VISUAL PERCEPTUAL PROCESSING AND OCCUPATIONAL PERFORMANCE IN SOUTH AFRICAN ADULTS WITH TRAUMATIC BRAIN INJURY - A VALDITY STUDY OF THE TEST OF VISUAL PERCEPTUAL SKILL-3.

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Declaration

I, Jane Bainbridge declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Occupational Therapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

[Signature of candidate]

15th day of May 2015

Dedication:

Undertaking this masters project was born of a seed planted by my late father, Don Alborough, who always said “never stop learning”, and with the impetus from ruthless cross examination by Advocate Ravi Padayachee, who fuelled my quest to know more.

Being able to complete this study has been possible only through the loving support and encouragement of my friends and family but in particular, with the patience and understanding of my husband Lance and my beautiful children Luke, Peter, Philip and Rebecca who have endured hours of their mother’s absence and crowding of the dining room table with books and papers and the ever-present computer. My mother Leslie and my mother in law Sheila have been indispensable in their help looking after these children over the several years it has taken me to complete this work. My sister Clare Houston has provided constant encouragement and help with her sharp appraising eye, gentle criticism and welcome help in editing this thesis.

Lastly, but most importantly, the greatest praise goes to Jesus without whom there is no meaning to anything we do.

Abstract

Occupational Therapists use the Test of Visual Perceptual Processing -3 Edition (TVPS-3) to assess clients with Traumatic Brain Injury (TBI) but encounter difficulties as the test is neither standardised in South Africa, nor for adult clients. This study aims to determine the validity of the TVPS-3 for assessing visual perceptual impairment in a sample of South African adults who had sustained TBI and to determine the association with occupational performance competency and values assessed with the Occupational Self- Assessment scale (OSA). Results indicate the TVPS-3 in a South African TBI population to be accurate for sensitivity (80%) and negative predictive value (98%) and can be used reliably as a measure of visual perceptual processing in adult patients with TBI. The z scores on the TVPS-3 account for 20% of the variability seen in the occupational performance competency scores but are not associated with the occupational performance value scores. Although the sample size was relatively small, results of this study show that occupational therapists working with adult clients can use the TVPS-3 confidently to assess residual visual perceptual processing ability. Results also show that reliable associations between clients' performance on this test and their occupational performance capacity in daily activities can be made. This allows occupational therapists to better predict therapeutic and independent living outcomes with far reaching implications for health care provision, access to care and assisted living facilities and appropriate occupational reintegration.

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Operational Definitions

Traumatic brain injury - Brain Injury Association defined traumatic brain injury as an insult to the brain not of degenerative or congenital nature but caused by external force that may produce a diminished or altered state of consciousness, which results in impairment of cognitive abilities or physical functioning. It can also result in the disturbance of behavioural and emotional function" (Uomotor and Uomotor, 2004) (Reed, 2001).

Mild traumatic brain injury is usually clinically classified as those with a history of closed head trauma, a GCS of 13-14/15 and above, and short duration loss of consciousness and post traumatic amnesia (PTA) of less than 24hours (McCrea, 2008).

Moderate traumatic brain injury is usually classified as having a GCS of between 9-13/15, 20 minute to 36 hour loss of consciousness and a PTA of 1-7 days (McCrea, 2008).

Severe traumatic brain injury has a GCS of 5-8/15, loss of consciousness exceeding 36 hours and PTA of more than 7 days (McCrea, 2008).

Visual perception - is the process of receiving, organising and interpreting visual information, requiring sophisticated analysis of environmental factors particularly in contexts in which factors are abstract, novel and/or detailed or in circumstances where important visual information is obscured. (McKenna, et al., 2006) . Warren described visual perception as the process in which the pattern of light falling on the retina is "transformed into images of the surrounding environment that can be compared with stored memories, combined with other sensory input and knowledge and used for decision making" (Warren, 1993).

Cognition: the process of understanding and ascribing meaning to sensory stimuli in order to affect an adaptive response. Cognition and higher intellectual function is mediated by the cerebral cortex. Several sensory deficits including visual, visual perceptual deficits and altered sensory processing can affect cognition (Zoltan, 1996).

Executive function: a set of interrelated skills necessary to maintain an appropriate problem solving set for future goal attainment. It encompasses an array of integrative cognitive functions. It includes the ability to formulate goals, initiate behaviours, anticipate consequences of behaviour, plan and organise actions taking into account the temporal, spatial and topical and logical sequences, and to monitor and adapt behaviour according to task or context (Cicerone, et al., 2000).

Pace - information processing speed, defined in literature as either the time taken to process information or the amount of information processed within a unit of time. (Johansson, et al., 2009)

Flouting – to disobey openly; to treat with contempt (Grosset, 2001) ; to break or ignore (a law, a rule etc.) without hiding what you are doing or showing fear or shame (Merriam-Webster, 2015)

Reliability – a term used to indicate the consistency of scores; an assessment of a tool's ability to measure something in a reproducible fashion (Streiner & Norman, 2008)

Accuracy - **"**diagnostic accuracy (effectiveness), expressed as a proportion of correctly identified patients among the population. Diagnostic accuracy is affected by the disease prevalence." (Šimundić, 2007)

Sensitivity – defined as the capacity of an assessment instrument to yield a *positive result* for a person with the diagnostic condition or attribute of interest (Glaros & Kline, 1988). It is "expressed in percentage and defines the proportion of true positive subjects with the disease in a total group of subjects with the disease. Hence, it relates to the potential of a test to recognise subjects with the condition" (Šimundić, 2007)

Specificity – reflects the capacity of an assessment instrument to yield a *negative result* for a person without a diagnostic condition or attribute (Glaros & Kline, 1988).

It is "defined as a proportion of subjects without the disease with negative test result in total of subjects without disease. It represents the probability of a negative test result in a subject without the condition and relates to the aspect of diagnostic accuracy that describes the test ability to recognise subjects without the condition" (Šimundić, 2007)

Both indices (sensitivity and specificity) are independent of sample size and can be used to represent the external validity of a an assessment tool

Predictive value – the positive predictive value of a test is the likelihood that a person with a positive test finding actually has the predicted attribute or “condition”, whilst the negative predictive value is that which indicates the likelihood of a person not having the attribute .Higher specificity and sensitivity values are associated with higher predictive value (Glaros & Kline, 1988)

Validity – Face validity assesses generally on the surface whether an instrument is assessing the desired qualities whilst content validity considers whether the instrument measures all the important domains. (Streiner & Norman, 2008)

Occupation –one’s chosen profession, career, livelihood or vocation. Choices are often shaped by an individual’s circumstances, beliefs, preferences. It is everything people do to occupy themselves including self-care, leisure and those tasks which promote economic activity (Holmqvist K, 2012) (Baron, et al., 2006)

Occupational therapy – the medically directed treatment of the physically and mentally sick and disabled, using specific tasks and techniques to develop and improve and restore the independent performance of specific functions in all aspects of daily skills, to minimise debilitation (Trombly, 1989)

“Occupational Therapy is a client centred health profession concerned with promoting health and wellbeing through occupation. The primary goal of Occupational Therapy is to enable people to participate in the activities of daily life” (WFOT, 2012)

Occupational Performance- refers to a person’s natural abilities which provide the basis for the execution of skilled performance, allowing for interaction with the physical world, objects, and events within a sociocultural context. (Baron, et al., 2006)

Psychometric tests- a measuring device or instrument, technique, questionnaire or test that assesses intellectual or cognitive ability/functioning, aptitude interest or personality functioning. Although most tests must be administered by psychologists according to the health professions Act, Act 56 of 1974, certain psychological tests can be used by other professionals including occupational therapists an speech therapists, provided that the test has been certified for use by the Psychometrics committee of the Professional Board for Psychology. (Health Professions Council of South Africa, 2010)

Abbreviations

ADL:	Activities of Daily Living
AIS:	Abbreviated Injury Scale
BRISC:	Barry Rehabilitation In patient Screening of Cognition
CT:	Computer Tomography scans
CVA:	Cerebrovascular Accident
DAI:	Diffuse Axonal Injury
ERP:	Event Related Potential
FIM:	Functional Improvement Measure
GCS:	Glasgow Coma Scale,
HPCSA:	Health Professions Council of South Africa
LOTCA:	Lowenstein Occupational Therapy Cognitive Assessment
MMSE -	Mini Mental State Examination
MRI:	Magnetic Resonance Imaging scans
MVA:	Motor Vehicle Accident
NRS:	Neurobehavioral Rating Scale
OSA:	Occupational Self-Assessment
OT APST:	Occupational Therapy Adult Perceptual Screening Test
PTA:	Post Traumatic Amnesia
RAF:	Road Accident Fund
TBI:	Traumatic Brain Injury
TFC:	Time Following Commands
USA:	United States of America

CHAPTER 1: INTRODUCTION

1.1 Introduction:

Visual perceptual processing is important in the development of visual skills used for all visual learning (i.e. reading, assimilating information or applied occupations) and for visual memory which forms the foundation of other higher order forms of visual learning (Goodrich, et al., 2007). Occupational performance of tasks in all aspects of daily life is based upon the visual perceptual processing of information inherent to tasks and the environmental contexts in which these tasks are undertaken. Occupational difficulties affecting the ability to attend to and complete tasks appropriately is of primary concern to occupational therapists, who are uniquely trained in the assessment and treatment of occupational dysfunction, in order to restore as close to normal a patient's ability to regain independent function. Assessment of South African patients who have sustained neurological damage through traumatic brain injury (TBI) is limited by the lack of appropriate cognitive and visual perceptual tools, as these are not standardised in South Africa. There are no standardised visual perceptual tests for a South African TBI population, nor are there any measures which associate visual perceptual dysfunction with occupational performance ability.

Visual perception facilitates functional vision required for active involvement in daily functional tasks, including independent participation in self-care tasks (personal and domestic); educational, occupational and leisure time activities (Cicerone, et al., 2000) (Brown, et al., 2012a)

This profound relationship between visual perception and daily occupational performance of tasks makes assessment of these performance components of particular interest to occupational therapists (Brown, et al., 2012a). Understanding the effects of a traumatic brain injury (TBI) upon visual perception and functional capacity is thus very important in planning treatment outcomes for clients with TBI. Occupational therapists have routinely included visual perceptual assessments in their evaluations of these clients over a 50 year history of practice (Brown, et al., 2012b). This allows for the formulation of intervention programmes to restore functional ability and perceptual skills, as a pre requisite to an overall goal of reaching optimal functional independence after TBI (Cate & Richards, 2000) (Brown, et al., 2009).

Determining the long term negative effects of TBI upon visual perceptual function and daily performance of tasks in clients with TBI helps occupational therapists make accurate predictions about a client's long term independent living and occupational outcomes. This is an essential part of the service offered by occupational therapists in various contexts including acute hospital settings, private practice, occupational health clinics as well as in the medico legal and disability assessment framework. In the latter context, therapists are required to perform assessments of claimants in legal cases to determine the functional consequences of their injuries.

In South Africa a large proportion of claimants present with TBI associated with motor vehicle accidents (MVAs) (Hyder, et al., 2007) (Blamire, 2012) and have recourse to the Road Accident fund (RAF) for damages. The process of claiming from the RAF means that occupational therapists and other medical and psychological professionals are called upon to present their assessments of claimants and defend their opinions in a court of law. In order to provide the court with an impartial opinion regarding future implications for occupation and independent living following a TBI, occupational therapists use outcome measures in determining the implications of the client's injuries. Amongst these measures are standardised tests used to evaluate the visual perceptual skills and functional ability of adult neurologically impaired patients.

1.2 Statement of Problem:

The use of psychometric tests by occupational therapists and their ability to integrate the effect of visual perceptual deficits on the overall functional capacity of the client in personal or occupational contexts is essential. The use of these tests however has not always been satisfactorily accepted when presented in court, as research evidence for these aspects is scarce.

Occupational therapists' opinions are increasingly being sought to quantify the future anticipated costs for care, education and loss of earnings in clients with TBI. Particular emphasis is placed upon the client's capacity to resume his former occupation or something similar, or whether there is potential to be accommodated in alternate avenues of employment. Essential to formulating such opinions and intervention strategies is the exploration of a client's sensory perceptual and functional performance skills which need to be evaluated with standardised assessments.

There are a number of limitations within the South African context related to the use of standardised psychometric tests by occupational therapists. Only a certain number of tests have been certified for use by the Psychometrics Committee of the Professional Board of Psychology of the Health Professions Council of South Africa (HPCSA) (Health Professions Council of South Africa, 2010) . This limits the availability of tests that occupational therapists are certified to administer.

Other challenges that face occupational therapists when using standardised tests within the South African medico legal context are the lack of research on the reliability of tests used in a brain injured population and the lack of validity of these tests for South Africa as there has been no standardisation of such tests on a South African population (Brown, et al., 2010) (Brown & Elliott, 2011a).

Amongst the tests that are used in South Africa as part of the general assessment of clients with TBI for clinical, disability and medico legal purposes is the Test of Visual Perceptual Processing-3 (TVPS -3) (Martin, 2006) (Brown, et al., 2010) (Brown & Elliott, 2011a). It has not been shown whether the test items are culturally or educationally appropriate for South African clients who may have selected incorrect responses which masked their true visual perceptual abilities (Brown & Elliott, 2011a). The test does display adequate psychometric properties and has been shown to identify visual perceptual components in adults but has not been shown to be effective in predicting functional ability (Douglas, et al., 2007). Research recognises the interrelatedness of visual perceptual processing and independent functional ability. Although research findings in various studies have not always identified a significant relationship between the presence of visual perceptual impairment and the level of cognitive and functional impairment following TBI, research has determined that overall there are visual perceptual changes evident in patients with severe TBI when compared to a normative sample. This can undermine functional capacity in daily and occupational contexts (McKenna, et al., 2006). Where occupational therapists work with occupational dissonance between that which the person needs to do and that which he can manage to do (Holmqvist K, 2012), accurate assessment of difficulties residual to TBI is essential to the therapist's ability to make prognostic evaluations concerning return to work, outcomes and independent living ability based on performance on these standardised assessments.

1.3 Purpose of the Study:

The purpose of the study is to determine whether the TVPS-3 can distinguish between adults with and without TBI to determine the validity of this test for use within a TBI population in South Africa. As there is limited literature on the incidence of visual perceptual processing difficulties following TBI in clients in South Africa, this study explores whether visual perceptual processing deficits can be determined by the TVPS-3, in a sample of brain injured adult South African adults. It compares the results to a sample without brain injury to determine the validity and reliability of the test. The study also investigates whether the scores on the TVPS-3 for this population could be associated with functional ability measured by the Occupational Self-Assessment (OSA). This association could be used by occupational therapists to predict anticipated functional difficulties after TBI.

1.4 Aim of the Study

This study aims to determine the validity and accuracy of the TVPS-3, in determining visual perceptual impairment in a sample of South African adults with a history of TBI compared to a sample without TBI. It also aims to determine the association of the TVPS-3 in relation to functional outcomes measured by the OSA for the same sample.

1.4.1 Objectives of the Study:

- To determine the validity of the Test of Visual Perceptual Skills-3 (TVPS-3) in the ability to discriminate between a sample of adult clients with and without TBI in South Africa
- To determine the accuracy of the TVPS-3 as an instrument able to identify visual perceptual processing difficulties in an adult South African population, with and without TBI, by determining the sensitivity, specificity and the prediction value of this instrument.

- To establish the association between visual perceptual processing assessed on the Test of Visual Perceptual Skills-3 (TVPS-3) and perceived competency and values of independent living and occupational performance skills measured on the Occupational Self-Assessment (OSA) test in adult clients with and without TBI.

1.5 Justification for the Study

Use of more standardised tests, appropriate for use in a South African population is necessary in determining the association between the TVPS-3 and client functional outcomes. This will help promote evidence based practice for occupational therapists, in helping determine associations between visual perceptual processing difficulties and functional difficulties in all spheres of life. Visual perceptual dysfunction impacts variably upon all activities of daily living, referred to in the literature as "occupational performance" (Baron, et al., 2006), compromising personal, social, recreational and vocational domains. The pervasive nature of visual perceptual impairment compromises an individual's ability to drive and negotiate his way safely within a community; attend to shopping or banking or community survival tasks; manage his household and domestic matters; engage with others appropriately; undertake recreational activities or work in a variety of jobs in which the processing of visual information is important. Such difficulties highlight the need for predictive measures for function. The predictive nature of the TVPS-3, used in context of TBI patients to predict functional outcomes in all spheres of life – personal, recreational, social and occupational, is important in the first instance for optimal rehabilitation and reintegration into a community , family, occupation appropriate for the patient. Secondly, the predictive qualities of the TVPS-3 are important for the quantification of future costs for rehabilitation, medical intervention, care, occupational intervention and financial support. Similarly within a medico legal or insurance / disability claim for loss of earnings and future medical costs, offered as part of a settlement claim or undertaking as with the Road Accident Fund, the prediction of occupational outcomes for a TBI patient is important.

1.6 Summary:

Visual perceptual processing skills are recognised as being important in the daily execution of activities particular to an individual's independent living, otherwise termed occupational performance. There are few readily available assessment tools to occupational therapists in South Africa for the assessment of these skills, with an associated predictive value for occupational performance. This study proposes to determine whether the TVPS-3 can differentiate between adult South Africans with and without TBI, to determine this instrument's validity for use within a TBI population in South Africa, and to predict functional outcomes in all occupational spheres as identified in the Occupational Self-Assessment.

CHAPTER 2. LITERATURE REVIEW:

2.1 Introduction

This chapter will review the literature on the classification and incidence of traumatic brain injury (TBI) as well as visual perception and how this relates to TBI. The assessment of TBI and the effects of visual perceptual processing deficits upon occupational performance will also be considered.

2.2 Traumatic Brain Injury:

Traumatic Brain Injury (TBI) is commonly defined as an induced head injury as compared to other pathologies resulting in brain damage such as cerebrovascular accidents (CVAs); dementia or aneurysm. Traumatic brain injury is properly defined as separate from the old fashioned term "head injury" which pertains rather to external injuries to the head. It refers to altered brain function which presents inter alia as altered level of consciousness, coma, focal neurological deficit of sensory or motor type, confusion and disorientation, secondary to blunt or penetrating force to the head (Bruns & Hauser, 2003). Traumatic brain injury may result from skull penetration (knife wound; gunshot) or from rapid acceleration-deceleration of the brain resulting in tissue damage at the point of contact with the skull in a contra coup pattern (anterior and posterior poles) and along temporal and frontal lobes. Such impact causes tissue damage, intra or extra cerebral ischaemia, haemorrhage, cerebral oedema and internal neuronal circuitry disruption, crucial to an individual's sensory motor and cognitive functioning (Aguerrevere, 2007) (Reed, 2001). Literature shows that TBI from assaults and MVAs are usually of greater severity than all other aetiologies combined (Bruns & Hauser, 2003)

The overall impact of TBI on individuals, their families, communities and South Africa as a whole is largely unknown. Even international data on the epidemiology of TBI is difficult to obtain and interpret. This is in part due to the non-uniformity of the definition for TBI, the use of various methodologies in research, the completeness of case findings and the reporting thereof (Koskinen & Alaranta, 2008). Traumatic brain injury is regarded globally as one of the most significant problems to face the public health systems in industrialised nations worldwide. TBI is anticipated by the World Health Organisation to surpass any other disease in being the lead cause of death and disability worldwide by 2020 (Fraser & Clemmons, 2000) (Bruns & Hauser, 2003)(Langlois, et al., 2006) (Hyder, et al., 2007) (McCrea, 2008) (Centres for Disease Control and Prevention, 2010) (Kinnunen, et al., 2011) This is expected to be especially prominent in low to middle income countries which face a higher grouping of risk factors and inadequate health systems to cope with the burden TBI places on medical facilities (Hyder, et al., 2007).

2.1.1. Incidence and Aetiology of Traumatic Brain Injury

International statistics conservatively estimate the incidence of TBI to be 200/100 000 people per annum. In developing countries like South Africa, in which statistical data is scarce, the incidence could be between 1.5 and 3.5 times higher than the global estimate (Hyder, et al., 2007) (Bryan-Hancock & Harrison, 2010). South African statistics in 2009 reported approximately 89 000 new TBIs every year (KwaZulu-Natal Department of Health, 2010)

Internationally, 40-60% of all TBIs reported annually are related to MVAs, indicative of its effects on an economically active population. All forms of vehicular transportation are regarded as common causes of TBI, including motorcycles, bicycles and pedestrian accidents. Countries like South Africa with a higher usage of formal public transportation report a lower rate in the 30% range

Table 2.1 Causes of Traumatic Brain Injuries in three countries.

Cause of TBI	United States of America	South Africa	Finland
Motor vehicle/pedestrian/bicycle accidents	17.3%	>50% to 16%	
Falls	35.2%	25%	62.1%
Violence	10%	20%	3.2%
Struck by/struck against	16.5%	11.7%	
Unknown	21%		7%

(KwaZulu-Natal Department of Health, 2010) (Koskinen & Alaranta, 2008) (Centres for Disease Control and Prevention, 2010) (Nell & Brown, 1992)

People most at risk of TBI are between 15 years and 24 years. This is a critical time of skill acquisition. Damage to frontal brain regions is frequently reported following TBI and is believed to be associated with deficits in memory, attentional abilities and executive function as well as affective changes as identified in a study by (Power , Catroppa , Coleman ,Ditchfield and Anderson(2007). South African statistics for TBI show three common causes, ranked in order of importance, as compared to American and Finnish statistics (Table 2.1).

Gender is regarded as another significant factor in an individual's risk of TBI. Approximately double the incidence occurs amongst males rather than females, particularly in adolescence and young adulthood (McCrea, 2008) (KwaZulu-Natal Department of Health, 2010) (Centres for Disease Control and Prevention, 2010) (Koskinen & Alaranta, 2008) (Bruns & Hauser, 2003). South African statistics from a study done by Nell and Brown (1992) showed the highest overall ratio between genders exceeding 4:1, largely attributable to interpersonal violence and motor vehicle collisions (Nell & Brown, 1992).

Additionally shifting demographic factors alter the aetiology of TBI within communities, as they become more or less economically active, engage new forms of transportation and/or are exposed to socio economic factors such as poverty and crowded living circumstances. Lower socioeconomic groups are regarded as being more at risk of violent crime and assault. The abuse of alcohol and drugs is also a common factor in TBI (Langlois, et al., 2006) (Hyder, et al., 2007). The high incidence of TBI in South Africa is attributed in large part to the high rates of violence and exceptionally high incidence of MVAs. It is thought of as a hidden epidemic of intentional and non-intentional injury within a context of poverty, socioeconomic inequality, rapid urbanisation and unequal access to adequate health care (Goosen, Bowley, Degiannis and Plani, 2003) (Levin, 2004). The use of explosive devices has increased the incidence of TBI, regarded as the mechanism in which visual pathways are damaged, in addition to damage to the visual cortex and to areas controlling memory, cognition, motor control and emotion (Goodrich, et al., 2007).

2.2.2 Traumatic Brain Injury Classification:

In order to determine the effect of TBI, it is necessary to understand the severity of the TBI. This is determined by classifying TBI along a continuum of mild or concussive brain injury to moderate brain injury to severe brain injury. The acceleration deceleration and rotational forces responsible for TBI induce a complex neuro-metabolic cascade which include microscopic damage to neuronal, axonal and vascular systems (Lachapelle, et al., 2008).

The determining diagnostic criteria for the severity of TBI are usually threefold – the level of consciousness measured by the Glasgow Coma Scale (GCS), rated out of 15; the period of loss of consciousness and the presence and period of post-traumatic amnesia (McCrea, 2008) The GCS assesses gross neurological status in three key areas of motor function, including response to pain or noxious stimuli, ability to obey verbal command; verbal response and the patient's ability to open their eyes voluntarily or in response to command or stimuli (McCrea, 2008).

Table 2.2. Classification criteria for Traumatic brain injury

Severity Classification	Glasgow Coma Scale	Loss of Consciousness	Post Traumatic Amnesia
Minimal to Mild	15 14-15	None Brief (<20minutes) LOC ; altered alertness, impaired memory	None Amnesia less than 24 hours
Moderate	9-13	Longer than 20 minutes to 36 hours, focal neurological deficit	Amnesia lasting 1-7 days
Severe	5-8	Exceeding 36 hours	Amnesia exceeding 7 days
Critical	3-4	Coma- persistent vegetative state	
Death	Fatal injury		

(McCrea, 2008)

The change in GCS scores between the field and arrival at an emergency room is regarded as highly predictive for outcome. Scales such as the GCS are thought to depend largely on the criteria susceptible to the more severe forms of TBI and are regarded as somewhat limited in accurately classifying the more subtle neurological conditions including mild traumatic brain injury (Meythaler, et al., 2001) (McCrea, 2008) . Literature suggests, however that the Glasgow Coma Scale may be a more accurate indicator of midbrain and brain stem injury than cortical injury, and therefore a more accurate predictor of outcome regarding diffuse axonal injury (DAI) than other radiological measures to determine cortical contusion. (Meythaler, et al., 2001)

Studies have shown that participants who had longer periods of unconsciousness and associated brain atrophy fared worse than those with only anatomic indices, whilst those with lengthy periods of loss of consciousness and anatomic indices fared worst of all. (Mackenzie, et al., 2002) (Povlishock & Katz, 2005). Early identification of TBI victims at high risk of long term morbidity was regarded as important in preparing family members for long term expectations, service provision and resource allocation (Mackenzie, et al., 2002).

2.2.2.1 Severe Traumatic Brain Injury

Statistically, 43% of patients with severe TBI have residual disability one year post injury (Centres for Disease Control and Prevention, 2010). Disability affects several domains of function. Studies using a Neurobehavioral Rating Scale (NRS) showed that patients produced high scores some six to twelve months post TBI for anxiety, expressive deficit, emotional dysregulation and depression, suspicion, fatigue, motor retardation and comprehension. Although sensory motor systems showed improvement after twelve months, and factors such as inattention, disorientation, planning and articulation improved within a six to twelve month period, data showed that generally deficits did not disappear post severe TBI. Self-appraisal, conceptual origination and affect were thought to even deteriorate over time, posing adaptive difficulties for patients and their families. (Lippert-Gruner, et al., 2005) (Power, et al., 2007)

2.2.2.2 Moderate Traumatic Brain Injury

Moderate TBI is classified with a Glasgow Coma Scale between 8 and 13, and is regarded as having far reaching consequences. Whole brain atrophy is considered to occur following moderate and even mild TBI, evident at eleven months post trauma. Such clinical radiological findings provide a platform to understand the aetiology of persistent or new neurological deficits occurring post injury (Mackenzie, et al., 2002). Persistent deficits present in 10-67% of the TBI population following mild to moderate head injury, suggest a strong correlation between TBI and existence of persistent deficits, which to date have remained understated and underestimated. The study by Mackenzie, Siddiqi and Babb, Bagley, Mannon, Simson and Grossman (2002) suggested that parenchymal cellular loss be the cause of the brain atrophy and that patients who suffered a loss of consciousness had a greater loss of volume. Consequences of parenchymal loss at the time of the study in 2002 were unknown but were viewed as having detrimental effects upon neuropsychological function (Mackenzie, et al., 2002) (Lachapelle, et al., 2008).

