The relationship between neuropsychological performance and depression in patients with Traumatic Brain Injury

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Abstract:

Traumatic brain injury (TBI) is a multi-faceted condition that affects individuals on physical, cognitive, and emotional levels. The study investigated the relationship between depression and neuropsychological performance in a group with TBI. A retrospective review was conducted on 75 participants who completed neuropsychological assessments. Information on clinical characteristics, sociodemographic information, neuropsychological outcomes and Beck Depression Inventory scores were included in the analysis. Results indicated that 36% of the participants reported experiencing severe symptoms of depression, 28% moderate symptoms of depression, and 36% mild/minimal symptoms of depression. Performance on the Rey Auditory Verbal Learning Test (RAVLT) indicated inverse relationships with depression scores suggesting that TBI patients with lower depression scores perform better on verbal memory tasks. Similarly, findings for the Written and Oral versions of the Symbol Digit Modalities Test (SDMT) reflected inverse correlations with depression scores, indicating that lower depression scores are correlated with increased processing speed and capacity. A significant positive association between the time taken to complete the Trail Making Test (TMT) Trail A and Trail B and depression scores was found, suggesting that higher depression scores in this sample were related to slower performance speed and lower executive performance. When certain clinical and sociodemographic variables were included as covariates in a partial correlational analysis, neuropsychological performance indicators and depression scores remained significant for SDMT (oral and written), the RAVLT Retrieval and Recognition trials, and TMT (Trail B). This study indicates that in a TBI cohort, depression levels are significantly associated with specific neuropsychological performance measures. The findings of this study have implications for psychosocial treatment planning after a TBI, and contribute to our understandings of the inter-relationship between cognition and emotion.

Keywords

Cognitive impairment, depression; neuropsychology; neuropsychological assessment; traumatic brain injury

The nomenclature for head injuries indicates that a traumatic brain injury (TBI) is an acquired head injury with complex and enduring physical, neurocognitive, and emotional features (Silver, Hales, & Yudofsky, 2012). Globally, the incidence of TBI per annum is estimated at 9.5 million (Anderson, 2009), with the incidence rate in South Africa estimated to be as high as 3.5 times the global incidence rate (Bryan-Hancock & Harrison, 2010). Between 1997 and 2002, a 60% increase in deaths due to brain injuries has been reported in South Africa (Soeker, Van Resnburg, & Travill, 2012). A study by Watt and Penn (2000) looking at rates of return to work after brain injury, emphasized the need for rehabilitation after TBI in the South African context. Therefore, the cost and impact of TBI on the South African healthcare system is significant. Additionally, with the resource constraints on the South African healthcare system, patients have limited accessibility to efficacious rehabilitation treatment programmes due to a lack of governmental services and medical insurance funding (Levin, 2004). Studies focusing on the various aspects of functioning affected after a head injury are integral to guiding rehabilitation programs.

During the last 30 years, advanced medical technology has allowed significant increases in post brain injury survival rates, without a concomitant increase in the focus on the quality of life and social reintegration of these survivors (McLean, Jarus, Hubley, & Jongbloed, 2014; van der Merwe, 2004). The neurocognitive deficits experienced after a TBI are well documented in international research; with attention, memory, executive functions, processing speed, and verbal fluency the primary domains being impaired (Himanen et al., 2009; Rapoport, McCullagh, Shammi, & Feinstein, 2005; Raskin & Meeter, 2000; Soldatovic-Stajic, Misic-Pavkov, Bozic, Novovic, & Gajic, 2014; Wilson, Gracey, Evans, & Bateman, 2009). However, emotional consequences after brain injury cause much distress in survivors' lives, and are often challenging to identify and measure in comparison with neurocognitive impairments (Osborn, Mathias, & Fairweather-Schmidt, 2014; Prigatano, 1999; Wilson et al., 2009). Furthermore, emotional consequences after a TBI may be related to the changed life circumstances of the patient and personality changes, as well as changes in cognitive abilities, and this has a cumulative impact on familial and social functioning (Clark, Brown, Bailey, & Hutchinson, 2009, Stålnacke, 2007; Hoofien, Gilboa, Vakil & Donovick, 2001). Exploring the emotional consequences of a TBI, as well as the interrelationship between emotional and cognitive changes is therefore needed to better understand the challenges patients encounter after a TBI.

