. Cognition and executive functioning also were examined, as they have direct connections to communicative ability.

SEARCH METHODS

There was very little research regarding the effects of TBI on communication in the elderly. Research studies on TBI and communication did not specifically compare the elderly with the adult population. The current study searched electronic databases using the specific search terms listed in Table 1 and examined those that included the following criteria: (a) investigated communication disorders in the elderly or adult populations, (b) assessed communication disorders across various age groups but included participants' ages, allowing an internal comparison of results, (c) assessed related topics such as cognition and executive functioning, and/or (d) included other related estimates of severity, such as GCS scales. Articles were selected if relevant to the question of the communicative outcome following TBI in the elderly. Five articles of interest were identified.

Table 1: Literature Search Methods

Keyword	**And**	**And/or**
Elderly, Adult, Older Adult	Traumatic brain injury (TBI), head injury, brain injury	Communication, receptive/expressive language, word retrieval, verbal fluency, pragmatics, speech, dysarthria, discourse, generative naming, cognition, executive functioning

Results

Cognition, communication, and functional outcome were the domains generally considered in the research when assessing individuals with TBI. Overall, research literature noted that elderly patients had a decrease in cognitive and communicative functioning after traumatic brain injury. Few studies, however, compared functioning in these areas in the elderly population (≥ 65 years of age) to adult populations (21 to 64 years of age).

In a systematic review by Rapoport & Feinstein (2000), the authors reviewed articles concerning cognitive outcome in the elderly following TBI and articles comparing older and younger subjects. Their review confirmed that older age was associated with poorer overall functional independence following TBI; however, results regarding cognition and communication were more variable. In studies limited to elderly samples, the authors revealed that elderly subjects performed more poorly on tests of language, memory, and executive functioning than age-matched controls (Goldstein et al., 1994; 1996; Mazzucchi et al.,1992). In studies comparing older and younger subjects, the authors reported that elderly subjects with TBI performed more poorly on tests of cognition than did both younger control groups (Klein et al., 1996). Wilson et al. (1991), however, did not find age to be a predictor of neuropsychological deficits. Rapoport & Feinstein conclude from their review that it is premature to claim that the elderly have a uniformly poorer outcome regarding cognition and communication following TBI. They do claim, however, that neuropsychological outcome is strongly correlated to functional outcome, for which age has clearer effects. They stated that problems with studies concerning the

elderly are generally small sample sizes, not identifying participants with pre-morbid cognitive difficulties, ascertainment bias, and short periods of follow-up, which limit the ability to make generalized conclusions.

LeBlanc, Guise, Gosselin, and Feyz (2006) compared functional cognitive and communicative outcome of young, middle-aged, and elderly patients. Cognitive-communicative outcome was classified using the Functional Independence Measure (FIM) rating scale (a uniform system of measurement for disability in activities of daily living) and severity level was classified using the GCS. A clear age effect was found for FIM cognitive ratings: younger patients had a higher rating (i.e. better outcome) than middle-aged patients, and middle-aged patients had a higher rating than elderly patients (18-39, 40-59, and 60-99 years of age, respectively). These findings resulted even though the majority of the elderly patients were classified as mild (72.23%). LeBlanc et al. hypothesized that the higher percentage of mTBI in the elderly was a result of low velocity injury (e.g. falls), as compared to other incidents like motor-vehicle accidents. Overall, findings from this study indicated that age, and not initial GCS severity level, had an effect on cognitive and communication impairment.

Klein, Houx, and Jolles (1996) studied long-term cognitive effects of TBI on 25 middle-aged (40-50 years old) and 20 "old" (>60 years old) subjects who had sustained mild and moderate TBI several decades earlier, considered themselves "normal and healthy," and were matched for severity and number of years elapsed since injury. Subjects were administered a battery of tests including the *Visual Verbal Learning Test* (VVLT), as a measure of word retrieval from memory and learning capacity. Klein et al.

found poorer overall cognitive functioning in elderly patients as compared with a younger group (≥60 years, 40-59 years of age, respectively). Elderly patients with TBI had fewer recalled words across all trials than did younger patients, but the authors claimed that the difference was not enough to be a significant age effect. The older TBI subjects did not perform significantly worse than their younger peers. Results from this study should be interpreted with caution, however, because participants had reportedly mild injury, were without cognitive complaints at the time of testing, and the time post-injury ranged from 2-63 years.