2.2.2.3 Mild Traumatic Brain Injury

Mild TBI represents an estimated 80-90% of emergency room diagnoses up to 15% of mild TBI cases are regarded as having long term functional difficulties due to persistent symptomatology (Lachapelle, et al., 2008). Although controversial, the correlation between TBI and persistent deficits suggests that even mild head injury may have greater consequences than originally thought. There is usually global functional improvement in early stages post TBI but a growing body of evidence in animal and human studies shows that information processing deficits do occur after mild TBI, extending beyond the acute recovery period to about three months post injury (Lachapelle, et al., 2008). Neuropsychological testing of individuals with mild TBI produce mixed results - some yielded no identifiable neurocognitive deficits whilst others show affected performances in various cognitive domains, particularly in the speed of information processing. Electrophysiology and neuro-imaging measures have made possible the detection of subtle deficits not detected using conventional scan methods. More specifically, recent studies involving complex event related potentials (ERPs) associated with the primary analysis of visual input necessary for object recognition, suggest that individuals with mild TBI could present with dysfunctional complex visual perceptual integration (Lachapelle, et al., 2008).

Post TBI complex visual processing deficits have previously been strongly correlated with global functional outcome. The results of a particular study designed by Lachapelle et al (2008) to correlate the return to work following mild TBI found only 41.2% of people returned to active work-related activities following rehabilitation interventions. Of those who did not return to work, 80% demonstrated marked ERP latency abnormalities whilst those that returned to work had a 14.3% latency abnormality rate. This suggests that those individuals, who on electrophysiological studies show latency abnormalities, are at significantly higher risk of not resuming active vocational function. This would be due to interplay of factors including severity of injury, residual post injury features, global cognitive functioning and perceptual functioning (Ownsworth & McKenna, 2004). Timing deficits were found to be the most prevalent in impacting on higher level functional activities such as work and which cause slow execution speed, confusion or wrongful interpretation of visual perceptual information and compromised work productivity (Lachapelle, et al., 2008).

Justification of deficits in mild TBI can be related to the neuropathology of TBI: acceleration – deceleration injuries and rotational forces present at the time of the trauma produce microscopic tearing of cellular bodies and cerebral axons. Frontal regions are compressed and posterior regions are stretched following mild acceleration, resulting in the deterioration of complex visual information processing requiring higher level processing (Lachapelle, et al., 2008). The authors of this study highlighted its usefulness in determining intervention strategies for individuals with mild TBI as well as for evaluating overall prognosis and assessing cerebral recovery. It is also useful in promoting early intervention to reduce the impact of difficulties processing information, thus minimising the social, economic and personal costs of sequelae following mild TBI. This is of particular importance to occupational therapists who are integrally involved in the multidisciplinary team responsible for the acute assessment and treatment of TBI patients, in order to optimise intervention strategies, inclusive of caregivers; and plan longer term follow up management and reintegration strategies for patients returning to their homes, social and leisure contexts and to work. The occupational therapist is regarded as primarily responsible for the interventions which address the consequences of cognitive impairments in occupational performance. Despite occupational therapy interventions being recognised as effective, there is insufficient detail pertaining to the therapeutic strategies used (Reed, 2001) (Holmqvist K, 2012).

2.2.2.4 Diffuse Axonal Injury

Diffuse axonal injury (DAI) is commonly diagnosed in patients with TBI. It is a misleading term as it affects discrete areas of the brain, rather than the whole brain, secondary to high speed, long duration acceleration/deceleration injuries. It is a consistent feature of TBI following motor vehicle accidents or transportation injuries (Meythaler, et al., 2001) (Smith, et al., 2003). DAI occurs when shearing forces are applied to the axons in the brain ; these forces usually affect axons in the brain stem, parasagittal white matter of the cerebral cortex, corpus callosum and in the grey – white matter junctions of the cerebral cortex. Axons in the white matter are regarded as susceptible to damage due to their viscoelastic properties and although generally supple, are brittle. A more recent study by Kinnuenen, Greenwood, Powell, Leech and Hawkins (2011) suggests that new Diffusion Tensor Imaging is a valid and sensitive means of determining the extent of DAI associated with diffuse white matter damage (Kinnunen, et al., 2011) (Smith, et al., 2003). Whilst not necessarily demonstrable on MRI or CT imaging done immediately post injury, DAI is referred to in some tests as the "stealth pathology" of TBI, microscopic damage making it nearly invisible to imaging techniques. Literature suggests that the Glasgow Coma Scale may be a more accurate indicator of midbrain and brain stem injury than cortical injury. It GCS would therefore be a more accurate predictor of outcome regarding DAI than other radiological measures to determine cortical contusion determining the extent of DAI (Meythaler, et al., 2001).

Although difficult to detect non-invasively, DAI is demonstrable histologically with micro pathological and radiological findings as well as medical and neuropsychological complications. It is regarded as the predominant mechanism of injury in 40-50% of TBI's requiring hospitalisation in the USA. It is consistent in all patients who have lost consciousness immediately following a MVA (Meythaler, et al., 2001) (Smith, et al., 2003) Regarded as a major cause of disability DAI is frequently missed in diagnostic work-ups (Meythaler, et al., 2001) (Blamire, 2012). It is critically associated with visual perceptual dysfunction, persistent memory and executive deficits following TBI.

Impaired visual perceptual functioning following TBI is regarded as a significant cause of disability and is often the most persistent and prominent sequelae of TBI in moderate to good neurological recovery (Cicerone, et al., 2000). Studies suggest that the number of persons with long term problems post injury is not dependent on the severity of the injury alone. There are opposing opinions regarding the extent to which deficits recover over time. Recovery is often affected by the interplay of factors including neurobiological, psychosocial and legal, which may mask true disability (Blamire, 2012).

A study conducted three to five years post TBI by Dikmen, Machamer, Powell and Tempkin (2003) identified the need to better understand the nature and magnitude of injury related disability in order to determine, more appropriately, the needs of TBI victims; project economic costs and draw national attention to the allocation of resources in order to provide appropriate services (Dikmen, et al., 2003).

Irrespective of the severity of the TBI, Cohen (1999) emphasises the inextricable link between structure and function, noting that anatomy allows for physiological function (Cohen, 1999) Moreover, the organisational concept of the nervous system is geared towards adaptive behaviour of the organism's individual cells and organs in general, and of the human being in particular, to elicit purpose driven activity. Such activity is regarded as goal directed and allows for adaptation to environmental change mediated through learning.

The brain, spinal cord and peripheral nervous system acts as a large mechanism to effect behavioural control (Cohen, 1999). Humans are able to adapt responses and behaviour to altered environmental demand as their physical capabilities change. Thus, individuals who have suffered anatomical or physiological injury to their nervous system through TBI have altered adaptive abilities and are in need of rehabilitative intervention where the process of restoration is facilitated and adaptation is taught (Cohen, 1999) (Cicerone, et al., 2000) (Brown, et al., 2012a).

2.2.3 Sequelae of Traumatic Brain injury

Although the number of people living with TBI related disability is not known, the related disability and the consequences thereof as indicated above, can include a dramatic change in the individual's life course. Advances in modern medicine mean more people are surviving TBI, returning to their communities and are living with significant disabilities which compromise their return to work and independence in other occupational areas

(Cicerone, et al., 2000) (McCrea, 2008). This also results in profound changes in their family’s function, enormous loss of income and earning potential and costly lifetime expenses (Koskinen & Alaranta, 2008). Such expenses are reflected as costly to a country’s medical services in direct expenditure for hospital care, extended care and other medical services, in addition to compensation for work loss and injury related disability payments. (Aguerrevere, 2007)

Literature reports that the South African systems are inadequate to cope with this burden TBI places on medical, social and development facilities making the societal impact of TBI even more onerous (Wedcliffe & Rose, 2001) (Goosen, et al., 2003) (Levin, 2004). The disparities in socioeconomic status, sociocultural factors and disparate educational systems make the management of TBI in South Africa more difficult and challenging than elsewhere in the world. Levin (2004) suggested that the access to medical and rehabilitation intervention through public health systems and inadequate access to public legislative compensation compromises optimal management of TBI patients (Levin, 2004). This burden is also compounded in developing countries such as South Africa where pre-hospital care, acute emergency care and rehabilitation services are in short supply. This is made more difficult by the distances many people find themselves from public health facilities and the time taken to access such (Goosen, et al., 2003). Moreover, patients with DAI or mild brain injuries may have not been properly diagnosed and are overlooked, making successful reintegration into daily life understandably difficult (Thurman, et al., 2007). Such difficulties would have a negative impact upon autonomous execution of occupational performance in all activities of daily living (ADL) (Krefting & Johnson, 1990). Physical and/or cognitive deficits would compromise productivity in personal management, community survival skills, home management and work related activities. They would undermine interest or ability to pursue leisure time pursuits and compromise interpersonal relationships (Watt & Penn, 2000) (Reed, 2001) (McKenna, et al., 2006).

Functional compromise following TBI may include sensory motor dysfunction, affecting muscle tone, reflexes, mobility, coordination and balance. It may result in dysarthric speech, slurring, heighted physical fatigue and reduced endurance. Psychosocial compromise includes agitation, aggression or passivity, confusion and disorientation, anxiety and altered mood control, sexual dysfunction and compromised reactivity within interpersonal relationships. These would significantly compromise relationships between parent and child and marital relationships, highlighting the need for therapeutic intervention (Krefting & Johnson, 1990) (Wedcliffe & Rose, 2001) (Reed, 2001). Diffuse axonal injury, in particular, is associated with visual perceptual dysfunction, persistent memory and executive deficits following TBI.

Cognitive dysfunction manifests as altered attentional skill, distractibility and executive dysfunction (initiation, sequencing, completion of tasks). It alters memory which then affects learning, acquisition of new skills or the inability to recall old skills. Cognitive dysfunction results in reduced judgement, reasoning, critical thinking and receptive language difficulty. Rainer Cheung, Yeung and Graham (2007) concluded that one third of patients with TBI showed substantial impairments of their cognitive abilities, with attentional and executive abilities regarded as mildly affected (Rainer, et al., 2007). Memory disturbances were however frequent and in half of these patients, memory impairments were rated as moderate to severe (Scheid, et al., 2006). A central aspect of cognition is the processing of information through sensory perceptual memory, supporting short term memory which in turn serves long term memory. Cognitive performance is thus regarded as a dynamic interaction of multiple factors including inherent processing capacity, a person's context, self-awareness, regulatory ability and processing strategies. These processing strategies include visual processing, attention, organisational abilities and problem solving (Kielhofner, 2009). Whilst cognitive dysfunction is highlighted in literature as including difficulties at various levels of function, specific difficulty with visual perceptual processing has been identified.

The assertion and conceptual framework of visual perceptual skill being hierarchically ordered suggests that these skill levels interact and sub serve one another. Higher skill levels are thus underpinned by lower visual level skills. Aspects of vision including oculomotor control, visual field and acuity form the foundation skills. These are followed by visual attention, scanning, pattern recognition, memory and visual cognition. The integrity and interaction of each skill is at risk of compromise through TBI, with an associated knock on effect upon daily living function (Zoltan, 1996).

2.3 Theories of Visual Perception:

To understand the deficits in visual perception that occur in patients with TBI it is essential to understand the theories which support this process. At the most primary level of skill is the registration of visual input through oculomotor control, visual fields and visual acuity. This is followed by visual attention, organised scanning and pattern recognition, upon which visual cognition, as the end point and highest level of visual skill integration, is based. Any disruption of or dysfunctional lower order processing will influence the person's ability to cognitively adapt to a situation (Zoltan, 1996)

Current perceptual theories recognise that visual perception is influenced by and, in turn, influences cognition. Visual perceptual processing is complex and involves the cognitive interpretation of visually perceived information from the environment, which is selectively extracted and organised. Underpinned by the highly complex visual system, visual perception is recognised as a sophisticated interpretative and adaptive process upon which independent function within environments is reliant.

2.3.1 Vision and Visual Processing

Vision is an important pre requisite to perception and cognition and influences both motor planning and postural control. Vision allows the anticipation of information in order to adapt to our environment . Visual deficits impact significantly upon ADL, reading, driving and hand- eye coordination. Without appropriate visual function, rehabilitation processes are adversely affected (Zoltan, 1996) (Goodrich, et al., 2007)

Warren (1993) highlighted the importance of visual systems, including oculomotor control, acuity and fields, being primary lower level visual perceptual skills upon which higher order skills are based (Warren, 1993). Vision is a special sense and is regarded evolutionarily as having three primary uses – watching moving or stationary objects as a potential food source; maintaining appropriate posture and recognising own position in space. The similarity in function to that of the vestibular system suggests a close physiological relationship and has obvious survival value for both lower order animals and humans (Cohen, 1999)

The visual field is the amount of information one can see at any time without eye movements. Organisation of the visual field is resultant on the anatomy of the visual pathway. Central to this are the retinas which are considered to be divided into superior and inferior quadrants according to an imaginary vertical line dividing nasal from temporal retinal halves and an imaginary horizontal line dividing the field into superior and inferior halves. Elements of each quadrant are representative of the visual fields opposite to them in the physical world. Visual acuity is regarded as the end product of integration of optical systems of the eye and central nervous system, without which effective spatial resolution is impossible (Cohen, 1999).

Difficulties with distance vision will alter ability to judge space; recognise faces and process depth perception. Near vision defects compromise reading, writing and other close work function. Similarly, visual field deficits are regarded as having a diverse impact upon function affecting reading, location of objects, visual memory and dressing. Deficits are dependent on the area and size of lesion and may include homonymous hemianopia, quadrantopia and scotoma (areas of decreased sensitivity) (Cohen, 1999)

Goodrich Kirby, Rotherham, Ingalla, Lew (2007) emphasised that although the eyes encompass only 0.25% of the body surface area, studies have shown that eye injuries are 20-50 times greater than would be predicted according to their relatively small size. They stressed that knowledge of the mechanism of visual loss and its possible interaction with brain injury is essential to effective rehabilitation. In practise, financial restrictions limit appropriate visual assessment and there abounds a belief that central visual disorders do not require treatment and they are thus overlooked. Contrary to this view is that which holds that whilst selected rehabilitative activities do not restore vision, they do increase independent function and perceived quality of life (Goodrich, et al., 2007).

Literature describes a conceptual hierarchy of visual skills from primary visual skills to attention scanning, pattern recognition, visual memory and visual cognition to achieve the highest level of function. Damage to the integrity and function of visual function at any of these levels through TBI will impact upon daily function and is regarded as extremely disabling, as most people rely on vision to orientate to and interact with their environments. Loss of vision or visual impairment causes disorientation, as up to 90% of spatial information is related to vision (Zoltan, 1996) (McKenna, et al., 2006). Visual perceptual dysfunction is “one of the most common devastating residual impairments of head injury” (Politzer, 2008).

Zoltan (1996) stresses the importance of therapists determining where in the visual hierarchy performance breakdown exists, evaluating the conditions which cause the breakdown in adaptation and identifying the changes which can be implemented within the task and environment to facilitate improved performance. As the impact of visual processing deficits is far reaching, intervention needs to be implemented in the early phases of rehabilitation (Zoltan, 1996).

Visual processing occurs through two modes – *focal vision* focuses attention on important features of an object for perception and discrimination. *Ambient vision* works in an interconnected manner with the proprioceptive, kinaesthetic, tactile and vestibular systems in a feed forward mechanism and is responsible for the initial stabilisation of the visual field. Ambient vision allows for the detection of events in the environment. It locates one in space and monitors the verticality and relationship to one’s body orientation. Ambient vision influences functional mobility. The visual deficits often residual to TBI are regarded as being due to the ambient process being disrupted from organising spatial information with the other sensory systems, in turn compromising the focal process (Zoltan, 1996)

Successful intervention requires that both systems work together in an integrated manner with other sensory motor systems in general and the proprioceptive system in particular (Zoltan, 1996). The concept of visual processing being arranged in a hierarchical manner has been upheld in literature and is viewed as an interactive product of both bottom up and top down processing, with vision and visual perception viewed as a holistic unified process used by the central nervous system to adapt to environmental stimuli.

2.3.2 Visual Perception:

Visual perception is the process of receiving, organising and interpreting visual information. This requires a sophisticated analysis of environmental factors, particularly in contexts in which factors are abstract, novel and/or detailed or in circumstances where important visual information is obscured (McKenna, et al., 2006). It is thus recognised as the essential ability to interpret information in the environment, upon which many daily activities depend (Martin, 2006) (Brown, et al., 2012a). This premise suggests that the recognition of objects necessitates the continual interplay of comprehension and visual perception in order to organise and interpret what is seen (Colarusso & Hammill, 2006) Visual perception is recognised in current literature as being influenced by and in turn having an influence on cognition (McKenna, et al., 2006) (Holmqvist K, 2012). Cognition and perception have historically been related on a continuum of function – perception being responsible for the immediate appreciation of sensory data, and cognition being responsible for the more abstract reflective processing resulting in the intention to act and formulate an action plan (Kielhofner, 2009).

One of the most basic principles of visual processing in the brain is the division between ventral and dorsal visual streams. The ventral stream originates in the primary visual cortex and extends along the ventral surface to the temporal cortex. The dorsal stream travels from the primary visual cortex to the parietal cortex (Hebart & Hesselmann, 2012). The ventral stream is termed the "vision for perception" pathway, whilst the dorsal stream is associated with "vision for action". The ventral stream sub serves the ability to discriminate and recognise visual objects and shapes, pattern, texture and colour. This system allows us to understand surroundings, lay down visual memories and formulate action plans based on past experience (Schenk & McIntosh, 2010). The dorsal stream however, is concerned with the visually guided reaching and grasping ability. It is guided by immediate analysis of the shape, orientation and spatial location of objects and plays a role in tool recognition and use. This allows for intentional use of objects through the activation of those brain regions able to execute actions and is integral to the fundamental premise of occupational training and skill acquisition inherent to occupational therapeutic intervention post TBI. The study by Hebart and Hesselmann (2012) identified that the brain appears to recognise shape attributes rather than category attributes and lends weight to the theory that the ventral and dorsal pathways are closely related and interconnected, although separate. The study strongly indicated the need for further work necessary to understand better the contribution of ventral visual regions to dorsal processing (Hebart & Hesselmann, 2012). Schenk and McIntosh propose that there is no absolute distinction between the visual attributes analysed by the two cortical streams, as both streams process information in different ways, determined by their behavioural goals. The ventral stream is regarded as that which is responsible for the capturing of visual representations for visual memory, higher cognition and the embellishment of visual awareness (Schenk & McIntosh, 2010) supporting the idea that complex cognitive processing is essential to convert retinal images to meaningful three dimensional ones, synonymous with the outside world.

In 1969, researchers Chalfant and Schefflin defined and categorised visual perceptual abilities into five categories including visual discrimination, visual spatial relationships, visual memory, visual figure ground and visual closure (Chalfant & Scheffelin, 1969). These areas represent theoretical constructs of visual perception that continue to be used in modern literature and are recognised as clinically significant. There appears to be an inter-relatedness and interplay between the broad definitions of these visual perceptual skill areas, summarised by Martin as “not merely a collection of discrete independent processes, it is the interpretation and organisation of what is seen” (Martin, 2006).

The differentiation of types of visual perception is used to describe function and difficulties a person may have with aspects of visual perception. It is held however that the categorisation of skill is artificial and does not represent real operation of visual perceptual skill in normal persons. Visual perceptual constructs are regarded as “inseparably meshed in individuals”, supported by early research work by pioneers in the area showing high correlations between scores for visual perceptual subtests. Martin argues that visual discrimination is the basic underlying ability influencing all types of visual perceptual processing (Martin, 2006).

2.3.2.1 Visual Discrimination

This is concerned with the ability to discern attributes from one another and is essential to the identification of differences between stimuli. Being able to distinguish between forms allows successful environmental interaction, playing an important role in the identification of different objects and in navigating in the environment. It is theorised that visual discrimination is accomplished by two processes and two distinct systems. The first system, called the Abstract Visual Form system, is thought to process abstractly recognised forms. The second system, termed the Specific Visual Form System processes more acutely the different types of the same form. The Abstract Visual Form system is regarded as that which is utilised when visual form information should be stored and processed in a non-specific manner (i.e. scanning for a general item rather than a preferred item), in contrast to the Specific Visual Form System which produces specific visual representations, enabling one to distinguish specific items from items of the same type. A disorder in form perception results in an inability to attend to the subtleties of form variance and functionally results in mistakenly substituting one item for another (Zoltan, 1996)

2.3.2.2 Spatial Relations

Spatial relations are important to orientation in the environment, recognising objects, scenes and language. The importance of spatial attention is regarded as key to spatial relations, involving the coordination of perceptual representations of space (objects on surfaces) and conceptual representations of space (language describing space – above/ below/next to). Visual perception is inherently spatial. Spatial relations require that the individual has an established body concept and scheme in order to provide a stable point of origin form which to interpret the relationship of objects in the environment to others and to self.

Successful navigation in the world requires an “integrated viewpoint dependant representation of the world" (Zoltan, 1996), the viewpoint acting as a preserver of environmental information and the relationship of objects in relation to the individual. In order to establish such a viewpoint, the individual must have adequate depth perception, 3D perception of forms and appropriate integration of form information. Additionally spatial working memory is required to hold the information sufficiently long enough to plan future movements. Cognitive mapping, achieved through the mental representation of information, is achieved through active seeking of information and the internalisation of information allowing for recognition of landmarks and surrounds.

2.3.2.2 Visual Memory

Visual memory relates to one’s ability to internalise and recall visual attributes particular to a certain item and apply this knowledge over time in order to recognise the item or part thereof again. Memory is defined as a function which relates to learning and the perception of our world. It is essentially perception which is stored at an earlier time and then can be brought forward (Zoltan, 1996). Memory requires constant interaction with the environment, central nervous system change, maintenance of change and an output that consistently relates to the stimulus. It requires the processing of sensory information to trigger sensory perceptual memory in order to build and retrieve from short and long term memory (Kielhofner, 2009). Various types of memory influence successful functional ability. TBI patients often lose the ability to automatically rehearse or encode information, affecting their ability to learn from past errors. Additionally they have difficulties with meta-memory, preventing them from remembering to remember a task. Visual sequential memory is regarded as more advanced and representative of executive function (Martin, 2006).

2.3.2.3 Figure Ground Perception

Figure ground perception allows one to distinguish between foreground and background. The foreground is that part of the visual perceptual field which is the focal point of the individual's attention at any given time. Separation of figures from the background relies on the visual system recognising the differences in texture or motion, depth, orientation and temporal information. This higher level of perception (Martin, 2006) allows for an individual to organise their environment layout, hence any difficulty with figure ground perception will result in difficulties operating in an environmental context for function (e.g. finding an item in a cupboard; selecting a grocery item off a shelf) and will ultimately affect an individual's ability to perform self-care tasks. It is considered that figure ground perception is reliant on visual memory, allowing for recognition of an object or shape before figure ground organisation is actually complete. Research has termed this "perceptual recognition processes" (Zoltan, 1996). Other research has highlighted the importance of "fixation location", allowing for figures to be separated from their backgrounds pre attentively and suggests that this skill exists separately to the inputs from pre figural shape recognition.

2.3.2.4 Visual Closure

Visual closure refers to the ability to identify a whole figure when presented with only part thereof and is regarded together with figure ground perception to be one of the two more complex forms of visual perception which develop last (Martin, 2006). Literature has demonstrated that subjects, post TBI, demonstrate visual perceptual and cognitive deficits.

2.4 Visual perceptual dysfunction following traumatic brain injury:

Dysfunction can occur in any of the visual, visual processing and visual perceptual aspects described above after TBI. Vision dysfunction is commonly seen in patients post TBI. A retrospective study of 160 patients identified visual dysfunction in 90% of subjects, the most common of which was binocular vision dysfunction (56.3%), oculomotor anomaly (51.3%), accommodative dysfunction (41.1%), strabismus (25.6%) and cranial nerve palsy (6.9%). Other vision abnormalities include myopia, visual perceptual dysfunction, visual motor dysfunction, visual field defects, unilateral spatial inattention and visual vestibular dysfunction (Tong & Zink, 2010) .

Deficits in body scheme are also seen and are regarded as resulting from a “loss of knowledge of the position of body parts and the spatial relationships between them" and usually comprise right/left differentiation difficulties (McKenna, et al., 2006). Severe unilateral neglect develops in patients post TBI with right hemispheric lesions whilst less severe forms of neglect relate to either right or left hemispheric lesions. The development of spatial relations is thought to require a “spatial indexing" process, allowing the selection of an object in the perceptual representation and corresponding this to the conceptual representation. Within this category is topographical disorientation which causes a person to become lost in space, confusing relationships of one place to another (Zoltan, 1996).

Visual agnosia is the inability to recognise familiar objects in the absence of sensory impairment and, although it is rare, TBI patients have reported object agnosia, prosopagnosia (failure to recognise faces) and colour agnosia. Agnosias may involve one or more of the sensory systems or may involve additional problems in body scheme such as somatoagnosia. Zoltan (1996) describes both perceptive and associative agnosia. A perceptive agnosia arises from disordered perception although basic visual function is intact, distorting the visual stimulus at the sensory perceptual level. Associative agnosia results from disordered association, unable to recognise familiar objects despite adequate perception. Functional impairments for patients with visual agnosia are devastating upon interpersonal relationships because of their inability to identify loved ones, important possessions or items required for daily functional tasks (self-care items/equipment). Within this framework is the inability to identify people's faces, thus unable to discern the subtle information about gender, race, age or expression (Zoltan, 1996) (Haxby, et al., 2000).

Body scheme is described as the representation of spatial relations among body parts and, as an intact system, allows for spatial indexing of sensory input from the environment. This in turn promotes the activation of and control of movement. It provides the foundation for future environmental perception. There are four broad categories or representations which contribute to body knowledge processing. The first is the *verbal or language based* understanding of body parts (names and functional relations of each). Second is category specific *visual spatial description* of where and how body parts are located in relation to each other in a part/whole analytical system. Third is the actual body image, relating to an individual's own body and changes in position thereof in relation to external space. Fourth is motor performance contributing to the spatial representation of the body. Deficits in body scheme can occur at any one or more of these levels and present in a number of ways. Consistent to all of these are deficits in self-care and ADLs (Zoltan, 1996) (McKenna, et al., 2006)

Apraxia is described as the inability to execute skilled purposeful actions in the absence of loss of motor power, sensory deficits or coordination loss. It is universally accepted that motor planning is the substructure to praxis, yet the nature of the programming deficit has been the subject of controversy. Deficits in praxis relate to spatiotemporal dysfunction, usually seen in production errors and affecting fine motor control. Motor sequencing errors appear to relate to damage to either hemisphere. The type of motor planning deficit relates directly to the area of damage – right brain damage results commonly in difficulties with spatial organisation and thinking, visual synthesis and analysis and unilateral inattention for the interpretation and imitation of movements. Major types of apraxia include oral, constructional, ideomotor, ideational and dressing apraxia, supporting much of daily life skill and have been demonstrated in studies of persons following CVA to be related to visual perceptual processing deficits, affecting gesture recognition, differentiation and production of praxis (York & Cermak, 1995).

In order to determine outcomes for rehabilitation goals, appropriate, adequate and valid assessment must be available for the rehabilitation professionals to use with patients with TBI. Occupational therapists are recognised as routinely evaluating patients and formulating intervention programmes to restore cognitive and perceptual skills as a pre requisite to an overall goal of reaching optimal functional independence (Cate & Richards, 2000) (Brown, et al., 2009).

