NEUROPSYCHOLOGICAL OUTCOMES, CLINICAL CHARACTERISTICS AND DEPRESSION IN A GROUP WITH TRAUMATIC BRAIN INJURY: A RETROSPECTIVE REVIEW

By

NOORJEHAN JOOSUB

SUBMITTED IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS OF THE DEGREE OF

MASTER OF ARTS IN COUNSELLING PSYCHOLOGY

IN THE

DEPARTMENT OF PSYCHOLOGY
FACULTY OF HUMANITIES
AT THE UNIVERSITY OF PRETORIA

SUPERVISOR: DR N. CASSIMJEE
CO-SUPERVISOR: MS A. CRAMER
2009

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SUMMARY

Traumatic brain injury (TBI) is a multi-faceted disease that affects individuals on physical, cognitive and emotional levels. The specific aims of this research are to explore the prevalence of depression and the relationship between depression, neuropsychological performance and clinical variables in a cohort with TBI. This is accomplished through the retrospective review of 75 neuropsychological reports containing information on clinical variables, performance on neuropsychological measures and Beck Depression Inventory- Second Edition (BDI-II) scores of individuals who had sustained a TBI.

The neuropsychological domains assessed via the standardized neuropsychological measures were the domains of attention, concentration, memory, learning, non-verbal and abstract reasoning, manual dexterity, verbal recall, working memory, perception, psychomotor performance, incidental learning, concept formation and verbal fluency. These results were statistically analysed to determine relationships with depression and clinical variables.

The investigations undertaken in this study signified particularly pertinent relationships in the interactions among the variables of interest. Higher education level was found to be extremely critical in assisting retention of cognitive abilities following a TBI. Primary language was also a significant differentiator of performance among tests. Age had contrasting effects, with increasing age being favourable on the Similarities Test and related to poorer performance on the Letter Cancellation Test. Increasing GCS scores were related to slower performance on the Letter Cancellation Test and decreased performance on the RAVLT Free Recall Test. Longer PTA duration was related to worse performance on the Matrix Reasoning Test. These results indicate that these indicators of injury severity did not correlate with cognitive performance in this sample after TBI. The high incidence of depression in this study confirms that major depression is a very common

occurrence after TBI. This has widespread implications for patient and family counselling, and psychotropic interventions in treatment planning after TBI.

Further research on the emotional and cognitive aspects of TBIs within the South African population is needed to supplement the lack of information currently available. It is recommended that further studies build on the current study by exploring larger samples, and using more stratification specificity in terms of the type of injury sustained as well as functional outcomes.

Key Terms

Traumatic brain injury
Neuropsychology
Neuropsychological assessment
Depression
Cognitive impairment
Neuropsychological impairment
Beck Depression Inventory-II
Education level
Primary language
Emotional sequelae

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

Functional outcomes after medical injuries require assessment and intervention that is beyond the scope of immediate medical and physical care (Ponsford, Draper & Schönberger, 2008). A traumatic brain injury (TBI) refers to any acquired injury to the head, and these injuries have widespread physical, cognitive and emotional consequences that endure after discharge from emergency care (Lezak, Howieson & Loring, 2004).

Neuropsychological assessment aims to investigate cognitive impairments resulting from medical or psychological diseases, using standardized and valid neuropsychological measures (Silverberg & Millis, 2009). Through ascertaining the cognitive difficulties the TBI patient is faced with on an everyday basis, we can devise and implement appropriate treatment strategies to assist everyday functioning. Emotional states, particularly depression, also influence everyday functioning, which is why screening for psychological disorders after TBI is extremely important (Moldover, Goldberg & Prout, 2004).

The complex relationships between physical injury, cognitive functioning and depressive symptoms are not easy to delineate or measure. However, by investigating their manifestations we gain knowledge about their functioning, which is valuable in both understanding theoretical ideas of brain functioning as well as in devising practical treatment interventions that improve a TBI patient's quality of life.

1.2 Aims of the Study

The specific aims of this study are to explore in a cohort with TBI,

- the prevalence of depression and

- the relationship between depression, neuropsychological performance and clinical variables.

1.3 Outline of the chapters

Chapter Two describes current theoretical perspectives on brain-behaviour relationships, particularly in the context of TBI and surveys the literature on this topic as well as the details of neuropsychological assessment in association with TBI.
The relevant neuropsychological domains are also defined and conceptualized in this chapter.

Chapter Three consists of a comprehensive description of the methodology utilised in this research including the assessment instruments and research design.

Chapter Four contains the results obtained from the statistical analyses.

Chapter Five contains a discussion of the implications of the results, as well as the limitations and evaluation of the research. It also contains recommendations for future research. All sources utilised are referenced in the last chapter.

CHAPTER 2
LITERATURE REVIEW:
TRAUMATIC BRAIN INJURY

2.1 Introduction

Traumatic Brain Injury is a phenomenon with many consequences and the extent of the damage often extends beyond the physical. Murrell (2007), a TBI survivor, describes his journey as follows:

> You see, I'm not fully recovered; my closed head injury is not over. I am a "survivor," yet my life is forever changed. I think the phrase "forever changed" has always struck fear into my heart. My accident was a scarce six months after I graduated college. In short, I felt the whole rug was pulled out from under me and I have been playing catch-up ever since. "Forever changed" only begins to scratch the surface. Nonetheless, lots of surfaces must be scratched when dealing with recovery from a closed head injury.

Depressive disorders can be extremely debilitating in the context of neurological impairment, affecting individuals' and their caregivers' lives as well as their functioning in society (Shenal, Harrison & Demaree, 2003). It is difficult to identify depression in individuals who have sustained a TBI as many of the symptoms of depression are similar to those manifested following a TBI (Rowland, Lam & Leahy, 2005).

This chapter attempts to understand the mechanisms involved in sustaining a TBI and looks at the effects these have on subsequent cognitive, emotional and psychosocial functioning. The phenomenon of TBI is examined with the aim of creating a context for the current study, by exploring how physical damage is associated with brain-behaviour relationships and neuropsychological processes.

2.2 Traumatic Brain Injury

A traumatic brain injury (TBI) refers to an acquired injury to the brain. TBIs can be broadly classified as closed head injuries (CHI) where the skull remains intact and the brain is not exposed, or penetrating head injuries (PHI), where the skull and dura mater are actually penetrated by the source of the injury (Zillmer & Spiers, 2001). The nature of the acquired injuries to the brain can either be focal or diffuse and this together with the type of injury (CHI or PHI), injury severity, age of the individual, site/s of lesion and premorbid personality characteristics influence the neuropsychological outcome post-injury (Ponsford, Draper & Schönberger, 2008). Globally the incidence of TBI per annum is estimated at 9.5 million (Anderson, 2009). Sociodemographic risk factors for contracting a TBI based on epidemiological studies are male gender, lower socioeconomic status, living in an urban area, lower educational levels and unemployment (Lezak et al., 2004).

2.2.1 Causes and Classifications of TBI

Causes of TBI include falls, motor vehicle accidents, and gunshot or stab wounds (Raskin & Mateer, 2000). Mild, moderate and severe TBIs are distinguished by the amount and type of postconcussional symptoms, the Glasgow Coma Scale (GCS) score, the duration of Post Traumatic Amnesia (PTA) and the resulting holistic functioning. The GCS is a widely accepted measure of the severity of a head injury and is calculated based on the duration and depth of altered consciousness. GCS scores range from 3 to 15, with scores of 13-15 indicating a mild level of TBI. Post Traumatic Amnesia (PTA), indicating a loss of memory regarding events just preceding or following the injury, is a common occurrence. PTA usually lasts up to four times the length of the coma and may be accompanied by retrograde amnesia (Murrey, 2000). Length of PTA is also an indicator of injury severity.

With closed head injuries (CHIs) the primary injury refers to the actual damage that occurs during the impact (Kolb, 2004). The mechanics of the primary injury are related to the neuropsychological symptoms manifested. Both contact forces (the impact on the head) and inertial forces (the movement of the brain within the head) have wide reaching neurological, physical and neuropsychological effects. When the etiology is a motor vehicle accident (MVA), the head is moving at speed and has momentum on impact. The resulting injury is called a diffuse axonal injury (DAI) and indicates that there is a large amount of diffuse damage involving many axons across the brain (Kolb & Cioe, 2004). Therefore, even if there is focal damage at the point of impact, the injuries will not be limited to that specific lobe or area but are more likely to be diffuse and to involve many different areas of the brain. Variables such as the velocity of the brain's movement at the time of the impact, the duration of the impact, the direction of head movement and acceleration-deceleration rates affect the extent of injuries as well as the consequent physiological and neuropsychological symptoms (Raskin & Mateer, 2000). Diffuse damage is identified by the patient taking much longer to complete the task despite completing it accurately, affecting speed more than precision. Further, this delayed mental processing can be perceived by the patient as problems with memory and learning and may result in compensation through obsessive-compulsive strategies and social withdrawal. Closed head injuries that are concentrated on the frontal and temporal lobes tend to manifest as memory and learning impairments, difficulties in conceptual and problem-solving behaviour and the control and regulation of activity as well as psychosocial difficulties (Zillmer & Spiers, 2001).

2.2.2 TBI in the South African Context

There is a general paucity of information on TBI's in South Africa. The only conclusive study done on the epidemiology of brain injury in South Africa indicated that the overall annual incidence of TBI in the South African population is 200-316 per 100 000 with approximately 80 000 new cases of TBI registered annually (Nell & Brown, 1991; Headway Gauteng, 2007). Considering that over 700 000 new vehicles are added to South African roads yearly (Venter, 2007), one can hypothesize an increase in motor vehicle accidents and a concomitant increase in TBI among South African road users. Further, it should be taken into account that incidence rates include only hospitalised cases and neglect TBI patients who do not receive medical care; therefore actual numbers of TBI cases are likely to be much higher (Fleminger, 2008). Levin (2004) attributes high rates of TBI in South Africa to the high incidence of violent crime as well as tremendously high rates of motor vehicle accidents in this country compared to other countries.

2.3. Neuropsychological assessment after a TBI

Shenal et al. (2003) state that neuropsychological research provides a useful framework from which to study emotional disorders such as depression, as neuropsychologists are able to use instruments to measure mood and a variety of cognitive, perceptual, emotional and expressive abilities affected by mood disorders. Brain injuries are known to affect all neuropsychological systems, despite the traditional focus on cognitive impairments (Lezak et al., 2004). Any change in the nervous system, such as in an acquired brain injury, would lead to a change in behaviour (Kolb, 2004).

The main aims of a neuropsychological assessment following any brain injury are to ascertain the patient's cognitive abilities and impairments, with implications for everyday functioning, as well as determining the change in cognitive abilities post-injury (Silverberg & Millis, 2009; Tsaousides & Gordon, 2009). Both of these aims relate to planning appropriate treatment interventions following a TBI (Tsaousides & Gordon, 2009). A major source of contention within neuropsychological assessment is the difficulty of establishing valid estimates of premorbid abilities to contrast with current cognitive functioning in order to isolate the effects of the TBI (Murrey, 2000; Raskin & Mateer, 2000). The measures in a composite neuropsychological battery are subject to each individual's presenting profile; however, the most common domains assessed are memory, attention, executive functions, language, processing speed and psychomotor speed (Tsaousides & Gordon, 2009).

2.3.1 Cognitive impairments resulting from a TBI

A TBI usually results in neuropsychological impairments, which affect attention, memory and executive functioning abilities (Rapoport, McCullagh, Shammi & Feinstein, 2005). Memory impairments, attention and concentration difficulties and mental slowing are common after a TBI and suggest diffuse damage (Raskin & Mateer, 2000). Many of the affective and cognitive symptoms that occur after a TBI are termed 'postconcussional'. A concussion refers to the disturbances in brain functioning that occur when the brain undergoes rapid acceleration or deceleration which may or may not involve loss of consciousness or coma (Murrey, 2000).

Cognitive impairments are extremely disabling postconcussional symptoms and engender more enduring impairments than physical difficulties (Rapoport et al., 2005). Executive functions, including cognitive, social, metacognitive and self-regulative functions, are frequently significantly impaired after a TBI (Levin & Hanten, 2005). These impairments may indirectly effect (a) the patient's physical wellness, as memory impairments interfere with medication compliance, (b) difficulties with executive functions may cause the patient to make irrational decisions with regard to treatment options and (c) attentional deficits may result in the patient neglecting important instructions from medical personnel (Tsaousides & Gordon, 2009).

Himanen et al. (2009) investigated depression and cognitive abilities 30 years after injury among 61 TBI patients and 31 controls. The domains they examined were attention, information processing speed, verbal fluency and executive functions. The controls scored significantly better on all of the domains and even the TBI patients without depression scored significantly lower on the attention, processing speed, working memory, cognitive flexibility and word fluency measures. These results indicate that the cognitive impairments sustained after a TBI are of a chronic nature.