Rates of depression in moderate to severely injured TBI patients have been found to be high compared to those in the non-brain injured population (Rapoport, 2012; Schönberger et al., 2011). The diagnosis of depression after brain injury is complicated as depressive symptoms such as irritability, frustration, fatigue, and poor concentration occur as a result of the brain injury itself (Fleminger, Oliver, Williams, & Evans, 2003). Risk factors for depression include female gender, depression at the time of injury as well as pre-injury depression, and a history of substance abuse (Rapoport, 2012). The depressive symptoms manifested after a brain injury are heterogeneous due to their various aetiologies such as organic factors, premorbid risk factors, and psychological responses to the injury (Rapoport, 2012). Depressive symptoms after TBI are similar to those manifested in the non-brain-injured population, but the symptoms most commonly reported are fatigue, frustration, and concentration impairment (Fleminger, 2008). However, depression after TBI is also related to poorer overall prognosis (Rapoport, 2012) which may necessitate more intensive and varied interventions for those susceptible to depression after TBI. An increasing awareness of the psychological impact of TBI is emerging, and investigations into emotional disturbances such as depression have become more established, and the relationship between depression and cognitive outcomes in TBI populations requires further exploration.

Depression has been shown in previous studies to have an association with the neurocognitive impairments evidenced after TBI (Clarke, Genat, & Anderson, 2012; Verfaellie, Lafleche, Spiro, & Bousquet, 2013). Rapoport et al. (2005) found that subjects who had sustained a TBI and who evidenced comorbid major depression scored significantly lower than subjects with no major depression in the domains of working memory, processing speed, and verbal memory. After mild to moderate TBI, depression has been associated with poorer performance on measures of processing speed, working memory, executive functions, and verbal memory (Rapoport, 2012). In a longitudinal study, Himanen et al. (2009) found, in a comparison of TBI patients with and without depression 30 years post-injury, that patients with depression scored lower on simple reaction time, visual recognition of letters, and the total hit rate on a vigilance test. These studies indicate that integrity of function in specific neurocognitive domains is impacted by the depression status of TBI cohorts.

Studies have however found that in the non-brain-injured population, affective disorders such as depression are related to cognitive impairments in the domains of memory, executive functions, and attention (Beblo et al., 2011). The cognitive impairments evidenced in mood disorders of patients without brain injuries may be related to structural and functional alterations in the brain particularly in regions such as the prefrontal cortex and anterior cingulate cortex (Beblo et al., 2011). Therefore, if these regions are affected by brain injuries in patients with depression, a cumulative effect on already compromised cognitive functioning may be evidenced.

Depression influences every day functioning and abilities making it a significant factor to consider after a TBI, specifically with regard to its association with neurocognitive functioning (Spitz, Schönberger, & Ponsford, 2013). . In the South African context, patients are often discharged from acute care and due to a lack of resources have limited options for therapy and rehabilitation (Levin, 2004). This implies that any residual emotional and cognitive consequences of the TBI are not diagnosed or treated. Investigating the interrelationship between cognitive and emotional outcomes after TBI in a South African sample may allow for more directed treatment plans that incorporate both cognitive rehabilitation and the oft-neglected assessment and treatment of emotional sequelae which could enhance the overall quality of life of individuals with TBI. The aim of this study is to explore the relationship between neuropsychological performance and depression in a South African sample of patients with TBI.

Method

Participants

A retrospective review of 75 neuropsychological assessments containing information on clinical variables (GCS Score, time since injury, age at injury, time spent in hospital and duration of PTA), sociodemographic variables (age at assessment, education level, gender, home language, handedness and relationship status), performance on specific neuropsychological measures, and BDI-II scores was undertaken. The sample was purposively selected from a database of participants who had undergone neuropsychological assessments that included a comprehensive neuropsychological battery as well as an emotional assessment, at a private practice between 2004 and 2008. An additional inclusion criterion was the availability of sufficient sociodemographic and clinical data to explore these variables in the sample. The mean age at assessment of the participants was 36.13 (*SD* = 11.49). Males comprised 68% of the sample. Forty four percent of participants 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. With regards to home language, 17 participants spoke English, 22 spoke Afrikaans, nine spoke Zulu, eight spoke Xhosa, six spoke Northern Sotho, five spoke Tswana, four spoke Southern Sotho, two spoke Tsonga, one spoke Venda and one spoke Seswati . The participants were all assessed in English, with the help of a psychologist who could speak their home language where necessary. Nineteen percent reported comorbid neurological problems and twelve percent reported comorbid psychiatric problems post-TBI. Eighty percent of the participants were in an intimate relationship while 20% were single. A large percentage of the sample were left handed (66%). The mean duration of post-traumatic amnesia (PTA) was 203.63 hours (8.5 days) categorized by Armstrong and Morrow (2010) as very severe. The mean Glasgow Coma Scale (GCS) score was 12.94 classified by Armstrong and Morrow (2010) as a mild TBI. The mean number of days spent in hospital was 42.32 and the mean number of months since the injury at the date of assessment was 50.61.