2.5 Assessment of Visual Perception and Functional Deficits following TBI:

Occupational therapists are trained to use standardised tests to evaluate the visual perceptual skills of neurologically impaired adult patients (Cate & Richards, 2000) (Brown, et al., 2009) (Brown, et al., 2012b). There is however controversy regarding occupational therapy approaches to both assessment and intervention. One faction terms the bottom-up assessment of component skills as "reductionist" and too focussed on dysfunction at a micro level. They favour a top-down occupational performance as the functional focus of assessment and intervention.

Traditionally the assessment and treatment of visual perceptual deficits has been divided into bottom-up remedial and top-down adaptive categories, although shorter hospital and rehabilitative stays and limited medical funds are by and large forcing the choice to an adapt1ive approach. The remedial approach is described by Zoltan (1996) as the restorative approach and focusses on the underlying impairment of skills underlying the disability. It utilises repetition and drill work aimed at restoring neural pathways and recovery of function through the promotion of synaptic reestablishment. This approach focusses on rebuilding the system with building blocks of skill, aimed at improving a patient's ability to process information so as to generalise this to everyday life.

The adaptive approach is a top-down model of intervention which promotes adaptation to the environment to capitalise on patient's residual abilities. It is usually used when restoration is unlikely and focuses on training actual occupational behaviours. Adaptive approaches utilise compensatory strategies (either external or situational) in order to make up for performance deficits. The patient however requires some awareness of self in relation to others and of existing deficits and requires that compensation strategies are learned to the point of automation (Zoltan, 1996)

It is held that a combination of a bottom-up assessment (evaluating the dysfunctional components towards overall function) and a top-down assessment (evaluating the functional competence and the tasks which define these) can co-exist and be used effectively to provide a complete and expedited assessment of a patient. In order to do so, the therapist must have a suitable framework for visual perceptual skill intervention as visual perception function is regarded -as multi-layered. However the relationship between component skills and higher level skills, and the influence of minimal abilities upon overall function, does need to be further researched (Warren, 1993) (Zoltan, 1996). More recent literature indicates that occupational therapy intervention strategies should be collaborative, demanding an approach which is client centred and in which the patient's needs, knowledge and experiences and choices are taken into utmost account. (Holmqvist K, 2012). This echoes the philosophy governing the use of the OSA in determining the needs of the client with intentional use as an instrument of learning and growth. (Baron, et al., 2006)

The standardised tests that are at the disposal of the occupational therapist for testing visual perception processing difficulties are approved by the HPCSA in South Africa (Psychometric Committee of the Professional Board for Psychology HPCSA, 2012). These tests are used routinely in the assessment in a clinical context. They include the Motor Free Visual Perceptual Test -3 (MVPT -3); Lowenstein Perceptual Assessment Battery (LOTCA); Developmental Test of Visual Perception – Adult (DTVP-A) and the TVPS-3. This is not an exhaustive list but includes those tests with a motor reduced or non-motor component (Brown, et al., 2009).

There is relatively little literature available on the use of cognitive tests by occupational therapists in the assessment of brain injured persons. Most of the literature and research has focussed on the use of the tests in the paediatric context (Brown, et al., 2003). Similarly, there is little research to support the impairment of visual perceptual skills following severe TBI. A study by McKenna; Cooke, Fleming, Jefferson and Ogden (2006) was conducted using 31 TBI patients and 195 control candidates. It used the Occupational Therapy Adult Perceptual Screening Test (OT-APST) and demonstrated that visual perceptual processing difficulties were present in severe TBI patients compared to the normal population. Within the TBI sample, the study identified significantly higher incidences of impaired body scheme, agnosia, weak constructional skills and apraxia than in the normative sample. The relationship between the presence of impaired visual perception and cognitive and functional impairment following traumatic brain injury was not significant. The authors concluded however that overall, there are visual perceptual changes evident in patients with moderate-severe TBI when compared to a normative sample (McKenna, et al., 2006).

Another study highlighted that the higher frequency of perceptual impairment in the TBI participants was not accompanied by significantly slower pace of performance which they felt was controversial as the TBI population usually has an overall slower processing speed on most tasks (Madigan, et al., 2000). In a study by Aguerrevere (2007) after controlling for effort, results for moderate to severe TBI, but not mild TBI, showed long lasting effects on visual perception (Aguerrevere, 2007). The effects of moderate-severe TBI are highly dependent on the location, nature and extent of the brain damage. The impairment effect of moderate –severe injury in his study which ranged from small to large suggested that time restricted tests may have played a role in results.

Brown Mullins and Stagnitti (2009) and Brown, Elliot, Bourne, Sutton, Wigg, Morgan, Glass and Lalor (2012) focussed on the convergent validity of the DTVP-A, MVPT-3 and TVPS-3. There is limited validity or reliability data to support the use of these tests outside the USA, the country in which they were developed and standardised (Brown, et al., 2009) (Brown, et al., 2012b). Similar visual perceptual tests have however been studied comparatively, largely on a stroke population. The Rivermead Perceptual Assessment Battery, MVPT and the LOTCA were compared in a study of 22 stroke subjects (Su, et al., 2000). Findings were similar to those in other studies, including that by York and Cermak in 1995, in which persons with right hemisphere lesions performed worse on tests of gesture discrimination, comprehension and visual perception, and in which figure ground differentiation difficulty was more prominent in patients with intracerebral haemorrhage (York & Cermak, 1995) (Su, et al., 2000).

The authors cited limitations including the small sample size, yet reported two clinical implications of this study. The first of these implications is that higher level perceptual skills are susceptible to the damaging effects of intracranial haemorrhage. Poor cognitive skills were also evident, including poor organisational skills, limited strategies for learning and inability to plan or adapt to change as demanded of changing task demands. The authors highlighted *real life difficulties* including difficulty generalising skills to various situations due to mental inflexibility, associated with visual perceptual processing difficulties. (Su, et al., 2000). This inflexibility is related to executive function and refers to cognitive processes responsible for dealing with novel contexts, selection of appropriate strategies, inhibition of inappropriate responses, monitoring performance and regulating feedback to adjust future responses (Fossati, et al., 2002). Executive function is mediated by the prefrontal cortex, which is especially vulnerable to TBI. Executive function also refers to the control of cognitive processes which control and integrate other higher level cortical processes such as memory, attentional control, supervisory, managerial and goal directed behaviours (Power, et al., 2007). Damage to the brain often results in frontal lobe damage, believed to be associated with deficits in memory, attention, affective change and executive deficit. Executive deficit is regarded as being the most devastating and pervasive secondary problem, compromising daily functional ability. This compromise is particularly for those activities which are considered novel, complex and unstructured activity contexts in which executive function is activated (Anderson & Catroppa, 2005) (Power, et al., 2007).

A number of studies have investigated the correlation between perceptual performance and activities of daily living in stroke patients. A study which focussed on the predictive nature of standardised test scores on functional outcome following cerebrovascular accident (Brown, et al., 2012a); suggest that, despite variables between the tests used, tests were able to predict functional performance skills of stroke victims. This study used four tests including the DTVP-A; the Neurobehavioral Status Examination (Cognisat) and the OT APST. The Functional Improvement Measure (FIM) was also used to determine functional ability on discharge from inpatient facilities. Results indicated that two subscales of the Cognisat, including that for comprehension, were the best predictors for functional competence, as assessed by the FIM. Although there were aspects of functional performance that were at variance with standardised testing, it was concluded that despite limitations, tests were able to predict functional performance skills (Brown, et al., 2012a).

2.5.1 Advantages of the Use of the TVPS-3 for assessing TBI patients:

The TVPS-3 used in this study has been researched in clients with TBI. It has proven a useful tool for several reasons. Firstly, it is relatively quick to administer and the administration ceiling of three consecutive failures allows for the therapist to move on to another section without wasting time in a section already proven too difficult. Secondly, the non-motor component allows a motoric impairment or executive dysfunction syndrome to be excluded from impacting on performance thus exposing actual visual perceptual ability. Third the non-timed nature of the test allows patients to have an indefinite response time and although accuracy is often at the expense of speed, it allows client's actual visual perceptual ability to be measured rather than their speed of processing time (although this is observed). Fourth, the design of the test allows for graduated difficulty of items. Clients usually understand the two practice items well and perform adequately for 30-60% of each subtest before reaching a threshold (Martin, 2006). The relative simplicity and directness of instructions limits information overload. This is coupled with relatively straightforward, clear introductory sample items to allow clients to almost immediately understand what is required of them. The study by Brown et al (2012) showed that the total score correlations between the TVPS-3 and the DTVP-A suggests selection of only one of these tests for its intended purpose. Some reservation was expressed by the authors regarding the concurrent validity of the DTVP-A as compared to that of the TVPS-3. They suggested that the TVPS-3 is the more appropriate tool of choice in testing for visual perceptual processing. It was also recommended however that those clinicians consider the age of the client assessed, as the DTVP-A caters for clients up to 74 y11m of age. The TVPS, whilst standardised on clients up to 18 years 11months of age, is regarded as appropriate for use in an adult population (Martin, 2006) (Brown, et al., 2012b) and is widely used within therapeutic contexts for this purpose. Moreover, it was with this intention that the TVPS was chosen for the purposes of this study to identify its reliability as a tool for use in a South African adult population.

The TVPS is not language based and responses can be indicated in any manner understood by the examiner. The TVPS-3 has been revised in its scoring structure. Individual subtests still yield raw and scaled scores and an overall score based on the sum of scaled scores. In addition there are three composite scores for Basic Processes, Sequential Processing and Complex Processes. Based on factor analyses, these composite scores allow for meaningful comparison of related skills (Martin, 2006)

2.5.2 Occupational Performance Assessment

The OSA was selected as a self-assessment measure as it is based on the Model of Human Occupation pioneered by Kielhofner (2002). It was designed to identify clients' self-appraisal of their competence in various daily tasks and occupations, with an added component which assesses what value they attribute to these occupations (Baron, et al., 2006). It was designed to be administered as part of an initial evaluation but also to be used as a tool to affirm and build upon client strengths. It was designed on the theory of human occupation and as such, provides a holistic understanding of not only occupation but the contributing factors related to motivation, performance capacity, lifestyle and environmental impact. Its structure, within a therapeutic context, allows for the therapist to work in synergy with the client to establish and prioritise areas for change, identify therapy goals and strategies to improve independent function. This test was useful as it was not designed for any specific diagnostic group and thus was appropriate for the TBI population assessed. It can be used for clients in a self-administered manner or can be verbally administered (with the assessor's assistance, where literacy is not adequate). It requires some insight and adequate cognitive skill for reflection upon own ability. Where this was not realistic, collateral information from family members helped to mediate responses (Baron, et al., 2006).

This measure is administered in questionnaire form, with competence scales set alongside value scales. Whilst both the competence and value scales are measured in descriptive terminology, without any indication of score, their scores are measured on two scales, both weighted with scores from 1-4. The higher the score, the higher the perceived competency and value attributed to these functions. The two sections allow for comparison between competency and value. The better a client believes he performs a task deemed valuable to him, the better the match between items. The degree of matching between scores allows for a sense of satisfaction experienced by the client with personal competence. The degree of mismatch between items, in which the client has performance difficulty, will be reflected by how much value the client ascribes to the item. Thus, the mismatch between an item which he may struggle to perform but does not value will be less than that which he deems to be very important (Baron, et al., 2006).

This study yielded similar results to those of the study by McKenna et al (2006) in which the OT-APST, FIM, Barry Rehabilitation In Patient Screening of Cognition (BRISC), the Rivermead Behavioural Memory Test and MMSE were used to show that the incidence of visual perceptual impairment in TBI sample was higher than the sample without TBI. Results suggested that visual perceptual difficulties in the TBI group may be attributable to cognitive impairment rather than to visual integration. It also suggested however that people with TBI have a discrete number of visual perceptual difficulties unrelated to level of injury or cognitive impairment (McKenna, et al., 2006). They found that functional implications for people with visual perceptual impairments included a higher risk for injury in terms of safety, particularly when coupled with cognitive difficulties and/or unilateral neglect. This would affect driving, negotiation of unfamiliar terrain, walking along pavements, negotiating stairs, compromised optimal engagement in rehabilitation and higher levels of emotional distress.

2.6 The Effects of Visual Perceptual Processing Deficits upon Occupational Performance

The role of visual perceptual processing difficulties upon resumption of daily functional activities, cannot be underestimated and is supported in the literature as having far reaching consequences upon successful integration into former life roles (Holmqvist K, 2012) (McKenna, et al., 2006). Martin (2006) reported a subtle but all-encompassing relationship between everyday activities and visual perception. Numerous daily activities rely upon visual perceptual abilities. They demand that we separate objects within our visual field e.g.: separating out letters in order to read meaningfully; separating relevant stimuli from others whilst driving and judging the speed of oncoming vehicles. Visual perception plays a definite role in the planning of action sequences, governing self-care activities such as dressing, feeding oneself, meal preparation but also regulates how one moves through space amongst objects (Martin, 2006)

A number of studies have identified specific visual perceptual deficits in head injured adults according to the region of the brain damage. Figure ground difficulties are regarded as occurring with either hemisphere involved, although are worse when the right hemisphere is damaged (York & Cermak, 1995) (Su, et al., 2000). Visual closure abilities were affected in persons having sustained right hemispheric damage (Martin, 2006). Failure to integrate visual perception, motor planning and motor execution to produce two or three dimensional forms (McKenna, et al., 2006) significantly compromises a person's ability to dress successfully or undertake other practical independent living tasks. Reading for leisure, study or functional independent living is all compromised. This also includes aspects such as following recipes/sign boards/instructions/names of grocery items in a shop and places the individual with TBI at higher risk for injury in terms of safety, particularly when coupled with difficulties such as unilateral neglect. Other aspects that are affected include driving, negotiation of unfamiliar terrain, walking along pavements and negotiating stairs. Compromised optimal engagement in rehabilitation creates higher levels of emotional distress and can be accompanied by reported difficulties with agnosia (recognition of familiar objects), prosopagnosia (non-recognition of faces), colour agnosia, acalculia (inability to solve mathematical problems) and constructional impairments (apraxia). Similarly, in a work context, difficulties are experienced in the execution of tasks of an applied practical nature e.g. construction; drawing or following diagrammatic plans; operating machinery reliably. Difficulties reading and processing visual information or responding logically and sequentially to such information are evident. Difficulty is experienced in recognising errors, discriminating between products, fault finding or carrying out quality control/checking tasks in order to produce work of a consistent quality. Compromised efficiency and productivity are also common (Fraser & Clemmons, 2000). In a study by Colantonio, Ratcliffe et al (2004) 306 participants, with moderate to severe TBI, were tracked over a 16 year period (1973-1989). Whilst significant limitation was identified between activity limitations and cognitive compromise, most limitation was experienced in activities such as managing money and shopping (Colantonio, et al., 2004).

A person's return to work is regarded as one of the most affected events after a mild TBI and is a good measure of social integration and functional independence. Traumatic brain injury inevitably leads to time off work and returning to a work place has significant psychological connotations. It is the final hurdle to restoring independence and provides tangible evidence of having achieved goals. (Japp, 2005). The pervasive functional consequences of TBI, despite successful medical rehabilitation, may result in a failure to return to work, associated with profound economic and psychosocial consequences for the patient and family (Shames, et al., 2007).

Several studies have attempted to correlate several factors including gender, age, education and history, lesion producing mechanisms and neuropsychological test scores with return to work. None has offered a consensus as to their predictive abilities. In an occupational context, visual perceptual deficits result in difficulties executing tasks of an applied practical nature like discriminating between products, fault finding or carrying out quality control/checking tasks. (Fraser & Clemmons, 2000). As a result, of those people who return to work post TBI, few rise above the basic routine jobs that are implemented by job coaches and most reach premature occupational ceilings (Japp, 2005).

International return to work statistics vary from 30-65% over one to two years post TBI, with a higher return to work evident in persons who have received rehabilitation (50-95%) as compared to those have not (10-40%) at one year post injury (Scollon, 2000). Where 84% of TBI patients are reported to return to work in the USA, other countries report about a 14% occupational resumption. A study by Watts and Penn reported a 32% return to work in South Africa, with significant changes in work status post-injury (Watt & Penn, 2000). Literature holds that TBI injury accounts for most lost productivity in the United States of America than any other disability, due to job changes or working on temporary bases. An estimate of injury related lost productivity amongst TBI victims is fourteen times that shown amongst spinal cord injured persons (Centres for Disease Control and Prevention, 2010) (Van Velzen, et al., 2009).

2.7 Summary:

Visual perception is concerned with five primary areas of visual perceptual processing which underpin our capacity for interpersonal interactions, adaptive abilities, independent living and occupational function.

Visual perceptual processing is inextricably related to the development of conceptual processes and cognition necessary to make sense of what is processed. Whilst the TVPS-3 is a visual perceptual assessment tool and makes no cognitive findings per se, the results yielded by and performance of subjects being assessed cannot be interpreted without taking cognisance of this interrelationship i.e.: the effects of visual perceptual processing upon cognition and the influence cognition will have upon visual perceptual processing ability (Kielhofner, 2009) (Martin, 2006) (Cicerone, et al., 2000) (Brown, et al., 2012b).

Traumatic brain injury has a profound and pervasive effect upon visual perceptual processing ability, contingent on the areas of the brain damaged in high velocity or high impact collisions. Similar to patients who have suffered cerebrovascular accidents, TBI patients exhibit depressed visual perceptual processing abilities on assessment (Mackenzie, et al., 2002) (McKenna, et al., 2006) with long term functional outcomes affecting all aspects of occupational performance including self-care, recreational and leisure pursuits, social and community interactions and vocational (work) performance .

Occupational therapists are routinely involved in the assessment and treatment of persons who have suffered TBI, assessing residual visual perceptual ability and functional ability. There is however little research to demonstrate the relationship between visual perpetual processing and functional deficit. Similarly there is little in the literature to support or describe the efficacy of occupational therapy practices in rehabilitation (Holmqvist K, 2012). The deficits described by Mc Kenna et al, related to TBI, are not always assessed by other tests of visual perception. Occupational therapists need to be aware of the effect of visual perceptual deficit patients may have during assessment or in therapeutic and / or functional tasks.

The use of recognised reliable tests such as the TVPS-3 as a suitable tool for the assessment of visual perceptual function in adults and its association with functional deficits is important to establish through research based evidence. The determination of such a relationship between visual perception and functional capacity will help provide valuable information for the development of appropriate rehabilitation goals as well as in the quantification of future expenses in terms of care, living conditions, medical and therapeutic requirements and occupational outcomes.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter aims to describe the methods used in undertaking this study. The context of the study was within an occupational therapy practice, specialising in medico legal assessments of claimants following road accidents. The occupational therapist consults with road accident victims routinely as part of the service delivered to attorneys who refer claimants for functional assessment in order to quantify damages residual to injuries sustained in the motor vehicle accident. The high number of clients assessed who present with TBI, and who have long term associated functional and independent living difficulties, prompted this research in order to better justify the results of testing within a court of law.

3.1.1 Research Design:

A descriptive cross-sectional, analytical, quantitative design was used to determine whether there is a difference in the visual perceptual abilities of adult clients, with and without TBI. This design was chosen as it allowed for convenient sampling of an already available population of brain injured clients. Cognisance was given to this being a small sample, similar to those used in other studies in the literature (Su, et al., 2000). It used the TVPS-3 on a South African sample to determine the predictive ability of the test to identify dysfunction in the group. This type of study is supported in the literature by similar studies which compared the results of injured and non-injured groups for TBI. These similar studies determined the relationship between visual perceptual processing difficulties, in persons with CVA and TBI, and functional deficits (Su, et al., 2000) (McKenna, et al., 2006) (Brown, et al., 2012a). The association between the clients visual perceptual processing and their occupational performance was also established using a correlational study. This design was based on a similar study undertaken by (Brown, et al., 2012a) in which it was determined that despite variances in tests, visual perceptual test performance can be regarded as a predictor for functional performance skills in persons following CVA (Brown, et al., 2012a) .

The study described in this thesis, comprised two parts:

- **Part 1:** to compare TVPS-3 scores of subjects with and without TBI. Participants without TBI were used to confirm the validity of using this test in a South African population, taking cognisance of any age and educational effects on results. The, sensitivity, specificity and predictive ability of the TVPS-3 for this sample was determined.
- **Part 2:** to determine the association between scores of the TVPS-3 with OSA scores and assess the ability of this test to associate visual perceptual processing abilities with functional capacity in clients with TBI.

3.2 Population:

Participants were limited to South African citizens of various racial and cultural groups. The study was based in Westville, KwaZulu Natal. Although the majority of participants lived within this regional grouping, it did not exclude participants from the Eastern Cape, and Free State provinces, referred by attorneys from these provinces, for medico legal assessment.

3.2.1 Subject Selection:

Participants were selected from two groups: a group of clients who had a documented TBI and a group of controls matched for age and as far as possible education level. The TVPS-3 has been shown not to be sensitive to culture, race or sex in the USA and is regarded as suitable for use across the broad demographic base so the participants were not matched for these variables.

Convenient sampling of Road Accident Fund claimants already referred for a medico legal assessment to the occupational therapist was used. The participants were selected from this group who were attending an occupational therapy practice in Westville, Durban. Claimants who had a TBI, for which they are referred for assessment, were asked to identify a family member or community member from a similar cultural group who could be matched to them according to set criteria.

Since a large number of the family members or community members did not meet the inclusion criteria and the participants with TBI were not always able to provide a closely matched control subject, similar participants without TBI who met the inclusion criteria were sourced by a convenient sampling method, through the medico legal assessment process in the same occupational therapy practice and from the community around the practice. These control participants were matched to the participants with TBI as closely as possible for age and educational status

The reasons the controls identified by the participants with TBI could not be used were because they did not meet the inclusion criteria as many had a previous history of head injury, alcoholism, or a history of epilepsy. Participants with TBI had also lost contact with their family or there was inappropriate educational matching. Some participants failed to comply with the request that they accompany the participants with TBI to their appointment.

3.2.1.1 Participants with Traumatic Brain Injury:

Inclusion criteria

- Adults (18 years and older).
- Clearly documented to have had a history of TBI, of variable degree ranging from severe (with Glasgow Coma Scale scores less than 8/15) to mild brain injury (with Glasgow Coma Scales of 13-15/15).
- Documented to have had periods of loss of consciousness and post-traumatic amnesia exceeding 20 minutes.
- Assessed for two years, post injury, to exclude possibility of further neurological improvement occurring. Literature supports this with a study conducted by Berkaw, Hanks et al (2010) which showed that altered learning and processing speed manifest in the first year of recovery following TBI, are sensitive markers for the prediction of future permanent disability and functional independence capacity.

Exclusion Criteria

- Confusion and a cognitive level of function too low to understand and give informed consent as determined by the MMSE.
- Any visual defects or uncorrected loss of visual acuity as this could mask actual visual perceptual processing ability.
- Any other pre-existing neurological conditions (e.g. stroke; tumours; previous head trauma; mental retardation), which are likely to have compromised visual perceptual function.

- Psychiatric illness which may compromise understanding of instructions and thus compromise test participation and yield weaker scores than anticipated.
- Alcohol or substance abuse, as use of these mind altering substances compromises instruction following, volition and visual perceptual function.
- Any suggestion of malingering or behaviour suggestive of deliberate underperformance, which necessitated that the testing be discontinued and results not used for study purposes.

3.2.1.2 Participants without Traumatic Brain Injury:

Participants without TBI were family or community members and were identified by the participants. They met the following criteria:

Inclusion criteria

Be as closely matched to the participant with TBI in terms of

- Their family or cultural background.
- Educational status with access to similar schooling systems.
- The same or similar age (adult milestones) (Kielhofner, 2002).
- Be without any other pre-existing neurological conditions (e.g. stroke; tumours; previous head trauma except concussion; mental retardation).

Exclusion Criteria

- Those who were unable to complete testing and/or who failed the MMSE.
- Any visual defects or uncorrected loss of visual acuity;
- Psychiatric illness which may compromise understanding of instructions;
- Alcohol or substance abuse.

3.3.2 Sample Size:

A sample group of thirty-four participants was used for the Participants with TBI. Thirty-four controls were matched for age and educational background. The sample size is recognised as being small, with implication for the predictive validity of this study. This sample size was based on a power of 90 with the significance set at 0.05 on a 20 point difference in the total TVPS-3 scores. This is less than that reported by Brown et al (2011) to accommodate different levels of TBI severity (Brown & Elliott, 2011a) but which was considered statistically significant.

3.3 Measurement Techniques

3.3.1 Demographic Questionnaire (Appendix A1).

This questionnaire was designed by the researcher to capture salient background detail, history of TBI, educational history and medical history, including medication currently taken. This information was routinely obtained from the clients through their medico legal interview process, and was documented for ease of reference in a demographic questionnaire sheet. Participants without TBI were interviewed and information captured in a demographic questionnaire to exclude the possibilities of having had previous TBI/neurological assault, alcohol or drug abuse, learning or developmental disorders, visual deficits, mental retardation or psychiatric illness which would preclude them from following instructions. The demographic questionnaire and the observation form described below were not piloted or standardised, and were used as a qualitative means of recording information pertinent to the participants' background histories and their performance of the test.

3.3.2 Observation of Behaviour during Testing (Appendix A1)

As part of the demographic questionnaire, an observation section was included. This too was designed by the researcher and used in the same format as the demographic questionnaire. It allowed all observations of the subjects' behaviour to be documented. This included emotional reactions, approach to the test, response speed, need for alternate focus, retention strategies, cognitive fatigue, physical fatigue, agitation, restlessness and attentional capacity while completing the TVPS-3. The observations were allocated a numerical coding for analysis and comparative purposes but had no weighted value or score allocation.

3.3.3 Mini Mental State Examination: (MMSE) (Appendix B).

This is an assessment tool used internationally by medical practitioners and allied medical personnel to routinely and quickly screen for cognitive impairment. It has been shown when compared with two other similar instruments to have greater sensitivity for increasing dementia severity in Alzheimer's Dementia; although it is regarded as a useful and reliable tool for first contact with patients with intellectual deficits or deterioration. (Simard Martine, 1998) , it is also recognised as not being standardised across all populations and has variable Interrater reliability amongst medical practitioners. The variability in scores however is regarded as being balanced by the widely spread use thereof in the study by Davey and Jameison (2004), to allow for meaningful conclusions to be drawn in accordance with the National Institute for Clinical Excellence (NICE) dementia guidelines (Davey & Jameison, 2004) It comprises eleven items for the assessment of orientation, registration, attention, language, praxis, recall and calculation. Scores lower than 24/30 indicates cognitive impairment (McKenna, et al., 2006).Subjects' cognitive orientation and basic functioning was assessed to exclude the possibility of assessing subjects who were unsuitable for this test. It was used to determine if the potential participants met the inclusion criteria.

3.3.4 The Test of Visual Perceptual Processing Abilities-3 (TVPS-3) (Appendix C).

The TVPS was originally designed for children but the author Dr Gardner also reported statistically significant differences between three groups diagnosed as having either developmental delay, head injury or learning disability (Gardner, 1992). This test in its third edition has been revised by Martin for appropriate use in an adult population, with scores compared against the highest age group of scores (i.e. 18y00-18y11m) (Martin, 2006). This test combines the forms of the Test of Visual Perceptual Skills (non-motor)-Revised (Gardner, 1996) with the Test of Visual Perceptual Skills (non-motor upper level) – revised (Gardner 1997) into a single reliable and valid measure of visual perceptual processing abilities for individuals up to 18 years of age (Martin 2006).