Cognitive and neurobehavioral functioning in older adults with mild and moderate TBI was examined in a study by Goldstein, Levin, Goldman, Clark, and Altonen (2001). Thirty-five patients aged 50 years and older were assessed using cognitive and neurobehavioral measures. They found that patients with moderate TBI performed significantly poorer than non-injured controls on cognitive measures, but patients with mTBI were similar to controls. Both TBI groups, however, had significantly higher depression and anxiety concerns than controls. As previously mentioned, Rapoport & Feinstein (2000) found a high correlation between functional outcome and outcome for cognition and communication. Goldstein et al. noted that depression is a significant comorbidity for adults aged 50 years or older with TBI; functional outcome due to depression and anxiety could adversely affect positive functional outcome, therefore affecting communicative outcome. In an elderly individual, a mild TBI apparently is a significant impediment to functional outcome that is greatly exacerbated in conjunction with cognitive impairment.

Humphries, Kinsella, Ong, and March (2009) examined verbal fluency as a measure of cognitive outcome at 3 and 6 months post-injury in a group of 25 TBI patients with mild to moderate severity over the age of 65, as compared with 25 matched non-injured peers. The authors tested phonemic and semantic verbal fluency measures and found that the TBI group produced significantly fewer words than the control group on the phonemic, but not the semantic task at both time-points. However, when the authors controlled for the role of executive attention set-shifting ability, the group difference in phonemic ability no longer remained, leading the authors to conclude that verbal fluency impairment in individuals with TBI is related to cognitive demands during the task. While the study did not compare the elderly TBI group with a younger impaired group, it did confirm the hypothesis that communication deficits following TBI highly correlate with underlying executive functioning impairments. Elderly persons often have premorbid cognitive decline; the elderly person will likely not be able to compensate for disruptions to executive functioning as easily as a younger person resulting in more significant impairment.

Discussion

There were few studies that discussed the impact of TBI on the elderly and the resulting communication deficits, and even fewer comparing the elderly to adult populations. The literature that resulted generally examined severity, cognitive functioning and neuropsychological behavior; little research examined more specific domains of communication such as word retrieval, pragmatics, speech, discourse, etc. Some conclusions can be made based on the information available, however. First, cognitive functioning is highly correlated with communication, and disruptions to executive functioning are thought to be the underlying reasons for linguistic impairments following TBI. Therefore, if cognition is found to be more severely impaired in the elderly following TBI, one can speculate that communication will be too. Second, initial level of severity upon hospital admission is a strong predictor of functional outcome. Functional outcome is thought to be a predictor of communicative outcome for TBI; therefore, studies that compare severity across age groups may provide predictions for communicative outcome.

Part Two: Survey

Method

SURVEY DESIGN AND DEVELOPMENT

An 18-question survey was developed to provide estimates of severity of individuals with TBI within varying age groups, as reported by SLPs. The survey was developed using Surveymonkey.com online survey software and hosted on the same website. Questions were multiple choice or open-ended types. Participation in the survey was volitional, participants were anonymous, and the option to withdraw participation was available at any point.

Section one of the survey included seven questions regarding demographic/behavioral information of the respondents. This section collected information on age and gender of respondents, highest level of education, number of years of experience worked as an SLP, number of years of experience treating clients with TBI, current workplace, and current region of the U.S.