Instruments

The neuropsychological domains assessed via standardized neuropsychological measures were: attention, concentration, memory, learning, non-verbal and abstract reasoning, verbal recall, working memory, perception, psychomotor performance, incidental learning, concept formation, and verbal fluency.

The assessment battery included the following tests: the Digit Span Forwards and Digit Span Backwards tests with a test-retest reliability ranging from 0.66 to 0.89 (Sbordone, Saul, & Purisch, 2007), the Trail Making Test (r= 0.79 for Part A and r=0.89 for Part B) (Strauss, Sherman, & Spreen, 2006), the Symbol Digit Modalities Test (SDMT) (r= 0.80 for the written version and r=0.76 for the oral version) (Sbordone et al., 2007), the Letter Cancellation Test with a split-half reliability of 0.96 reported by Uttl and Pilkenton-Taylor (2001), the Rey Auditory Verbal Learning Test (RAVLT) with a test-retest reliability ranging from 0.60 to 0.77

(Fichman et al., 2010), the Controlled Oral Word Association Test (*r*=0.83) (Ruff, Light, Parker, & Levin, 1996), the Category Fluency Test (*r*=0.74) (Rosselli, Tappen, Williams, Salvatierra, & Zoller, 2009), the Similarities Test (*r*=0.92) (Kamphaus, 2005), the Mazes Test (*r*=0.57) (Kamphaus, 2005), the Matrix Reasoning Test (*r*=0.94) (Kamphaus, 2005), and the Tower of London test (*r*=0.70) (Jurado Noboa, 2009).

Depressive symptoms were measured by the 21-item self-report measure, the Beck Depression Inventory Second Edition (BDI-II). The BDI-II has been reported to have a test-retest reliability ranging from 0.74 to 0.96 (Strauss et al., 2006).

Procedure

For the retrospective review, cases over a four year period were accessed and included in the review if all information criteria stipulated below were met and if consent for the utilization of information was obtained. All the cases were related to closed head injuries and the original neuropsychological assessments were conducted to primarily determine the level of neuropsychological functioning post-injury.

Ethical considerations

The information obtained was separate from any interpreted clinical records, clinical reports, or identifying information to ensure confidentiality of the participants. Informed consent for the use of the data was obtained. Ethical approval for the study was obtained from the postgraduate research and ethics committee at the University of Pretoria.

Data analysis

Descriptive statistics were utilised to describe characteristics of the sample. Spearman correlational analyses were computed to investigate the relationships between depression scores, neuropsychological performance, clinical variables and sociodemographic variables. The variables of education, age at injury, duration of PTA, and time since injury were used as covariates in partial correlational analyses to see if the relationship between depression scores and performance on neuropsychological tests would still be significant when controlling for specific sociodemographic and clinical variables.

Results

Depression Scores

The mean score on the BDI-II was 23.5 (*SD*=11.4). Thirty six percent of participants reported experiencing severe symptoms28% indicated moderate symptoms, 16% experienced mild symptoms and 20% experienced minimal symptoms of depression.

Associations between sociodemographic variables, clinical characteristics, depression, and neuropsychological performance

Table 1 details the significant relationships between sociodemographic factors, clinical characteristics, depression, and neuropsychological performance. Performance scores on the Similarities Test increased with increased age, indicating that age may allow for greater retention of these abilities after a TBI. However, as age increased, scores on the written version of the SDMT and the Letter Cancellation Test decreased, indicating that age may have a slowing effect on response speed.

Neuropsychological test performance and depression

Depression scores were significantly associated with three neuropsychological measures: the RAVLT, SDMT, and TMT. The free recall, recognition, and retrieval trials 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 Trails A and B of the TMT showed that the participants who scored higher on depression displayed poorer performance on this test.