There are seven subtests of eighteen stimuli figures each, which assess seven key areas of visual perception. Each subscale consisting of eighteen figures including two example items and sixteen test items are arranged in order of increasing complexity. The test is largely an untimed instrument with the exception of subtests for visual memory and visual sequential memory being allocated a five second presentation time per item. Response time is however not restricted for any of the items. This test allows the subject's performance in each specific area of performance to be determined, against a large normative sample in the United States of America.   It also aggregates the overall scores to allow analysis of collective abilities.

The validity of visual perceptual tests used in the assessment of persons with cognitive impairment or disability has come under scrutiny. The validity of the TVPS-3 is important in the selection of instruments to measure a client's visual perceptual processing abilities in order to ensure accuracy of measurement and to determine appropriate intervention methods (Brown, et al., 2009).

The concurrent validity of a test is assessed by calculating the correlation between instruments used to determine the same construct. The work of Brown, Mullins and Stagnitti (2009) highlighted the use of three visual perceptual tests commonly used with adults. These include the Developmental Test of Visual Perception – Adolescent and Adult (DTVP-A) (Reynolds, et al., 2002) (Brown, et al., 2009); The Motor Free Visual Perception Test – Third Edition (MVPT3) (Colarusso & Hammill, 2006) and the Test of Visual Perceptual Skills (Non Motor) – Third Edition (TVPS-3) (Martin, 2006). These three tests are newly revised or developed and have in common the motor free component of visual perception. Results of the study by Brown et al (2010) determined that there was a significant correlation between the DTVP-A and the MVPT-3 for overall total non-motor scores ($p<0.01$) and that the correlation demonstrated that constructs measured by three individual tests were associated with one another (Brown, et al., 2010).The correlation results obtained in a more recent study by Brown et al determined that total scores of all three visual perceptual tests shared correlation coefficients of between 0.39 and 0.51, satisfying the criteria of Streiner and Norman (Streiner & Norman, 2008) (Brown, et al., 2010). These criteria stipulate that correlations which measure the same attribute should fall between 0.4 and 0.80. Correlations above this range would be undesirable and would suggest that the tests were testing exactly the same constructs, negating the purpose of separate tests. TVPS-3 indices and overall standard scores are reported as standard scores based on population distribution having a mean of 100 and a standard deviation of 15. The standard deviations are traditionally reported for a range of +- 3 standard deviations from the mean and do not extend below 55 or above 145, representing the most extreme scores obtained by less than 0.02% of the population. Cognisance is given to the construct validity of the TVPs-3 in which it is reported that several assumptions underlie the use of the TVPS-3. Data for this highlighted that chronological age is directly proportional to the increase in a person's visual perceptual skills, associated with maturity. The TVPS-3 test scores should thus show a positive relationship to chronological age.

It was concluded by Brown et al (2012) that the TVPS-3, DTVP-A and MVPT-3 demonstrated acceptable levels of concurrent validity. Moreover, the TVPS-3 total score was found to be statistically significant when correlated with both the DTVP-A total score (rho=0.48) and the MVPT-3 total score (rho=0.51). The TVPS-3 total score was found to have a moderately strong correlation with the visual perceptual supplemental subtest of the Visual Motor Integration test (VMI-5), with a rho coefficient of 0.67, stronger than both those of the MVPT-3 and DTVP-A. Although the total score correlations between the DTVP-A and TVPS-3 (rho-0.48) suggest the potential to use only one of these instruments, some concern was raised by Brown et al. regarding the concurrent validity of the DTVP-A motor reduced subscales, with the suggestion that clinicians select the TVPS-3 as a more appropriate tool choice for assessment of visual perceptual ability (Brown, et al., 2012b). Previous studies of the same tests to determine convergent validity, conducted by Brown et al in 2011, showed the TVPS-3 to be the most reliable measure of both subscales and overall visual perception ability (Brown, 2011b). Predictive validity of the test will determine the extent to which a score on the test predicts scores on some criterion measure (e.g. occupational performance ratings; independent living performance ratings). It is similar to concurrent validity as both are measured as correlations between a test and a criterion measure. The test would be considered to have predictive validity if the correlation was statistically significant. These correlations are however not usually high, but regarded as valuable in terms of evidenced based research comparing relationships between test scores and other variables (Messick, 1995).

3.3.4 Occupational Self-Assessment (OSA) (Appendix D).

The OSA was developed in 1998. The aim of the OSA was to create an objective client centred assessment tool that evaluated the client's perspective of their occupational competence and the values that they place on their occupations. The OSA was developed reflecting the Model of Human Occupation as well as the principles of the client centred approach (Baron, et al., 2006).

Whilst not standardised in South Africa, a number of international studies have been conducted on the OSA which has confirmed it to be a valid and reliable measure of client's occupational competence and value of occupation. The OSA evaluates self-report of the following components: skills/occupational performance, habituation and volition as well as ADLs. Each of these components has two response sections. The first response section is related to competence and the second refers to the extent to which the client values the component. Each item is derived from the Model of Human Occupation and has been translated into everyday language. As it is a recognised occupational therapy outcomes measure, use of the OSA in assessing study subjects and participants without TBI will help determine a pattern of association between scores of the OSA and TVPS-3.

Recent studies by Kielhofner, Forsythe, Kramer and Lyenger (2009) determined that used together, the items of the OSA are regarded as having good internal validity and measure the uni-dimensional constructs of Occupational Competence and Values. The changed rating scales, from three to four point scales were regarded as having resulted in improved person separation and increased sensitivity and was able to be used by 90% of the participants with a range of disability, from varied contexts (Kielhofner, et al., 2009).

The OSA was selected as a self-assessment measure as it is based on the Model of Human Occupation pioneered by Kielhofner (2002) and was designed to identify clients' self-appraisal of their competence in various daily tasks and occupations. This is an added competence which assesses what value they attribute to these occupations. It was designed to be administered as part of an initial evaluation (Kielhofner, 2002).

This measure is administered in questionnaire form, with competence scales set alongside value scales. Whilst both the competence and value scales are measured in descriptive terminology, without any indication of score their scores are measured on two scales both weighted with scores from 1-4. The higher the score, the higher the perceived competency and value attributed to these functions. The two sections allow for comparison between competency and value. The better a client believes he performs a task deemed valuable to him, the better the match between items. The degree of matching between scores allows for a sense of satisfaction experienced by the client with personal competence.

The degree of mismatch between items, in which the client has performance difficulty, will be reflected by how much value the client ascribes to the item. Thus, the mismatch between an item which he may struggle to perform but does not value will be less than that which he studies and deems to be very important.

This test was useful as it was not designed for any specific diagnostic group and thus was appropriate for the TBI population assessed. It can be used for clients in a self-administered manner or can be verbally administered (with the assessor's assistance, where literacy is not adequate). The test requires some insight and adequate cognitive skill for reflection upon the client's own ability. Where this was not realistic, collateral information from family members helped to mediate responses.

3.4 Ethical Considerations

Ethical clearance for this study was obtained from the University of the Witwatersrand Human Research Ethics Committee (Appendix E). Ethical considerations in conducting this study included providing an information sheet for the participants in a language easily understood (home language) and asking for signed, informed consent (Appendix F). It also ensured and upheld the claimant's confidentiality when representing the nature of their TBI and their test scores. All identifying information was kept separate by the researcher and results were kept confidential as corresponding test scores and demographic forms were all coded. No names were used on these forms. As the majority of this particular occupational therapy practice's clients were Zulu speaking, the information sheet was translated into IsiZulu. The participants who were Afrikaans speaking were able to understand and read and write in English. There were no other indigenous language speakers included in this study.

Cognisance was taken of the claimants being seen in the context of a litigious process against the Road Accident Fund or Workman's' Compensation or personal injury suits. External incentive was thus recognised as being a limiting factor in terms of effort (Aguerrevere, 2007).

Referring attorneys were informed by an information letter (Appendix G) about the nature of the study, the need for subject participation and that of a control subject. This ensured that attorneys understood the nature of this study, the need for the client to be accompanied by a control subject and that the medico legal process was not compromised.

Upholding the confidentiality of scores was highlighted and emphasis was placed on there not being an additional cost to their medico legal process, as the testing was done as part of the medico legal process. Any additional costs incurred in bringing the control subject to the assessment were covered by the researcher. All participants were permitted to refuse to participate or withdraw from the study without consequence and feedback was made available on request. Information sheets and test scores will be safely stored for a period of six years as per HPCSA regulations.

3.5 Research Procedure:

Referring attorneys make appointments for clients' assessments well in advance of the scheduled appointment date and accompanying documentation is forwarded prior to the assessment. Appropriate candidates with a history of TBI could be identified from this referral process and the perusal of documentation. The time frame for such data collection would average about three months ahead of being seen for assessment.

Potential participants were requested by telephone to select a suitable matched control, to accompany the claimant to the assessment. This was not however a successful method of recruiting matched controls. Reasons included participants without TBI being unable to leave work, loss of contact with such, failure to arrive for the appointment and being ineligible for testing due to previous TBI/ drug use/ learning disability. 17% of subjects were thus matched with family or community members known to them. 26% of controls were sourced conveniently from an uninjured population of persons, matched as closely for age and education, whilst 55% of participants without TBI were sourced from other medico legal candidates without TBI who had suffered orthopaedic injury.

Table 3. 1. Selection Process of Participants

Participants without TBI	Percentage of study group	Selection process
6/34	17%	Matched to subject
9/34	26%	Convenient community selection
19/34	55%	Convenient medico legal client selection (Non TBI injuries)

Only qualified and experienced occupational therapists assessed experimental participants and control participants. Both therapists were qualified to administer and interpret the TVPS-3 and OSA and MMSE tests. Both therapists were familiar with the standardised administration requirements for the TVPS-3, the timed aspect of the two memory subtests and the need for observation of behaviours in this test. Tests were scored by the assessing therapists. The participants without TBI, where sourced as a matched control for the TBI participants with TBI, were introduced to the therapist who was responsible for their interview and testing procedure.

All TBI participants were assessed at the practice where medico legal assessments take place. These assessments were completed by the researcher or another experienced occupational therapist familiar with the assessments. Study participants and control participants were introduced to the study by the researcher.

Participants were interviewed to complete the demographic questionnaire. The MMSE was used as a screen to determine baseline cognitive function and was administered to all potential participants to determine if they met the inclusion criteria. Once this was established, the assessments of participants with TBI, using the TVPS-3 and OSA were conducted in a quiet room with minimal interference. The participants without TBI were assessed in a quiet place at a time suitable to them, either within their home or the assessment venue.

All tests were administered in a face to face context, in one sitting. Participants were permitted to take comfort breaks at any stage of the testing process.

Assessments of the participants with and without TBI, including the administration of MMSE, TVPS-3 and OSA, took approximately 60-75 minutes, although some participants without TBI completed the testing process in less time. As the tests were not time specific, formal timing of the testing procedures was not undertaken.

Since the MMSE and TVPS-3 were used in the screening and assessment process of claimants with TBI for medico legal purposes, the participants were not subject to additional testing, except for the OSA.

The participants pointed to or verbalised the response numbers in the TVPS-3. Responses were recorded on the test form by the therapist. Participants were given no indication as to the accuracy of their responses. The tests were administered according to the standardised scoring criteria. TVPS-3 subtests were discontinued when the participant reached a ceiling of three consecutive incorrect responses, as per test requirements.

The Occupational Self-Assessment test sheets were completed by the participants, assisted where appropriate by the therapist in instances where a question may not have been understood.

Where appropriate, an interpreter usually available for the purposes of the medico legal process assisted candidates in responding to the information sheets and consent forms or in answering the demographic questionnaire and assisted in interpreting test instructions given in English.

Interrater reliability testing was not required for this study as the assessments are standardised and have all been tested for Inter-rater reliability. Observations of behaviour were recorded by the assessing therapists on the observation section of the demographic questionnaire form: Participants were closely observed for cognitive, physical or emotional fatigue, pain, concentration and attentional difficulties, anxiety and other behavioural traits suggestive of stress or irritability. Additionally, any compensatory strategies were noted and written for observational analysis to be included in the discussion of results by the researcher.

As the tests are standardised and have no qualitative attribute to them regarding scores, the therapists scored the respective tests, aware of the incumbent's group profile. There was no interpretative aspect of the TVPS-3 requiring blinding. Similarly the OSA scoring system is value based and requires no interpretation of response choices.

3.6 Data Analysis:

Descriptive statistics were used to determine the socio-demographic and clinical characteristics of TBI and participants without TBI populations.

The difference between the scores on the TVPS-3 and for its sub scales for all the participants was determined using a non-parametric Mann Whitney U test. This was due to the small sample size and because the data could not be assumed to be normally distributed. (Brown, et al., 2009) (McKnight & Najab, 2010) (Brown, et al., 2012b) All subtest scores and composite scores of the TVPS-3 were converted to z scores to compare with converted scores of the OSA.

The association between visual perceptual processing difficulties on the TVPS-3 and OSA results were measured with the Spearman rho (two tailed), a non-parametric type of statistic and regression analysis. Data entry, storage and retrieval and generation of description statistics was achieved using the Statistica v 12.

The participants' socio-demographic information included the level of traumatic brain injury (TBI) sustained, and was ranked from mild to severe head injury. This allowed for comparison of scores between similarly injured persons and between persons with differing levels of TBI. The internal consistency of this sample of participants (0.88) matched the internal consistency of the TVPS-3 as described by Martin (2006). Cronbach's Coefficient alpha and Spearman Brown coefficients, and split half coefficients, computed per subtest ranged between 0.75-0.88 for subtests and 0.96 for the test overall.

3.7 Summary:

Although the sample size is recognised to be relatively small, and will be considered as a limitation of this study, the results showed that the TVPS-3 discriminated between those participants with and without TBI. The reliability of the TVPS-3 used in this context of adults with and without TBI correlated with the reliability of the TVPS-3 as described in the manual, with internal consistency for this sample scoring 0.88, matching that of the TVPS-3 which showed high correlations between test items.

CHAPTER 4: RESULTS

4.1 Introduction:

The Test of Visual Perceptual Processing skills -3(Martin 2006) and the Occupational Self-Assessment tool (OSA) (Baron, et al., 2006) were completed on a sample of 34 participants with TBI and 34 peers without TBI, or any known neurological injury or other conditions as specified in the exclusion criteria. There was no drop out from the study as it was cross sectional and participants were seen on only one occasion for assessment. The results of this study supported the objectives of the study and was able to determine the discriminative ability of the TVPS-3 between participants with TBI and those without, for all subtests except for visual sequential memory; and to establish the association between visual perceptual processing difficulties and self-reported deficits in occupational performance skills for OSA competence scales but not for Value scales.

4.2 Demographics

4.2.1 Personal Demographics

The sample consisted of 68 participants (34 participants with TBI and 34 participants without TBI) of South African origin. The sample comprised 56% male participants and 44% female participants (Table 4.1). The majority of participants were aged between 18 and 25 years and grouped according to Kielhofner's model into early, middle and late adulthood stages i.e. : 18-44 years , 45-65 years respectively (Kielhofner, 2008). Participants represented a mix of population groups, gender and age groups. English was the most common language spoken within this study (66%), isiZulu the next most common (31%) followed by other languages including Afrikaans and isiXhosa.

Of the participants 40% were White, and an equal distribution of Black and Indian participants was measured at 29% each, with a small minority of coloured participants (Table 4.1). There were no statistically significant differences between the groups of participants with and without head injuries for gender, population group and language. This meant the groups were comparable.

Table 4.1: Demographics of participants with and without Traumatic Brain Injury.

		Total number participants (n=68)	Participants with traumatic brain injury (n=34)	Participants without traumatic brain injury (n=34)	p- value
		(n)%			
Gender	Male	(38)55.8%	(22)64.7%	(16)52.9%	0.21
	Female	(30) 44.2%	(12)35.3%	(18)47.1%	
Age range	Early adulthood 18-44 years	(40)59.8%	(23)67.6%	(23)67.6%	0.10
	Middle adulthood 45–65 years	(6)8.8%	(11)32.4%	(11)32.4%	
Population Group	White	(27)39.7%	(11)32.2%	(16)47.1%	0.30
	Black	(20)29.4%	(11)32.3%	(9)26.5%	
	Indian	(20)29.4%	(12)35.2%	(8)23.5%	
	Coloured	(1)1.4%		(1)2.9%0	
Language	English	(45)66. 2%	(23)67.6%	(22)64.7%	0.73
	Zulu	(21)30.9%	(11)32.35%	(10)29.4%	
	Afrikaans	(2)2.9 %(		(2)5.88%	

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

4.2.2 Geographical Location

The majority of subjects resided in KwaZulu Natal province and there were no statistically significant differences between the groups of participants with and without head injuries for geographic location. Participants also came from the Eastern Cape and the Free State provinces. (Table 4.2).

Table 4.2: Geographical location of participants with and without traumatic brain injury. (n=68).

		Total number participants (n=68)	Participants with traumatic brain injury (n=34)	Participants without traumatic brain injury (n=34)	p- value
		(n)%			
Province of Residence	Kwa-Zulu Natal	(63)92.7%	(30)88.2%	(33)97.1%	0.54
	Eastern Cape	(3)4.4%	(3)8.8%		
	Free State	(2)2.9%	(1)2.9%	(1)2.9%	

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

4.2.3 Educational level and employment status

The participants' educational status ranged from just over 4% with primary school and no education to the highest proportion being educated to a grade 12 level (41%).

Table 4.3: Educational level and employment status of participants with and without traumatic brain injury.

		Total number participants (n=68)	Participants with traumatic brain injury (n=34)	Participants without traumatic brain injury (n=34)	p- value
		(n)%			
Educational status	Up to Grade 11	(13)19.11%	(6)17.64%	(7)20.58%	0.89
	Grade 12	(18)26.47 %()	(9)26.47%	(9)26.47%	
	Diploma level	(28)41.17	(14)41.17%	(14)41.17%	
	Degree level	(9)13.23%	(5)14.70%	(4)11.76%	
Employment Status	Unemployed	(21)30.9%	(4)41.2%	(7)20.6%	0.13
	Self employed	(7)10.3%	(3)8.8%	(4)11.8%	
	Formal employed	(35)51.5%	(15)44.1%	(20)58.8%	
	Student	(5)7.3%	(2)5.9%	(3)8.8%	

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

In the group with tertiary education a higher percentage had attained a college education with 19% having a university education (Table 4.3). The educational levels of the participants without TBI, and the participants with TBI were similar. One more participant in the Group with TBI had degree level education and one in the Group without TBI less than a grade 11 level of education.

The participants' occupational status overall demonstrated 51% of participants to be formally employed whilst 31% were unemployed. Compared to the 58% employment rate of participants without TBI only 41% of participants with TBI were employed. Employment levels showed no statistically significant differences so the groups were considered comparable for employment.

4.3 Severity of the Traumatic Brain Injury, Associated Injuries and Sequelae

4.3.1 Severity of the Traumatic Brain Injury

The levels of brain injury of the participants with TBI were classified according to medical documentation and GCS levels on admission and period of loss of consciousness.

Table 4.4: Severity of injury of participants with and without TBI.

		Total number participants (n=68)	**Participants with traumatic brain injury (n=34)**	**Participants without traumatic brain injury (n=34)**	**p- value**
		(n)%			
TBI Severity	Mild	(10)14.7%	(10)29.5%	0	0.00**
	Moderate	(7)10.2%	(7)20.5%	0	
	Severe	(17)25.0%	(17) 50%	0	
	Concussive	(2)2.94%	(2)2.9%	(2)2.9%	
	No TBI	(32)47.5%	0	(32)47.05%)	

Significance set at $p \leq 0.05$*
Significance set at $p \leq 0.01$**

Of the participants without TBI, 2.9% had experienced a concussive episode without long term sequelae, and 47.05% of participants overall had not sustained a TBI. Within the group with TBI, half of the participants had sustained severe TBI, 20.5% sustained moderate TBI and 29.5% mild TBI (Table 4.4).

4.3.2 Associated injuries and sequelae

As most of the participants with and without TBI had a history of injury through high velocity motor vehicle accidents, 56% of participants had sustained orthopaedic injuries and 11% combined features of orthopaedic, facial, neurological injuries. 19% had no associated injuries. Some participants had more than one type of associated injury associated with the mechanics of such accidents and the nature of the polytrauma sustained in high velocity MVAs or bicycle accidents, and contributed to residual psychological and pain sequelae. Of the participants with TBI, 58% sustained orthopaedic injuries, 20.5% facial injuries (commonly associated with head injury), 2.9% a combined level of injury, whilst 17.6% sustained no associated injuries at all. There was no significant difference in the percentage of associated injuries between the groups with and without TBI so the groups were comparable for this variable. Although the participants without TBI, who were referred for assessment after being involved in MVAs, did not have significantly less associated injuries than those with TBI, they had significantly less pain and psychological sequelae. Both the pain *($p \leq 0.01$)* and psychological *($p \leq 0.00$)* sequelae were significantly greater for the participants with TBI where 85% reported pain with 96.8% reporting the presence of psychological sequelae related to their injuries and trauma. These included residual depression, anxiety, noise intolerance, short temperedness or a combination of these sequelae. Just over a third of participants without TBI also reported depression and anxiety sequelae (Table 4.5).

Table 4.5: Associated injuries and sequelae of participants with and without traumatic brain injury

		Total number participants (n=68)	Participants with traumatic brain injury (n=34)	Participants without traumatic brain injury (n=34)	p- value
		(n)%			
Associated injuries	Orthopaedic	(38)55.8%	(20)58.8%	(18)52.9%	0.07
	Facial	(8)11.7%	(7)20.5%	(1)2.9%	
	Internal	(1)1.4%			
	Combined	(8)11.7%	(1)2.9%	(2)5.8%	
	Nil	(13)19.1%	(6)17.6%	(13)38.2%	
Pain sequelae	Pain	(47)69.1%	(29)85.2%)	(18)52.9%	0.01**
	No pain	(21)30.8%	(5)14.7%	(16)47.0%	
Psychological sequelae	Depression/ Anxiety	(26)38.2%	(14)41.1%	(12)35.2%	0.00**
	Short temper	(1)1.4%		(1)2.94%	
	Noise intolerance	(3)4.4%	(3)8.8%		
	Inattention	(1)1.4%		(1)2.9%	
	Combined	(18)26.4%	(16)47.0%	(2)5.8%	
	No psychological sequelae	(19)27.9%	(1)2.9%	(18)52.9%	

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

4.4. Comparison of the Test of Visual Perceptual Skills -3rd edition (TVPS-3) for participants with and without traumatic brain injury

4.4.1 Behavioural Observations:

Observations of behaviour during testing, is important when interpreting performance and results. Interfering factors of pain and discomfort can affect performance on a test such as this, which requires a lengthy period of static sitting. This needs to be taken into account in terms of distractibility and concentration.

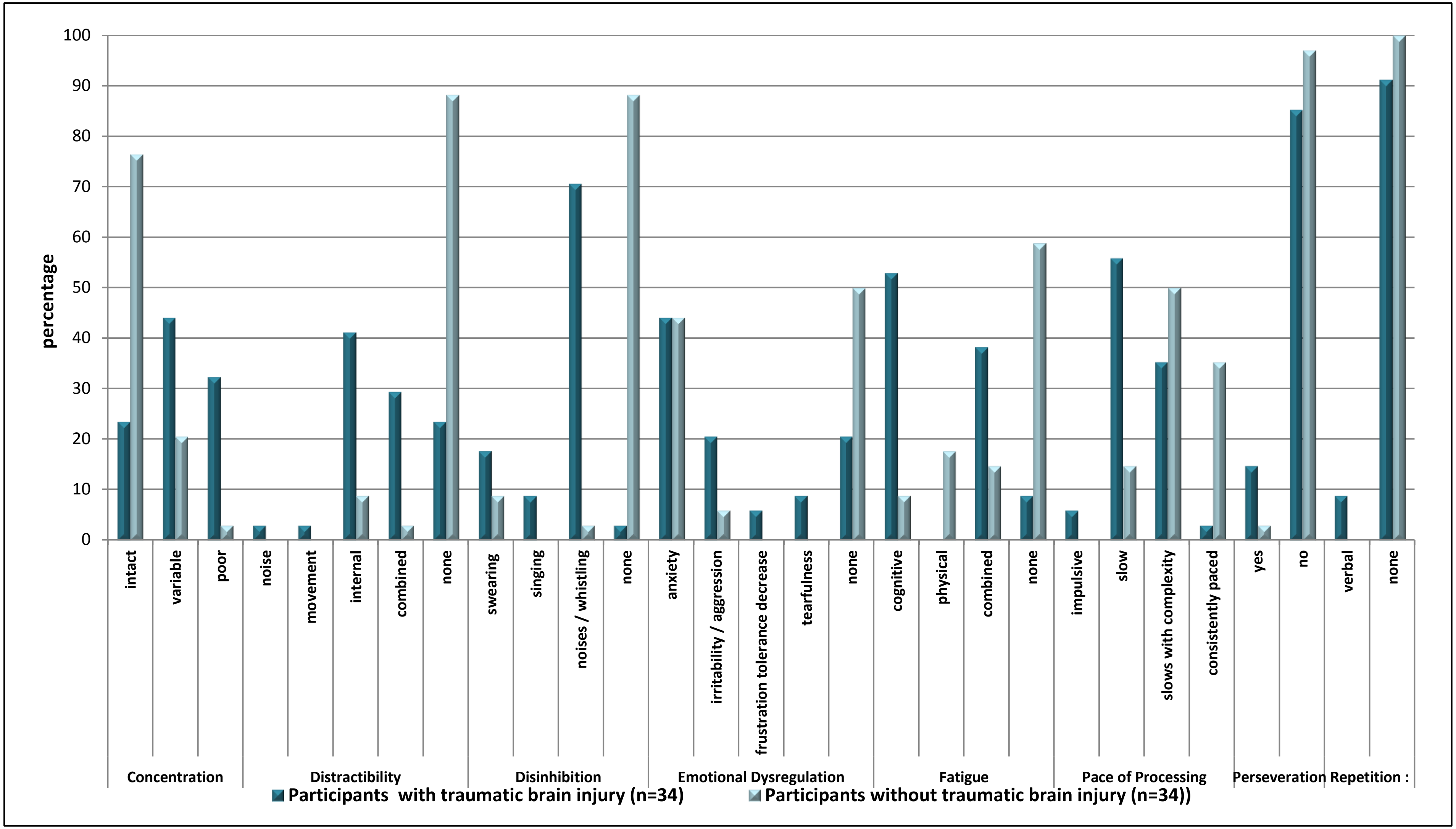

Figure 4.1: Frequency of behavioural observations of participants with and without traumatic brain injury while completing the Test of Visual Perceptual Skills -3rd edition

Descriptive observational analysis of participants' behaviours in the TVPS-3 was compared for participants with and without TBI. Significant differences were found for the behavioural observations between groups (Table 4.6). All the behavioural observations with statistically significantly differences between the two groups had lower scores for the participants with TBI indicating they had more problems with behaviour. This included distractibility, fatigue and pace of processing speed and physical features. The participants with TBI had a lower score for concentration which was significantly different (p≤ 0.00) from the participants without TBI (Table 4.6). Only for the prompts score did the participants with TBI need fewer than those without TBI.