2.3.2. Anatomical and neurochemical explanations for cognitive impairment after a TBI

Cognitive deficits after a TBI are well documented, but the exact neurochemical substrates responsible for these deficits have yet to be completely understood (Salmond, Chatfield, Menon, Pickard & Sahakian, 2005). Structurally, the frontal and prefrontal cortex, involving the orbitofrontal and dorsolateral regions as well as the subcortical structures, are involved in mediating executive functions (Levin & Hanten, 2005). Any damage or injury to the regions themselves, or pathways involving these regions would imply disruptions in the higher-order processes required for optimal functioning in everyday life.

Salmond et al. (2005) propose that there are three indicators that cholinergic mechanisms, those involving the neurochemical acetylcholine, are related to post-head injury deficits: (1) functional impairments after head injury are usually those regulated by the cholinergic system, (2) post-mortem studies on humans and animals point to abnormal cholinergic regulation after head injury and (3) the results of pharmacological interventions after head injury correlate with abnormal functioning of cholinergic pathways. To investigate the hypothesis that the cholinergic system is involved in the cognitive deficits experienced after TBI, Salmond et al. (2005) formulated a comprehensive neuropsychological profile of 31 TBI patients and 32 healthy controls. The neuropsychological assessments used were known to be sensitive to cholinergic functions. Further, MRI scans were used to detect any structural changes in the head injury survivors that implied dysfunction of the cholinergic system. The head injured group performed significantly worse on measures of rapid visual information processing, pattern and spatial recognition, reaction time and paired associate learning, and had a higher incidence of depression. However, the researchers concluded that cognitive deficits found in the group with TBI could not be attributable to the incidence of depression alone. All of the cognitive functions found to be impaired have been found to depend on the functioning of the cholinergic system. Analysis of MRI scans revealed that reduced grey matter density was found in areas neuroanatomically known to be rich in cholinergic innervations; and significant reductions in white matter density were found in areas of cholinergic pathways.

One implication of these findings is that cognitive impairments after head injury may be positively influenced by pharmacological interventions that enhance cholinergic functions. In one of the few studies examining the use of anti-depressant medication following a TBI, Fann, Uomoto and Katon (2001) investigated the effects of the Selective Serotonin Reuptake Inhibitor (SSRI), Sertraline, on 60 patients with mild TBI and depression using a non-randomized, single-blind placebo run-in procedure. They found improvements in psychomotor speed, cognitive efficiency, flexible thinking and recent memory ability as well as in patients' subjective perceptions of their functioning. This indicates that pharmacological treatment of the depressive symptomatology following a TBI may contribute to improved cognitive outcomes.

2.4 Psychological Sequelae of TBI

While cognitive impairments after TBI may improve marginally between one and three months post injury, postconcussional, emotional and behavioural symptoms may persist for months (Levin et al., 2001; Perino, Rago, Cicolin, Torta & Monaco, 2001). Emotional functioning after a TBI may be affected by variables that are difficult to measure such as pain, financial strains, litigation pressures, loss of employment and difficulties adjusting to changed circumstances (Raskin & Mateer, 2000). Fleminger (2008) asserts that psychological difficulties after TBI are more common when patients are also enduring social and financial problems.

Disorders from the Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition (DSM-IV) that have been found to have increased prevalence after a TBI are major depression, panic disorder, psychotic disorders, personality disorders, alcohol abuse or dependence and specific phobia (Koponen et al., 2004). Personality changes after TBI have been well documented, and such changes have a greater effect on the day to day activities of patients and their significant others than the physical disabilities associated with TBI (Franulic, Horta, Maturana, Scherpenis & Carbonell, 1999). The patient is experienced as more irritable, aggressive and impulsive and has impairments of judgement and insight that affect their psychosocial functioning. These personality changes have been found to be linked to neuroanatomical lesions in specifically the frontal and temporal lobes of the brain as well as the limbic system (Franulic et al., 1999). McAllister (2008) further reports that individuals with TBI usually have higher premorbid rates of psychopathology inferring a reciprocal interaction between the two constructs.

Emotional functioning also affects neurocognitive performance. As many neural and activation patterns influence depressive symptoms, the patterns of cognitive impairments evidenced in depressed patients may vary. TBI has a strong predilection for involvement of the anterior temporal and frontal lobes, and the deeper midline structures which is the likely reason for memory and executive dysfunction in affected patients (McAllister, 2008; Rapoport et al., 2005). Further, the orbital surface of the frontal and temporal lobes, which plays a significant role in regulating social behavior, is particularly vulnerable to TBI (Fleminger, 2008). This accounts for many of the changes in social behavior exhibited by patients after a TBI.

Emotion regulation ultimately depends on coordination and networking among the brain stem, limbic and cortical processes. Abnormal functioning and processing in those regions may be directly related to major psychiatric disorders (Green & Malhi, 2006). Changes in emotional and social behaviour have been linked to the impairments in control or regulation of emotions that are commonly manifested after a TBI (Henry, Phillips, Crawford, Theodorou & Summers, 2006). Research has indicated that hemispheric dysfunction is correlated with the type of mood disorder manifested (Shenal et al., 2003). Patients with right-hemisphere damage appear indifferent or euphoric, and patients with left-hemisphere dysfunction present as agitated and sad (Shenal et al., 2003). However, almost every psychological function within the brain operates on a combination of localization and distribution of function, with the entire function being distributed throughout the brain and specific aspects of the function being concentrated in one area (Kolb & Cioe, 2004).

Alexithymia refers to impairments in the ability to think about, describe, experience and identify emotions (Henry et al., 2006). This is an important facet of emotional and social competence and is related to changes in emotional and social functioning after a TBI. After a TBI many patients display postconcussive symptoms which show up on the Minnesota Multiphasic Personality Inventory (MMPI) and suggest emotional problems related to attentional impairments, depression, health concerns and anxiety. The etiology of the head injury influences the psychological consequences. An existing psychological disorder that preceded the injury also affects the somatic and psychosocial symptoms manifested (Lezak et al., 2004).

Recent research has found that the cerebral cortex is significantly involved in emotional behaviour (Shenal et al., 2003). Regulating emotions requires the coordination of complex processes involving cognitive, biological, social and behavioural mechanisms within the brain (Green & Malhi, 2006). Neuroimaging studies of non-brain injured individuals have revealed that the lateral and dorsal regions of the prefrontal cortex have an inhibitory role when modulating neural activity during emotional regulation (Green & Malhi, 2006). Some brain structures are therefore more active than others during the emotion regulation process. It thus follows that after a brain injury the areas affected may have an impact on the emotional sequelae exhibited. For example, regions of the prefrontal cortex are hypothesized to be actively involved in the processing of different ways of interpreting emotional information using mechanisms of cognitive control such as working memory and selective attention (Green & Malhi, 2006).

Studies on alexithymia have identified frontal region contusions, with their important role in controlling executive functions, as being linked to difficulties in processing emotions (Henry et al., 2006). Lack of awareness of deficits has a significant impact on social interaction and self-care (McAllister, 2008). The impact of alexithymia on quality of life was assessed by Henry et al. (2006) with a cohort of 28 participants who had sustained a TBI, whose results were compared to 31 demographically matched controls. Two aspects of alexithymia, namely reduced introspection and difficulty identifying emotions in oneself and others, were identified as significantly increased in the TBI cohort. Further, even when depression and anxiety were controlled, in the TBI group difficulty in identifying emotions was associated with poorer quality of life, as well as executive function deficits (Henry et al., 2006). This study also found that patients who had sustained a TBI are significantly more depressed, and perceive themselves as having a worse quality of life when compared to controls. The authors posit that the study implies a tentative association between emotional and cognitive deficits after a TBI, which may be due to a common neurological deficit (Henry et al., 2006). This study highlights the impact of emotion regulation in everyday functioning and satisfaction as well as its relation to executive functions.

2.4.1 Depression manifested after TBI

The DSM-IV identifies individuals as suffering from major depression through a number of persisting and unusual symptoms including loss of interest, depressed mood, eating and/or sleeping irregularities, impairment in concentration and/or decision making, fatigue and feelings of worthlessness or guilt (Sadock & Sadock, 2003). These symptoms have to reflect a change from previous functioning, cause significant impairment in everyday functioning and not be caused by the physiological effects of a substance or a general medical condition.

2.4.1.1 Prevalence of depression after a TBI

Major depression after a traumatic brain injury (TBI) has a point prevalence of 14-29%, which is seen as relatively common (Rapoport et al., 2003). Time since injury is an important variable to take into consideration when discussing estimates of depression after TBI, as depressive symptoms may only occur many months after the injury based on delayed insight into deficits or loss of previous functionality (Murrey, 2000). It is difficult to ascertain whether depression diagnosed after TBI is a direct result of neurophysiological damage (organic depression) or if the depressive symptoms are related to psychological factors surrounding the TBI (Murrey, 2000). Depression after TBI does not differ from depression in the non brain-injured population, but the symptoms most commonly manifested are fatigue, frustration and concentration impairment (Fleminger, 2008).

Rapoport et al. (2003) emphasize that, due to the debilitating effects of major depression not complicated by head injury, research needs to focus on the extent to which poor outcomes of patients with TBI are associated with major depression. Disability due to TBI is also associated with increased economic burdens as it decreases patients' productivity (Rapoport et al., 2005).

2.4.1.2 Previous research investigating depression after a TBI

Research on the association between the cognitive and psychological effects of TBI has a long history. Satz et al. (1998) claim that in the decade from 1988 to 1998, all empirical studies focusing on depression and TBI found an association between the two variables regardless of procedures and instruments used. Studies on the physical, functional and cognitive impact of TBI have a history spanning several decades, whereas emotional distress and depression have only recently been identified as significantly hampering the functionality of people with TBI (Kreutzer, Seel & Gourley, 2001). The paucity of research on the emotional and psychological sequelae of TBI is largely due to the difficulties associated with accessing reliable subjective information in patients where cognitive integrity is compromised.

In a study by Levin et al. (2005), a prospective cohort of 129 participants with mild TBI were assessed to develop a screening measure for a major depressive episode (MDE). Their findings support previous research that indicates that a MDE is a frequent secondary condition after a TBI. The significance of this study for further management of depression following traumatic brain injury lies in the finding that using a clinical screening measure one week after injury can assist in the prediction of a MDE up to three months after injury. Physiologically, major depression is associated with significantly reduced left prefrontal gray matter volumes, notably in the ventrolateral and dorsolateral areas (Jorge et al., 2004). Therefore the physiological site of the trauma may be related to the incidence of depression. Neuroimaging studies have shown that major depression affects the frontal and subcortical limbic regions, giving the two illnesses, depression and TBI, a shared neurobiological substrate (Rapoport et al., 2005). This could be the underlying reason that cognitive deficits attributed to TBI may be particularly magnified with the comorbid development of major depression.

2.5 Sociodemographic and risk factors for depression after a TBI

Certain sociodemographic indicators have been identified as predisposing an individual to experience depressive symptoms after a TBI. In a study examining the link between subjective complaints and neuropsychological performance, patients who had subjective cognitive complaints were demographically more likely to be women and have a higher Glasgow Coma Scale score (Chamelian & Feinstein 2006).

In terms of variables influencing the outcome of a TBI, Glenn, O'Neil, Goldstein, Burke and Jacob (2001) investigated the association between depression and subject characteristics in 41 patients with TBI. Through multiple regression analyses, it was revealed that depression was positively correlated with age, female gender, mild TBI and use of antidepressant and stimulant drugs; and negatively correlated with violent etiology of injury.

The frequency of and risk factors for major depressive disorder (MDD) following mild and moderate TBI were examined three months after injury among 69 TBI and 52 general trauma patients (Levin et al., 2001). Risk for MDD was found to be unrelated to severity of brain injury. Jorge et al. (2004), in a study of 91 TBI patients, found that those with TBI and MDD had increased likelihood of a history of mood and anxiety disorders, displayed comorbid anxiety and aggressive behavior, had notably more executive function impairment and poorer social functioning. Intracranial lesions visible on computed tomography (CT) scans, as well as older age were identified through statistical analyses as possible risk factors for major depression (Levin et al., 2005). Those with major depression also had a higher likelihood of sustaining their TBI through a motor vehicle accident (Rapoport et al., 2003). Rapoport et al. (2005) found that the 28.4% of subjects diagnosed with major depression in their post TBI study, were more likely to be older and have a history of depression. However, this relationship between depression and neuropsychological performance may be moderated by clinical and sociodemographic variables. The studies discussed above indicate that demographic and premorbid clinical variables may act as covariates in the etiology of depression after TBI.

2.6 The relationship between TBI and depression

The etiology of the strong association between depression and brain injury has not been established, although neurochemical changes and psychosocial reactions to the neurological insult have been implicated (Fannet al., 2001). There is continuing controversy between psychosocial explanations for depression after TBI versus neuroimaging explanations that implicate specific damaged areas of the brain as responsible for depression (Rowland, Lam & Leahy, 2005). Lezak et al. (2004) postulate that the emotional disturbances of brain-injured patients can be attributed to complex networks of interaction between their social roles, neurological impairments, established behaviour patterns and reactions to the above variables. In other words, there are complex interactions and processes that implicate both the brain's cerebral structure as well as the external psychosocial environment, as involved in the manifestation of depression after a TBI.