Section two included eleven questions regarding populations of clients clinically treated and asked for estimates of severity for various age categories. Respondents were asked to estimate the proportion of patients seen as classified into gender and four categories of age (pediatric (birth to 21 years of age), early adult (22 to 40 years of age), late adult (41 to 64 years of age), and elderly (65 years of age or older)). These categories were chosen based on generally accepted definitions in published literature, which generally classifies adults as 21-64 years of age and elderly >64 years of age (Susman et al., 2002). The adult category was divided into two categories for purposes of

the survey to create more evenly distributed age ranges. Respondents were asked to estimate the relative severity among the patients in each age category using *The Glasgow Outcome Scale* (GOS) definitions of assessment of disability (Jennett & Bond, 1975). The GOS is widely used upon hospital admission as an initial classification of severity.

Lastly, respondents were asked to estimate the proportion of clients that had concomitant disorders. Premorbid cognitive decline and other disorders are nearly impossible to exclude when investigating the elderly population; exclusion of subjects with these deficits limits the applicability and clinical meaningfulness of results because it is very likely that multiple conditions will exist in actual clinical cases. Estimates of the proportion of elderly clients with comorbid deficits may help clinicians make decisions regarding treatment.

Four speech-language pathologists reviewed the survey to determine face validity and evaluate use of the survey with the online software. After final edits were completed, the survey was submitted to and approved by the University of Texas at Austin Institutional Review Board (IRB). Information regarding the study and consent to participate in research was included with the online survey; signature was not required. (See Appendix A for a copy of the survey).

PARTICIPANTS

Survey participants were required to meet the following criteria: 1) experience as an SLP in the United States, 2) experience clinically treating patients with TBI, and 3) 21 years of age or older. 50 individuals attempted the survey. Surveys were considered

usable if all demographic information and at least part of the second section were completed; the final result yielded 39 surveys.

DATA COLLECTION

Results of the survey were analyzed using Surveymonkey.com after at least 50 surveys were received and the survey was closed. Item analysis for each individual respondent was conducted in addition to respondent summaries for each question. Not all respondents answered every question; therefore, results for individual items were calculated based on the number of participants who answered that item, not the total number of participants taking the survey.

Results

DEMOGRAPHICS

Fifty respondents attempted the survey (See Table 2 for response rate). Respondents were not prompted to continue the survey if they did not have at least one year of experience clinically treating patients with TBI; therefore 11 survey respondents were considered ineligible. The first five questions of the survey asked respondents for personal information regarding age, gender, highest level of education, number of years as an SLP, and number of years treating clients with TBI. Approximately 92% of the respondents were female and 8% were male. All respondents were at least 24 years of age; the highest percentage of respondents was between the ages of 30-39 (≈38%), and equal percentages of respondents were 40-59 and 50-59 years of age (≈23%). The highest level of education obtained was Ph.D. (≈8%) and the majority had obtained a graduate degree (≈92%). An equal number of respondents (≈26%) had 1-5 or 21 or more years of experience working as an SLP; only 2.5% had less than 1 year of experience. For the question regarding number of years of experience clinically treating clients with TBI, approximately18% responded 1-5 or 6-10 years, ≈21% responded 11-15, ≈15% responded 16-20, and ≈8% responded less than 1 and 0.

The majority of respondents practiced in the East North Central region of the U.S. (Ohio, Indiana, Illinois, Michigan, and Wisconsin; ≈28%) and the second largest groups were equally from the West South Central (Arkansas, Louisiana, Oklahoma, and Texas) and Middle Atlantic (New York, New Jersey, Pennsylvania) (≈17%). No respondents

answered from the East South Central region (Kentucky, Tennessee, Alabama, and Mississippi).

The majority of respondents currently work in outpatient care (25%); the remainder work in acute care (≈22%), inpatient care (≈17%), skilled nursing facility (≈11%), home health (≈8%), private practice (≈6%), and school (≈3%). Approximately 8% of respondents responded "other" and included information such as "part-time ECI/adult home health," "university," "college clinic," "residential treatment center," and two respondents indicated that they work in more than one setting.