Table 4.6: Behavioural observations of participants with and without traumatic brain injury while completing the Test of Visual Perceptual Skills -3rd edition

	Participants with traumatic brain injury (n=34)		Participants without traumatic brain injury (n=34))				
	Mean	**SD**	**Mean**	**SD**	**Differences between means**	**U**	**p value**
Concentration	2.09	0.51	1.27	0.75	-0.82	232.50	0.00**
Distractibility	3.75	0.59	4.78	0.97	1.03	204.00	0.00**
Disinhibition	3.39	0.87	3.69	1.18	0.30	478.00	0.39
Emotional. Regulation	2.45	1.98	3.12	1.61	0.67	454.50	0.25
Fatigue	2.00	1.04	3.27	1.14	1.27	222.00	0.00**
Pace	2.36	0.68	3.18	0.64	0.82	234.50	0.00**
Perseveration	1.84	0.17	1.96	0.35	0.12	478.50	0.40
Instruction. Repetition	1.90	0.00	2.00	0.28	0.10	495.00	0.52
Flouting	1.90	0.28	1.90	0.28	0.00	544.50	0.99
Prompts	1.78	0.85	1.63	0.64	-0.15	458.00	0.27
Physical Features	3.27	1.44	5.75	2.10	2.48	184.50	0.00**

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

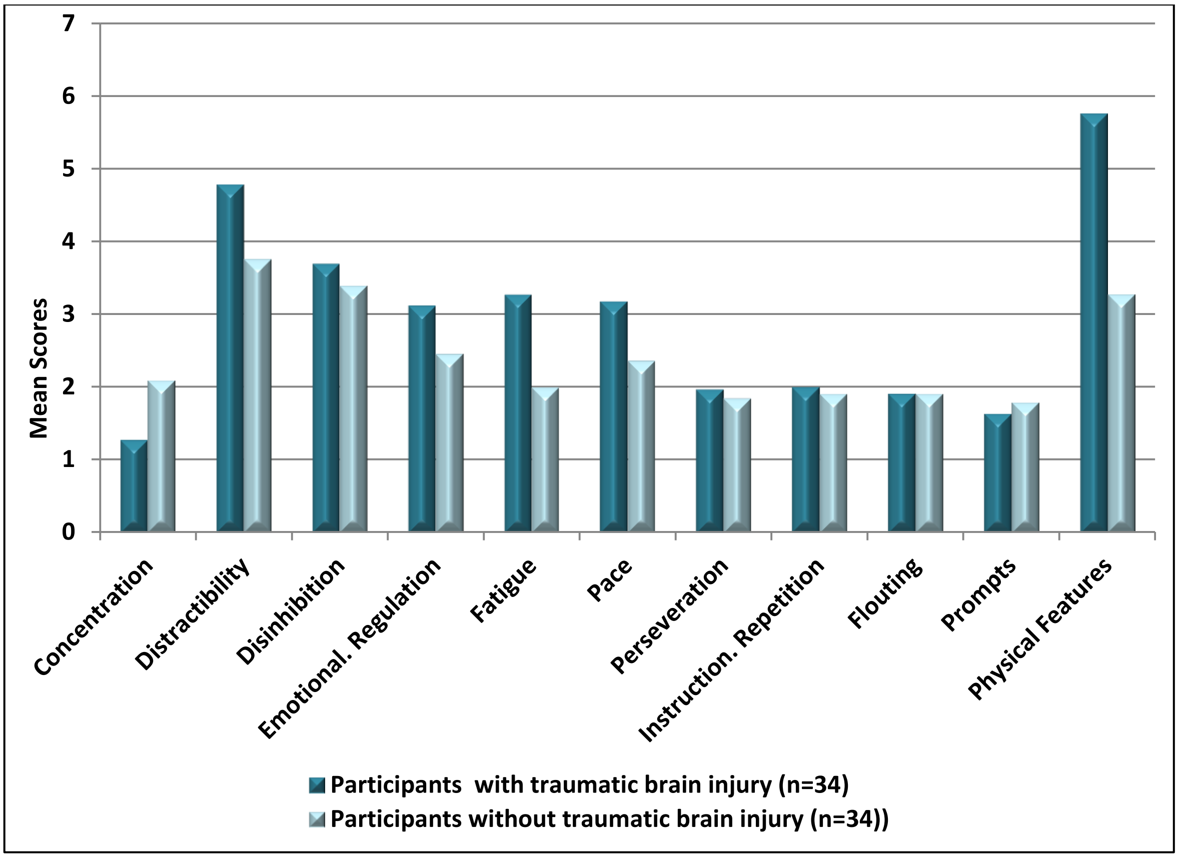

Figure 4.2: Behavioural observations of participants with and without traumatic brain injury while completing the Test of Visual Perceptual Skills - 3rd edition

4.4.2 Test of Visual Perceptual Skills -3rd Edition

The first objective of this study was to determine whether the use of the TVPS-3 can discriminate patients with TBI in a South African context. The results for the participants with TBI showed a lower aggregation of scores for visual perceptual processing in areas of overall processing (all subscales together); basic processing, sequential skills and complex processing. The greatest difference between mean scores for the two groups occurred in overall processing (mean difference of 12.44) and basic processing (mean difference 12.41). Overall Processing comprises all subtests, whilst basic processing consists of the first four subtests (Visual Discrimination, Visual Memory, Visual Spatial Relations and Form Constancy). The smallest difference in mean scores lay in the Sequencing category, encompassing only one subtest for Visual Sequential Memory (mean Difference of 4.38). An intermediate difference between mean scores (8.35) was achieved for complex processing, showing a statistically significant difference, where p=0.03, using the Mann Whitney U Test. The Mann Whitney U Test is a non-parametric test which tests for differences between two groups on a single variable with no specific distribution (McKnight & Najab, 2010)

Results indicate thus, that the TVPS-3 did discriminate between the participants with and without TBI for all subtests, except for sequential memory.

Table 4.7: Scores of participants with and without traumatic brain injury for the Test of Visual Perceptual Skills -3rd edition

		Participants with traumatic brain injury (n=34)		**Participants without traumatic brain injury (n=34))**				
		Mean	**SD**	**Mean**	**SD**	**Differences between means**	**U**	**p value**
Overall Processing	Standard score	**72.61**	**20.81**	**85.05**	**15.44**	**12.44**	**339.00**	**0.00****
	Overall Percentile	15.05	23.07	31.38	28.80	16.33	312.00	0.00**
Basic Processing	Standard score	**66.26**	**26.44**	**78.67**	**25.45**	**12.41**	**367.50**	**0.01****
	Overall Percentile	13.42	24.32	30.00	29.84	16.58	288.00	0.00**
Sequencing	Standard score	**75.14**	**21.15**	**79.52**	**24.81**	**4.38**	**492.00**	**0.29**
	Overall Percentile	17.52	21.42	30.94	31.89	13.42	415.50	0.04*
Complex Processing	Standard score	**77.26**	**21.79**	**85.61**	**22.71**	**8.35**	**406.50**	**0.03***
	Overall Percentile	18.11	25.80	40.38	35.79	22.27	323.50	0.00**
z score		-1.66	1.25	-0.78	0.92	**0.88**	286.00	0.00**

Significance set at p< 0.05*
Significance set at p< 0.01**

TVPS-3 Indices and Overall standard scores are reported as standard scores based on population distribution having a mean of 100 and a standard deviation of 15. The standard deviations are traditionally reported for a range of +- 3 standard deviations from the mean, and do not extend below 55 or above 145, representing the most extreme scores obtained by less than 0.02% of the population. The standard scores for both the participants with TBI and those without fell into this range from 66.26 to 85.61 so no extreme scores were noted.

Percentile ranks corresponding to scaled and standard scores are valuated according to tables provided, and are regarded as conceptually less complex than scaled scores. This is useful for explaining scores to those unfamiliar with scaled scores (Martin 2006; Gardner M 1992.) In this study the percentile ranks for the participants with TBI fell between 13.4 and 18.11. The ranks for the participants without TBI were significantly higher and fell between 30 and 41.4.

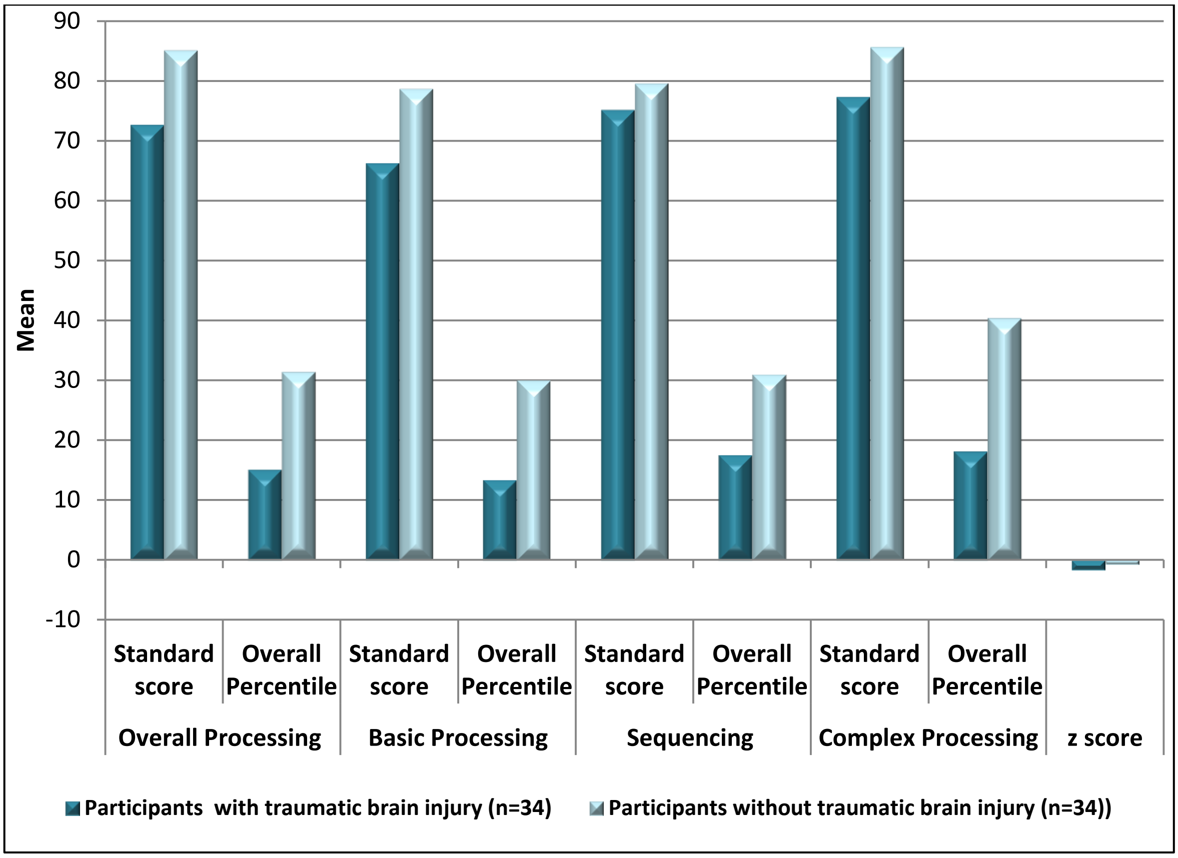

Figure 4.3: Scores for participants with and without traumatic brain injury on the Test of Visual Perceptual Skills -3rd edition

The Z score for participants with TBI (-1.66) was significantly lower than that for participants without TBI (-0.78), suggesting that the visual perceptual processing abilities of participants with TBI were more compromised (p= 0.00) (Figure 4.3). Participants in neither group, with the exception of two participants in the group with TBI, scored above 1 standard deviation. The majority of the participants without TBI (70.59%) had scores which fell in to the typical range between 1 and -1 SD.

Of the participants with TBI the scores of 67.65% fell -1.5 SD below the mean indicating identified visual perceptual problems. Another 8.82% of subjects' scores fell below -1 standard deviation indicating high risk for visual perceptual problems. A total 76.47% of participants with TBI with z scores below -1 SD. The TVPS-3 therefore identified a high proportion of participants with TBI as performing below the typical range (-1 to 1 standard deviations) when compared to a normal population (29.41% of whom fell below the typical range).

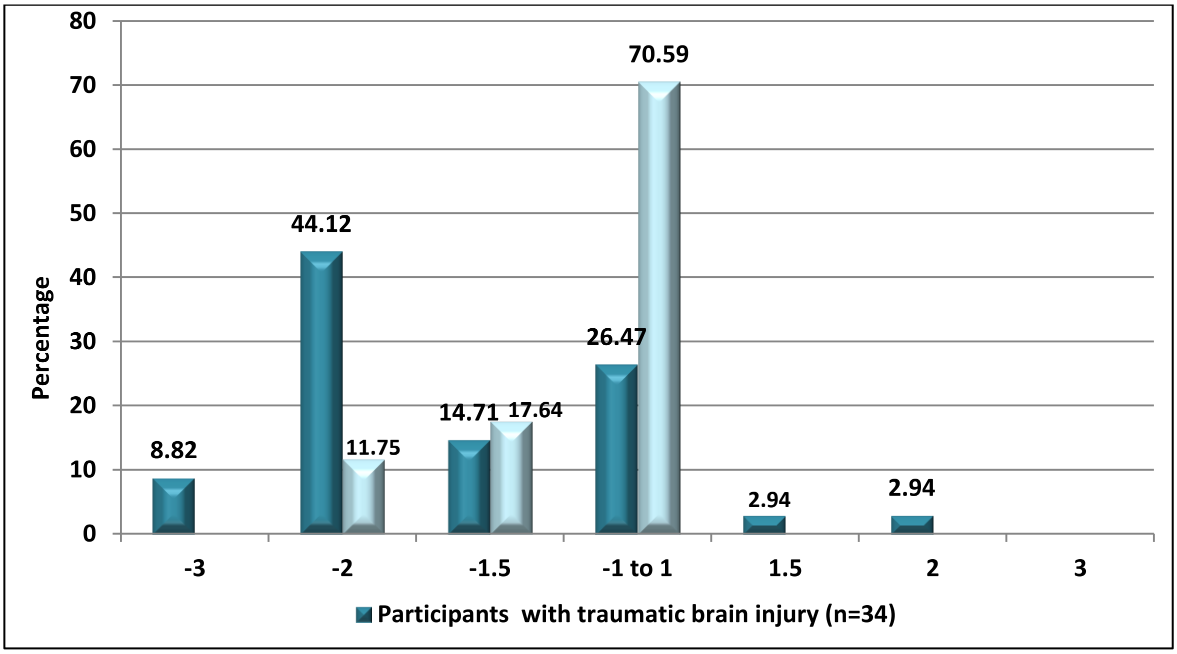

Figure 4.4: z Scores for participants with and without traumatic brain injury on the Test of Visual Perceptual Skills -3rd edition

4.4.2.1 Test of Visual Perceptual Skills -3rd edition Subscale Results:

Table 4.9 confirms the results for the overall standard scores with a significant difference between the Visual Discrimination, Visual Memory, Visual Spatial relations and Visual Form Constancy subtests for the participants with and without TBI.

The highest scores obtained were 16/16 for the participants without TBI. This score was obtained for spatial relations, form constancy and figure ground. The participants with TBI obtained similar high scores for Visual Spatial Relations and Visual Figure Ground but not Visual Form Constancy. The greatest difference in the mean scores was therefore for Visual Form Constancy between the two groups with Visual Memory showing a similar result.

Table 4.8 Subtest scores of participants with and without traumatic brain injury for the Test of Visual Perceptual Skills -3rd edition

	Participants with traumatic brain injury (n=34)		Participants without traumatic brain injury (n=34))				
	Mean	**SD**	**Mean**	**SD**	**Differences between means**	**U**	**p value**
Visual Discrimination.	4.4	4.65	7.17	4.15	2.77	348.50	0.00**
Visual memory	3.58	4.12	6.61	3.40	3.03	318.50	0.00**
Visual Spatial relations	5.44	4.69	7.88	3.05	2.44	401.50	0.03*
Visual Form Constancy	4.67	5.01	8.00	4.72	3.33	346.50	0.00**
Visual Sequential memory	5.11	3.81	6.82	3.53	1.71	430.00	0.07
Visual Figure Ground	4.38	4.40	7.55	4.47	3.17	321.00	0.00**
Visual Closure	6.70	3.98	9.00	3.56	2.30	392.00	0.02*

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

Visual memory was the subtest with the lowest mean scores for both groups while Visual Sequential memory proved to be amongst the higher scoring subtest for participants with TBI. The participants without TBI failed to achieve scores above 12/16 for Visual Sequential memory, indicating this was a more difficult subtest for them. There was no significant difference between the scores for the participants with and without TBI for this subtest. The difference between the mean scores for the two groups is 1.71 which is the smallest difference (Table 4.10).

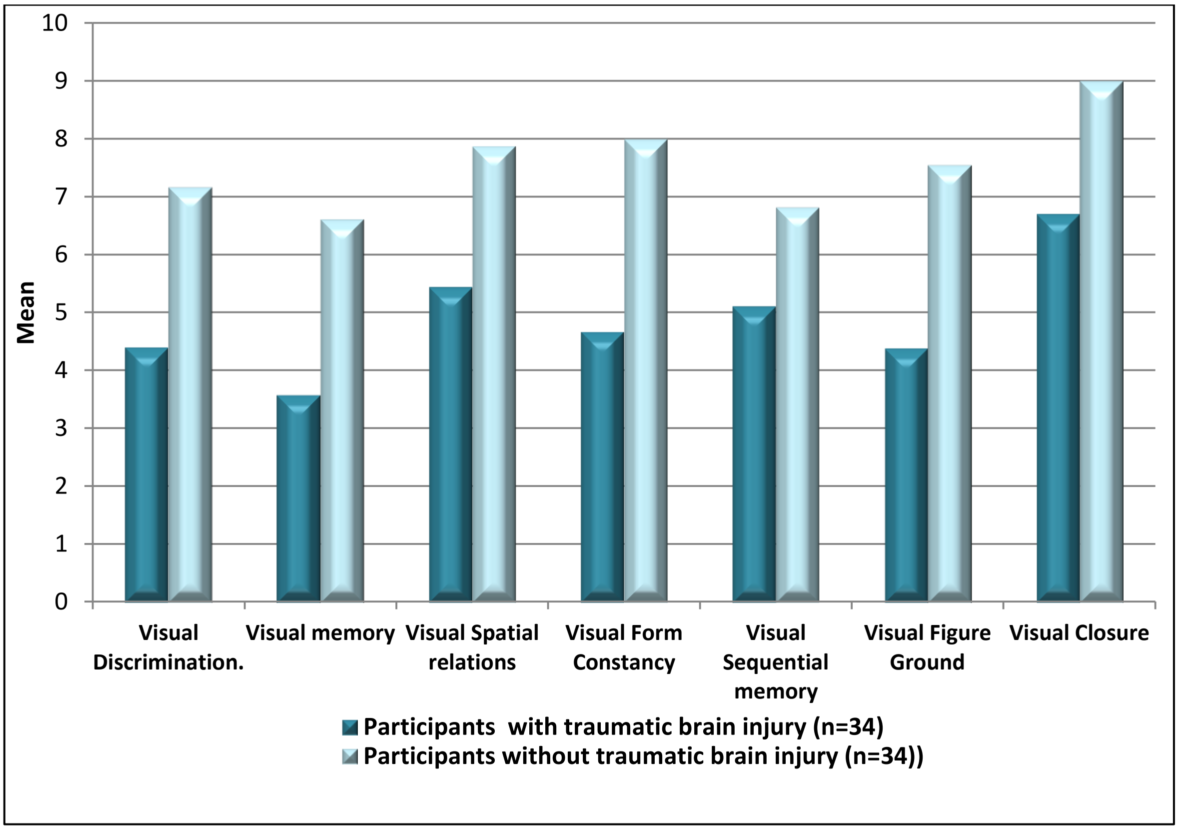

Figure 4.5: Subtest scores for participants with and without traumatic brain injury on the Test of Visual Perceptual Skills -3rd edition

4.4.3 Accuracy of the Test of Visual Perceptual Skills -3rd edition

The second objective of the study was to determine the accuracy of the TVPS-3 for visual perceptual processing difficulties in a sample of adult South African clients with TBI by determining the sensitivity, specificity and prediction value as well as reliability of this instrument to produce consistent results. The accuracy of the TVPS-3 was calculated based on the assumed prevalence of TBI in the South African population of approximately 5%, since the results must be based on population prevalence (Bryan-Hancock C, Harrison J, 2010). Sensitivity of 0.80 is the ability of the TVPS-3 to indicate a visual perceptual deficit below 1.5 standard deviations for participants with a TBI. A specificity of 0.71 indicates that 71% of participants without TBI will not be identified with a visual perceptual deficit below -1.5 standard deviations (Table 4. 10).

Table 4.9 The Accuracy of the Test of Visual Perceptual Skills -3rd edition for participants with traumatic brain injury (n=68)

		95% confidence intervals
Prevalence	4.76%	1.58% to 10.77%
Sensitivity	0.80	0.28 to 0.96
Specificity	0.71	0.61 to 0.79
Negative predictive value (%)	12.12%	3.48% to 28.22%
Positive predictive value	98.61%	92.47% to 99.77%

The positive predictive value indicates the probability that a participant has a TBI when the test has a positive result indicating a problem with visual perception. 98.61% of the population with negative results indicates no problem and will not have a TBI.

The accuracy of the TVPS-3 is also measured by the area under the ROC curve. The Area under the curve (AUC) determines the discriminative ability of a test : Streiner and Norman indicated that AUC's which fall between 0.50 and 0.70 are low ; moderate if between 0.70 and 0.90 and high when this value exceeds 0.90 (Streiner & Norman, 2008).

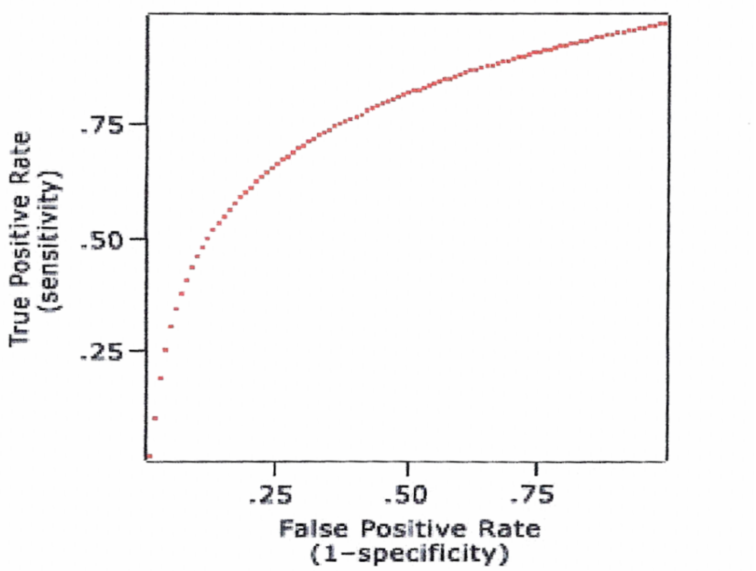

Figure 4.6: Receiver operating characteristic (ROC) curve, for participants with and without traumatic brain injury on the Test of Visual Perceptual Skills -3rd edition

In this study the area of 0.76 under the curve shows that the TVPS-3 has a fair ability to discriminate visual perceptual ability of participants with and without TBI if dysfunction level is set at -1.5 SD. The small sample used to calculate this ROC curve must be taken into consideration however and this may have affected the results, so the AUC needs to be interpreted with caution.

4.5 Reliability of the Test of Visual Perceptual Skills -3rd Edition

The internal consistency of the TVPS-3 for this sample of participants was 0.88 with all subtests scoring in the 0.85 range (Table 4.11). This is in keeping with and matches the internal consistency of the TVPS-3 which showed high correlations between test items indicating homogeneity of test items. Cronbach's alpha coefficient and Spearman Brown coefficients and split half reliability coefficients , computed per subtest, ranged from 0.75-0.88 for subtests and 0.96 for the test overall, and between 0.76 and 0.88 for subtests and 0.96 overall, respectively (Martin, 2006).

Table 4.10 The Cronbach's alpha values for the Test of Visual Perceptual Skills -3rd edition

Visual Discrimination.	0.88
Visual memory	0.88
Visual Spatial relations	0.87
Visual Form Constancy	0.87
Visual Sequential memory	0.89
Visual Figure Ground	0.87
Visual Closure	0.88

4.6 Occupational Self-Assessment (OSA)

The participants self-report on their competence in occupational performance skills and the value they place on their occupational performance was assessed on the OSA. The OSA competency and value scores for the participants without TBI were similar. This is indicative of their occupational performance skills being in line with the value placed upon the items they ranked that they were competent in. Whilst the participants with

TBI placed the same value on the occupational performance skills, they had a significantly lower competency score for these occupational performance skills, indicating disparity between their capacities to execute these ranked skills and the value they placed on them (Table 4.12).

Table 4.11 Scores of Participants with and without Traumatic Brain Injury for Occupational Self-Assessment

	Participants with traumatic brain injury (n=34)		Participants without traumatic brain injury (n=34))				
	Mean	**SD**	**Mean**	**SD**	**Differences between means**	**U**	**p value**
Occupational competence scale	39.79	8.74	53.44	11.05	13.65	204.5o	0.00**
Occupational competence scale error	2.52	0.66	2.85	0.35	0.32	371.50	0.01**
Values Scale	58.38	3.42	59.8	3.38	1.42	459.50	0.14
Values Scale error	3.00	0.00	3.00	0.00	0	578.00	0.99

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

Competency measures for the participants with TBI showed a mean of 39.79% as compared to the mean scores for the participants without TBI at 59.2%. This is indicative of lower perceived functional abilities and more executive tasks amongst the participants with TBI, for ADLs. This correlates with the lower mean score for the TVPS Z score. Contributing factors such as orthopaedic compromise and pain were not however accounted for in this test and were noted on an anecdotal basis to have contributed to lower scores for both groups by observing and recording behaviour during testing.

The values component of this questionnaire was more difficult to interpret accurately. Statistical analysis did not show sufficient variance within the standard error of measurement scores to produce a frequency table. Value attribution to ADLs was regarded as being similar across both groups, with those subjects who had sustained serious injury still aspiring to be able to live independently and placing similar value for independent function as did participants without TBI.

4.7 Association between Visual Perception and Occupational Performance

The third objective of the study was to establish if there was an association between residual visual perceptual processing difficulties and self-reported deficits for occupational performance skills. While correlations and regression analysis showed a significant association between the z scores of the TVPS-3 and the OSA competence scale there was no significant association between the TVPS-3 z scores and the OSA value scale (Table 4.13).