2.6.1 The relationship between cognitive impairment and depression after TBI

Studies are increasingly illustrating that depression has a significant impact on clinical and rehabilitation outcomes after a TBI (Green, Felmingham, Baguley, Slewa-Younan & Simpson, 2001). This is important in lieu of the fact that even in populations with no neuropathology, depression affects the normal expression of cognitive abilities (Lezak et al., 2004).

In a large study, Rapoport et al. (2003) assessed 170 patients with TBI for major depression. The instruments used were self-report measures of psychosocial dysfunction, physical symptoms and psychological distress as well as examiner-rated neurobehavioural disturbance. Statistical analysis revealed that 15.3% of the sample met the criteria for major depression and illustrated subjective and objective evidence of impaired outcomes. The subjective perception of impaired outcomes demonstrated that insight into deficits was apparent. Those with major depression also had a higher likelihood of having sustained their TBI through a motor vehicle accident. This was postulated to be related to the lack of control the participant had over the incident of injury. The researchers concluded that the etiology of injury was a variable to be considered. Further analysis revealed that major depression was correlated with poorer outcome across all neuropsychological domains (Rapoport et al., 2003). Levin et al. (2001), in a study of 69 TBI and 52 general trauma patients, found that verbal and nonverbal memory, information processing speed, and flexibility in problem solving as well as functional outcome were more impaired in depressed than non-depressed patients.

Rapoport et al. (2005) found that subjects who had sustained a TBI with major depression scored significantly lower than subjects with no major depression in the domains of working memory, processing speed and verbal memory. Therefore cognitive domains were directly affected by post-TBI depression, and one implication of this study is that antidepressant treatment may ameliorate not only the mood symptoms, but also the cognitive deficits following a TBI. Himanen et al. (2009) found, in a comparison of TBI patients with and without depression 30 years post-injury, that those patients with depression scored lower on simple reaction time, visual recognition of letters and the total hit rate of the vigilance test. They postulate that this result is be related to hypotheses that depression after TBI is linked to a specific prefrontal–subcortical circuit. Time since injury needs to be accounted for in this study as the neural plasticity of the brain allows for improvement and deterioration of cognitive abilities after injury (Himanen et al., 2009).

2.6.2 The subjective experience of depression after a TBI

In a study by Sbordone, Seyranian & Ruff (1998) 50 TBI patients' subjective complaints of physical, emotional and behavioral difficulties were contrasted with the observations of their significant others. The results demonstrated that in the emotional, cognitive and behavioral domains, patients consistently underreported their symptoms when compared to the observations of significant others. This finding was consistent across injury severity and was postulated to be due to patients' poor awareness of deficits as opposed to being a result of psychological denial. Therefore, the psychological effects of TBI are less easily verifiable than the somatic complaints due to the discrepancies between patients' reports and caregiver observations. Due to the discrepancies among subjective reports of somatic complaints, subjective complaints alone are not used to identify mild TBI (Lezak et al., 2004).

In a study investigating the relationship between subjective complaints and objective results on neuropsychological and cognitive tests among a group with TBI, Chamelian and Feinstein (2006) found that patients with subjective cognitive complaints had an 18.5% diagnosis of major depression, whereas those without self-reported cognitive difficulties showed no symptoms of major depression. Moreover, patients with subjective complaints performed significantly worse on measures of working memory, verbal and visuospatial memory, immediate and delayed total recall, attention and information processing speed and executive functioning and perseverative responses, than those with no subjective complaints. Therefore depression was found to be directly related to subjective cognitive complaints, but did not account for all significant differences between patients with and without subjective cognitive complaints. No differences were found between the two groups on CT scan results. This study highlights the role of subjective perception of impairment and its importance in the manifestation of psychological symptoms post-injury.

2.7 Conclusion

Since depression in patients with TBI is treatable, the early identification and treatment of affected patients will improve their functioning, quality of life and clinical outcomes. Therefore, research on the prevalence, temporal pattern of onset and risk factors for major depression is extremely pertinent (Rapoport et al., 2003; Levin et al., 2001). Despite the development of high-technology procedures to "save and prolong life" after a TBI, the development of procedures to optimize quality of life outcomes has lagged behind (Ownsworth & Oei, 1998, p. 737). The accumulated body of evidence, summarized in the preceding discussion, indicates that the association between neuropsychological performance and psychological variables following a TBI is not completely linear or parsimonious. What is evident, however, is that TBI has extensive cognitive and psychological effects that cause difficulties in the patient's everyday functioning. By examining the variables involved in the injury, the cognitive decline and the depressive symptoms, neuropsychological studies attempt to understand how these processes unfold. The next chapter outlines the precise methodology of investigating the multiple variables involved in this study.

CHAPTER 3
METHODOLOGY

3.1 Introduction

The objectives of this study are to explore, in a cohort with TBI, the prevalence of depression as well as the relationship between depression, neuropsychological performance and clinical variables. These objectives are achieved through examining the following data sources: performance on neuropsychological tests, results from a depression inventory and the sociodemographic and clinical characteristics of 75 subjects who had sustained a TBI.

3.2 Research design

The research methodology is a retrospective review of neuropsychological reports. Retrospective research is defined as the analysis of existing information that was collected for non-research purposes, and is a favoured technique in epidemiological studies, quality assessment investigations, residency training and clinical research (Gearing, Mian, Barber & Ickowicz, 2006; Hess, 2004).

Advantages of utilizing a retrospective review methodology include it being less resource and time intensive than prospective, controlled trials; having access to a large amount of quality data; increased objectivity resulting from the data being collected separately from the research hypotheses and assumptions; examining the consequences of a phenomenon once they have had time to appear; and the testing of hypotheses that may have been formulated before examining the data (Gearing et al., 2006). Hess (2004) also advocates the use of retrospective reviews in exploratory research to prepare the ground for a prospective study by clarifying and focusing areas of interest and feasibility considerations. However, there are drawbacks in this methodology. These include unrecoverable or incomplete data affecting the formulation of the complete clinical picture, ambiguous information contained in reports that may decrease the validity of the study, lack of a control group or premorbid data which would allow the inference of causality and lack of control over the quality of information that was recorded (Gearing et al., 2006).

This study aims to explore the relationships between depression, cognitive performance and TBI, using retrospective neuropsychological reports that contain this information, as well as information on relevant sociodemographic variables. The data in these reports was collected through neuropsychological assessments conducted by a qualified professional. The aim is not to infer cause and effect, as this is an inductive enquiry, but rather use statistical analysis to find relationships among the variables.

3.3 Selection of Participants

The data was collected from a private practitioner with extensive experience working with TBI patients. From a total of 124 reports, 75 were purposefully selected based on the following criteria:

(1) They contained information on cases of TBI that were referred for neuroforensic purposes,
(2) They contained BDI-II scores
(3) The cases referred to closed head injuries
(4) The assessments on which the reports were based took place between 2004 and 2008

The study utilized purposive sampling as the research question was not applicable to the general population.

3.4 Data Collection

The neuropsychological reports were derived following neuropsychological evaluations for the purposes of determining the level of neuropsychological functioning post-injury. These evaluations were conducted in the private practice of a professional qualified in neuropsychological assessment. The neuropsychological assessment utilized standardized instruments covering the domains of attention, concentration, memory, learning, non-verbal and abstract reasoning, manual dexterity, verbal recall, working memory, perception, psychomotor performance, incidental learning, concept formation and verbal fluency. Depressive symptoms were measured by the Beck Depression Inventory- Second Edition (BDI-II), which is a self-report measure.

Sociodemographic data reflected in the neuropsychological reports:

- Age at assessment
- Gender
- Marital Status
- Highest level of education
- Home language

Clinical Data reflected in the neuropsychological reports:

- Duration since injury
- Right or left handedness
- Age at injury
- Glasgow Coma Score
- Length of hospitalization
- Duration of Post Traumatic Amnesia
- Psychiatric History

3.5 Measurement Instruments

The clinical, diagnostic, research and interpretative value of the results of a neuropsychological assessment depend on the ability of the tests administered to reliably and validly test the applicable domain (Strauss, Sherman & Spreen, 2006). Different neuropsychological domains were tested during the assessments, with multiple measures used to assess a particular domain in order to increase the quality of the data collected on the functioning of this domain. Table 1 below details rovides a summary of the domains tested and the measures used to test them, and Table 2 below outlines a brief description of these measures. More detailed descriptions of the tests may be found in Lezak et al., (2004) and Strauss et al., (2006).

Table 1. *A summary of the neuropsychological domains tested and the measures used to test them and a brief description of these measures*

Domain	Description of domain	Name of Tests that measure domain
Attention and Concentration	A set of multifaceted processes including the abilities to select relevant stimuli, manipulate and contain mental images, and modulate responses to the environment (Strauss et al., 2006). Concentration difficulties may be traced back to attentional difficulties or difficulties with maintaining attentional focus (Lezak et al., 2004).	Digit Span Forwards Digit Span Backwards Trail Making Test Symbol Digit Modalities Test (SDMT) Letter Cancellation Test
Memory and Learning	Memory is defined as the process of encoding, storing and retrieving information (Strauss et al., 2006). Learning implies consolidation of this information, meaning that it has been stored in long-term memory (Lezak et al., 2004).	Rey Auditory Verbal Leaning Test (RAVLT) Symbol Digit Modalities Test (SDMT)
Abstract Reasoning and Executive Functions	Executive functions are categorized as those functions that allow us to function effectively and adaptively succeed within our social contexts. Lezak et al. (2004) list the following as components of executive functions: volition, planning, purposive action and effective performance.	Similarities Tower of London
Verbal Fluency	The production and understanding of words in response to stimuli (Lezak et al., 2004).	Controlled Oral Word Association Test Category Fluency Test
Planning, Problem-Solving and Reasoning	These abilities deal with a number of complex and multi-faceted brain processes. Planning involves making decisions and organizing information in order to achieve a required outcome. Problem-solving is similar, yet involves a component of failure. Reasoning is the process within both planning and problem-solving that increases the likelihood that the outcomes will be favourable (Lezak et al., 2004).	Mazes Tower of London Matrix Reasoning
Response Inhibition	This is the ability to inhibit a learnt response to a stimulus	Luria's Test of Echopraxia

Table 2. *A brief description of the measures used in the study*

Name of Test	Description of Test
Digit Span Forwards	Measures attention efficiency, the ability to counter distraction and immediate verbal recall (Lezak et al., 2004).
Digit Span Backwards	A test of working memory and mental double-tracking (Lezak et al., 2004).
Trail Making Test	Measures the ability to maintain both simple and complex visual attention, visual scanning and visuomotor tracking.
Letter Cancellation Test	Measures psychomotor skill as well as capacity for sustained attention (Lezak et al., 2004).
Rey Auditory Verbal Leaning Test (RAVLT)	Measures immediate memory span, acquisition, retention and storage capacities; learning and learning strategies, retroactive and proactive interference and comparisons of types of errors (Golden, Espe-Pfeifer & Wachsler-Felder, 2000).
Symbol Digit Modalities Test (SDMT)	Measures divided attention, visual attention, processing speed, psychomotor performance and sustained attention (Strauss et al., 2006; Lezak et al., 2004)
Similarities	Measure of general mental ability with a high verbal factor loading and utilises abstract verbal skills (Lezak et al., 2004; Golden et al., 2000).
Tower of London	Assessment of executive planning ability (Lezak et al., 2004).
Controlled Oral Word Association Test	Evaluates the unprompted production of words or verbal fluency, motor expression of language, production of internal speech, self-awareness, inhibition of inappropriate responses and mental flexibility (Golden et al., 2000).
Category Fluency Test	Measures response generation and semantic memory (Strauss et al., 2006).
Mazes	Measures levels of planning and foresight (Lezak et al., 2004).
Tower of London	Measure of executive planning and problem-solving (Lezak et al., 2004).
Matrix Reasoning	A test of non-verbal concept formation and abstract reasoning (Lezak et al., 2004).
Luria's Test of Echopraxia	Measures ability to monitor and inhibit motor responses to conditioned stimuli.

3.6 Assessment of Depression

The Beck Depression Inventory- Second Edition-II (BDI-II-II) is a 21-item scale that is used for the clinical diagnosis of depression, using the DSM-IV criteria for depression as a guideline and assessing the cognitive, behavioural and physiological symptoms of depression (Rowland et al., 2005). It is a revised version of the original Beck Depression Inventory and seeks to improve the original version by being more consistent with the DSM-IV symptoms of Major Depressive Disorder (MDD) (Osman, Barrios, Guttierez, Williams & Bailey, 2008, Osman et al., 1997). Beck and colleagues (1996, quoted in Buckley, Parker & Heggie, 2001) investigated the psychometric properties of the BDI-II and found it to have high internal consistency reliability estimates and good convergent and discriminatory validity. Factor analyses have found the BDI-II to have cognitive and somatic-affective factors (Buckley et al., 2001; Whisman, Perez & Ramel, 2000). Rowland et al. (2005) investigated the factorial structure of the BDI-II in 51 TBI patients and determined it a useful measure to detect depression after a TBI. The BDI-II scores determine the level of depressive symptoms the individual is experiencing with the following cut-off scores indicating severity levels:

- 0-13: Minimal
- 14-19: Mild
- 20-28: Moderate
- 29-63: Severe

3.7 Data Analysis

All relevant data, including sociodemographic variables, details of the TBI and the scores of the neuropsychological tests were captured by the researcher. The following statistical analyses were conducted.