Table 2: Response Rate: Number and Percentage of Respondents Responding

Question (Note: some questions are abbreviated in this table. See Appendix A for complete question wording).	**Number of Responses**	**Percentage of Total Survey Respondents**
1. What is your age?	50	100
2. What is your gender?	50	100
3. What is the highest level of school you have completed or the highest degree you have earned?	50	100
4. Total years worked as an SLP	50	100
5. Total years clinically treating clients with TBI	50	100
6. In which region of the U.S. do you currently work?	36	72
7. Which option best describes your current work environment?	36	72
8. % of individuals whom you have treated clinically that were (age ranges given)	36	72
9. % of pediatric clients with TBI treated that are male/female	22	44
10. % of early adult clients with TBI that were male/female	34	68
11. % of late adult clients with TBI that were male/female	33	66
12. % of elderly clients with TBI that were male/female	29	58
13. % of pediatric clients with TBI that were (severity levels given)	19	38
14. % of early adult clients with TBI that were (severity levels given)	29	58
15. % of late adult clients with TBI that were (severity levels given)	28	56
16. % of elderly clients with TBI that were (severity levels given)	25	50
17. % of clients with TBI with concomitant disorders	31	62
18. % of those with concomitant disorders that were (age ranges given)	30	60

ESTIMATES OF SEVERITY

Estimates of severity were analyzed and reported as an average from all respondents. Respondents estimated that the majority of patients with TBI treated have been early adult (38%), followed by late adult (28%), elderly (21%), and pediatric (13%). Respondents estimated that the majority of clients treated were male across all age categories, with the exception of the elderly group, which was divided almost evenly by gender. Those respondents with experience treating pediatric clients with TBI estimated that the majority of clients were of moderate severity (47%), followed by mild (34%), severe (28%), and persistent vegetative (5%). Respondents with experience treating early adult clients with TBI estimated that an approximately equal number were mild and moderate (38% and 37% respectively), followed by severe (26%), and persistent vegetative (6%). Respondents with experience treating late adult clients with TBI estimated that the majority were moderate (43%), followed by mild (37%), severe (23%), and persistent vegetative (6%). Respondents with experience treating elderly clients with TBI estimated that the majority were moderate (45%), followed by mild (35%), severe (19%), and persistent vegetative (5%). The average percentage of clients with TBI who also had concomitant disorders (e.g. dementia, stroke, diabetes, other neurological disorders) was 57%, 55% of whom were estimated to have been elderly, 35% late adults, and 13% either early adult or pediatric.

Table 3: Estimates of Severity (in %)

	Mild	Moderate	Severe	PV
Pediatric	34	47	28	5
Early Adult	38	37	26	6
Late Adult	37	43	23	6
Elderly	35	45	19	5

Discussion

In summary, the purpose of the survey was to gather additional information regarding estimates of severity of communication deficits in the elderly following TBI from SLPs with experience clinically treating this population. Upon initial evaluation of their clients, SLPs assign severity of language processing deficits based on levels established in standardized assessment batteries. Therefore, SLPs would be presumed to provide an idea of overall estimate of severity that may not have been expressed in previously published literature.

Based on the data collected from the present survey, the elderly population was not the largest group represented, despite statistics typically reported in the literature and despite the fact that the majority of survey respondents worked in environments where the elderly population typically would be treated (i.e. outpatient, acute, inpatient, and skilled nursing facilities). Low reports of incidence for the elderly could be explained by higher mortality rates or under-admission due to milder injury. Additionally, the majority of survey respondents worked in an outpatient setting; by the time elderly patients are discharged from a hospital, it may be more difficult to return for rehabilitation to an outpatient setting.

The elderly were not estimated to have the highest percentage of severity level in any of the four age groups, and had the lowest overall percentage in the "severe" category. This is surprising in lieu of the fact that milder initial forms of injury common in the elderly (e.g. falls versus motor vehicle accidents) reportedly often result in more

severe trauma due to reduced brain mass, decreased neuroplasticity, and natural atrophy in the elderly brain (Flanagan, Hibbard, Riordan, & Gordon, 2006).