Table 4.12 Association between the Test of Visual Perceptual Skills -3rd edition and Occupational Self-Assessment

Test of Visual Perceptual Skills -3rd edition					
	R	**Variance r^2**	**Coefficient**	**Std. Error**	**p value**
Occupational Self-Assessment Competence Scale	0.40	20%	0.03	0.01	0.00**
Occupational Self-Assessment Value Scale	0.12	3.4%	0.02	0.03	0.56

Significance set at p≤ 0.05*
Significance set at p≤ 0.01**

Z scores for participants with TBI are associated with the TVPS-3 scores suggesting those with visual perceptual problems also report lower competency scores for occupational skills. When employment status in terms of “employed” or “student” as opposed to “unemployed” was correlated with the TVPS-3 z scores, a significant moderate correlation of 0.43 was obtained; indicating lower scores on the TVPS-3 were associated with unemployment.

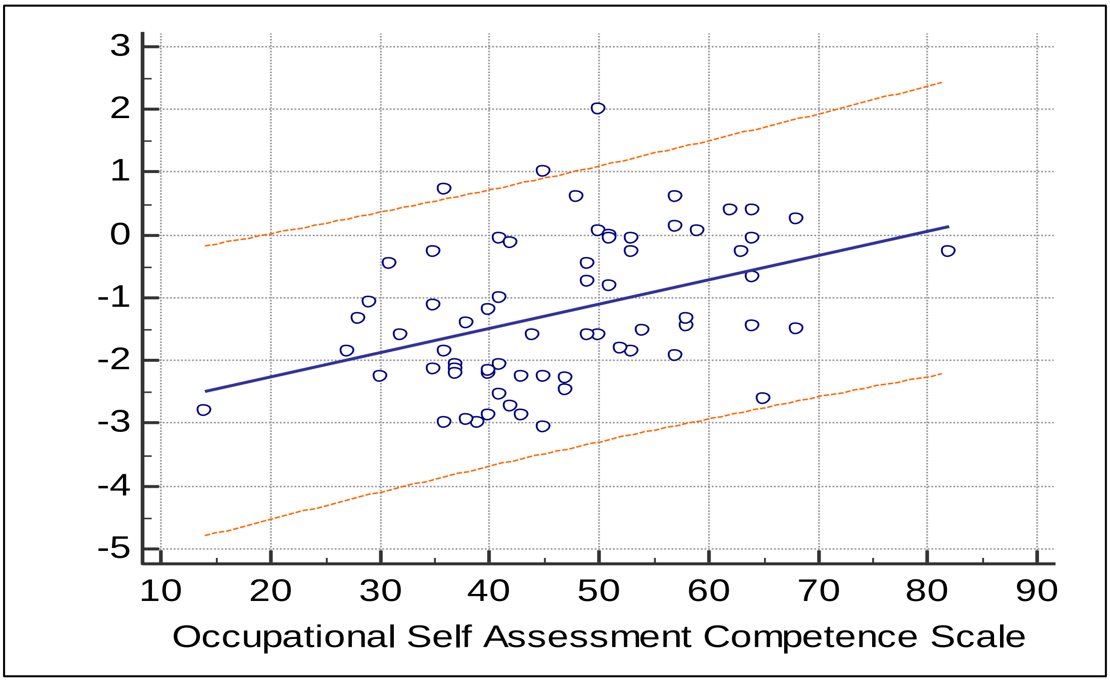

Figure 4.7 Association between the z scores of the Test of Visual Perceptual Skills -3rd edition and the Competence Scale of the Occupational Self-Assessment

Figure 4.8 Association between the z scores of the Test of Visual Perceptual Skills -3rd edition and the Value Scale of the Visual Occupational Self-Assessment

4.8 Medical history, Injuries, Behavioural Observations and Test of Visual Perceptual Skills -3rd Edition

4.8.1 Level of Traumatic Brain Injury and Scores on the Test of Visual Perceptual Skills -3rd Edition

There were no significant differences between the participants with mild, moderate or severe TBI on the scores for the TVPS-3 except for the Visual Figure Ground Score when the severe and mild level of TBI was compared (p=0.02). Overall the participants with severe TBI had higher scores but those with moderate TBI did better on the TVPS-3 than those with mild TBI. (Table 4.13).

Table 4.13 Scores for different severity of traumatic brain Injury on the Test of Visual

	Severe traumatic brain Injury (n=17)			Moderate traumatic brain Injury (n=7)			Mild traumatic brain Injury (n=10)		
	Low Quartile	Median	Upper Quartile	Lower Quartile	Median	Upper Quartile	Lower Quartile	Median	Upper Quartile
Visual Discrimination.	1.00	5.00	7.00	0.00	1.00	7.00	0.00	2.00	8.00
Visual memory	1.00	2.00	9.00	0.00	0.00	5.00	0.00	1.00	6.00
Visual Spatial relations	0.00	7.00	11.00	0.00	4.00	9.00	0.00	5.00	9.00
Visual Form Constancy	0.00	7.00	11.00	0.00	4.00	9.00	0.00	5.00	9.00
Visual Sequential memory	1.00	5.00	11.00	0.00	0.00	5.00	0.00	1.50	5.00
Visual Figure Ground	2.00	7.00	9.00	0.00	4.00	8.00	3.00	5.00	5.00
Visual Closure	2.00	6.00	9.00	0.00	2.00	5.00	1.00	1.50	2.00
Overall Standard score	5.00	9.00	10.00	2.00	7.00	9.00	1.00	5.00	8.00

4.8.2 Association between Behavioural Observations and Test of Visual Perceptual Skills -3rd Edition

Correlation analysis indicated a moderate association between the physical features and concentration and distractibility when the behavioural observations were considered. Those with more physical problems presented with lower concentration capacity and were more distractible. A low physical feature score was also associated moderately with lower concentration and higher distractibility (Table 4.15).

Table 4.14 Association between the Test of Visual Perceptual Skills -3rd edition and behavioural observations made during the administration of the test (n=68)

	Distractibility	Physical Features	Instruction. Repetition	Pace
Concentration	-0.67*	-0.61*		
Distractibility		0.54*		0.50*
Perseverative response			0.69*	
Visual Figure Ground				0.51*
Overall Standard score				0.54*
Overall percentile				0.56*
Basic Processing percentile				0.57*
Complex Processing percentile %				0.50*
z scores				0.58*

Significance p≤ 0.05

The scores on the TVPS-3 and distractibility were associated with deficits in pace with participants scores being lower when the pace was impulsive or slow (Table 4.15). There was also a moderate correlation between perseverative response and the need for instruction repetition. All of these correlations were significant at the 0.05 level.

4.9 Summary:

This study aimed to determine the discriminative validity of the TVPS-3 for visual perceptual impairment in a sample of South African adults with and without TBI, and to determine an association between visual perceptual function and occupational ability. Results of this study have shown that there exists a significant difference between visual perceptual processing abilities of persons with TBI and those without, as tested on the TVPS-3. These show significant differences in scores for all subtests with the exception of visual sequential memory. Overall, composite scores for basic, overall and complex processing showed there to be a significant difference in visual perceptual processing between adults with and without TBI. The TVPS 3 did not discriminate between TBI participants with severe and mild injuries in order to determine the predictive validity of the TVPS-3.

Low TVPS-3 scores, as identified in the participants with TBI, showed correlation with lower competency scores on the OSA. This suggests that weaker visual perceptual abilities contribute to lowered functional and occupational competence.

Correlations and regression analysis showed that the association between the TVPS-3 z scores and the OSA value scale was not significant; the association between the z scores and the OSA competence score was significant, with a significant moderate correlation of 0.43 reflecting that lower scores on the TVPS-3 were associated with unemployment.

Overall, the objectives of this study were met and determine that the TVPS-3 can be used as a discriminative instrument in a South African TBI population, to identify visual perceptual processing ability, whilst also having a moderate predictive ability for identifying occupational competence difficulties in a TBI population.

Norman indicated that AUC's which fall between 0.50 and 0.70 are low; moderate if between 0.70 and 0.90 and high when this value exceeds 0.90 (Streiner & Norman, 2008). In this study the area of 0.76 under the curve shows that the TVPS-3 has a fair ability to discriminate visual perceptual ability of participants with and without TBI if dysfunction level is set at -1.5 SD.

CHAPTER 5: DISCUSSION

5.1 Introduction:

This study aimed to determine the discriminative validity of the TVPS-3 for visual perceptual impairment in a sample of South African adults with a history of TBI. It also aimed to determine the association or correlation of the TVPS-3 scores with occupational competence for a sample of a South African adult population, where occupational competence refers to a person's capacity to undertake all aspects of human occupation. The three objectives of this study were concerned with: first, the determination of the validity of the Test of Visual Perceptual Skills-3 (TVPS-3) in discriminating visual perceptual processing difficulties in adult clients with TBI. Second, to establish the accuracy of the TVPS-3 for visual perceptual processing difficulties in an adult TBI population ; third, to establish the association between residual visual perceptual processing difficulties assessed on the Test of Visual Perceptual Skills-3 (TVPS-3) and reported deficits in TBI clients' independent living and occupational performance skills measured on the Occupational Self-Assessment (OSA) test. This was in order to determine the predictive validity of the TVPS-3.

This chapter will consider the demographics of the sample as well as difference in visual perceptual processing difficulties assessed by TVPS-3 in adult clients with and without TBI in South Africa. The sensitivity, specificity and the prediction value of the TVPS-3 for visual perceptual processing difficulties as well as the internal consistency of the test for this sample will be discussed.

The association between visual perceptual processing and perceived competency, the values of independent living and occupational performance skills and the clinical implications of the findings will also be considered.

5.2 Demographics and Medical Information

South African subjects were used for this study, sourced by convenient sampling from a client base of injured persons referred for medico legal assessment. A sample of 34 participants with TBI and 34 participants without TBI were recruited into the study. They were matched for age and educational background as closely as possible. Due to the selection procedure of the participants having to be changed as described in Chapter 3, matching was difficult. Participants without TBI were sourced through convenient sampling from the community at large, and from a medico legal client base of orthopedically injured persons.

All participants were below the age of 65 years. The revision of this test by Martin allows for appropriate use in an adult population, recognising that there is not much development of visual perceptual skill after 18 years, and before 65 years of age. As the TVPS-3 is not age specific for adult clients over 18 years 11 months and the construct validity of this test accommodates for age in scoring (Martin, 2006), age was not regarded as an essential matching variable. The manual stipulates that since TVPS-3 indices and overall scores are based on sums of scaled scores, age is not a factor, having already been accounted for in the age related raw-to-scaled score conversions (Table 4.1). The age groups used for matching were large and represented young and middle adulthood.

There was no significant difference between the participants with and without TBI for other demographic factors including geographic location and the groups were considered comparable. Participants represented a South African demographic with a spread of racial groupings including Black, White and Indian clients. Coloured subjects were the smallest minority grouping. Participants were not matched for population group or culture as the TVPS-3 is considered culture free. The group comprised persons of all race groups in South Africa, although the demographic of the group represented more white participants than other race groups. This was surprising considering the number of Black persons injured in motor vehicle accidents in South Africa daily, made more vulnerable by their mode of public transportation and pedestrian habits. The demographic slant in the occupational therapy practice is more towards Black claimants, a factor of high population density of Black and particularly Zulu people in KwaZulu Natal. More Black candidates, with and without TBI however were excluded from the study than other race groups, due to the presence of exclusionary factors such as alcohol or drug dependence ; prior learning difficulties or a history of previous assault and /or illness resulting in neurological compromise. This correlated with the studies carried out in South Africa concerning the prevalence of TBI through violent means, and under impoverished conditions. (Nell & Brown, 1992) (Goosen, et al., 2003)

As with the general TBI population and those TBI samples reported in literature, most subjects were males. Gender is not a determining factor in this test either and subjects were thus not paired according to gender (Table 4.1). As with the study by McKenna et al (2006), and despite efforts to control for sameness, the TBI sample differed from the normative sample in terms of culture and employment. Participants in this study were matched as much as possible for educational backgrounds (Table 4.3), which is regarded in literature as being linked, and having more influence than other demographic variables (McKenna, et al., 2006).

Due to the change in the selection of participants, a number of participants without TBI also presented with orthopaedic injuries (Table 4.5). There was no significant difference in the injuries between the participants with and without TBI for demographic factors and the groups were considered comparable. Some participants had more than one type of attendant injury associated with the nature of high velocity MVAs. The persistent sequelae to these injuries however, were more prevalent amongst the participants with TBI. 85.2% of participants with TBI reported pain whilst 52.9% of participants without TBI experienced on-going pain .Similarly the participants with TBI described more persistent psychological sequelae including noise intolerance, combined features of depression, anxiety and short temperedness. It is accepted that these factors may have influenced the participants' performance on the assessments used in the study and this is discussed under section 5.5.

5.3 Visual Perceptual Processing in Clients with and without Traumatic Brain Injury

The TVPS -3 was selected as the assessment tool of choice, as it is routinely used in South Africa by occupational therapists, in both paediatric and adult clinical and assessment contexts. In the absence of other relatively quick and easy to use tools, the TVPS -3 has proven itself a useful tool, particularly as it is designed to be non-race, age or sex dependant. It is also non-motor and is thus useful for use in persons who may be motorically affected. Although designed and developed on a paediatric population up to 18 years 11 months of age, the TVPS has been used to reliably differentiate scores between adults with and without strokes (Titus M, 1991) (Su, et al., 2000) Further studies showed that brain injury to either hemisphere may result in some type of visual perceptual disability and all clients with brain injury should be considered for testing.

Results of this study showed a significant difference between scores for participants with TBI and those without TBI. Participants with TBI demonstrated mean z scores (-1.66) lower than that for participants without TBI (-0.78), indicating that the visual perceptual processing abilities of participants with TBI were more compromised. This supports literature in which studies have found that participants with TBI have consistently scored lower on various visual perceptual tests than participants without TBI. Deficits in visual perceptual abilities were frequently related to neurological conditions including cerebrovascular accidents and acquired brain injury (Brown, et al., 2009).

Visual perceptual problems were identified as dysfunctional in 67.65% of participants with TBI, with z scores falling -1.5 SD below the mean. Another 8.82% of subjects' scores fell below -1 SD indicating high risk for visual perceptual problems. This result indicates that the TVPS-3 identified a small proportion of participants with TBI (26.47%) as performing in the typical range (-1 to 1 SD) when compared to participants without TBI, where 70.59% scored in the typical range (Figure 4.4).

These results showed that the distribution of the typical z scores on the TVPS-3 for the participants without TBI did fit into a normal distribution with the percentage falling into the typical category just slightly more than expected in a normal curve. The test results indicate a skewing towards the negative side of the distribution for -1 and -2 SD indicating the TVPS-3 is more difficult than expected for a sample of South African adults without TBI.

The accuracy of the TVPS-3 in determining visual perceptual dysfunction was determined by the sensitivity and specificity of the tool based on a prevalence of approximately 5% of the global estimate of TBI , in South Africa (Bryan-Hancock & Harrison, 2010). Sensitivity is defined as the capacity for an instrument to yield a positive result for a person with the diagnostic condition (Glaros & Kline, 1988), or the true positive rate (Streiner & Norman, 2008). In this study the sensitivity of the TVPS-3 to indicate a visual perceptual deficit below -1.5 SD in participants with a TBI was 80%. The specificity of the tool, reflecting the capacity of the tool to yield a negative result for a person without TBI, was 0.71; this indicates that 71% of participants without TBI will not be identified with a visual perceptual deficit below -1.5 SD (Table 4.10). These values fall into the acceptable range above 0.7 for sensitivity and specificity indicating that the TVPS-3 can be used to discriminate between patients with and without TBI. The high negative predictive value can be used to determine that if the TVPS-3 results do not indicate a visual perceptual problem of 98.61% of individuals tested, they will not have TBI (Parikh, et al., 2008) The low negative predictive value of 12.12% needs to be interpreted with respect to the low prevalence of TBI in the South African population.

The evaluation of the TVPS-3 as a diagnostic test for visual perceptual problems in patients with TBI using a ROC indicates that an acceptable level is reached when using it as a diagnostic tool. The TVPS-3 can therefore be used to discriminate between those with and without TBI one to two years post injury.

When the different sections of the TVPS were considered (Table 4.8), the scores were significantly higher for participants without TBI for all four aspects assessed by the TVPS-3 – overall processing, basic processing, sequencing and complex processing. The greatest difference in mean composite scores for participants with and without TBI fell within the categories for overall visual perception and basic visual perception. Overall visual perception refers to aggregation of all subtest scores, whilst basic visual perception refers to the scores for visual discrimination, visual memory, visual formal constancy and visual spatial relations.

A smaller difference between mean scores was achieved for complex processing which comprised the visual figure ground and visual closure subtests and it appears that the participants with TBI had slightly higher scores for this section showing less dysfunction in the complex aspects of visual perception. .

When comparing the other subtest scores between groups, the greatest difference in mean scores above 3 points, fell in the subtests for visual form constancy and visual figure ground. Visual figure ground was the one subtest when comparing mild moderate and severe TBI that showed a relative increase in scores with the severity of the TBI. This suggests that that the more severe the TBI the greater dysfunction in this area of visual perception. Visual figure ground is regarded in literature as being a higher order level of perception as it draws on visual memory, and requires recognition of features of the object including haptic, temporal, spatial orientation and motion (Zoltan, 1996) . This finding also supports the argument that visual perceptual skills are interdependent (Richmond & Holland, 2011). These features are particular to the ventral visual pathways and essential for the interaction of vision for perception and vision for action in the dorsal visual pathways (Schenk & McIntosh, 2010). Figure ground difficulties are regarded as occurring with either hemisphere involved, although worse when the right hemisphere is damaged (York & Cermak, 1995) (Su, et al., 2000). This higher level of perception allows for an individual to organise their environment layout, hence any difficulty with figure ground perception will result in difficulties operating in an environmental context for function (e.g. finding an item in a cupboard; selecting a grocery item off a shelf) It will ultimately affect an individual's ability to perform self-care tasks including the selection of appropriate clothing, grocery items required for cooking, tool or utensil selection. Figure Ground difficulties will have enormous bearing upon driving ability, reading fluency, writing or word processing and the use of social media devices. This lends itself strongly to the purpose of this study in which the association between visual perceptual processing and occupational performance competency as assessed by the OSA was the focus.

Lower z scores for TVPS-3 were associated with lower competency scores on the OSA. This was validated anecdotally with the assessment by caregivers or family members of the TBI subjects, who were rated as having difficulty with the execution of activities of daily living in all domains of function including self-care, domestic responsibility, transportation, community survival and appropriate care of others. Occupational performance of work tasks for those participants with TBI, who had returned to work, as reported by employers, was invariably compromised for speed, quality, and accuracy. This compromise demanded monitoring and supervision, and specific accommodations for accuracy, the need to double check work, provision of extra time, in excess of that required previous to the TBI.

The Visual form constancy subtest appeared to be a more difficult subtest generally, for participants with but not those without TBI with a mean difference of 3.33. Gestalt theorists proposed that form constancy was key to perceptual organisation which helps make sense of our world. Difficulties in this subtest may apply to the position of the subtest in the TVPS-3 (the fourth of seven subtests), or to the material presented. In participants with TBI the form constancy test results may have been affected as this aspect of visual perception is reliant on the interplay of several other visual perceptual processes such as visual figure ground, visual memory and spatial orientation. This inter relationship of skills highlights the reliance of certain skills on others to process this higher order thinking (Martin, 2006), and thus any one subtest cannot be considered an absolute measure of a discrete perceptual ability. Supporting the TBI group's lower score profile for visual form constancy are lower scores for Visual Spatial relations (mean difference of 2.44) and Visual Memory (mean difference 0f 3.03). The presentation of visual material for visual form constancy is manipulated for size, spatial orientation and spatial relationship to other extraneous features. Difficulties with any one of these visual perceptual skills will undermine capacity to hold an image in memory whilst mentally manipulating the image to match the stimulus figure. Subjects struggled in particular with the disparity in spatial sizing of stimulus and response figures, or those which were adjacent to or within other extraneous forms. This resulted in subjects rejecting those forms which were smaller or larger or orientated differently to the stimulus picture. Functionally, this was associated with subjects having reported and subjective difficulties with reading, interpreting diagrammatic information, attending to a repetitive stimulus and remembering visual information, thus compromising occupational performance of daily life tasks. Zoltan (1996) proposes that executive dysfunction affects mental flexibility and abstraction, causing TBI subjects to have difficulty forming concepts or moving outside of an individualised event; they are unable to analyse the relationship between objects and their properties. (Zoltan, 1996). This suggests that perhaps visual form constancy (by virtue of it's inter relatedness and complexity) is really a measure of executive function, despite it being argued that this is one of the earlier developed visual perceptual constructs (Martin, 2006). Memory is defined as a function which relates to learning and the perception of our world and is essentially perception which is stored at an earlier time and then can be brought forward (Zoltan, 1996). Memory is defined in literature within various theoretical and conceptual frameworks. Consensus is reached however that memory is not a single function or entity but a combination of cognitive processes responsible for acquisition, retention and retrieval of information (Lowther & Mayfield, 2004).

Memory requires constant interaction with the environment, central nervous system change, maintenance of change and an output that consistently relates to the stimulus. Memory is one of the most important elements in learning and essential to academic success (Lowther & Mayfield, 2004). Various types of memory influence successful functional ability. TBI patients often lose the ability to automatically rehearse or encode information, affecting their ability to learn from past errors. Additionally, they have difficulties with Meta memory, preventing them from remembering to remember a task. The mean difference for the scores between the participants with and without TBI for visual memory was still above three. This indicated a significant problem with visual memory in the participants with TBI, supporting literature which suggests that memory deficits are in part responsible for concrete thought processes, reduced mental flexibility and conceptualisation. They are thus unable to perceive differences and similarities or identify important features or events and owing to memory deficit, they are unable to make comparisons or retain those already made (Zoltan, 1996). Although a timed task, as with sequential memory, the visual memory subtest stimuli figures are deceptively simple and probably do not focus attention as much as sequential memory subtest items do. The items do increase in complexity and subtle differences between response options; suggest that other visual perceptual functions such as figure ground, visual form constancy and visual discrimination are important in processing these stimuli. Subjects did not however use the same strategies as observed in the sequential memory subtest to process sensory memory to working memory, accounting in part for the significant difference in scores (mean difference of 3.03) between subjects with and without TBI.

The scores for visual sequential memory however did not show a significant difference between groups (Table 4.9). In the visual sequential memory subtest the participants with TBI scored in a similar range to the participants without TBI. This occurred despite it being a timed test with a limited exposure time to the stimulus before having to choose a matched response. Participants without TBI presented with a lower score which meant some of them found this aspect of the test more difficult. This score was based on the subtest of visual sequential memory (Table 4.9). Higher scores for this subtest are at face value curious, as sequencing ability should reflect higher order processing and executive ability, and should theoretically be reflected as more dysfunctional in brain injured persons than not. Reasons for higher scores in this subtest are theorised and based on observations of the subjects as follows. The perceived difficulty of this material in terms of the number of items to be remembered may have resulted in subjects focussing more effort on the task. They were aware of time being an issue and thus used the time limit rather than flicking through pages impulsively. The nature of the items is simplistic. Presentation is clear, logical and uncomplicated by the presence of overlying pictures (as in subtests for figure ground, form constancy). The items are also presented in exactly the same way, without subjects having to manipulate spatial or directional components (as with form constancy, spatial relations). This allowed for subjects to utilise compensatory methods more easily, memorising order with mnemonics, parroting order to themselves, using kinaesthetic feedback and counting off against their fingers. These strategies may have complimented ability in this subtest through the processing of sensory memory to working memory where information is remained thorough repetition. Working memory is regarded as being able to deal with up to 7 information pieces at once and is considered as part of a control mechanism for higher order intellectual processing (Zoltan, 1996). The working memory is then encoded into long term memory. The deeper the working memory processes information the better the recall thereof, hence higher scores for this subtest through the active processing of sensory to working memory function.

These findings suggests that the material used for visual memory, presented in isolation may have been more challenging than those forms presented in sequenced memory patterns with others. A comparative study by Brown et al however, indicated that the memory and visual sequential memory subtests of the TVPS-3 were rated as the most difficult subscales of the TVPS-3, for a typical population, as compared to the DTVP-2 and MVPT-3. This is echoed by Martin, although she noted that the subtests for memory and visual sequential memory have lower correlations than the other subtests, with the total score. Factor analysis of the TVPS-3 scores also indicated that there may be differentiation between perception and memory. An alternate view however suggests that the four visual perceptual skills assessed first in the TVPS-3 represent those basic processes which develop early and utilise similar processes. These subtests are reported to have loaded strongly when the TVPS-3 was analysed using three factors - general perception (visual discrimination, memory, spatial relations and form constancy); sequencing (mediated by the prefrontal cortex and suggests executive control) and memory. These three factors, showed more variance than a two factor solution (perception and memory) and were adopted in determining the validity of the TVPS-3. Sequential memory loaded strongly on a second factor and complex processes of figure ground and closure (the last perceptual tasks to develop) loaded on a third factor (Martin, 2006). Martin suggests that visual memory is one of the earlier constructs to develop, and hence loaded on the first factor, distinct from visual sequential memory which loaded strongly on the second factor. Sensory memory (the first phase of information processing) has the capacity to process large amounts of information for brief durations. It is broken into iconic (sensory vision) and echoic (auditory) sensory memory (Zoltan, 1996). The repetition or rehearsal of information encodes sensory memory to working memory, hence better recollection of information which has been repeated through verbal/visual/kinaesthetic strategies. This conceptual framework helps to understand, in part, the higher scores for TBI and non TBI subjects for the visual sequential memory subtest as compared to the difficulty evident for TBI subjects in the visual memory subtest, as subjects did not commit or rehearse the visual memory stimuli figures for retention or recall as they did the visual sequential memory figures.

The difference in the visual discrimination scores between the participants, with and without TBI, also showed the participants without TBI performed significantly better. The difference in the scores was not as great as for form constancy, figure ground and visual memory (Table 4.9). The score on the visual discrimination test was the second lowest for the participants with TBI and thus a deficit in this aspect may have influenced all the other subtests. Martin (2006) argued that visual discrimination is the basic underlying ability influencing all types of visual perceptual processing. It is essential to the identification of differences between stimuli. Being able to distinguish between forms allows successful environmental interaction, playing an important role in the identification of different objects and in navigating in the environment. It is theorised that visual discrimination is accomplished by two processes and two distinct systems. The first system is thought to process abstractly, recognised forms, whilst the second processes more acutely the different types of the same form. Being unable to process form perception, results in an inability to attend to the subtleties of form variance, and may functionally result in mistakenly substituting one item for another (Zoltan, 1996).

Participants with TBI of a range of severity (mild to severe) were selected for the group with TBI. In this group, 50% of participants had sustained severe head injury, 20.5% moderate and 29.4% mild head injuries (Table 4.4). When the scores on the subtests were considered in relation to the severity of the TBI, all the participants with moderate TBI scored better than those with mild TBI, except for visual form constancy and visual figure ground as discussed above (Table 4.14). This finding is supported by literature which shows that information processing deficits in persons with mild TBI extend for about three months beyond the acute recovery period (Lachapelle, et al., 2008). Neuropsychological testing Electrophysiology and neuro imaging measures have detected subtle deficits associated with the primary analysis of visual input, necessary for object recognition, which suggest that dysfunctional complex visual perceptual integration can be seen in individuals with mild TBI (Lachapelle, et al., 2008). Persistent deficits, until recently poorly recognised in the literature, are ascribed to 10-67% of the TBI population following mild to moderate head injury and suggest a strong correlation between TBI and existence of persistent deficits (Mackenzie, et al., 2002), A similar study conducted by Lowther and Mayfield (2004) on a paediatric TBI population looking at comparisons between children with severe and moderate brain injuries demonstrated no significant difference on performance, suggesting that the effects of moderate TBI were as significantly disabling as those with severe TBI. (Lowther & Mayfield, 2004)

5.4. Association between Visual Perception and Occupational Performance

The third objective of the study was to establish if there was an association between residual visual perceptual processing and self-reported occupational performance skills. In order to determine the association, participants were asked to complete the OSA. The choice of the OSA as an appropriate tool to measure occupational competence and values was based on its original form, the Model of Human Occupation by Kielhofner (Baron, et al., 2006). As such, this was designed to provide a holistic approach to understanding human occupation whilst considering the interplay of several factors including motivation, lifestyle, performance capacity and environmental impact. This tool was designed to capture a range of occupational concerns a client may have. In the context of clients in this study having sustained injury with far reaching consequences, this tool was considered to be appropriate.