3.7.1 Descriptive Statistics

Descriptive statistics were utilized to describe characteristics of the sample, as well as to calculate constructs such as the mean, standard deviation and the frequency of depression in the cohort.

3.7.2 Correlational Analyses

The primary aim of this study was to investigate the relationships between depression, neuropsychological performance and clinical variables. Correlational analysis describes the degree and direction of a relationship between two variables

(Minium, King & Bear, 1993). The Pearson product-moment correlation coefficient is a parametric measure and as such assumes that (1) the variable measured has a normative distribution in the populations of the two groups it is computed on and (2) that this variable has equal variance in both groups (Pallant, 2001). On variables such as education level which was discrete not continuous, the non-parametric rank-order Spearman Correlation Coefficient was utilized. Partial correlations, which eliminate the effects of third variables on the correlation between two variables (Rosenthal & Rosnow, 2008), were conducted by controlling for the covariates of education, language, age at injury, length of PTA and duration since injury on the significant correlations between depression levels and the performance on neuropsychological tests.

3.7.3 Between-group Comparisons

The *t* test is a multivariate statistic used to compute the differences in means between two groups (Minium, King & Bear, 1993). The scores of the neuropsychological tests were compared to the variables of gender and relationship status using this statistical method of analysis. The independent samples *t* test is a parametric measure and as such assumes that (1) the variable measured has a normative distribution in the populations of the two groups it is computed on and (2) that this variable has equal variance in both groups (Pallant, 2001). Where these assumptions are not satisfied, the non-parametric rank-order Mann Whitney U Test is utilized. The Mann Whitney U Test, unlike *t* tests, is not based on a comparison of means but rather a comparison of the medians of groups (Pallant, 2001).

The analysis of variance (ANOVA) parametric statistic was used to investigate variance among the means of three or more variables (Aron & Aron, 1994). This statistic was applied to the means of the different language groups for each of the neuropsychological tests.

Chi-square tests for goodness-of-fit were applied to investigate the relationships between categorical variables, in particular selected sociodemographic data and neuropsychological test scores.

3.8 Ethics

The data for this project was collected in an ethical manner by a qualified professional. However, issues of confidentiality, informed consent, anonymity and deception are still applicable (Struwig & Stead, 2001). All the patient records are kept at the private practice of the assessing practitioner (who was a staff member at the Department of Psychology until 1 February 2007). Due to the retrospective nature of the study the practitioner provided consent to use the above-mentioned information, which is separate from any interpreted clinical records, clinical reports or identifying information. As an additional check on the proper utilization of information, the private practitioner acted as co-supervisor and ensured that only the relevant information was available for analyses and that no breaches of confidentiality occurred. The Ethics Committee of the Department of Psychology approved the research proposal.

3.9 Conclusion

The current research is a retrospective review of 75 neuropsychological reports chronicling sociodemographic and injury variables, depression profiles and cognitive performance on neuropsychological tests. These variables were statistically analyzed for significant associations, the results of which are presented in the next chapter.

CHAPTER 4
RESULTS

4.1 Introduction

In this chapter, the results obtained from the statistical data analysis of the socio-demographic variables, the clinical characteristics, the scores on the neuropsychological tests and the BDI-II scores are reported and described. Firstly, the descriptive statistics of the socio-demographic and injury variables are described. Secondly, the results from the correlations, analysis of variance (ANOVA) and Chi-square analyses are reported and explained.

4.2 Demographic characteristics of the sample

Due to the retrospective research review methodology, the composition of the sample is not representative of the general population of South Africa and this caveat frames the generalisation of findings.

The socio-demographic and clinical characteristics of the sample are shown in Table 3.

Table 3: *Socio-demographic and Clinical Data*

Variable	n	Mean	Std Dev	Range
Socio-demographic variables				
Age	75	36.13	11.49	9-60
Education (in years)	75	11.29	2.07	3-16
Clinical variables				
Age at injury	75	32.01	11.80	3-57
GCS score	49	12.94	2.72	6-15
Hours of PTA	40	203.63	339.06	0-1440
Days in hospital	68	42.32	74.15	0-504
Duration of injury (months)	75	50.61	26.72	14-146

The age at injury of the participants in the reports ranged from 3 to 57 years, with the majority (60%) being in the age range 21 to 40 years. Gender distribution was biased towards males, there were more than twice as many males as females in the sample. From the data reviewed, there were 51 male protocols and 24 female protocols. The majority of participants (44%) had left school before obtaining a Senior Certificate, 36% had obtained a Senior Certificate, while (20%) had tertiary qualifications ranging from a diploma to a doctorate. From the reviewed reports of the sample, 20% were first language English speakers, 29% were first language Afrikaans speakers and the majority, 51% spoke an African language. Based on the reviewed data, 80% of the TBI patients were in an intimate relationship while 20% were single. A large percentage of the sample were left handed (66%).

4.3 Clinical characteristics of the sample

19% of the participants had previous neurological problems and 12% of them had past psychiatric problems, including depression and post-traumatic stress disorder.

The mean duration of PTA is 203.63 hours, which translates into eight and a half days. Lezak et al. (2004) categorize PTA of between one and seven days as very severe, therefore the post-traumatic amnesia in the sample was rather high. The mean GCS score is 12.94 which Lezak et al. (2004) report as classifying the injury as a mild TBI.

4.4 Neuropsychological test performance

Descriptive statistics of the sample's performance on the neuropsychological measures are summarized in Table 4.

Table 4: *Neuropsychological test performance*

Test	n	Mean	SD	Range
Letter Cancellation (s)*	46	409.59	97.80	287-697
Digit Span Forwards	75	5.64	1.69	3-16
Digit Span Backwards	75	4.08	1.15	2-7
Matrix Reasoning	40	13.80	4.84	5-22
Mazes	42	23.88	10.91	5-47
RAVLT Free Recall	73	47.30	14.30	22-140
RAVLT Retrieval	73	17.99	6.17	5-33
RAVLT Recognition	68	13.22	2.01	8-16
SDMT Written	67	41.73	12.85	8-69
SDMT Oral	68	48.13	16.14	14-90
Similarities	64	19.09	8.21	0-39
Trail A (s)*	66	46.80	26.18	16-210
Errors on Trail A	17	4.41	16.42	0-68
Trail B (s)*	65	106.51	82.62	32-600
Errors on trail B	20	1.30	1.90	0-7
Tower of London Correct Ratio	59	0.38	0.74	0-5
Category Fluency Test	44	26.16	7.62	11-47
Controlled Oral Word Association Test (COWAT)	42	37.07	12.69	13-70

**Note:* (s) indicates time in seconds taken to complete the test

4.5 Depression Scores as Measured by the BDI-II

Of the total reviewed reports, 75 BDI-II scores were available for analyses. The mean score on the BDI-II was 23.5 (11.4). The figure below illustrates the self-reported prevalence of depression among the sample, as measured by the BDI-II. The largest percentage of participants (36%), reported experiencing severe symptoms of depression, represented by a score of 29 or above on this scale. 28% indicated moderate symptoms of depression. On the lower end of the depression spectrum, 16% experienced mild symptoms of depression and 20% experienced minimal symptoms of depression.

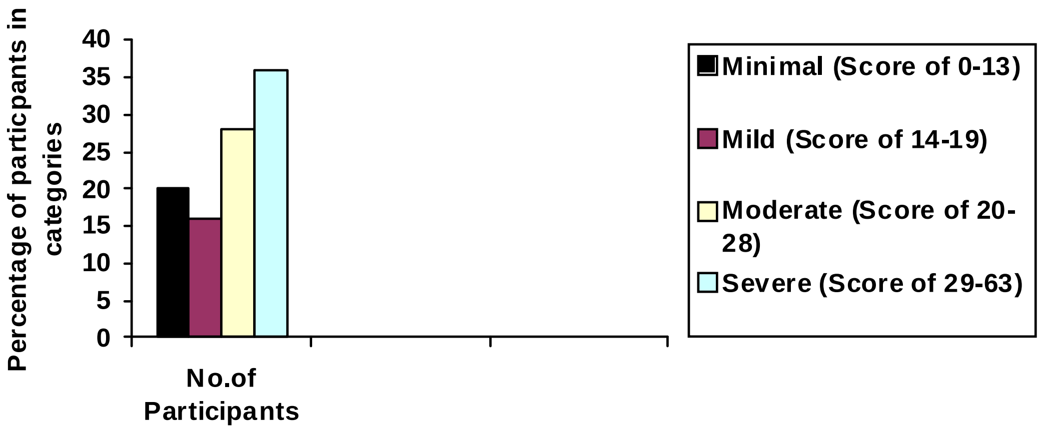

Figure 1: BDI-II levels of severity

4.6. Correlational Analysis

A Pearson product-moment correlation coefficient was used to construct a correlation matrix. Table 5 details the Pearson correlation coefficients and the significant correlations between the socio-demographic variables, clinical characteristics, depression scores and neuropsychological tests. There were no significant relationships with past psychiatric history, the Test of Echopraxia or the Tower of London test.

Table 5. *Significant Pearson correlations between socio-demographic factors, clinical characteristics, depression and neuropsychological performance*

	Age at Injury	GCS	Hours of PTA	Days spent in hospital	BDI-II Score
Letter Cancellation	0.49	0.31	--	--	--
n	75	28			
p	0.0005	0.10			
Matrix Reasoning	--	--	0.32	--	--
n			22		
p			0.14		
RAVLT Free Recall	--	-0.31	--	--	-0.41
n		48,			73
p		0.03			0.0004
RAVLT Retrieval	--	--	--	--	-0.40
n					73
p					0.0005
RAVLT Recognition	--	--	--	--	-0.31
n					68
p					0.009
SDMT Written	--	--	--	--	-0.47
n					67
p					0.0001
SDMT Oral	--	--	--	--	-0.52
n					68
p					<0.001
Similarities	0.35	--	--	--	--
n	64				
p	0.05				
Trail B	--	--	--	--	0.39
n					65
p					0.001
Errors on trail B	--	--		0.76	--
n			--	18	
p				0.0003	

4.6.1 Neuropsychological tests and socio-demographic and clinical factors

Performance scores on the Similarities Test increased with increased age, indicating that age allows for greater retention of these abilities after a TBI. The Similarities Test measures abstract executive functions, which are accumulated over time, so it is possible that these stores of learnt information allow the better retention of such knowledge (Lezak et al., 2004). However, as age increased, scores on the written version of the SDMT decreased. This implies that the cognitive domains measured by the Written Trial of the SDMT may be negatively affected by increased age. Participants also performed slower on the Letter Cancellation Test as their age increased. Both the Letter Cancellation Test and the SDMT are measures of response speed, indicating that age may have a slowing effect on response speed.

Time to complete the Letter Cancellation Test increased as GCS score increased, whereas performance on the RAVLT Free Recall Trial of the RAVLT decreased as GCS score increased.

Performance on the Matrix Reasoning Test improved as length of PTA increased.

The number of errors on Trail B of the TMT increased as the number of days in hospital increased.

4.6.2 Neuropsychological test performance and depression

As indicated in Table 3, depression scores were significantly associated with three neuropsychological measures: the RAVLT, SDMT and TMT. The free recall, recognition and retrieval trails of the RAVLT indicated inverse relationships with depression scores suggesting that TBI patients with lower depression scores perform better on these trials of the RAVLT. Similarly, findings for the written and oral versions of the SDMT reflected inverse correlations, indicating that lower depression scores are correlated with better performance. The significant association with Trail B of the TMT showed that the participants who scored higher on depression displayed poorer performance on this trail by taking longer to complete the test. These tests represent the cognitive domains of sustained attention, immediate memory span, acquisition, retention and storage capacities, learning and learning strategies, divided attention and processing speed. All of these domains could have been affected by higher depression scores.