As indicated in Table 2, the variables duration of PTA, time since injury, age, and education were used as covariates in a partial correlational analysis to determine if the associations between the specific neuropsychological performance indicators and depression scores remained significant. The relationship between performance on SDMT (oral and written), on Trail B of the TMT, and the RAVLT Retrieval and Recognition trials and depression scores still remained significant. This may indicate that the lowered performance may be related to the depression itself and not to these sociodemographic or clinical characteristics. Age at injury and education level appeared to influence the relationship between depression scores and performance on the RAVLT Free Recall Trial.

Gender

The neuropsychological test performance scores of male and female participants were compared using the independent samples *t*-test. 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 ($t(71)=0.25$, $p=0.04$) and a medium effect size for this difference (r=0.32) with males performing better.

Discussion

This South African sample had a significantly high incidence of depression which is consistent with the reported incidence of depression after TBI globally (Mauri, Paletta, Colasanti, Miserocchi, & Altamura, 2014). Researchers have reported a prevalence of major depressive disorder (MDD) in the range of 14%-77% in patients after TBI. (Deb & Burns, 2007; Mauri et al., 2014, Rapoport 2012). Major depression was also found to be the most reported psychiatric disorder in comparison to the other psychiatric disorders measured on the Structured Clinical Interview for DSM IV Disorders (SCID I), and was evident up to 5.5 years after the injury (Whelan-Goodinson, Ponsford, Johnston, & Grant, 2009). Longitudinally, Mauri et al. (2014) found a MDD prevalence of 37.5% six months post- injury, which was lower than the prevalence at earlier follow ups. However, Koponen et al. (2002) in a long-term follow up study found a lifetime prevalence of depression of 26.7%, 30 years after TBI, which indicates that although some symptoms may improve, depression after TBI can persist. These results confirm that although symptom alleviation may occur due to interventions, depression remains a persistent consequence of TBI and needs to be managed and monitored over the long term. This study did not infer cause and effect therefore we cannot infer whether the depression after TBI was related to changed life circumstances as many studies suggest, or due to morphological changes in the brain due to the injury. Further studies in the South African context could attempt to isolate the causes behind the high levels of depression in this context. Neuropsychological rehabilitation programs are often resource-intensive and therefore directing the focus of treatment may assist with more efficient and effective outcomes. Treating emotional sequelae with psychosocial or psychiatric interventions may have a positive effect on cognitive functioning, due to the relationship between depression and impaired cognitive performance evidenced in this and previous studies. In the South African context many TBI patients do not have access to neuropsychological rehabilitation and therefore the lack of support structures and resources available after an injury may be related to the increased depression levels after TBI.

Age is a common variable explored in studies focusing on psychosocial outcomes following TBI (Hessen, Nestvold, & Anderson, 2007; Spitz et al, 2014). In the current study, older participants performed slower on the Letter Cancellation Test and the written version of the SDMT. These results also indicate that injury at an older age may have a more detrimental impact on attention. Soldatovic-Stajic et al. (2014) in their investigation of cognitive impairments one year after closed TBI found that age impacted significantly on scores on the Digit Span, Block Design, and Wisconsin Card Sorting tests, indicating that performance on aspects of memory, attention, and executive functioning may be impacted by the age of the patient with TBI. The pre-existing process of cognitive decline involving slowed information processing and a loss of cerebral white matter integrity in the aging population could also interact with the TBI sequelae and result in compromised cognitive integrity for older adults (Kinsella, 2011). Therefore, the temporal gradient of attentional and information processing decline in the older adult with TBI could contribute to lower scores in cognitive domains subserved by the functional integrity of information processing capacity.