Results from the present survey estimated that over half of all clients with TBI with concomitant disorders were elderly. Research has indicated that the elderly are often under- or misdiagnosed following TBI because cognitive and/or behavioral signs following TBI may be misinterpreted as manifestations of cognitive decline due to age (Flanagan, et al., 2006). The number of actual elderly individuals with TBI at all severity levels may therefore be significantly underestimated. Furthermore, research has shown that comorbid disorders adversely affect functional and communicative outcomes (Goldstein et al., 2001); higher percentages of elderly patients with concomitant disorders indicate a need for examination of all patient factors during the rehabilitation process.

Conclusions

Conclusions regarding communicative abilities and/or deficits in the TBI population as a whole are difficult to make because TBI can manifest in a wide variety of deficits and the individuals affected are an inherently heterogeneous group. Generalized conclusions about uniformly poorer outcomes regarding communication in the elderly population following TBI are even more difficult to make because there is a lack of published information specifically entailing assessment results following TBI as a comparison between elderly and adult age groups. The elderly are often under- and misdiagnosed for TBI and have high mortality rates, making estimates difficult and resulting in research studies with small sample sizes.

Most studies use scales of severity upon hospital admission to predict outcome following TBI. However, research has shown that age of onset is more strongly correlated with epidemiology, etiology of injury, mortality rates, pathophysiology, and overall functional outcome than is severity. Age of onset is a lesser-known variable with regards to language processing following TBI, but research has shown that age correlates with functional outcome and functional outcome correlates with cognitive and communicative ability (Rapoport & Feinstein, 2000). It is premature to conclude that age of onset is a predictor of communicative outcome, but it appears to be a factor. Clinicians should use initial levels of severity in conjunction with age of onset to make decisions regarding prognosis, diagnosis, and treatment.

Elderly individuals with cognitive and communication impairments following TBI should be considered for rehabilitation as soon as they are medically stable and able

to participate in therapy. Elderly individuals can achieve significant functional recovery from rehabilitation, however recovery may be realized over a longer period of time than younger patients (Flanagan et al., 2006). Since insurance companies often have caps on the number of sessions a patient can attend, it is imperative that the SLP provide therapy for the elderly patient that is efficient and functional and helps the patient demonstrate regular gains. SLPs should take into account all possible confounding factors when treating the elderly population in order to provide the best and most effective care possible.

LIMITATIONS OF THIS STUDY

A significant limitation of this study was the limited amount of published research available concerning communication deficits in the elderly following TBI. Existing studies often investigated the elderly population with age-matched control groups, but did not compare the elderly population across age groups. Studies that examined communication deficits following TBI very rarely published individual ages of participants, making it difficult to conduct an internal analysis of assessment results by age group. Furthermore, some studies intentionally omitted elderly patients from the participant groups to exclude for effects of natural cognitive decline due to the aging process (Gruen, Frankle, & Schwartz, 1990). There is limited clinical relevance for research literature that does not include one of the largest represented age populations with TBI.

Survey research poses further limitations and complications. One limitation was the small sample size of respondents; of the resulting 50 respondents, several responses

were deemed unusable because of lack of incompletion of required portions and not all questions were answered because of they were optional. Finally, due to the limitations of survey research, it is not possible to assess the accuracy of responses.

DIRECTIONS FOR FURTHER RESEARCH

Future research studies should include a comparison across age groups of communicative functioning following. Prospective studies should control for initial severity of head injury and estimates of premorbid cognitive impairments. Due to the wide range of possible language impairments resulting from TBI, assessment comparisons should attempt to be domain specific (e.g. word retrieval, memory, attention, discourse). Additionally, a similar survey could be replicated. The survey should attempt to reach a larger audience (e.g. expand outside of the U.S.) and recruit a larger number of respondents. Furthermore, the survey could be expanded to include domain-specific estimates of impairment (e.g. percentage of impairment in areas of cognition, expressive language, receptive language, etc.). Additional information gathered from prospective studies will allow SLPs and other rehabilitation professionals to make effective, evidence-based decisions regarding the diagnosis and treatment of the elderly population with TBI.