Table 6. *Partial Correlations controlling for language, age and education, and length of PTA and duration in hospital in the relationship between BDI-II score and the Free Recall, Recognition and retrieval trials of the RAVLT, the SDMT and Trail B of the TMT*

	BDI-II Score in the Afrikaans language group	BDI-II Score in the English language group	BDI-II Score in the African Language group	Age and Education	Length of PTA and Duration since injury
RAVLT Free Recall	-0.36	-0.49	-0.45	-0.39	-0.40
n	21	14	38	73	38
P	0.11	0.08	0.005	0.001	0.02
RAVLT Retrieval	-0.42	-0.57	-0.31	-0.37	-0.33
n	21	14	38	73	38
p	0.06	0.03	.06	0.001	0.05
RAVLT Recognition	-0.38	0.22	-0.31	-0.30	-0.38
n	20	12	36	68	33
p	0.10	0.50	0.07	0.02	0.03
SDMT Written	-0.48	-0.48	-0.45	-0.47	-0.60
n	18	14	35	67	35
p	0.04	0.08	0.007	<0.01	0.0003
SDMT Oral	-0.45	-0.73	-0.49	0.5224	-0.68
n	19	14	35	68	35
p	0.05	0.003	0.002	<0.01	<0.001
Trail B	0.15	-0.41	0.45	0.39	0.47
n	19	14	32	65	34
p	0.53	0.90	0.01	0.002	0.01

When the results were controlled for length of PTA, time since injury, language, age and education, the relationship between SDMT oral and written performance, the RAVLT Trials and performance on Trail B with depression remained significant, indicating that the lowered performance was related to the depression itself and not to socio-demographic or clinical characteristics. Table 6 reports the partial correlations for the relationships mentioned above.

4.6.3 Neuropsychological Test Performance and Education Levels

The variable of education level was categorized as an ordinal variable and therefore the Spearman Rank order correlation coefficient, as opposed to the parametric Pearson correlation coefficient, was computed on the education level data. The significant Spearman correlations between education level and performance on neuropsychological measures are reported in Table 7.

Table 7: *Significant Spearman correlations between neuropsychological test performance and education levels.*

Neuropsychological test performance	r *value with Education Levels*
COWAT	0.47 (*n*=42, *p*=0.02)
Category Fluency Test	0.33 (*n*=44, *p*=0.03)
Digit Span Forwards	0.37 (*n*=75, *p*<0.01)
Digit Span Backwards	0.41 (*n*=75, *p*<0.01)
RAVLT Free Recall	0.48 (*n*=73, *p*<0.01)
RAVLT Retrieval	0.43 (*n*=73, *p*<0.01)
SDMT Written	0.45 (*n*=67, *p*<0.01)
SDMT Oral	0.41 (*n*=68, *p*<0.01)

Therefore, higher educational levels were significantly correlated with high scores on the:

- Category Fluency Test
- Controlled Oral Word Association Test
- Digit Span Forwards
- Digit Span Backwards
- The Free Recall and Retrieval Trials of the RAVLT
- The Oral and Written versions of the SDMT

These results indicate that participants with higher education levels scored higher on tests representing the cognitive domains of verbal fluency, immediate attention, working memory, sustained attention, divided attention and processing speed, than those with lower levels of education.

The relationship between the BDI-II and education levels did not yield any significant correlations.

4.7 Between Group Comparisons

4.7.1 *T* tests

T tests are used the compute the differences in means between two groups (Minium, King & Bear; 1993). Therefore, *t* tests were computed to compare the neuropsychological test scores to the variable of gender.

A significant difference in performance between males and females was found on the Mazes Test. Males had a mean score of 26.17 (*SD*= 10.62) whereas females had a mean score of 18.77 (*SD*= 10.14). There was a significant difference between these two means ($t(71)=0.25$, $p=0.04$) with males performing better .

4.7.2 Analysis of Variance

The analysis of variance (ANOVA) parametric statistic is used to investigate variance among the means of three or more variables (Aron & Aron, 1994). This statistic was applied to the means of the neuropsychological test scores of the three categories of language groups (English, Afrikaans and African languages) to determine significant differences in the means of comparable groups. Table 8 summarizes the performance on the significant neuropsychological test scores according to the different language groups.

Table 8: *Analysis of Variance of the significant neuropsychological test scores for each of the language groups*

Source	*N*	*P*	dF	F	*M* (English)	*M* (Afrikaans)	*M* (Other)
Digit Span Backwards	75	0.02	2	3.97	4.70	4.1	3.8
Matrix Reasoning	40	0.0007	2	8.81	15.0	16.8	10.9
RAVLT Free Recall	73	0.0011	2	7.54	59.40	44.7	44.2
SDMT Written	67	0.0002	2	9.99	50.00	46.7	35.9
SDMT Oral	68	0.0001	2	12.98	62.00	51	40
Trail Making A	66	0.0003	2	9.14	28.80	39.7	58.5
Trail Making B	65	0.0012	2	7.47	68.00	73.20	143.20

$p \leq 0.05$

The participants with English as a first language performed much better on the Digit Span Backwards Test than participants who spoke African languages.

Participants who were first language Afrikaans speakers performed better on the Matrix Reasoning test than those who spoke African languages.

English speakers performed better on the Free Recall trial of the RAVLT than both the Afrikaans and African language speakers.

English and Afrikaans speakers performed better than African language speakers on the oral and written trial of the SDMT.

African language speakers performed slower than English and Afrikaans speakers on Trail A and B of the TMT.

All of these results will be explored further in the discussion chapter.

4.7.3 Chi-Square Analyses

Chi-square tests for goodness-of-fit were applied to investigate the relationships between categorical variables, namely, gender, language, and the number of sequences on the digit span forwards and backwards tests. Chi-square analyses revealed no significant relationships.

4.8. Conclusion

The above statistical analyses indicate that there are significant relationships between the socio-demographic variables, the depression scores and the neuropsychological performance of TBI patients. Due to the inherent design limitations of a retrospective review, exact causality cannot be ascertained and it can only be postulated as to how these relationships have arisen. The next chapter details the significance of these findings in the light of existing neuropsychological knowledge.

CHAPTER 5
DISCUSSIONS AND CONCLUSIONS

5.1 Introduction

This study attempted to investigate the relationships between depression scores, socio-demographic variables and performance on neuropsychological assessment instruments. The following relationships were evident from the data analysis:

- BDI-II results for the sample: 36% reported experiencing severe symptoms of depression, 28% indicated experiencing moderate symptoms of depression, 16% experienced mild symptoms of depression and 20% experienced minimal symptoms of depression.

- Performance on tests related to specific cognitive domains was related to certain socio-demographic variables such as age at injury and time elapsed since injury, and clinical variables such as length of PTA.

- Depression after a TBI, and lowered performance on certain neuropsychological tests representing the cognitive domains of sustained attention, immediate memory span, acquisition, retention and storage capacities, learning and learning strategies, divided attention and processing speed, have a significant correlation.

- The education level of the TBI patients was found to have a significant positive association with scores of neuropsychological tests representing the cognitive domains of verbal fluency, immediate attention, working memory, sustained attention, divided attention and processing speed.

- Primary language was a variable that influenced the scores of certain neuropsychological tests.

- The Mazes Test had a performance discrepancy between the genders, with males performing better.

5.2 Prevalence of depression in the cohort

The BDI-II results for the sample indicate that 36% of the sample reported experiencing severe symptoms of depression, 28% indicated experiencing moderate symptoms of depression, 16% experienced mild symptoms of depression and 20% experienced minimal symptoms of depression. The DSM-IV lists the risk for major depressive disorder in the cognitively intact population as 10- 25% for women and 5-12% for men (American Psychiatric Association, 1994). Therefore this sample had a significantly high incidence of depression when compared to the general population. This could be mediated by the presence of traumatic brain injury. However, the prevalence of depression in this sample was high even when compared to other studies on depression following TBI. Deb and Burns (2007) found that the ICD-10 diagnosis of depressive disorder was prevalent in 32% of 18-65 year olds in a cohort of 120 TBI patients. Levin et al. (2001) found that in 69 TBI patients investigated for psychiatric disorders with the Structured Clinical Interview for DSM-IV, 17% met the criteria for Major Depression, and Rapoport et al. (2005), using the same instrument, found a 28.4% prevalence of depression in a cohort of 74 patients.

The variability in estimates of depression following TBI is possibly related to non-equivalent assessment instruments (Kreutzer, Seel & Gourley, 2001). The BDI-II has been proven to have high reliability in diverse populations, has been extensively utilized in clinical and research settings for the past 35 years, and is one of the best screening tests for depression in psychiatric and medical settings (Green et al., 2001; Lasa, Ayuso-Mateos, Va’zquez-Barquero & Di’ez Manrique, 2000; Lustman et al.,1997; Strauss et al., 2006). In a study of 117 patients assessed with the BDI-II two years after TBI, Green et al. (2001) found evidence that the BDI-II may be a proficient self-report screening instrument for depression after TBI. According to Kreutzer et al., (2001), the BDI-II has a Cronbach Alpha ranging from .73 to .92 and test-retest reliability of more than .90, indicating that this instrument has satisfactory reliability. Lasa et al. (1997) found that the BDI-II's screening value is independent of age and gender, thereby demonstrating its validity. The BDI-II was proven to be a proficient discriminator of the presence of depression among 172 subjects who also had diabetes, on the domains of sensitivity and specificity, with the cognitive items being somewhat more accurate than the somatic items (Lustman et al.,1997). Lustman et al. (1997) therefore advocate the use of the BDI-II to uncover often overlooked problems with depression among the medically ill due to its ease of administration and scoring. In this study, the depression estimates could have been confounded by the BDI-II having been administered in English to many second language English speakers. Further, since the context of the assessment was related to claims for compensation, this could have caused an over-reporting of symptoms, a phenomenon that has been reported in the literature on TBI and compensation (Banchini, Curtis & Greve, 2006).

Depression in those with physical ailments or injuries is correctly diagnosed and treated in fewer than a third of cases (Lustman et al., 1997). These results confirm that depression is a serious consequence of TBI that needs to be properly addressed.

5.3 Relationship between neuropsychological test performance and socio-demographic variables

The variable of age at injury was related to certain cognitive domains.

5.3.1 Correlation between the Letter Cancellation Test and Similarities Test with Age at injury

The time taken to complete the Letter Cancellation Test increased as age at injury increased. This implies that age at injury had a slowing effect on performance on this test. The Letter Cancellation Test requires subjects to identify target letters among random sequences and cancel them out within a prescribed time limit, as a measure of psychomotor speed and the capacity for sustained attention (Strauss et al., 2006). Age at injury is a common variable explored in studies focusing on psychosocial outcomes following TBI (Hoofien, Vakil, Gilboa, Donovick & Barack, 2002). These results indicate that increasing age at injury has a detrimental impact on attention. In a consecutive sample of 243 patients assessed one year after injury, Katz and Alexander (1994) found that being older than 40 years at the time of injury was related to poorer functional outcome and longer PTA duration. Hoofien et al. (2002), in a sample of 76 patients thoroughly assessed 14 years after injury, found that age at injury did not have any association with chronic psychosocial functioning.

The Similarities Test requires the subject to utilise abstract verbal skills in order to describe what a pair of words have in common (Golden et al., 2000). The scores on the Similarities Test improved as age at injury increased. The age at injury of participants was treated as a continuous variable, with a range from 3 years to 57 years, the mean age was 32.01 years. However, since occupation was not a variable taken into consideration during the analysis, it is possible that older participants may have had more vocational experience and these reserves could have been utilized for superior performance. Anderson, Catroppa, Morse, Haritou and Rosenfeld (2000) investigated the intelligence profiles of 124 children one year post injury. The children ranged in age 3 to 12 years. They found that those injured when they were older had greater recovery than those injured when younger, especially in the more severe cases. This is attributed to the vulnerability of an immature brain, with earlier exposure to injury increasing the likelihood of abnormalities in cerebral development, as well as the lack of a store of abilities and skills which could compensate for affected domains (Anderson et al., 2000). This is consistent with the results of the variable of education level as a protective factor (discussed under 5.7). Ewing-Cobbs et al. (2004) conducted a prospective longitudinal study on 77 TBI patients from the ages of 5 to 15 years, and found that those injured earlier had less improvement on measures of Arithmetic and Reading-Decoding, implying that the acquisition of academic skills is affected by injuries in early childhood.

5.4 Relationship between neuropsychological test performance and clinical variables

The variables of GCS score, length of PTA and amount of days spent in hospital and time since injury were related to certain cognitive domains.

5.4.1 Correlation between GCS score and time taken to complete the Letter Cancellation Test and performance on the Free Recall Trial of the RAVLT

The Glasgow Coma Scale (GCS) score is a widely accepted measure of head injury severity, which is calculated based on the duration and depth of altered consciousness. It is also the longest-used predictor of functional outcome after a TBI (Hoofien et al., 2002). It is scored on best eye-opening, verbal and motor responses and has a score that ranges from 3 to 15. The GCS is routinely measured by medical personnel on admission to hospital, and has been proven to be a good, although not foolproof, predictor of post-TBI outcome. There is also doubt regarding the validity of the GCS, since severity could be artificially inflated by sedation medication administered by emergency personnel or alcohol intoxication (Lezak et al., 2004) and a measure of subjectivity is involved in the scoring of a patient's functioning. The scoring is often done in a hurry and by medical personnel with varying degrees of experience and training. Further, physical injuries may complicate the scoring of certain categories, and there has also been found to be variation in scoring principles that could decrease the reliability of scores (Lezak et al., 2004). Nevertheless, the GCS is the most universally utilized medical measurement of TBI severity and has been utilized for this purpose in this discussion. Van Baalen, Odding and Stam (2008) find the GCS score to be more related to acute morbidity and mortality than long-term functional outcome.