Higher scores on abstract verbal skills were associated with injury at an older age. Horn and Cattell (cited in Friedman et al., 2006) distinguished between fluid intelligence which refers to higher mental abilities such as reasoning, and crystallised intelligence which refers to knowledge acquired through education, culture, and other experiences. Patients with frontal lobe damage may evidence more difficulties with tasks requiring fluid intelligence since acquired knowledge is more intact after frontal damage. The Similarities Test is a primary measure of the verbal comprehension factor index which some scholars indicate is more heavily influenced by crystallised intelligence (Rozencwajg & Bertoux, 2008; Ryan, Sattler, & Lopez, 2000). It is postulated that tests that measure fluid intelligence evidence more decline with age than tests that measure crystallised intelligence (Ryan et al., 2000). In a study of 20 young adults and 20 elderly adults without brain injury, Rocenwacjg and Bertoux (2008) found that in the elderly participants taxonomic ability, the ability to categorize items on the Similarities Test, was preserved; however emotionally charged items distracted the older adults more than young adults. This preservation of crystallised intelligence abilities may contribute to the participants in this study who were injured at a later age having better scores on the Similarities Test. In a study of long-term neuropsychological outcomes 23 years after mild TBI, Hessen and colleagues (2007) found that children and adolescents may fare worse than adults in subtle long-term neuropsychological deficits. The authors suggest that younger age at injury may indicate more risk of deficits in the domains of learning, attention, and memory. Therefore, verbal concept formation processes may have been negatively influenced by those injured at younger ages in this sample.

Both depression and TBI, even when independent of each other, are related to cognitive impairment (Baune, Czira, Smith, Mitchell, & Sinnamon, 2012; Keiski, Shore & Hamilton, 2007). Depressed individuals have been found in previous studies to demonstrate worse performance on neuropsychological tests than non-depressed individuals, including on measures of spatial learning, selective attention, memory, executive functions, and processing speed (Baune, McAfoose, Leach, Quirk, & Mitchell, 2009; Doumas, Smolders, Brunfaut, Bouckaert, & Krampe, 2012; Marazziti, Consoli, Picchetti, Carlini, & Faravelli, 2010). In this study cohort, 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 indicating that increasing depression scores were correlated with lower performance on these tests. Therefore, TBI patients with higher levels of depression performed lower on measures of sustained attention, immediate verbal memory span, acquisition, retention, and storage capacities, learning and learning strategies, divided attention, and processing speed.

The SDMT has been found to be useful in screening for depression, and therefore this result is congruent with previous findings on the relationship between the SDMT and depression (Spitz et al., 2014; Sbordone et al., 2007). In a sample of 75 depressed and 103 non-depressed older adults, poorer performance on the SDMT was found to be related to higher levels of depression (Ayotte, Potter, Williams, Steffens, & Bosworth, 2009). Spitz et al. (2014) similarly found in a study of 97 patients with mild to severe TBI that performance on the SDMT was directly related to higher levels of depression and anxiety. In the current study when the variables of duration of PTA, time since injury, and education were included as covariates, the relationship between depression scores and performance on the SDMT oral and written versions remained significant.

Memory deficits in the recall, recognition, and retrieval functions are common both in TBI patients and in individuals with depression, and depression most commonly affects effortful processing such as spontaneous retrieval (Farrin, Hull, Unwin, Wykes, & David, 2003). In the present study, performance on immediate free recall and delayed retrieval tasks was poorer than performance on recognition tasks. When the variables of duration of PTA, time since injury, and education were included as covariates, the relationship between depression scores and lowered performance on the retrieval and recognition trials of the RAVLT remained significant but the relationship between depression and performance on the free recall trial appeared to be influenced by the age at injury and education levels of the participants. Rapoport et al. (2005) found that 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. In a recent study Spitz et al. (2014) corroborate the link between depression and verbal memory deficits. They found higher levels of self-reported depression to be predicted by poorer performance on recall and recognition memory tasks in patients with mild to severe TBI. Studies have also indicated that depression after a TBI affects free recall more than recognition memory in these patients (Keiski et. al, 2007). Unstructured free recall as measured by word list tasks demand processing that requires self-generating strategies and is directly related to frontal lobe integrity. The impaired acquisition hypothesis of verbal memory impairment after a TBI postulates that memory deficits apparent after a TBI are more related to faulty acquisition or encoding, than retrieval (DeLuca, Schultheis, Madigan, Christodoulou, & Averill, 2000).

Time taken to complete the Trail Making Test Trail A and Trail B increased with increased scores on the BDI-II, indicating that higher depression scores are related to slower performance speed. The TMT is a measure of cognitive flexibility, divided attention, scanning, and visuomotor tracking (Lezak et al., 2012). 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. They found that depressive symptoms were more related to slower psychomotor speed and sustained attention difficulties, whereas non-depressed patients with TBI exhibited more complex attention processing impairment. Therefore, on this timed task, depression had an impact on psychomotor speed and attention.