Appendix

Survey Form

1. What is your age?
    a. 24-29
    b. 30-39
    c. 40-49
    d. 50-59
    e. 60 or older
2. What is your gender?
    a. Female
    b. Male
3. What is the highest level of school you have completed or the highest degree you have earned?
    a. Bachelor degree
    b. Graduate degree
    c. PhD
4. Total years worked as a speech-language pathologist
    a. Less than 1
    b. 1-5
    c. 6-10
    d. 11-15
    e. 16-20
    f. 21 or more
5. Total years clinically treating patients with TBI
    a. Less than 1
    b. 1-5
    c. 6-10
    d. 11-15
    e. 16-20
    f. 21 or more
6. In which region of the U.S. do you currently work?
    a. New England (Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut)
    b. Middle Atlantic (New York, New Jersey, Pennsylvania)
    c. East North Central (Ohio, Indiana, Illinois, Michigan, Wisconsin)
    d. West North Central (Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas)
    e. South Atlantic (Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida)
    f. East South Central (Kentucky, Tennessee, Alabama, Mississippi)
    g. West South Central (Arkansas, Louisiana, Oklahoma, Texas)
    h. Mountain (Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada)
    i. Pacific (Washington, Oregon, California, Alaska, Hawaii)
7. Which option best describes your current work environment?
    a. Acute care
    b. Inpatient care
    c. Outpatient care

d. Skilled Nursing Facility
e. Private Practice
f. School
g. Home Health
h. Other (Please explain)

8. In your best estimate, what percentage of individuals whom you have treated clinically occurs in the following categories
    a. Pediatric (birth to 21 years of age)
    b. Early adult (22 to 40 years of age)
    c. Late adult (41 to 64 years of age)
    d. Elderly (65 years of age or older)
9. If you have treated pediatric clients (birth to 21 years of age) with TBI, what percentage would you estimate were (if N/A, please skip to the next question)
    a. Female
    b. Male
10. If you have treated early adult clients (22 to 40 years of age) with TBI, what percentage would you estimate were (if N/A, please skip to the next question)
    a. Female
    b. Male
11. If you have treated late adult clients (41 to 64 years of age) with TBI, what percentage would you estimate were (if N/A, please skip to the next question)
    a. Female
    b. Male
12. If you have treated elderly clients (65 years or older) with TBI, what percentage would you estimate were (if N/A, please skip to the next question)
    a. Female
    b. Male

For questions 13-16, please estimate based on the following definitions of assessment of disability using your clinical expertise/judgment:
Mild- Minor neurological, psychological, and/or speech-language impairments
Moderate- May have motor impairment, speech-language impairment, intellectual and/or memory impairment, and personality disruptions
Severe- Dependent on others for daily care by reason of physical or mental disabilities
Persistent Vegetative (PV)- Displays sleep-wake cycles but makes no organized responses to stimulation during periods of wakefulness

13. If you have treated pediatric clients with TBI, what percentage would you classify as (if N/A, please skip to the next question
    a. Mild
    b. Moderate
    c. Severe
    d. PV
14. If you have treated early adult clients with TBI, what percentage would you classify as (if N/A, please skip to the next question
    a. Mild
    b. Moderate
    c. Severe
    d. PV

15. If you have treated late adult clients with TBI, what percentage would you classify as (if N/A, please skip to the next question
    a. Mild

    b. Moderate
    c. Severe
    d. PV
16. If you have treated elderly clients with TBI, what percentage would you classify as (if N/A, please skip to the next question
    a. Mild
    b. Moderate
    c. Severe
    d. PV
17. Of the individuals with TBI that you have treated clinically, what percentage would you estimate also had concomitant disorders, injury, or diseases (i.e. dementia, stroke, diabetes, other neurological disorders)?
18. Of those individuals with concomitant disorders, what percentage were
    a. Pediatric
    b. Early adult
    c. Late adult
    d. Elderly

References

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

Barrow, I., Hough, M., Rastatter, M., Walker, M., Holbert, D., & Rotondo, M (2006). The effects of mild traumatic brain injury on confrontation naming in adults. *Brain Injury* 20(8), 845-855.