The RAVLT Free Recall Test is a sensitive measure of deficits in attention, concentration, memory storage and retrieval and learning abilities. Performance on this test has been correlated with age, gender and education and has been found to be significantly associated with psychosocial outcome and later cognitive outcome (Millis et al., 2001; Ross, Millis & Rosenthal, 1997). The RAVLT is also reported to be correlated with community integration after TBI (Millis, Rosenthal & Lourie, 1994). The finding that scores on the RAVLT decreased with a higher GCS score is anomalous as an increasing GCS score conventionally indicates better functioning, with less cognitive impairment, as opposed to the current relationship indicating worse performance being related to increasing GCS scores.

Hammond, Grattana et al. (2004), in a prospective study of functional outcome one and five years after injury of TBI patients, found that increasing GCS Eye Opening Score was predictive of worsening functional outcome among a cohort of 3787 TBI patients. In their study they noted that GCS score was not predictive as a whole of change in functional and employability outcome one to five years after injury. They recommend that with regards to predictors of later functional decline, other indicators may need to be investigated. However, GCS Motor Score predicted improvement in the functional domains of Social Interaction and Memory/ Problem Solving in a prospective cohort of 627 individuals assessed at one year and five years after injury (Hammond, Hart, Bushnik & Corrigan, 2004). In a study of 82 patients with mild TBI, Shores et al. (2008) found that of the 60% that were unable to lay down new memories, 87% had been assigned a GCS score of 15, indicating that the GCS cannot be universally applied as an indicator of adequate brain functioning. There are many possible explanations for such anomalous results such as inconsistent capturing of GCS scores, statistical errors and inadequate sample size (Shores et al., 2008).

5.4.2 Correlation between length of PTA and performance on the Matrix Reasoning Subtest of the WAIS-III

The Matrix reasoning subtest of the WAIS-III measures non-verbal concept formation and abstract reasoning, as it consists of visual pattern completion and analogy exercises (Lezak et al., 2004). As length of PTA increased, performance on the Matrix Reasoning decreased. Length of PTA is considered a particularly sensitive indicator of injury severity, with the longer the duration the more severe the injury and therefore the more extensive the cognitive impairment (De Monte, Geffen & Massavelli, 2006).The length of PTA in the current sample ranged from 0 to 1440 hours, which is a range from none to extremely severe, with the mean duration being eight and a half days, classified as extremely severe. However, the PTA duration recorded in the reports was mostly an estimation made by a medical practitioner or the patients themselves, as opposed to a measurement by a standardized test of orientation and ability to lay down new memories.

There is a scarcity of quantitative studies on the PTA using standardized measures in recent years (Shores et al., 2008). De Monte et al. (2008) found that presence of PTA was related to slower information processing and difficulties with word recall in 90 patients with mild TBI. Tate et al. (2006), in a study of different measures of PTA, report that deciding when PTA ends is an ambiguous and difficult to delineate task, which commonly leads to medical practitioners using varied guidelines and reporting durations of PTA that are not reliable. Although PTA duration has been proven to be more predictive of functional outcome than GCS, the difficulties in classification of impairment with PTA means that it lacks the sensitivity needed for research (Lezak et al., 2004).

The Matrix Reasoning Test has been proven to be a sensitive indicator of executive and higher order processes deficits, which may have a verbal mediation component (Dugbaartey et al., 1999). However, there has been doubt with regard to its sensitivity in detecting impairment in TBI, learning disabilities and attention-deficit-hyperactivity disorder (Ryan, Carruthers & Miller, 2005). In a comparison of the WAIS-III scores of 100 TBI patients and 100 matched controls, Donders, Tulsky and Zhu (2001) found that the Matrix Reasoning subtest did not differentiate between patients with moderate to severe TBI and controls, casting doubt on the test's sensitivity to TBI severity. One possible reason for this is that it is not a timed test and therefore does not assess response speed, which is sensitive to TBI severity (Donders et al., 2001). Therefore performance on the Matrix Reasoning subtest of the WAIS-III failed to correlate with injury severity in this sample.

5.4.3 Correlation between errors made on Trail B of the TMT and amount of days spent in hospital

The amount of time spent in hospital (measured in days) was found to be directly proportional to the amount of errors made on Trail B of the TMT. The amount of days in hospital ranged from 0 to 180 days. One possible explanation for this could be because more time spent in hospital indicates greater physical complications and injuries and trauma to other areas of the body greatly impairs already hindered cognitive functions (Lezak et al., 2004).

Errors on the TMT are a source of qualitiative data about the patient's functioning (Kortte, Horner & Windham, 2002). Perseverative errors and errors of impulsivity on Trail B are an indication of the patient's difficulties with cognitive flexibility and shifting from numbers to letters (Ruffolo, Guilmette & Willis, 2000). Errors could also be an indication of accuracy being compromised in participants' haste to complete the test faster as performance is scored on time to complete (Ruffolo et al., 2000). It is assumed that the stresses associated with increased physical injury could have affected these functions, or that the brain injuries were more severe and extensive, indicated by a longer stay in hospital. Van Baalen et al. (2008) found no association between length of stay in hospital and eventual discharge destination. Ratcliff et al. (2007) using multivariate analyses found that patients with shorter hospital stays performed better on the cognitive domains of attention, working memory, verbal memory, language, visual analytic skills, problem solving and motor functioning, one year after injury. There are not many studies that investigate the length of time in hospital due to the amount of confounding variables within a hospital setting. However, the present study found a significant association between longer hospital stay and difficulties with double tracking and psychomotor accuracy which could be attributed to orthopaedic and other physical injuries which would hinder these abilities.

5.5 Relationship between depression as measured by the BDI-II and the performance on neuropsychological tests

In contrast to the findings of the studies cited in the literature review in Chapter Two, the current study found no direct associations between depression and socio-demographic variables. A possible explanation of this could be that the sample demographics were not distributive enough, or the sample size was not large enough, to detect such associations.

The BDI-II was found to have a negative relationship with the oral and written Versions of the SDMT and the recognition, free recall and retrieval trials of the RAVLT. That is, increasing depression scores were correlated with lower performance on these tests. These tests represent the cognitive domains of sustained attention, immediate memory span, acquisition, retention and storage capacities, learning and learning strategies, divided attention and processing speed, all of which could have been affected by higher depression scores. The SDMT is frequently used as a screening test for cognitive impairment for the domains of processing speed, motor execution, visuo-perceptual skills, learning abilities and visuomotor coordination (Crowe et al., 1999). This finding suggests that depression, as measured by the BDI-II, has a detrimental effect on these domains.

Both depression and TBI, even when independent of each other, are related to cognitive impairment (Keiski, Shore & Hamilton, 2007; Rapoport, et al., 2005). Liotti and Myberg (2001), in their investigation of the physiological correlates of depression, state that the most common domains affected by depression based on neuropsychological testing are attention, concentration, executive functions and immediate memory. Their research indicates that the right dorsal prefrontal cortex is significantly impaired by negative or sad affect, and that lowering of negative affect was associated with significant improvement on attentional domains (Liotti & Myberg, 2001). Both arousal and the regulation of emotion have been linked to the same neural substrate within the cortex, namely the right cerebrum (Shenal et al., 2003; Liotti & Myberg, 2001). Studies have also consistently associated sad affect with lower reaction time for right hemispheric processing (Liotti & Myberg, 2001). Mathias and Coats (1999), in a study of 27 Mild TBI patients and 27 controls, found that verbal fluency was the cognitive domain most affected by the brain injury.

The RAVLT is an unstructured list-learning memory task which tests the individual's ability to use learning strategies to enhance coding and retrieval of information (Golden et al*.,* 2000). Memory deficits in the recall, recognition and retrieval functions are common both in TBI patients and in individuals with a diagnosis of depression (Keiski et al., 2007; Sadock & Sadock, 2003). Depression most commonly affects effortful processing such as retrieval (Farrin, Hull, Unwin, Wykes & David, 2003). Rapoport et al. (2005) found that, in a cohort of 74 TBI patients, depression as measured by the Structured Clinical Interview for the DSM-IV (SCID), was associated with lower scores on tests of verbal memory, processing speed and working memory six months after injury. They reason that the high risk of anterior and frontal lobe lesions in TBI contributes to the probability of memory and executive dysfunction thereafter (Rapoport et al., 2005). Studies have also indicated that depression after a TBI affects unstructured memory tests more than tests that have information that already has some level of organization and that free recall is more impaired than recognition memory in depressed subjects (Keiski et. al, 2007). In the present study free recall and retrieval were also significantly more affected than recognition abilities. Keiski et al. (2007) found that depression had no effect on the recall and recognition of short stories on the Wechsler Memory Scale-III for their group of 53 TBI patients. However, depression did have a significant negative effect on the recall and recognition trials of the California Verbal Learning test (CVLT). This finding was postulated to be related to reduced learning strategies, encoding and semantic clustering by the depressed group of individuals compared to the control group. Previous studies have linked these findings to decreased prefrontal cerebral blood flow (Keiski et. al, 2007).

Time taken to complete the Trail Making Test increased with increased scores on the BDI-II, indicating that higher depression scores are related to slower performance speed. The BDI-II also had a significant positive relationship with errors made on

Trail B of the TMT indicating that higher depression scores are related to more errors on the TMT. The TMT is renowned as a measure of cognitive flexibility, divided attention, scanning and visuomotor tracking (Lezak et al., 2004). It has also been demonstrated to be a good predictor of independence in activities of daily living following a TBI (Lezak et al., 2004). Ruffolo et al. (2000) attest to the validity of the TMT for indicating impairments after TBI. However, they also report that according to their research, performance errors do not serve as reliable indicators of cognitive impairments (Ruffolo et al., 2000), thereby indicating that cognitive impairments are more strongly linked to the BDI-II evaluation of depression, which increased with slowed performance, not performance errors. Himanen et al. (2009) in a study of 61 TBI patients 30 years post-injury, compared the neuropsychological profiles of those with and without a diagnosis of major depression. The TMT formed part of their neuropsychological battery. They found that depressive symptoms were more related to decreased psychomotor speed and sustained attention difficulties, whereas non-depressed patients with TBI exhibited more complex attention processing impairment. Therefore, depression after TBI is a significant factor which has a detrimental effect on cognitive functioning.

5.6 Relationship between Education Level and performance on neuropsychological tests

Education level had a positive relationship with the following tests from the neuropsychological battery:

- Category Fluency Test
- Controlled Oral Word Association Test
- Digit Span Forwards
- Digit Span Backwards
- The Free Recall and Retrieval Trials of the RAVLT
- The oral and written versions of the SDMT

These tests represent the cognitive domains of verbal fluency, immediate attention, working memory, sustained attention, divided attention and processing speed. The current sample had education levels ranging from Grade Three to postgraduate levels of education.

Basso and Bornstein (2000) found premorbid IQ to have a protective effect against cognitive decline in HIV positive patients. Kesler, Adams, Blasey and Bigler (2003) investigated the cognitive reserve hypothesis, which postulates a protective effect of higher education level of cognitive domains after brain injury. Their results indicate that higher education level helps to preserve cognitive function after brain injury. Further, lower premorbid education levels were associated with greater change in cognitive functioning based on psychometric testing after injury (Kesler et al., 2003). Their findings indicate that total intracranial volume (TICV) is a protective measure against cognitive impairment, which is related to the cognitive reserve hypothesis that greater brain volume and higher education levels decrease vulnerability to impaired cognitive outcome after brain insult, and further that brain size and IQ are related (Kesler et al., 2003). One possible flaw of the present study's results is the variation in intellectual ability within years of education (Basso & Bornstein, 2000). From the results cited above it is clear that higher education levels had a significant positive effect on cognitive prognosis after TBI.

5.7 Relationship between primary language and performance on neuropsychological tests.

Lezak et al. (2004) caution that bilingual speakers who are tested in their second language may have performance deficits that would not appear if they were tested in their first language. Since 51% of the sample had a primary language that was classified as an African language, it is probable that a large percentage of the sample was not assessed in their first language.

The participants with English as a first language performed much better on the Digit Span Forwards Test than participants who spoke African languages. English speakers also performed better on the Free Recall trial of the RAVLT than both the Afrikaans and African language category. Participants who were first language Afrikaans speakers performed better on the Matrix Reasoning test than African language speakers. English and Afrikaans speakers performed better than African language speakers on the oral and written trial of the SDMT.

Abrahams and Mauer (1999, cited in Van der Vijver & Rothmann, 2004) found that historically disadvantaged groups in South Africa - the majority of whom speak African languages - are discriminated against in psychological assessment in South Africa as they tend to be unfamiliar with test content, and they are not satisfactorily represented in test norms. Further, in South Africa previously disadvantaged groups have received varying levels of education (Gaylard, 2005). In particular, research on intelligence testing has found differential performance on domains of intelligence for different ethnic groups based on socio-cultural factors rather than innate capacities (Gaylard, 2005).