The OSA was used to assess the participants' perceived competency in occupations and the value they place on their occupational performance of life tasks. The OSA showed a significant difference between the scores for competency of the participants with and without TBI. There was no significant difference for the value scores ascribed to performance of these occupational tasks. The competency and value scores on the OSA for the participants without TBI were similar. This indicated that their capacity to execute occupational performance skills was congruent with the value attributed to the items for which they ranked themselves as being competent in. The participants with TBI placed the same value on the occupational performance skills as the participants without TBI, but demonstrated significantly lower competency scores for these occupational performance skills (Table 4.12). This indicated disparity between their capacities to execute these ranked skills and the value they placed on them. The *values* component of this questionnaire indicated those subjects, who had sustained serious injury, still aspired to be able to live independently and they placed similar value for independent function as did participants without TBI.

The OSA is presented in a hierarchical structure of performance tasks, commencing with those more practical basic tasks of daily living, to the habituation items. It deals with management and relational tasks and moves to volitional items, which depict more abstract and higher order experiences of satisfaction, enjoyment and self-actualisation. This presents increasing executive demand and hence difficulty in performing these tasks effectively (Kielhofner, et al., 2009). This allows for the assessment of aspects like planning, building concepts or appraising their own abilities accurately. Neuropsychological studies by Lippert Gruner et al (2006) have identified these struggles in persons who had suffered severe TBI. They report that as individuals with TBI recover, deficits often become more apparent. The most prominent deficits appear related to attentional ability, thought processes involved in planning, affective oscillation capacity, memory deficits as well as compromised critical capacity (Lippert-Gruner, et al., 2005).

These findings lend support to the OSA results of this study. Although participants with TBI reported diminished capacity for occupations as a result of the sequelae to their TBI, they still valued and expected to be able to accomplish these occupations in the future. The average time, post TBI, for subjects of this study was in excess of two years, supporting literature findings that such deficits persist, even appearing more severe than in the sub-acute phase of recovery.

Although broad-based and fairly straightforward in their intended meaning, the OSA items posed difficulties for several of the subjects in this study, prompting possibly lower than anticipated scores. These may have been due not only to literal interpretation of the items and their perceived difficulties undertaking the tasks, but rather to their inability to manage extraneous factors which have a direct bearing upon their execution of the tasks. These extraneous factors had a pervasive effect upon all three task categories in the OSA and were largely underscored by poverty and /or financial and economic difficulties, commonplace in impoverished, mostly Black families and communities.

They reported that these difficulties compromised their ability to take care of others. They limited the participants' access to public health care and/or being able to afford private health care. They reported a lack of personal transportation and inability to afford alternate transportation. Financial difficulties also compromised their capacity to take care of where they lived, engage in recreational activities; undertake studies or be employed in a meaningful occupation. They also affected their ability to attain goals which needed finance (Complete studies; build a house etc.). The effects of depression and anxiety as having influence on the scores on the OSA cannot be disregarded. The use of the OSA in the context of once off assessment cannot deem it a therapeutic tool, as it served to highlight difficulties and socioeconomic or psychosocial plight rather than strength.

When the association between visual perception and occupational performance was determined, a moderate significant correlation was found between the TVPS z scores and the OSA competency mean scores (Table 4.15). This suggested that for both participants with and without TBI, lower visual perceptual scores may be indicative of lower competency scores for daily activity profiles. The association found indicates that the lower competency scores for the participants with TBI related to their lower perceived functional abilities in occupational performance tasks. This lends support to the findings by Dikmen et al (2003). Their study identified that approximately 60% of individuals with TBI reported difficulties in undertaking daily self-care tasks and required total or partial help from others. This study took place three to five years post TBI (Dikmen, et al., 2003). They found that individuals with TBI who had lower scores on their Abbreviated Injury Scale (AIS) and their Time Following Commands (TFC) assessment, were receiving assistance or had relinquished substantial aspects of their daily routine. They were experiencing difficulties undertaking major role activities, social relationships and managing the demands in everyday life including planning, handling finances and being responsible for taking care of themselves.

The moderate correlations of OSA mean competency scores and TVPS z scores may be attributed to the measurement of two different components – scores derived from actual ability as opposed to scores derived from anticipated ability. The study by McKenna et al (2006) showed similarly weak correlation between visual perceptual impairment assessed on the OT-APST and functional outcomes using the FIM cognitive and BRISC assessments. The weak correlation was attributed in part to the OT-APST being a brief screening tool, best used in conjunction with more detailed functional assessment and observations to determine real impact upon specific areas of cognitive function and visual perceptual impairment (McKenna, et al., 2006). Dikmen et al (2003) suggest that the level of severity of TBI sustained may influence the reporting of deficits with those less severely injured reporting fewer problems. Those with more severe injuries however, may lack the insight or appreciation of their problems' significance and their appreciation of survival may outweigh their focus on functional competence. They highlight however that although severity of injury is clearly related to the degree of functional limitations still experienced three to five years post injury, there is a lack of substantive relationship between the severity of injury and awareness of deficit. This finding applies to the findings of this study, indicating that the competency scores reported by participants with TBI are probably realistic.

There was also a moderate, significant correlation between employment status and the z scores on the TVPS-3, supporting literature findings that persons with deficits, residual to

TBI, struggled to secure employment. This was due to difficulties executing tasks of an applied practical nature, undermined by visual perceptual processing difficulty affecting ability to engage successfully in tasks such as construction; drawing or following diagrammatic plans; operating machinery reliably. Additionally difficulties reading and processing visual information or responding logically and sequentially to such information are regularly reported. Residual difficulties with error recognition or correction, discrimination between products, inability to accurately fault find or work in a quality control capacity, managerial or supervisory capacity are common features post TBI (Fraser & Clemmons, 2000) (Japp, 2005).

No correlation was found between the TVPS -3 z scores and OSA mean value scores, which were not significantly different for participants with and without TBI, as the value scores attributed to functional tasks should have been lower than assessed, in keeping with lower competency scores. The higher value scores on the OSA could be associated with aspirations based on lack of insight or appreciation of the permanence of their deficit. This supports literature which suggests that families and subjects are not prepared for gloomy or negative predictors about anticipated long term functional capacity or of the lasting implications of deficits which do not recover over time (Dikmen, et al., 2003) (McKenna, et al., 2006). Kielhofner highlighted the factors which may influence self-appraisal as being firstly, cognitive limitations resulting in impaired comprehension. Secondly, psychological pain can be associated with knowing and acknowledging one's limitations and failings resulting in denial and avoidance. Thirdly, secondary gain through incapacity can result in overestimation of limitations (Kielhofner, 2008). This indicates that visual perceptual difficulties did not affect the participants' aspirations and the value they place on their occupations. It can be concluded that for participants, two years post TBI, the presence of visual perceptual processing problems are associated with a decrease in competency in occupational performance. This study shows that only r^2 =20% of variance in occupational performance can be accounted for by this dysfunction. The value participants placed on their occupational performance has no relationship with their visual perceptual abilities.

During the administration of the test in this study, scores which fell lower than expected could have also been affected by the physical deficits for both groups with factors such as orthopaedic injuries and other interfering factors of pain and discomfort playing a role. Cognisance is given however to the appropriateness of the OSA for the client group selected, particularly in view of the attentional difficulties displayed by participants with TBI, difficulties with reading and comprehension amongst others, lack of insight associated with TBI and subjects' sense of being overwhelmed by their condition or psychosocial circumstances (Baron, et al., 2006).

5.5 Influencing Behavioural Variables:

Martin (2006) indicated that very low scores (scores of 0) should be considered carefully against the subjects' typical capacity, or whether they are due to other factors such as fatigue, inattentiveness or poor cooperation, which will deem the results not truly representative of the subjects' actual abilities (Martin, 2006). These factors in a predictive context, will provide strong indicators for capacity to resume functional roles in personal, social and occupational contexts (McKenna, et al., 2006) (Brown, et al., 2012a). Observations of behaviour during testing, particularly in a test as static as the TVPS-3, were taken into consideration when interpreting performance and results.

Descriptive observational analysis of participants' behaviours in the TVPS-3 was compared for participants with and without TBI. Several significant differences were found for the behavioural observations between groups indicating the participants with TBI had more behavioural regulation problems, including distractibility, information processing speed and physical features. The participants with TBI had lower scores for concentration which was significantly different ($p \leq 0.00$) from the participants without TBI, and they required more prompts than the participants without TBI.

Correlations between the TVPS -3 and the behavioural observations made during the administration of the test raised some moderately significant associations. Concentration and distractibility were negatively associated, as concentration was negatively associated with physical features for both groups (Table 4.15). Distractibility seems to be related to physical features in the participants with TBI rather than concentration in these participants. Poor concentration associated with overt distractibility was reported in 32.35% of the participants with TBI as compared to 2.95% of the control sample. It manifested in disinhibited behaviours including singing and whistling to maintain levels of arousal important to remaining focussed on the task. Distractibility markers included noise intolerance, extraneous movement, internal features (pain, anxiety, and ruminating thought) and combined features of fatigue, sound and movement intolerance, pain and fatigue. The correlations between distractibility and physical features may have been influenced by pain and fatigue. Although no correlation was found between these factors, the participants with TBI had significantly higher levels of pain and fatigue and were significantly slower in the assessments.

With cognisance given to research on the effects of pain upon ventral visual perceptual processing, this is regarded as significant in terms of head injured persons. Findings of a study conducted by Bingel, Rose, Glacher and Buchal (2007) showed that reduced recognition accuracy related directly to intensity of pain stimuli, associated with the interference of pain upon attentional ability. Magnetic Resonance Imaging showed that recognition accuracy of forms decreased as subjects' experienced increased nociceptive stimulation. This was found to influence visual object processing in the ventral visual system, particularly the lateral occipital cortex. It was concluded that the modulation of visual processing by pain, is behaviourally relevant because of the parallels which reduced the recognition accuracy of visual stimuli. This finding may lend support to the view that within a brain injured population, with already vulnerable neurological systems for visual perpetual processing, additional distractors such as pain would undermine attentional processes, further contributing to lower visual perceptual scores (Bingel, et al., 2007).

Cognitive fatigue is documented in literature as being a pervasive feature post TBI, although its aetiology is not clear or well understood. The effects however upon information processing have been documented, affecting functional outcomes in subjects who have suffered mild or more severe TBI (Johansson, et al., 2009). It is recognised as being a common feature post TBI, associated with altered concentration and memory, increased fatigability following mental tasks and resulting in energy depletion, sometimes taking days to recover (Stulemeijer, et al., 2006).Cognitive fatigue is distinct from depression, pain or sleep deprivation and literature holds that it is not related to the severity of injury, age of subject or time elapsed since the injury. It can persist for longer than 10 years in TBI victims.

Studies have shown correlation with complex selective attentional ability and information processing speed. Such slowing has been identified as being most apparent in tasks in which strategies or response measures to compensate for slowness are not available (DeLuca & Kalmar, 2008). This would be true of the TVPS-3. Due to its motor free nature, it offers no capacity to compensate for purely visual processing, contributing to pressure to perform without a sensory motor component or alternate means of expression of what is seen. It also highlights the demand of this test for retention of information in order to arrive at a conclusion (Lane Brown & Tate, 2009).

The apparent lack of concentration in the participants without TBI may have been misinterpreted in relation to their need for prompts more quickly and nearly as often as the participants' with TBI as the pace of participants without TBI in the assessments was significantly faster (Table 4.6).In the results of all the subtests, the TVPS-3 was significantly correlated with pace, indicating that the participants who performed slowly obtained lower scores. Pace is regarded as having indisputable pervasive impairment on performance, slowing as the complexity or number of tasks increases. Such slowing has been identified as being most apparent in tasks in which strategies or response measures to compensate for slowness are not available (DeLuca & Kalmar, 2008). This would be true of the TVPS-3, due to its motor free nature, offering no capacity to compensate for purely visual processing. It also highlights the demand of this test for retention of information in order to arrive at a conclusion.

Slow pace in participants with TBI was observed in slow ponderous methods of arriving at a response, using compensatory verbal and kinaesthetic strategies to try and recall memory items or to facilitate comparison between items. Whilst scores could be positively affected by this, accuracy was usually at the expense of general speed. The findings in relation to pace in this study are supported by Johansson,Berglund and Ronnback (2009). They demonstrated that information processing speed in subjects who had sustained mild or more severe TBI was significantly slower than in participants without TBI. They found that the ordering of tests in their study did not explain slower processing speed due to fatigueability in the test session, as slower pace of processing was evident in other tests conducted earlier in the test session where fatigue was not evident (Johansson, et al., 2009). This observation is of interest to this study where the findings were similar. Although scores for visual form constancy were lower than any other scores (this subtest occurring in the middle of the test), when compared to the first subtest, they were similar.

The findings for pace, while well supported by literature, are contrary to the findings of McKenna, Cooke, Flemming, Jefferson and Ogden (2006) where they found pace did not influence the outcomes of the OT-ASPT (McKenna, et al., 2006). Although the two subtests for memory and sequential memory are the only timed subtests in the TVPS-3, this did not appear to have a significant effect on scores as compared to non-timed tests. This may pertain to the exposure of the stimulus falling within a time limit, but the test not imposing time limits on subjects' response time, hence not really measuring pace of processing.

It has been recognised in literature that whilst visual perceptual abilities of clients is important, it was identified as one of the most difficult areas of assessment for the practicing rehabilitation clinician. It has been highlighted in literature that although certain visual perceptual deficits are immediately observable, others only become apparent when subjects function in certain distracting contexts, and in which subjects compensate for altered visual perceptual abilities with other abilities.

Anxiety was prevalent in both groups at 44.12%. Anxiety was evident on initialising this test, possibly associated with the length of the test, perceived difficulty undertaking the tasks, fear of failure and a need to prove themselves in a clinical context. Anxiety was also evident when participants were unable to arrive at a conclusion or select a response, or when faced with a limited time in which to attend to the stimulus figure. Irritability and aggression was strongly evident in the participants with TBI at 20.59% as compared to 5.88% of the participants without TBI. Reduced frustration tolerance and tearfulness was observed in the participants with TBI. These behaviours were suggestive of emotional disinhibition consequent to frontal lobe damage in the participants with TBI. Participants with TBI appear to need to self-regulate in order to maintain levels of arousal and focus, due to reduced attentional and concentration abilities.

The TVPs manual is clear in its cautionary wording that the test results provide a "snapshot" of a subject's performance at any one time, but does not elaborate on the full profile of that subject. It is thus the responsibility of the clinician to observe as closely and understand as fully as possible, reasons or factors which could contribute to a subject's tests performance in order to obtain a more accurate profile of actual abilities (Martin, 2006).

5.6 Limitations of the study:

5.6 1 Demographic:

Whilst effort was made through convenient sampling to match participants with TBI with family or community members, this proved in the main to be very difficult. Participants with TBI were not always able to provide a closely matched participant without TBI as explained in Chapter 3 and therefore participants could only be matched as closely as possible for educational status, and not occupational status or cultural background. Participants without TBI who were unable to complete testing and / or who failed the MMSE were excluded from the study.

It is recognised however that not matching for several variables (i.e.: education, culture and occupation) could pose a limitation on the study. Cultural bias in South Africa may play a role in the suitability of the tests chosen for the following reasons: the TVPS -3, as with most table top perceptual tests may have presented participants (who have limited education or exposure to diagrammatic input, little to no exposure to reading or visual material, and exposure to more animate or concrete objects), with stereotypical, fairly meaningless graphic images. These could be regarded as meaningless and abstract, which may have overwhelmed them. Anecdotal observation included noting that subjects of both TBI and participants without TBIs, of impoverished communities, used word associations to prompt memory on certain forms ("there is a church" ; I see a window" ; " there it looks like a moon").

5.6.2 Effort and Litigation:

Literature does question the effect of poor effort affecting the preservation of visual perceptual impairments in patients with TBI. The concept of dose - response effect between injury severity and visual perceptual performance is also highlighted in by Agguerreve (2007): He concluded that in his study insufficient effort shown by participants, had more impact upon scores than severity of injury: (Aguerrevere, 2007) Cognisance was given to most of the test participants in the study by Aguerrevere (2007) as having a personal injury claim context, similar to that of this particular study. This precept is considered to be a limitation of this study where the claimants were assessed in the context of a litigious process against the Road Accident Fund or Workman's Compensation or personal injury suits, and as such were possibly vulnerable to magnifying difficulties. Damages refer legally to the money and / or benefits awarded for the claimants physical loss, functional compromise, pain and suffering, and typically occurs in the context of occupational injury, motor vehicle accident, or in other situations in which liability is at issue (Cottingham, et al., 2014).

Data analysis of compensation agencies has identified however those disability seekers as a group are more likely to feign difficulties than do personal injury litigants, attributable to their need to prove inability to work rather than functional loss. Although this factor did not apply directly to this group, all of whom were personal injury litigants, external incentive was thus recognised as being a potentially limiting factor in terms of effort (Aguerrevere, 2007).

A study by Iverson and Binder (2000) indicated however that within the context of assessing head injured persons in litigious frameworks, suboptimal effort could be attributed to other independent causes. Exaggerated features of difficulty may thus not be true of malingering but could reflect other factors or differential diagnoses including somatoform disorders (functional impairment greater than the physical condition), depression or factitious disorder (a psychological need to be in the sick role) (Iverson & Binder, 2000). This was supported in the study by Cottingham Victor, Boone and Zeller (2014) who established that TBI litigants as compared to feigning psychiatric patients, had lower sensitivity rates on testing for visual attention, visual perception and processing speed. Generally this study showed that disability seekers as opposed to brain injured litigants were more likely to exceed cut off scores on performance validity tests, performed in a less sophisticated manner than litigants. This suggests that the risk of participants with TBI in this particular study feigning difficulty in testing was probably low. The observed anxiety, distractibility and concentration difficulties, associated with attentional difficulty and often in the context of persistent pain could also be explanatory for lower than anticipated scores for this study, and not necessarily an attempt to fake disability.

5.6.4 Tests:

The TVPS-3 relies on intact decision making, and although not timed the manual suggest that subjects be prompted to make decisions fairly quickly (Martin, 2006). The presence however of anxiety, pain and discomfort, distractibility and attentional difficulties would impact upon the speed at which responses could be elicited. Response time could thus be ponderous and was not limited by any inherent construct in the test.

The presence of pain residual to both TBI and orthopaedic injuries in both TBI (56%) and participants without TBIs (53%)suggests that visual perpetual scores were probably reduced as compared to a group of uninjured , non-painful participants. The compounding effects however of residual pain upon already compromised visual perceptual systems through diffuse brain injury would be expected to have further diminished visual perceptual function in the participants with TBI, with attention focussed away from already vulnerable ability.

The OSA although appropriate for assessment of occupational performance was however designed to be used in a therapeutic framework, allowing therapist and client to identify areas of strength and those priority areas for change, allowing the development of therapeutic goals and strategies (Baron, et al., 2006).In this context, the tool allows for review and is designed to be used by therapists as a client centred assessment. In the context of this study however, this tool was used as an evaluative tool only, and provided little in the way of solution based outcomes. Observations of clients completing this self-assessment tool identified too that lesser educated and / or impoverished clients in particular, and TBI clients in general, focussed on the literal meaning of questions and replied in a literal context. This pertained particularly to issues of finance which provided a platform or context for most questions concerning the management of responsibility (i.e.: unable to do so as they were financially strapped), seeing to other’s needs (i.e.: unable to manage due to financial straits), managing finances (i.e.: scored low as there were none to be had). (Appendix H)

Cognisance is given to the OSA manual administration chapter in which it is suggested that therapists determine the appropriateness of the OSA for their clients. Although the OSA is not designed for specific diagnostic groups, but rather to suit a wide range of subjects within rehabilitation programmes, it is recognised as being of more value to clients who are insightful, and thus able to appraise their abilities, have higher functional abilities, adequate cognitive skills for planning and forethought, are able to read adequately and have motivation to collaborate with the therapist in setting goals (Baron, et al., 2006).

5.7 Summary:

TBI subject's performance in the TVPS -3 was poorer than that of the participants without TBI, for all subtests except that for visual sequential processing, showing that the presence of brain injury undermines visual perceptual processing abilities generally. The TVPS-3 therefore was able to discriminate between persons with and without TBI, showing high sensitivity and specificity for this study group. TheTVPS-3 can be used to determine visual perceptual problems in patients with TBI in South Africa and it has high accuracy in terms of sensitivity and negative predictive ability, which will eliminate those without TBI as not having visual perceptual processing dysfunction.

The lack of discrimination for visual sequential processing scores for subjects without TBI and participants with TBI requires further exploration, as sequential memory should correlate with lower executive function attributable to frontal lobe injury, common in TBI of all types of severity. Reasons for higher scores in this category relative to other subtests, were surprising but could be attributed to subjects using compensatory strategies to cope with this test, perceived to be difficult, and thus applying more attention and focus on the test items; the five second time limit may have forced them to focus for discrete periods upon the stimulus figure, longer than they may have done on other stimuli. These factors need more careful empirical research to establish correlation with higher scores for this one subtest.

Lower scores on the TVPS 3 were found to be associated with lower competency scores on the OSA accounting for 20% of the variance. This supported literature which shows that persons with TBI have more difficulty undertaking occupational roles as efficiently or independently as a normative sample : Dysfunction in visual perceptual processing severely compromises one's ability to safely engage in and effectively , perform a variety of daily life tasks affecting self-care, productivity, leisure and occupation (McKenna, et al., 2006) (Brown, et al., 2012a). The deficit in visual perceptual processing is associated with 20% of the occupational performance deficits reported by participants in this study. The OSA value scale did not show the same pattern of decrement as the competence scores did , and may be related to altered levels of insight, literacy issues, or the aspiration to be as independent as possible but in the context of altered insight for actual ability.

Contributing variables to lower scores included both physical features of pain and emotional / behavioural sequelae to a TBI. These factors were associated with heightened distractibility, thought to undermine the visual perceptual processing speed and capacity of persons with TBI, supporting literature which has shown that mental fatigue can be profoundly disabling, affecting working capacity and social activities, and correlates mainly with objectively measured information processing speed, slowing of which has been identified as one of the most pervasive cognitive changes post TBI (DeLuca & Kalmar, 2008) (Johansson, et al., 2009)

Both the TVPS-3 and OSA require that the clinician administering the tests be cognisant of the subjects' individual diagnostic profile, contextual factors of his psychosocial, educational, cultural and occupational background, and any sequelae to attendant injuries sustained and the effects these may have upon test performance. Close observation of the individual's test performance is indicated.

In view of the high specificity and sensitivity scores for the TVPS-3, it is determined that the TVPS-3 has a high predictive value for functional competence of subjects , and could be used as a valuable screening tool for not only visual perceptual processing difficulties, but anticipated functional difficulties in various spheres of life demanding visual processing of information.

CHAPTER 6: CONCLUSION

6.1 Introduction:

Occupational therapists in South Africa have faced several challenges in using standardised testing within therapeutic and medico legal contexts. These challenges have included the reliability of tests used in a brain injured population; the use of the tests and their validity in South Africa as there has been no standardisation of such tests on a South African population; limited availability of tests that occupational therapists are certified to administer ; and limited ability to make prognostic evaluations concerning occupational competence including work related tasks, based on performance on tests which assess performance components and skills. Use of the TVPS-3 as a versatile assessment tool will broaden the scope of visual perceptual assessment whilst adding depth to the holistic evaluation of patients with TBI. In the context of medico legal or disability assessment, the challenge of justifying results and test use is very important as the occupational therapist's predictions and projected outcomes based on test results, have large financial implications for future care, medical interventions and occupational capacity. The diagnosis of visual perceptual difficulties is regarded as being essential to the effective planning of therapeutic goals for brain injured persons, as the relationship between cognition and perception is a close one and has influence on every aspect of daily activity. (Brown & Elliott, 2011a) (Martin, 2006) (McKenna, et al., 2006)

6.2 Discussion:

The body of research shows that although many standardised cognitive and perceptual tests display adequate psychometric properties and identify perceptual and cognitive components, they may not be effective in predicting functional ability (Douglas, et al., 2007). Although research has been completed overseas on the psychometric properties on various standardised tests including the Test of Visual Perceptual Processing-3 (TVPS-3), for the adult TBI population (Brown, et al., 2010) (Brown & Elliott, 2011a), no similar research has been done on a South African group. Whilst the TVPS-3 is used as part of the general assessment of clients with TBI for clinical, disability and medico legal purposes, it has not been known if the test items are culturally or educationally appropriate for South African clients who may select incorrect responses which mask their true visual perceptual abilities (Brown & Elliott, 2011a).

Although this study sample was small (n=68), results reflected important outcomes with implication for occupational therapy assessment protocol:

This study's results show the TVPS-3 to be a valid test instrument to be used to determine visual perceptual processing difficulties in adult persons with TBI, with high sensitivity and specificity; whilst also providing predictive value for anticipated occupational competence.

These factors are valuable within an economically challenged South African Health and Allied health context in which the utilisation of cost effective assessment and intervention strategies is important. This instrument proves extremely valuable in terms of its inherent properties including its universal application across a wide age range; its non-racial or gender bias; its size and transportability; the relatively quick administration time; cost effectiveness and non-reliance on either language or motor output. In this regard it is deemed a wholly appropriate tool to be used in a South African occupational therapy context, in which it has wide applicability suitable to several clinical settings including physical/neurological, psychiatric and vocational rehabilitation settings, as well as to disability and medico legal contexts. Judicious use of this instrument allows for baseline measures of ability against which later performance can be measured. The predictive nature of the TVPS-3, used in conjunction with a tool for functional assessment in the context of a South African TBI population will help occupational therapists more accurately quantify the future costs for rehabilitation, occupational support and intervention, independent living ability and need for care. Used in conjunction with an occupational competence measure such as the OSA, occupational therapists would be able to offer a comprehensive, analytical and holistic assessment of a patient's residual abilities and, broadly applied will benefit planning of rehabilitation goals for the individual and their families; help identify more specifically, areas of occupational deficit anticipated within a work context, thus complementing disability assessment and functional capacity assessment. Occupational Therapists can now use the TVPS-3 results confidently within a medico legal context, with the knowledge that this test is appropriate for use in the South

African adult TBI context, and further, that results are able to be reliably interpreted as having a predictive value for anticipated occupational difficulties. This will allow therapists to provide more definitive identification of long term deficit, associated with costing for care provision, rehabilitation interventions, need for accommodated occupational contexts , and loss of earning capacity within a medico legal quantum process.