Bigler, E. (1990). Neuropathology of traumatic brain injury. In E. Bigler (Eds.), *Traumatic brain injury: Mechanisms of damage, assessment, intervention, and outcome* (181-205). Austin, TX: Pro-Ed.

Brookshire, R. (2007). Introduction to neurogenic communication disorders (7th ed.). St. Louis, MO: Mosby Elsevier.

Coelho, C., Le, K., & Mozeiko, J. (2011). Discourse analysis: characterizing cognitive-communication disorders following TBI. *ASHA Leader*, 16(2), 18.

Cuthbert, J., Harrison-Felix, C., Corrigan, J., Kreider, S., Jeneita, M., Coronado, V., Whiteneck, G. (2014). Epidemiology of adults receiving acute inpatient rehabilitation for a primary diagnosis of traumatic brain injury in the United States. *Journal of Head Trauma Rehabilitation*.

Depreitere, B., Meyfroidt, G., Roosen, G., Ceuppens, J., & Grandas, F. G. (2012). Traumatic brain injury in the elderly: a significant phenomenon. In *Intracranial Pressure and Brain Monitoring XIV* (pp. 289-294). Springer Vienna.

Faul, M., Xu, L., Wald, M. M., & Coronado, V. G. (2010). Traumatic brain injury in the United States: emergency department visits, hospitalizations and deaths 2002–2006. *Atlanta, GA: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control*, 2-70.

Flanagan, S., Hibbard, M., & Gordon, W. (2005). The impact of traumatic brain injury. *Physical Medicine and Rehabilitation Clinics of North America*, 16, 163-177.

Flanagan, S., Hibbard, M., Riordan, B., & Gordon, W. (2006). Traumatic brain injury in the elderly: Diagnostic and treatment challenges. *Clinics in Geriatric Medicine*, 22, 449-468.

Goldstein, F., Levin, H., Goldman, W., Clark, A., & Altonen, T. (2001). Cognitive and neurobehavioral functioning after mild versus moderate traumatic brain injury in older adults. *Journal of the International Neuropsychological Society*, 7, 373-383.

Goldstein, F., Levin, H., Presley, R, et al. (1994). Neurobehavioral consequences of closed head injury in older adults. *Journal of Neurology, Neurosurgery and Psychiatry*, 10, 961-966.

Goldstein, F., Levin, H., Roberts, V. et al. (1996). Neuropsychological effects of closed head injury in older adults: A comparison with Alzheimer's disease. *Neuropsychology*, 10, 147-154.

Green, B., Stevens, K., Wolfe, T. (1997). Mild traumatic brain injury: A Therapy and resource manual. San Diego/London: Singular Publishing Group, Inc.

Gruen, A., Frankle, B., & Schwartz, R. (1990). Word fluency generation skills of head-injured patients in an acute trauma center. *Journal of Communication Disorders*, 23, 163-170.

Harvey, L. & Close, J. (2012). Traumatic brain injury in older adults: Characteristics, causes, and consequences. *Injury*, 43, 1821-1826.

Henry, J., & Crawford, J. (2004). A meta-analytic review of verbal fluency performance in patients with traumatic brain injury. *Neuropsychology*, 18(4), 621-628.

Humphries, A., Kinsella, G., Ong, B., & March, E. (2009). Older traumatic brain injury patients display impaired phonemic verbal fluency at 3 months post-injury. *Injury*, 40(1), S20-S21.