African language speakers performed better than English and Afrikaans speakers on Trail A and B of the TMT. The TMT is primarily a measure of visual scanning and visuomotor tracking, requiring motor speed and agility and a low verbal component. It is expected that non-verbal tests within neuropsychological assessment are more culturally and educationally fair than tests with a high verbal factor loading (Roselli & Ardila, 2003), while accepting that a ’culture-free’ test is not possible. Education has also been proven to have a significant impact on performance in tests with more non-verbal items, with both child and adult samples (Roselli & Ardila, 2003). Roselli and Ardilla (2003) further report that non-Western cultures perform better on tests of certain non-verbal abilities.

In the present study both the Digit Span Forwards and SDMT tests were significantly correlated with Education Level. It is therefore postulated that those that fared less well in those tests had lower Education levels. It is interesting that those that did less well on those tests spoke African languages, implying that some of them were from educationally disadvantaged groups. However, since there is no empirical evidence relating demographic and other variables with language, further interpretations cannot be attempted. It is sufficient to mention that language is a very significant factor within neuropsychological assessment in South Africa and further exploratory research is required in this regard.

5.8 Gender discrepancy on the Mazes Test of the WISC-R

The Mazes Test of the WISC-R measures levels of planning and foresight (Lezak, et al., 2004). In the present study males performed significantly better on the Mazes Test of the WISC-R.

Lynn, Raine, Venables, Mednick and Irwing (2005) report that males routinely obtain higher means on tests of the following cognitive domains: spatial orientation, visualization, line orientation, mathematical reasoning and throwing accuracy. Therefore, in the WAIS-III, they perform better on the four visuo-spatial subtests, namely Block Design, Picture Completion, Mazes and Object Assembly (Lynn et al., 2005). According to Lezak et al. (2004), studies on brain lateralization show that women perform better on tests of verbal functions whereas males perform better on tests of nonverbal, visuo-spatial tasks. Lynn et al.(2005) report similar results for studies in the United States, Europe and Mauritius. They reason that since this phenomenon is apparent across cultures, it is probable that it is a function of hormonal differences rather than socialization. Ratcliff et al., (2007) found gender to be significantly correlated to better performance on certain domains when using multivariate analyses to investigate the relationship between gender and six cognitive domains. Females displayed better performances on working memory, attention and language whereas males performed better on measures of visual analytical skills, based on the Block Design test of the WAIS-III. In their study, women performed better overall than men. They postulate that these results are related to hormones such as progesterone and oestrogen that act as neuroprotective factors. Further, since females have stronger right frontal activation and males more parietal activation, males generally perform better on tests of visuo-spatial ability (Ratcliff et al., 2007).

The results indicate that the physiological and hormonal male advantage in visual analytical skills is a protective factor of this domain after TBI.

5.9 Conclusion

The investigations undertaken in this study did signify particularly pertinent relationships in the interactions among the variables of interest. Higher education level was found to be extremely critical in assisting retention of cognitive abilities after a TBI. Primary language was also a significant differentiator of performance among tests. Age at injury had contrasting effects, with increasing age being favourable on some domains but related to poorer performance on others. Increasing GCS scores were related to slower performance on the Letter Cancellation Test and decreased performance on the RAVLT Free Recall Test. Longer PTA duration was related to worse performance on the Matrix Reasoning Test. These results indicate that neuropsychological assessment has a complex relationship with injury severity. The high incidence of depression in this study confirms that major depression is a very common occurrence Following TBI. This has widespread implications for patient and family counselling, and psychotropic intervention in treatment planning after TBI.

5.10 Limitations

All research endeavours have inherent limitations that need to be acknowledged and stated. The following limitations must be taken into account when evaluating the conclusions:

- Statistical analyses require a large sample size for results to be reliable. The current sample size of 75 is moderately suitable for an analysis of this scope, yet a bigger sample would be more applicable and relevant to the larger South African population.

- The sample was not a random sample, with the reports requiring TBI and neuropsychological evaluation details. This indicates that the results may not be easily generalizable. The age range of 3 to 57 years indicates that for older samples and younger samples these results may not be valid.

- The diagnosis of depression was based on a self-report measure, the BDI-II, which, although proven reliable and valid, does not have the sensitivity or detailed evaluation of a qualified professional.

- The nature of the data (retrospective neuropsychological reports with no premorbid data) does not allow the comparison of the emotional and cognitive profiles before and after the TBI. Therefore causality cannot be inferred from this analysis.

- The demographic variables included in this sample were not extensive and lacked important information such as socio- economic status and occupation, which previous studies have found to be important.

- The reports lacked in-depth physiological information for example sites of lesions and Magnetic Resonance Imaging scans. These would have allowed more exploration of the relationships of the direct neurological effects of TBI with the cognitive and emotional facets.

- The data did not include an assessment of real life everyday functioning such as the Glasgow Outcome Scale, which prevented the exploration of functional outcome profiles. Cognitive neuropsychological tests are not always a true reflection of everyday basic functioning. Such data would be more relevant to the prognosis of employability as well as social and relationship functioning.

5.11 Recommendations

The following are recommendations based on the information gathered in this study:

- The high incidence of depression in this study indicates that depression should be regarded as one of the more serious, if delayed, manifesting sequelae of TBI and should be included in treatment considerations. This counters the prevailing perception that the psychosocial and emotional consequences of a physical injury are secondary to the medical sequelae.

- The cognitive repercussions of depression should also be considered as contributing to the general cognitive deficits observed after TBI.

- Due to the variety of languages, ethnic and tribal groups within South Africa, neuropsychological test norms and interpretations have to be undertaken with caution. The results of this study highlight the need for further exploration in how language and other socio-cultural factors interact within the context of neuropsychological assessment in South Africa.

- Further research on the emotional and cognitive aspects of TBIs within South African populations is needed to supplement the lack of information currently available. It is recommended that further studies build on the current study, exploring larger samples, with more stratification specificity to the type of injury sustained as well as functional outcomes.

REFERENCES

American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders* (4th Ed.). Washington, DC: American Psychiatric Association.

Anderson, J.M. (2009). Traumatic Brain Injury: Complex Condition with Lasting Effects. *Journal of Controversial Medical Claims, 16* (1), 5-15.

Anderson, V., Catroppa, C., Morse, S., Haritou, F. & Rosenfeld, J. (2000). Recovery of Intellectual Ability following Traumatic Brain Injury in Childhood: Impact of Injury Severity and Age at Injury. *Pediatric Neurosurgery, 32* (1), 282-290.

Aron. A. & Aron, E.N. (1994). *Statistics for Psychology*. New Jersey: Prentice Hall.

Basso, M.R., & Bornstein, R.A. Estimated Premorbid Intelligence Mediates Neurobehavioral Change in Individuals Infected with HIV across 12 Months. *Journal of Clinical and Experimental Neuropsychology, 22* (1), 208-218.

Bianchini, K.J., Curtis, K.L. & Greve, K.W. (2006). Compensation and malingering in Traumatic Brain Injury: A dose-response relationship? *The Clinical Neuropsychologist, 20* (1), 831-847.

Buckley, T.C., Parker, J.D. & Heggie, J. (2001). A psychometric evaluation of the BDI-II-II in treatment-seeking substance abusers. *Journal of Substance Abuse Treatment, 20* (1), 197-204.

Chamelian, L. & Feinstein, A. (2006). The effect of major depression on subjective and objective cognitive deficits in mild to moderate Traumatic Brain Injury. *The Journal of Neuropsychiatry and Clinical Neurosciences, 18*(1), 33-38.

Crowe, S.F., Benedict, T., Enrico, J., Mancuso, N., Matthews, C. & Wallace, J. (1999). Cognitive determinants of performance on the digit symbol-coding test, and the symbol search test of the WAIS-III, and the Symbol Digit Modalities Test: An analysis in a healthy sample. *Australian Psychologist, 34* (3), 204-210.

Deb, S. & Burns, J. (2007). Neuropsychiatric consequences of traumatic brain injury: A comparison between two age groups. *Brain Injury, 21* (3), 301-307.

De Monte,V.E., Geffen, G.M., & Massavelli, B. M. (2006). The effects of post-traumatic amnesia on information processing following mild traumatic brain injury. *Brain Injury, 20* (13/14), 1345-1354.

Donders, J., Tulsky, D.S. & Zhu, J. (2001). Criterion validity of new WAIS–III subtest scores after traumatic brain injury. *Journal of the International Neuropsychological Society, 7*, 892–898.

Dugbartey, A.T., Sanchez, P.N., Rosenbaum, J.G., Mahurin, R.K., Davis, M. & Townes, B.D. (1999). WAIS-III Matrix Reasoning Test Performance in a Mixed Clinical Sample. *The Clinical Neuropsychologist, 13* (4), 396-404.

Ewing-Cobbs, L., Barnes, M., Fletcher, J.M., Levin, H., Swank, P.R. & Song, J. (2004). Modeling of longitudinal academic achievement scores after paediatric traumatic brain injury. *Developmental Neuropsychology, 25* (1), 107-133.

Fann, J.R., Uomoto, J.M. & Katon, W.J. (2001). Cognitive improvement with treatment of depression following mild Traumatic Brain Injury. *Psychosomatics, 42(*1), 48–54.

Farrin, L., Hull, L., Unwin, C., Wykes, T. & David, A. (2003). Effects of Depressed Mood on Objective and Subjective Measures of Attention**.** *The Journal Of Neuropsychiatry And Clinical Neurosciences, 15* (1), 98-104.

Fleminger, S. (2008). Long-term psychiatric disorders after traumatic brain injury*.* *European Journal of Anaesthesiology, 25* (42), 123-130.

Franulic, A., Horta, E., Maturana, R., Sherpeis, J. & Carbonell, C. (1999) Organic personality disorder after traumatic brain injury: cognitive, anatomic and psychosocial factors. A six-month follow-up. *Brain Injury, 14* (5), 431-439.

Gaylard, E.K. (2005). *Cross-cultural differences in IQ test performance: Extension of an existing normative database on WAIS-III test performance.* Unpublished Masters Dissertation, Grahamstown: Rhodes University.

Gearing, R.E., Mian, I.A., Barber, J. & Ickowicz, A. (2006). A Methodology for Conducting Retrospective Chart Review Research in Child and Adolescent Psychiatry. *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 15* (3), 126-134.

Geldmacher, D.S. & Riedel, T.M. (1999). Age effects on random-array letter cancellation tests. *Neuropsychiatry, Neuropsychology, And Behavioral Neurology 12* (1), 28-34.

Gill, M., Windemuth, R., Steele, R. & Green, S.M. (2005). A Comparison of the Glasgow Coma Scale Score to Simplified Alternative Scores for the Prediction of Traumatic Brain Injury Outcomes. *Annals of Emergency Medicine, 45* (1), 37-42.

Glenn, M.B., O-Neil, P., Goldstein, R., Burke, D. & Jacob. L. (2001). Depression amongst outpatients with brain injury. *Brain Injury, 15*(9), 811-818.

Golden, C.J., Espe-Pfeifer, P. & Wachsler-Felder, J.W. (2000). *Neuropsychological Interpretations of Objective Psychological tests.* New York: Kluwer Academic/ Plenum Publishers.

Green, A., Felmingham, K., Baguley, I.J., Slewa-Younan, S. & Simpson, S. (2001). The clinical utility of the Beck Depression Inventory- Second Edition after traumatic brain injury. *Brain Injury, 15* (12), 1021-1028.

Green, M.J. & Malhi, J.S. (2006). Neural Mechanisms of the Cognitive Control of Emotion. *Acta Neuropsychiatrica, 18*(1): 144-153.

Hammond, F.M, Grattana, K.D., Sasser, H., Corrigan, J.D., Rosenthal, M., Bushnik. T. & Shull, W. (2004). Five years after traumatic brain injury: A study of individual outcomes and predictors of change in function. *NeuroRehabilitation, 19* (1), 25-35.

Hammond, F.M., Hart, T., Bushnik, T. & Corrigan, J.D. (2004) Change and Predictors of Change in Communication, Cognition, and Social Function. *Journal of Head Trauma Rehabilitation, 19* (4), 314-328.

Headway Gauteng. (2007). *Information.* Retrieved 5 August 2007 from the World Wide Web: http://www.headway-gauteng.org/info.html.

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

Hess, D.R. (2004). Retrospective Studies and Chart Reviews. *Respiratory Care, 49* (10), 1171-1175.

Himanen, L., Portin, R., Tenovuo, O., Koponen, S., Hiekkanen, H., & Helenius, H. (2009). Attention and depressive symptoms in chronic phase after traumatic brain injury. *Brain Injury, 23*(3), 220–227

Hoofien, D., Vakil, E., Gilboa, A., Donovick, P.J. & Barack, O. (2002). Comparison of the predictive power of socioeconomic variables, severity of injury and age on long-term outcome of traumatic brain injury: sample-specific variables versus factors as predictors. *Brain Injury, 16* (1), 9-27.

Jorge, R.E., Robinson, R.G., Moser, D., Tateno, A., Crespo-Facorro, B. & Arndt, S. (2004). Major depression following traumatic brain injury. *Archives of General Psychiatry, 61*(1), 42-50.