The relationship between depression after TBI and lowered performance on specific cognitive tests is related to current developments in our understanding of how cognition and emotion interact in the brain. Neuropsychological impairments in non-brain injured populations with affective disorders are linked to increased psychosocial difficulties, risk of suicide, and less compliance to psychiatric treatment (Beblo et al., 2011). With the advent of sophisticated neuroimaging procedures, the once established distinction between emotional and cognitive processes in the brain is now being questioned (Cunningham & Kirkland, 2012; Pessoa, 2015). Some evidence exists to suggest that emotion could even be considered a type of cognition and some models divide cognitions such as executive functions into “hot” and “cold” components, the former being processes involving emotion and the latter involving rationality (Fonseca et al., 2012). Pessoa (2015) advances a convincing argument that emotional and cognitive processing in the brain is interdependent and integrated, with emotional processing affecting cognitive processes such as attention, memory and inhibition. Further, cognitive processes have also been found to influence emotional processing through mechanisms such as reinterpreting or changing the amount of attention directed at, emotional stimuli (Ochsner & Gross, 2005). Therefore the labels emotion and cognition are not directly applicable to specific brain processes and regions (Pessoa, 2015). The significant relationships between depression and cognitive impairments highlighted in this cohort with TBI should be further explored in the context of such conceptual developments. The need for integrated rehabilitation after TBI is evident in the results of this study with the high levels of depression in this sample.

One of the limitations of this study was that the sample was tested in English when majority of the sample had a first language that was not English. Language proficiency has been identified as a pertinent factor for improvement in the practice of psychological assessment in South Africa (Laher, & Cockcroft, 2014). The diverse home languages spoken by this sample indicate the difficulties of psychological assessment in home language in South Africa, both in finding suitable assessments developed in these languages or having interpreters that are skilled enough to assess in all of the languages. A further limitation is the lack of control for the impact of lowered motivation in depressed individuals to complete neuropsychological tests, which could have influenced participants' performance.

Conclusion

This study indicates that in a TBI cohort, depression levels are significantly associated with specific neuropsychological performance measures. When clinical and sociodemographic variables were included as covariates, the relationships between neuropsychological test performance and depression scores remained significant for specific domain related tasks, indicating that the lowered performance may be related to the depression itself and not to these sociodemographic or clinical characteristics. Age at injury had contrasting effects, with participants injured at a later age performing better on some domains but poorer on others suggesting that age at injury is an important variable to consider when evaluating various neuropsychological domains. The incidence of depression as measured by the BDI-II is congruent with previous studies indicating that depression is a common occurrence after TBI. This has widespread implications for patient and family counselling, and treatment planning after TBI. Future studies should attempt to isolate the variables that could be linked to decreased depressive symptomatology, including the impact of lowered motivation in depressed individuals and the resulting impact on neuropsychological performance, after TBI in order to inform practice and the planning of interventions. Enhancing our understanding of the relationship between emotional and cognitive aspects of TBIs within the South African population could substantially improve treatment plans, quality of life outcomes and further interventions with TBI patients.

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Table 1:

Neuropsychological Tests	Age at Injury	BDI-II Score
Letter Cancellation	0.53**	--
RAVLT Free Recall	--	-0.43**
RAVLT Retrieval	--	-0.39**
RAVLT Recognition	--	-0.25*
SDMT Written	--	-0.42**
SDMT Oral	--	-0.48**
Similarities	0.35*	--
TMT Trail A		0.31*
TMT Trail B	--	0.30*

Significant Spearman correlations between sociodemographic factors, clinical characteristics, depression and neuropsychological performance

*p≤0.05, **p ≤ 0.01

Neuropsychological Tests	Age at injury	Duration of PTA	Time since injury	Education
RAVLT Free Recall	-0.35 (p=0.129)	-0.41*	-0.39**	-0.41 (p=0.071)
RAVLT Retrieval	-0.42**	-0.31**	-0.38**	-0.35**
RAVLT Recognition	-0.34**	-0.36*	-0.30*	-0.28*
SDMT Written	-0.50**	-0.60**	-0.45**,	-0.43**
SDMT Oral	-0.55**	-0.69**	-0.50**	-0.49**
TMT Trail B	0.42**	0.48**	0.37**	0.36**

Table 2: Partial correlational analyses on the relationship between neuropsychological performance and depression, controlling for sociodemographic factors and clinical characteristics

*p≤0.05, **p ≤ 0.01

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