Jennett, B., & Bond, M. (1975). Assessment of outcome after severe brain damage: A practical scale. *Lancet*, 1, 480-484.

Jennett, B., & Teasdale, G. (1981). *Management of head injuries*. Philadelphia: F.A. Davis.

King, K., Hough, M., Walker, M., Rastatter, M., Holbert, D. (2006). Mild traumatic brain injury: Effects on naming in word retrieval and discourse. *Brain Injury*, 20(7), 725-732.

Klein, M., Houx, P., & Jolles, J. (1996). Long-term persisting cognitive sequelae of traumatic brain injury and the effect of age. *The Journal of Nervous and Mental Disease*, 184(8), 459-467.

LeBlanc, J., Guise, E., Gosselin, N., & Feyz, M. (2006). Comparison of functional outcome following acute care in young, middle-aged and elderly patients with traumatic brain injury. *Brain Injury*, 20(8), 779-790.

Naugle, R. (1990). Epidemiology of traumatic brain injury in adults. In E. Bigler (Eds.), *Traumatic brain injury: Mechanisms of damage, assessment, intervention, and outcome* (69-103). Austin, TX: Pro-Ed.

Maas, A., Stocchetti, N., & Bullock, R. (2008). Moderate and severe traumatic brain injury in adults. *Lancet Neurology*, 7, 728-741.

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

Marquardt, T., Stoll, J., & Sussman, H. (1990). Disorders of communication in traumatic brain injury. In E. Bigler (Eds.), *Traumatic brain injury: Mechanisms of damage, assessment, intervention, and outcome* (181-205). Austin, TX: Pro-Ed.

Mazzucchi, A., Cattelani, R., Missale, G. et al. (1992). Head-injured subjects aged over 50 years: Correlations between variables of trauma and neuropsychological follow-up. *Journal of Neurology*, 239, 256-260.

Mcauliffe, M., Carpenter, S., & Moran, C. (2010). Speech intelligibility and perceptions of communication effectiveness by speakers with dysarthria following traumatic brain injury and their communication partners. *Brain Injury*, 24(12), 1408-1415.

Papathanasiou, I., Coppens, P., & Potagas, C. (2011). *Aphasia and related neurogenic communication disorders*. Jones & Bartlett Publishers.

Rapoport, M. & Feinstein, A. (2000). Outcome following traumatic brain injury in the

elderly: A critical review. *Brain Injury*, 14(8), 749-761.
Roosen, G., Vandenbussche, N., & Depreitere, B. (2013). Traumatic brain injury in the elderly: beyond the tip of the iceberg. *Aging Health*, 9(1), 81-87.
Serino, A., Ciaramelli, E., Di Santantonio, A., Malagu, S., Servadei, F., & La'davas, E. (2006). Central executive system impairment in traumatic brain injury. Brain Injury 20(1): 23-32
Shukla, D. & Devi, I. (2010). Mild traumatic brain injuries in adults. *Journal of Neurosciences in Rural Practice,* 1(2), 82-88.
Susman, M., DiRusso, S., Sullivan, T., Risucci, D., Nealon, P., Cuff, S., Haider, A., & Benzil, D. (2002). Traumatic brain injury in the elderly: Increased mortality and worse functional outcome at discharge despite lower injury severity. *Journal of Trauma Injury, Infection, and Critical Care*, 53, 2.
Teasdale, G. & Jennett, B. (1974). Assessment of coma and impaired consciousness: A practical scale. *Lancet*, 2, 81-84.
Thompson, H., McCormick, W., & Kagan, S. (2006). Traumatic brain injury in older adults: Epidemiology, outcomes, and future implications. *Journal of the American Geriatric Society*, 54, 1590-1595.
Wilson, B., Vizor, A., & Bryant, T. (1991). Predicting severity of cognitive impairment after severe head injury. *Brain Injury*, 5, 189-197.