Katz, D.I. & Alexander, M.P. (1994). Traumatic brain injury: Predicting course of recovery and outcome for patients admitted to rehabilitation. *Archives of Neurology, 51* (7), 661-700.

Keiski, M.A., Shore, D.L. & Hamilton, J.M. (2007). The Role of Depression in Verbal memory After Traumatic Brain injury. *The Clinical Neuropsychologist, 21* (1), 744-761.

Kesler, S.R., Adams, H.F., Blasey, C.M., & Bigler, E.D. (2003). Premorbid Intellectual Functioning, Education, and Brain Size in Traumatic Brain Injury: An Investigation of the Cognitive Reserve Hypothesis. *Applied Neuropsychology, 10* (3), 153-162.

Kolb, B. (2004). Mechanisms of Cortical Plasticity after Neuronal Injury. In J. Ponsford (Ed.), *Cognitive and Behavioural Rehabilitation, (Page numbers)*. New York: The Guilford Press.

Kolb, B. & Cioe, J. (2004). Neuronal Organization and Change after Neuronal Injury. In J. Ponsford (Ed.), *Cognitive and Behavioural Rehabilitation, (page numbers)*. New York: The Guilford Press.

Koponen, S., Taiminen, T., Portin, R., Himanen, L., Isoniemi, H., Heinonen., et al. (2002). Axis I and II Psychiatric Disorders After Traumatic Brain Injury: A 30-Year Follow-Up Study. *American Journal of Psychiatry, 159* (1), 1315-1321.

Kortte, K.B., Horner, M.D., & Windham, W.K. (2002). The Trail Making Test, Part B: Cognitive Flexibility or Ability to Maintain Set? *Applied Neuropsychology, 9*(2), 106-109.

Kreutzer, J.S., Seel, R.T. & Gourley, E. (2001). The prevalence and symptom rates of depression after traumatic brain injury: a comprehensive examination. *Brain Injury, 15* (7), 563-576.

Lasa, L., Ayuso-Mateos, J.L., Va'zquez-Barquero, J.L. & Di'ez Manrique, F.J. (2000). The use of the Beck Depression Inventory- Second Edition to screen for depression in the general population: a preliminary analysis. *Journal of Affective Disorders, 57* (1), 261–265.

Levin, H.S., Brown, S.A., Song, J.X., McCauley, S.R., Boake, C., Contant, C.F. et al. (2001). Depression and posttraumatic stress disorder at three months after mild to moderate traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology , 23*(6), 754-769.

Levin, K. (2004). Paediatric traumatic brain injury in South Africa: Some thoughts and considerations. *Disability and rehabilitation, 26* (5), 306-314.

Levin, H.S. & Hanten, G. (2005). Executive Functions After Traumatic Brain Injury in Children. *Pediatric Neurology, 33*(2), 79-94.

Levin, H.S., McCauley, S.R., Josic, C.P., Boake, C., Brown, S.A., Goodman, H.S., et al. (2005). Predicting Depression Following Mild Traumatic Brain Injury. *Archives of General Psychiatry, 62* (1), 523-528.

Lezak, M.D., Howieson, D.B. & Loring, D.W. (2004). *Neuropsychological Assessment* (4th ed.). Oxford: Oxford University Press.

Liotti M. & Mayberg, H.S. (2001). The Role of Functional Neuroimaging in the Neuropsychology of Depression. *Journal of Experimental Neuropsychology, 23* (1), 121-136.

Lustman, P.J., Clouse, R., Griffith, L.S., Carney, R.M., & Freedland, K.E. (1997). Screening for Depression in Diabetes Using the Beck Depression Inventory- Second Edition. *Psychosomatic Medicine, 59* (1), 24-31.

Lynn, R., Raine, A., Venables, P.H., Mednick, S.A. & Irwing, P. (2005). Sex Differences on the WISC-R in Mauritius. *Intelligence, 33* (1), 527-533.

Mathias, J.L. & Coats, J.L. (1999). Emotional and Cognitive Sequelae to Mild Traumatic Brain Injury. *Journal of Clinical and Experimental Neuropsychology, 21* (2), 200-215.

McAllister, T.W. (2008). Neurobehavioural sequelae of traumatic brain injury: evaluation and management. *World Psychiatry, 7* (1), 3-10.

Millis, S.R., Rosenthal, M. & Lourie, I.F. (1994). Predicting Community Integration After Traumatic Brain Injury with Neuropsychological Measures. *International Journal of Neuroscience, 19* (1), 165-167.

Millis, S.R., Rosenthal, M., Novack, T.A., Sherer, M., Nick, T.G., Kreutzer, J.S., et al. (2001). Long-Term Neuropsychological Outcome after Traumatic Brain Injury. *Journal of Head Trauma Rehabilitation, 16* (4), 343-355.

Minium, E.W., King, B.M. & Bear, G. (1993). *Statistical Reasoning in Psychology and Education* (3rd ed). New York: John Wiley & Sons., Inc.

Moldover, J.E., Goldberg, K.B. & Prout, M.F. (2000) Depression After Traumatic Brain Injury: A Review of Evidence for Clinical Heterogeneity. *Neuropsychology Review, 14*(3), 143-155.

Murrey, G.J. (Ed.). (2000). *The Forensic Evaluation of Traumatic Brain Injury: A Handbook for Clinicians and Attorneys*. London: CRC Press.

Murrell, M. (2007). My 25-year Sabbatical. Retrieved 15 March 2009 from http://www.ncneuropsych.com/traumatic-brain-injury-publications.html.

Nell, V. & Brown, D.S. (1991). Epidemiology of traumatic brain injury in Johannesburg-II. Morbidity, mortality and etiology. *Social Sciences and Medicine, 33(*3), 289-296.

Osman, A., Downs, W.R., Barrios, F., Bopper, B.A., Gutierrez, P.M. & Chiros, C.E. (1997). Factor Structure and Psychometric Characteristics
of the Beck Depression Inventory- Second Edition-H. *Journal of Psychopathology and Behavioral Assessment,* 19 (4), 359-376.

Osman, A., Barrios, A., Gutierrez, P.M., Williams, J.E. & Bailey, J. (2008). Psychometric Properties of the Beck Depression Inventory- Second Edition-II in Nonclinical Adolescent Samples. *Journal of Clinical Psychology*, 64 (1), 83-102.

Ownsworth, T.L., & Oei, T.P.S. (1998). Depressiona fter traumatic brain injury: conceptualisation and treatment considerations. *Brain Injury, 12* (9), 735-751.

Pallant, J. (2001). *SPSS survival manual: a step-by-step guide to data analysis using SPSS*. Buckingham: Open University Press.

Ponsford, J., Draper, K. & Schönberger, M. (2008). Functional outcome 10 years after traumatic brain injury: Its relationship with demographic, injury severity, and cognitive and emotional status. *Journal of the International Neuropsychological Society , 14*(1), 233–242.

Rapoport, M.J. & Feinstein, A. (2001). Age and functioning after mild traumatic brain injury: the acute picture. *Brain Injury, 15* (10), 857-864.

Rapoport, M.J., McCullagh, S., Streiner, D. & Feinstein, A. (2003). The clinical significance of major depression following mild traumatic brain injury. *Psychosomatics, 44*(1), 31-37.

Rapoport, M.J., McCullagh, S., Shammi, P. & Feinstein, A. (2005). Cognitive impairment associated with major depression following mild and moderate traumatic brain injury. *Journal of Neuropsychiatry and Clinical Neurosciences, 17*(1), 61- 65.

Raskin, S.A., & Mateer, C.A. (2000). *Neuropsychological Management of Mild Traumatic Brain Injury*. New York: Oxford University Press.

Ratcliff, J.J., Greenspan, A.I., Goldstein, F.C., Stringer, A.Y., Bushnik, T., Hammond, F.M., et al. (2007). Gender and traumatic brain injury: Do the sexes fare differently? *Brain Injury, 21* (10), 1023-1030.

Roselli, M. & Ardila, A. (2003). The impact of culture and education on non-verbal neuropsychological measurements: A critical review. *Brain and Cognition, 52* (3), 326-333.

Rosenthal, R. & Rosnow, R.L. (2008). *Essentials of Behavioural Research*. (3rd ed.). New York: McGraw Hill.

Ross, S.R., Millis, S.R. & Rosenthal, M. (1997). Neuropsychological Prediction of Psychosocial Outcome After Traumatic Brain Injury. *Brain Injury, 4* (3), 165-170.

Rowland, S. M., Lam, C.S. & Leahy, B. (2005). Use of the Beck Depression Inventory-Second Edition-II (BDI-II-II) with persons with traumatic brain injury: Analysis of factorial structure. *Brain Injury, 19* (2): 77–83

Ruffolo, L.F., Guilmette, T.J. & Willis, W.G. (2000). Comparison of Time and Error Rates on the Trail Making Test Among Patients with Head Injuries, Experimental Malingerers, Patients with Suspect Effort on Testing, and Normal Controls. *The Clinical Neuropsychologist, 14* (2), 223-230.

Ryan, J.J., Carruthers, C.A., & Miller, L.J. (2005).The WASI Matrix Reasoning subtests: performance in Traumatic Brain Injury, Stroke and Dementia. *International Journal of Neuroscience, 115* (1), 129-136.

Sadock, B.J. & Sadock, V.A. (2003). *Synopsis of Psychiatry* (9th ed.). New York: Lippincott, Williams & Wilkins.

Salmond, C.H., Chatfield, D.A., Menon, D.K., Pickard, J.D., & Sahakian, B.J. (2005). Cognitive sequelae of head injury: involvement of basal forebrain and associated structures. *Brain, 128* (1), 189-200.

Satz, P., Forney, D.L., Zaucha, K., Asarnow, R.R., Light, R., McCleary, C., Levin, H., et al. (1998). Depression, cognition, and functional correlates of recovery outcome after traumatic brain injury. *Brain Injury, 12* (7), 537-553.

Sbordone, R.J., Seyranian, G.D., & Ruff, R.M. (1998). Are the subjective complaints of traumatically brain injured patients reliable? *Brain Injury, 12* (6), 505-515.

Shenal, B.V., Harrison, D.W. & Demaree, H.A. (2003). The neuropsychology of depression: A literature review and preliminary model. *Neuropsychology Review, 13*(1), 33-42.

Sheridan, L.K., Fitzgerald, H.E., Adams, K.M., Nigg, J.T., Martel, M.M., Puttler, L.I., et al. (2006). Normative Symbol Digit Modalities Test performance in a community-based sample. *Archives of Clinical Neuropsychology, 21* (1), 23-28.

Shores, E.A., Lamme'l, A., Hullick, C., Sheedy, J., Flynn, M., Levick, W., et. al. (2008).The diagnostic accuracy of the Revised Westmead PTA Scale as an adjunct to the Glasgow Coma Scale in the early identification of cognitive impairment in patients with mild traumatic brain injury. *Journal of Neurology and Neurosurgical Psychiatry, 79* (1), 1100-1106.

Silverberg, N.D. & Millis, S.R. (2009). Impairment *versus* deficiency in neuropsychological assessment: Implications for ecological validity. *Journal of the International Neuropsychological Society, 15* (1), 94 – 102.

Strauss, E., Sherman, E.M.S. & Spreen, O. (2006). *A Compendium of Neuropsychological Tests: Administration, Norms and Commentary.* (3rd ed.). Oxford: University Press.

Struwig, F.W., & Stead, G.B. (2001). *Planning, Designing and Reporting Research.* Cape Town: Maskew Miller Longman.

Tate, R.L., Pfaff, A., Baguley, I.J., Marosszeky, J.E., Gurka, J.A., Hodgkinson, A.E., et al. (2006). A multicentre, randomised trial examining the effect of test procedures measuring emergence from posttraumatic amnesia. *Journal of Neurology and Neurosurgical Psychiatry, 77* (1), 841-849.

Tsaousides, T. & Gordon, W.A. (2009). Cognitive Rehabilitation Following Traumatic Brain Injury: Assessment to Treatment. *Mount Sinai School of Medicine, 76* (1), 173-181.

Van Baalen, B., Odding, E. & Stam, H.J. (2008). Cognitive status at discharge from the hospital determines discharge destination in traumatic brain injury patients. *Brain Injury, 22* (1), 25-32.

Van der Vijver, A.J.R. & Rothmann, S. (2004). Assessment in Multicultural groups: the South African Case. *SA Journal of Industrial Psychology, 30* (4), 1-7.

Venter, I. (2007). *Faltering vehicle market now hopes to equal 2006 sales figures.* Retrieved 5 August 2007 from the World Wide Web: http://www.engineeringnews.co.za/article.php?a_id=111977.

Whisman, M.A., Perez, J.E. & Ramel, W. (2000). Factor Structure of the Beck Depression Inventory- Second Edition—Second Edition (BDI-II-II) in a Student Sample. *Journal of Clinical Psychology. 56 (*4), 545-551.

Zillmer, E.A. & Spiers, M.V. (2001). *Principles of Neuropsychology***.** New York: Wadsworth.