6.2 Summary and Recommendations

Results of this study show an association between visual perpetual processing abilities and functional competence. These are two areas in which occupational therapists are skilled at assessing and remediating. The causal nexus or link between the two areas is not always clearly understood however. Occupational therapists are at risk of conducting this and other tests in an automatic manner neither understanding the constructs which support the test findings, nor attributing functional deficits in practice to test performance. It is hoped that the results of this study will promote more in depth understanding of the TVPS-3 when used in an adult context and be utilised with more interpretative and analytical cognisance; that the TVPS-3 be supported by universities at undergraduate level as a reliable tool for training students to use it in a South African adult TBI population, with emphasis placed on it being considered as a reliable predictive tool of occupational competence.

Further studies to standardise this tool for a South African population would be most valuable for assessment purposes.

Further studies to refine use and understanding of the OSA in terms of competence and value scales, within the South African population would be a valuable contribution to the assessment repertoire of the occupational therapist practicing in the culturally and socio economically diverse population that is South Africa.

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Appendix A

Participant Demographic Sheet	
Name of Client:	**Control**:
Age:	Age:
Education:	Education:
Language:	Language:
Sex:	Sex:
Province of Residence:	Province of Residence
History of Illness:	
Injury:	
Neurological Disorder:	
Visual Disorder	

TBI History: ____

Mechanics of Injury: ____

Date of Injury: ____

Level of Injury:

GCS: ____

PTA: ____

LOC: ____

Associated Injuries: (i.e. Facial, skull, other):

____

____

____

Radiological Investigation:

X-ray. ________________________

CT ________________________

MRI ________________________

Surgical Intervention:

____

____

____

Medications taken:____

Observations of Behaviour:

Concentration. ____

Attention. ____

Distractibility ____

Disinhibition: (e.g. swearing commentary, noises) ____________________________

____

Emotional Dysregulation: (i.e. Irritability/aggression, anxiety, frustration tolerance).

____

____

____

Cognitive fatigue: (i.e. Restless, fidgety, fiddling, yawning, decreased energy).

____

____

____

____

Pace of Processing: (i.e. Hurried, impulsive, slow and considered).

____

____

____

Perseverative response:____

Instruction repetition/demonstration: _______________________________________

Flouting test results: ____

Kinaesthetic feedback – tracking with finger/hand/tracing forms: _______________

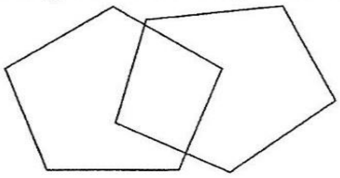
Verbal prompting / feedback strategies:______________________________________

Appendix B

Mini-Mental State Examination (MMSE)

Code _____________ Date:_______________

Instructions: Ask the questions in the order listed. Score one point for each correct response within each question or activity.

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day of the week? Month?"
5		"Where are we now: State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then asks the patient to name all three of them. The patient's response isused for scoring. The examiner repeats them until patient learns all of them, if possible. Number of trials: _____________
5		"I would like you to count backward from 100 by sevens." (93, 86, 79,72, 65, …) Stop after five answers. Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"3 "Take the paper in your right hand, fold it in half, and put it on the floor."(The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1	"	Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10angles must be present and two must intersect.) 
30	TOTAL	

(Adapted from Rovner & Folstein, 1987)
Source: www.medicine.uiowa.edu/igec/tools/cognitive/MMSE.pdf Provided by

Appendix C

TEST OF VISUAL PERCEPTUAL SKILLS
3RD EDITION

TVPS 3

Name: ______________________ Gender: ______ Grade: ______________

School: ______________________ Examiner: ______________________

Reason for Testing: ____

Date of Test	year	month	day
Date of Birth	year	month	day
Chronological Age	year	month	day*

*Do not round months up by one if days exceed 15

Student has known (diagnosed) attention problems? ☐ Y ☐ N

Student has known (diagnosed) visual problems? ☐ Y ☐ N

Subtests	Subtest Scores			Index Scores			
	Raw Score	Scaled Score	Percentile Rank	Overall	Basic Processes	Sequencing	Complex Processes
1. Visual Discrimination (DIS)							
2. Visual Memory (MEM)							
3. Spatial Relations (SPA)							
4. Form Constancy (CON)							
5. Sequential Memory (SEQ)							
6. Figure Ground (FGR)							
7. Visual Closure (CLO)							
Sum of Scaled Scores							
Standard Scores							
Percentile Rank							
				Overall	Basic	Sequencing	Complex

%ile Rank	Scaled Score	DIS	MEM	SPA	CON	SEQ	FGR	CLO	OVERALL	BASIC	SEQUEN.	COMPLEX	Standard Score	% ile Rank
		SUBTEST SCALED SCORES							INDEX AND OVERALL SCORES					
>99	19												145	>99
>99	18												140	>99
99	17												135	99
98	16												130	98
95	15												125	95
91	14												120	91
84	13												115	84
75	12												110	75
63	11												105	63
50	10												100	50
37	9												95	37
25	8												90	25
16	7												85	16
9	6												80	9
5	5												75	5
2	4												70	2
1	3												65	1
<1	2												60	<1
<1	1												55	<1

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Appendix D 1

Occupational Self-Assessment

Myself

Name: ____

Date: ____________________________________

Step 1: Below are statements about things you do in everyday life. For each statement, circle how well you do it. If an item does not apply to you cross it out and move on to the next item.					Step 2: Next for each statement circle how important this is to you.				Step 3: Choose up to 4 things about yourself that you would like to change. (You can also write comments in this space).
	I have a lot of problem doing this	I have some difficulty doing this	I do this well	I do this extremely well	This is not so important to me	This is important to me	This is more important to me	This is most important to me	I would like to change
Concentrating on my tasks	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Physically doing what I need to do	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Taking care of the place where I live	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Taking care of myself	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Taking care of others for whom I am responsible	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Getting where I need to go	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Managing my finances	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Managing my basic needs (food, medicine)	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Expressing myself to others	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Getting along with others	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Identifying and solving problems	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	

Step 1: Below are statements about things you do in everyday life. For each statement, circle how well you do it. If an item does not apply to you cross it out and move on to the next item.					Step 2: Next for each statement circle how important this is to you.				Step 3: Choose up to 4 things about yourself that you would like to change. (You can also write comments in this space).
	I have a lot of problem doing this	I have some difficulty doing this	I do this well	I do this extremely well	This is not so important to me	This is important to me	This is more important to me	This is most important to me	I would like to change
Relaxing And enjoying myself	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Getting done what I need to do	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Having a satisfying routine	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Handling my responsibilities	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Being involved as a student, worker, volunteer, and/or family member	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Doing activities I like	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Working towards my goals	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Making decisions based on what I think is important	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Accomplishing what I set out to do	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	
Effectively using my abilities	Lot of problem	Some difficulty	I do this well	Extremely well	Not so important	Important	More important	Most important	

Appendix D2

OSA Data Summary Sheet: Initial OSA Results

Client: ____________________________ DOB: __________________ Diagnosis: ________

Therapist: ____________________________ Date Completed: _____________________

Myself	Competence				Values				
	Lots of Problems	Same Difficulty	Well	Extremely Well	Not so Important	Important	More Important	Most Important	Priority
Concentrating on my tasks									
Physically doing what I need to do									
Taking care of the place where I live									
Taking care of myself									
Taking care of others for whom I am responsible									
Getting where I need to go									
Managing my finances									
Managing my basic needs (food, medicine)									
Expressing myself to others									
Getting along with others									
Identifying and solving problems									
Relaxing and enjoying myself									
Getting done what I need to do									
Having a satisfying routine									
Handling my responsibilities									
Being involved as a student, worker, volunteer, and/or family member									
Doing activities I like									
Working towards my goals									
Making decisions based on what I think is important									
Accomplishing what I set out to do									
Effectively using my abilities									

Competence Scale	Values Scale
OSA Key Form Results	OSA Key Form Results
Client Measure: _______________________________	Client Measure: _______________________________
Standard Error: _______________________________	Standard Error: _______________________________

Comments: ____

____

____

____

Appendix E :

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Mrs Jane C Bainbridge

CLEARANCE CERTIFICATE	**M121164**
PROJECT	The Validity of the Test of Visual Perceptions Skill-3 (TVPS-3) for Assessing Adults with Traumatic Brain Injury in South Africa
INVESTIGATORS	Mrs Jane C Bainbridge.
DEPARTMENT	Department of Occupational Therapy
DATE CONSIDERED	30/11/2012
DECISION OF THE COMMITTEE*	Approved unconditionally

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 05/02/2013 **CHAIRPERSON** ....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor : Mrs Denise Franszen

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University.

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES...

Appendix F 1

INFORMATION SHEET

Good Day.

I am an occupational therapist, in private practice in Westville, KwaZulu Natal. I am registered for a Master's degree through the University of the Witwatersrand, to study the predictive validity of the use of the Test of Visual Perceptual Skills used to measure visual perceptual processing abilities, in South African adults following a traumatic brain injury. I would be most grateful if you would agree to be part of this study.

What is the Purpose of the Study?

South Africa has very little research to support the use of the Test of Visual Perceptual Processing, developed overseas, on its own diverse population.

The effects of traumatic brain injury on visual perceptual processing are documented in overseas population groups but not on a South African group. Visual perceptual processing is important in the development of visual skills used for all visual learning (such as reading; studying), visual memory and functional community survival skills (such as shopping/driving /cooking).

Understanding the effects of such traumatic brain injury upon functional capacity and visual perception is very important as visual perception forms the basis for other forms of visual learning including visual memory. Understanding the long term negative effects of a traumatic brain injury on visual perceptual function will help occupational therapists draw more accurate conclusions about a client's long term work and independent living abilities. I will be studying the validity of the Test of Visual Perceptual Skills on a South African population of people with traumatic brain injury.

What are the Expectations of participants in the study?

You will be assessed independently, during your usual medico legal assessment process. A copy of your score sheet will be kept on file for the purposes of this study, whilst the original form will be kept in your medico legal assessment file for medico legal purposes. Your name will not be used for the purposes of this study, and hence your results will be anonymous and have no bearing whatsoever on your medico legal claim process.

In order to provide me with a control group of people who have not had traumatic brain injuries, against whom your scores can be matched and compared, I have asked that a close relative or community member, with as closely matched educational and cultural background as possible, accompany you for this assessment in order to also be tested. This person's transport costs for the day will be covered by myself. This person will serve a control or comparison function in comparing your results against somebody who has *not* had a brain injury. This person's results will also be anonymously represented and will have no bearing upon any future assessment process that they may undergo.

What about Confidentiality?

As the results of this study will be represented in terms of coded identity, broad age group bands, the severity of the traumatic brain injured suffered, and not along personal classification lines, your identity and that of your family member/community member will be protected. This study is not intended to highlight any specific racial group or cultural group, nor individual capacity. This will ensure that your results are completely anonymous and will have no bearing whatsoever upon your medico legal claim or any subsequent disability process or assessment you may enter into. Only the researcher will have access to the copies of the test booklets which will be kept locked in her office. There will be no correlation between the material collected for this study and that represented in your medico legal process.

What is the benefit to Participants?

As the test will be scored almost immediately by the examiner, these results can be discussed with you, in order for you to better understand your own visual perceptual processing difficulties which may be impacting upon your functional capacity at work or home. Strategies for compensation for such difficulties may be discussed with you. Similarly any deficits evident in the control subject's results can be communicated to them for better clarity as to how to compensate for such difficulties.

May Participants withdraw from the Study?

You have the right to refuse to take part in the study, for no reason at all, without prejudice to you or your medico legal claim. Similarly you have the right to withdraw from the study at any stage of the process, without having to give a reason.

This study is completely voluntary and carries no penalty of any sort: Your medico legal claim process will not be influenced in any way.

Thank you

Jane Bainbridge

Occupational Therapist

Zulu Translation :

Sawubona! Ngingudokotela owuchwepheshe osebenza ukubheka ukuthi yini umanakalo noma ungakanani umonakalo owenzekile emzimbeni womuntu uma kunomonakalo, ngisebenzela endaweni ngokuzimele e Westville, Kwa Zulu Natali.

Ngifundile ngokwezemfundo ephakeme, ngibhalisile ukusebenza ngokusemthethweni, ngazuza neziqu ezinkulu emfundweni ephakeme eNyuvesi yase Witwatersrand, ngikufundeleukubheka nokusebanza ngokucophelela ukwenza izivivinyo ezifanele ukuthola ukuthi indlela uokubona izinto ngendlela efanele kuyenzeka, kulelizwe lase Ningizimu Africa Kubantu abakhulile nabadala ngokweminyaka kulandela ukulimala kanzima ingqondo. Ngabe yini injongo/inhloso yalocwanigo/izifundo?

Luncane kakhulu ucwaningo ezweni lase Ningizimu Africa olwenziwe ukulekelela izinga eliphezulu elifanele lokuvinvinya, oluthathelwe emazweni aphesheya kwezilwandle, ngokuzimela ngokwemiphekathi eyahlukahlukene. Ngithanda ukuthi ngibhekisise ubuqotho uma kuvivinywa indlela yokubona izinto ngendlela efanele ingxenye yesithathu eyenziwa uDokotela Nancy Martin, esetshenziswa ezindaweni eziningi yilabochwepheshe ukuthola ukuthi umuntu olimale kanzima ingqondo usakwazi yini ukubheka nokwenza izinto ngendlela efanele.

Umthelela wokulimala kanzima kwengqondonukubheka izinto ngendlela efanele ithathelwe emibhalweni kubantu emphakathini phesheya kwezilwandle hhayi kubantu base Ningizimu Africa. Ukucabanga ukuthi izinto uzibheka/uzibona ngendlela efanele kubalulekile ekutheni ukwazi uthola izindlela zohubona ezisetshenziswe kubobonke abafunda ukubona (njengokufunda; ukufundela), ukubona ungakhohlwa nokusebenza emphakathini ukuziphilisa (njengokuthenga/ukushayela/ukupheka).

Ngokocwaningo lwezempilo olusemthethweni okubhekeke ukuthi uchwepheshe wezengqondo akuthole ukuthi umonakalo ohleli ngokulimla komqondo nokuthi uyakwazi yini ukwenza izinto ezithile, ukuqondisisa kahle ngemithelela yokulimala kokubona kubalulekile kakhulu njengoba umuzwa wokubona wakha isisekelo ngizifundo zokubona ngamehlo kuhlanisa nokukhumbula isithembe engqondweni. Ukuqondisisa kahle ngemphumela engimihle ehlala isikhathi eside ngokulimala kanzima ekhanda phezu kokuba umuzwa wokubona usebenza, ungaba nosizo kokokotela abangochwepheshe bezengqondo besibeka isiphetho esiqondile ngokuthi umntu olimele asebenza yini isikhathi eside aphinde akwazi ukuziphilisa ngokuzimela.

Iziphi izinto ezilindelekile kubantu ababambe iqhaza kulezizifndo?

Kunamakhasimende akhethekile engikwazile ukuxhamana nawo, ngenxa yocwaningo lwezempilo oolusemthethweni. Ngokujwayelekile lokhu kunikeza amakhasimende ahlukene, avela ezinhlangeni ezahlukene kanye nemvelaphi yamasiko abo, ngokuhlukana ngqmazinga ezemfundo kanye nemininingwane ephelele ngemisebenzi yabo. Ngokujwayelekile ukufunda ngamaqoqo kuyabonisa ngempela ukulimala kanzima komqondo, nakuba imbangela yakho yehlukile phakathi kokulimala okubucayi ekhanda kanye nokulimala nje okuncane ekhanda.

Ngikhethe abantu abadala/abakhulile emphakathini (kusukela Kwabano 18 years kuya phezulu) njengoba abantu abakuleminyaka bengakathinteki ngokocwaningo.

Lowo nalowo muntu uzohlowa ngayedwana, ngokusebenzisa indlela efanele ejwayelekile yocwaningo lezwempilo olusemthethweni. Imiphumela esepheshaneni lalowo wesilisa noma owesftazane lizogcinwa kwifayela ngenhloso yesifundo, bese kuthi iphepha langempela libekwe kuleyo fayela yocwaningo lwezempilo olusemthethweni. Igama lakho ngeke lisetshenziswe ngenhloso yocwaningo, kanti nemiphumela yakho iyoba imfihlo futhi ngeke iphazamise isinxephezelo nocwaningo lwezempilo olusemthethweni.

Ukuze ngikwazi ukulawula abantu abangakaze balimale kanzima emqondweni, nalabo imiphumela yakho eqhathanisekayo futhi efanayo, ngibuzile kumuntu engihlobene naye noma ilunga lomphakathi, nokusondelana ngokuqhathanisa imfundo nomlando wesiko ngokushesha, makabe nawe ngalesivivinyo ukuze kuhlolwe. Izindleko zokuhamba kwalomuntu ngalolosuku ziyothwalwa yimi. Lomuntu uzoba namandla noma uzosebenza ukuqhathanisa imiphumela yakho kuleyo yomuntu ongakaze abe nokulimala ingqondo. Imiphumela yalomuntu izonphinde futhi imelwe ngokuyimfihlo kanti futhi ngeke iphazamise nanoma iluphi uhlelo lokuvivinya olungavela ngokuzayo.

Kuthiwani ngolwazi oliyimfihlo?

Njengoba imiphumela yalolucwaningo imelekile nangokuvikeleka komnikazi, ububanzi beminyaka yabantu, ubucayi bokulimala ingqondo okwenzakele, kanye nokuthi futhi amazinga abantu, umazisi wakho, kanye nowomndeni wakho/noma ilunga lomphakathi kuyovikeleka. Lolucwaningo aluqondile ukuphakamisa/ukuqhakambisa uhlobo lwabantu oluthile noma amasiko abantu, nanoma iliphi izinga lomuntu. Lokhu kuzoqinisekisa ukuthi imiphumela iyifihlo ngokuphelele kanti futhi ngeke iphazamise nanoma iluphi uhlobo lwesinxephezelo socwaningo lwezempilo olusemthethweni noma iluphi uhlelo olusiza abakhubazekile noma isivivinyo ongafisa ukusenza.

Umcwaningi kuphela onelungelo lokuthola amapheshena emiphumela egciniwe futhi avalelwe ngokuphephile ehhovisi lakhe. Ngeke kubekhona ubudlelwano phakathi kwezinto eziqukethwe ilolu cwaningo nalolo lwazi uluthuliwe ilolu cwaningo nalolo lwazi olutholiwe kulolucwaningo lwezempilo olusemthethweni nohlelo lwakhona.

Ngizozuza ini mina? Njengoba isivivinyo sinikwa imiphumela ngalesosikhathi umhloli, lemiphumela ingakhulunywa nawe, ukuze nawe uyiqonde kahle indlela obuka ngayo ngokwakho nobunzima ongahlangabezana nabo emsebenzini noma ekhaya. Izindlela zokukhokheleka ngalobobunzima zingakhulunywa nawe. Ngokufanayo futhi uma kwehla kuya phansi imiphumela kunobufakazi ezintweni ezilawulekayo kungakhulunywa nabo ukucacisa kahle ukuthi bangakhokhelwa kanjani ngalobubunzima.

Ngingakwazi ukuyeka ucwaningo?

Unelungelo lukunqaba ukuba ingxenye yocwaningo, ngaphandle nje kwesizathu, nanoma inini uma uzwq unganeliseki noma ngesivivinyo socwaningo lwesinxephezelo. Ngokufana futhi unelungelo lukuhoxa kulo ucwaningo nanoma ingasiphi isikhathi sohlelo oluqhubekanyo, nangaphandle kokuthi unikeze isizathu. Lolucwaningo/isifundo senziwe ngokuphelele ngokuthanda nangokuzivumela mina futhi akunazijeziso ezikhona. Ucwaningo lwezempilo olusemthethweni lohlelo lwesinxephezelo olungeke lushintshwe/luguqulwe.

Ngiyabonga.

Jane Bainbridge

Appendix F2

<u>Masters Protocol</u>: <u>Consent Form (TBI)</u>

I ____________________________ acknowledge that the details pertaining to this research project and moreover, the need for my participation in this project has been clearly explained to me.

I acknowledge that I have been assured of the results being used anonymously and without prejudice to my third party or personal injury claim, which is the primary reason for which I am being assessed by Jane Bainbridge.

I understand and accept that Mr/Mrs______________________ a person known to me through family and/or community relationship exposure has been used as a comparative control subject for the purposes of this study. I accept that his/her results are also confidential.

Signed: ________________________at 21 Springvale Road, Westville, on ___________________________.

Witness: ________________________

<u>Masters Protocol</u>: <u>Consent Form (Control)</u>

I ______________________________ acknowledge that the details pertaining to this research project and moreover, the need for my participation in this project has been clearly explained to me. I acknowledge that I have been assured of the results being used anonymously and without prejudice.

I understand and accept that Mr/Mrs_______________________ a person known to me through family and/or community relationship exposure has been used as a part of a study group population, through their involvement in medico legal assessment process. I understand that I will serve as a comparative control subject for the purposes of this study.

I accept that my his/her results are also confidential.

Signed: _________________________at 21 Springvale Road, Westville, on _____________________________.Witness: _________________________

Appendix G

Jane Bainbridge

Occupational Therapist

BSc (O.T.) Wits

PR. No: 6609872 **Registered with HPCSA**

Dear Sirs

I am a registered for a Master's Degree through the University of Witwatersrand. I propose to explore the validity of a specific visual perceptual test (The Test of Visual Perceptual Processing-3) used routinely in my practice to determine the presence of visual perceptual processing difficulties in clients after traumatic brain injury.

Through the medico-legal process of assessment, I have encountered many adults with TBI. As this is a group of people I encounter on a daily basis I have chosen to assess such, using their medico legal assessment process as a means of obtaining this information.

The client will be assessed independently, during the client's usual medico legal assessment process. In order to provide me with a control group of people who have not had traumatic brain injuries, against whom scores can be matched and compared, I have asked that a close relative or community member, with as closely matched educational and cultural background as possible, accompany the client for this assessment in order to also be tested. This person will serve a control or comparison function in comparing your client's results against somebody who has not had a brain injury. This person's results will also be anonymously represented and will have no bearing upon any future assessment process that they may undergo. The control subject where possible will be used as a collateral source of information for the medico legal purpose. Where this is not appropriate, I request that another family member accompany the client, as is usual practice. I will be responsible for the transport costs for the family member/friend used as a control subject for my study.

I address this letter to you as a courtesy to assure you that neither your client's confidentiality, nor his medico legal claim will in any way be affected by this study. No additional testing, nor cost outside that which the client's medico legal costs would have incurred anyway, will be incurred.

Yours sincerely,

Jane Bainbridge

Appendix H

The following table illustrates the OSA performance items, their intended meanings and the literal or interpreted meanings of the subjects. Those items marked with a tick indicate consistency with intended and interpreted meanings. Most limitations of these questions apply to economic factors, affecting poorer or less sophisticated subjects. The associated visual perceptual demand for each items are listed in the far right column.

Table showing OSA performance items with Intended meanings as per the manual, and literal meanings derived from study subjects

Performance Item	**Intended meaning**	**Literal / interpreted meaning**	**Visual perceptual Demand**
Concentrating on my tasks	Attending to a task to complete it	√	Visual attention on a stimulus
Physically doing what I need to do	The motor skills for moving self and objects to execute daily life tasks	√	Spatial orientation ; visual figure ground; form constancy
Taking care of the place where I live	Keeping ones residence cleaned and maintained	Financial limitations prevent doing maintenance or refurbishment	Figure ground Visual memory Form constancy Visual Discrimination
Taking care of myself	Doing one's personal care and health maintenance(dressing, hygiene grooming)	Influenced by inability to collect water due to physical compromise	Visual Discrimination Figure ground Visual Memory Sequential memory
Taking care of others for whom I am responsible	Taking care of dependants, such as children or elderly relatives	Unable to provide for school fees ; clothing etc. due to financial difficulties	Visual Memory Figure Ground Form constancy Visual discrimination Visual Closure
Getting where I need to go	Using public transportation, driving, walking to school, work, shopping, recreation	Inability to afford transportation.	Visual Discrimination Figure Ground Form constancy Visual closure Sequential and visual memory

Managing my finances	Budgeting and living within ones means, paying bills in a timely manner	In some instances, subjects had no or limited financial means, resulting in negative responses	Figure ground Visual Closure Visual sequential memory Visual memory
Managing my basic needs(food and medicine)	Eating a proper diet, taking necessary medicine, attending to health	Inability to afford medicines ; lack of transport to clinics to obtain medicines	Figure Ground, visual discrimination, form constancy, memory, sequential memory
Expressing myself to others	Talking with others to make ones opinions known, to share information	√	Visual discrimination to respond to facial features/ expression
Getting along with others	Being able to engage, relate , respect and collaborate with others	√	Visual discrimination ; figure ground; spatial relations, visual memory
Identifying and solving problems	Seeking and using information, identifying solutions…sequencing steps in a task	Where solutions had a financial focus, responses were scored down as these could not be met.	Visual discrimination ; visual figure ground, closure, to read information,
HABITUATION ITEM			
Relaxing and enjoying myself	Having a routine which allows for stress reduction, enjoying interests, relaxation, time to unwind	Candidates spent weekends and "down time" engaged in housework and had no resources for recreation	Figure Ground; visual discrimination, form constancy, visual memory
Getting done what I need to do	Having habits that are effective for completing necessary tasks	√	Sequential memory, visual discrimination
Having satisfying routine	Feeling content because ones routine allows them to do what one wants to or needs to do	Responses to this hinged on the above	Based on sequential memory, visual discrimination, form constancy, figure ground
Handling my responsibilities	Fulfilling expectations associated with particular roles (student, worker, parent)	Financial pressures influenced such decisions and roles. Certain subjects did no work at all.	Figure ground, closure, memory, discrimination and form constancy necessary for effective study / administration/ planning
Being involved as a student, worker, volunteer or family member	Identifying with and participating in roles, having adequate roles to provide avenues for performance and fill ones time	Lack of work or defined roles undermined capacity for this item, but was reflected as something upon which value was placed.	As above, reliant on visual skills for literacy, numeracy : figure ground, spatial relations, closure

VOLITION ITEM

Doing activities I like	Finding pleasure and satisfaction in occupation	Interpreted literally – if not working, scored down. Many jobs were not “dream” jobs and thus pleasurable.	Enjoyment is underpinned by successful execution of basic steps of tasks thorough appropriate visual perceptual function
Working towards my goals	Sustaining an effort towards things one wants and plans to accomplish	Plans to build a home / send a child to school hinged upon financial means; inability to meet these demands resulted in lower responses	Sequential planning, stepwise solutions; sequential and visual memory
Making decisions based on what I think is important	Having freedom and confidence to choose to do what one believes	Economic limitations and personal educational limitations, narrowed choices	Executive function underpinned by ability to discriminate between choices, plan sequentially
Accomplishing what I set out to do	Having realistic goals and being able to achieve them	Inability to meet those goals which depend upon financial resources, with a knock on educational compromise	Focussed attention on the end goal ; sequential planning, ordering
Effectively using my strategies	Choosing the activities or tasks that one feels adequate at in order to accomplish ones goals	Despondency associated with limited choices due to life and economic circumstances.	Executive decision making, planning and prioritising

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