A Research Report

Entitled:

# Investigating the effects of Paediatric Mild Traumatic Brain Injury on Speed of Processing of South African Children within a polyglot society, at Chris Hani Baragwanath Academic Hospital.

By:

Kajol Nair

Student number: 1054711

submitted to the Faculty of Humanities as a partial fulfilment of the requirements for the Master of Arts (Psychological Coursework and Research) degree in the field of Research, University of the Witwatersrand, Johannesburg,

<20 April 2020>.

Supervisor: Enid Schutte

## Abstract

This study explored the cognitive sequelae of Mild Traumatic Brain injuries (Mi-TBI) on the speed of processing (SP) in children living in Soweto township, previously admitted to Chris Hani Baragwanath Academic Hospital (CHBAH) with a diagnosis of Mi-TBI. The Coding and Symbol Search subtests from the Wechsler Scale of Intelligence for Children Fourth Edition (WISC-IV) were used to assess the participants cognitive SP. This study included a total of 40 participants: 20 children who previously experienced Mi-TBI and 20 neurotypical controls. The principal investigator identified the above mentioned research participants according to specific inclusion criteria implemented for the Traumatic Brain Injury (TBI): Neurocognitive and Behavioral Assessment and Management in Kids (THINK) Study. The current study is nested within the THINK study. An independent t-test was used to compare the measured SP for the Mi-TBI and Neurotypical groups. The SP proved to be significantly slower for the test group than for the neurotypical control group. The reduced SP in the Mi-TBI sample was further interrogated in terms of possible predictor variables though a simple regression and correlation analyses. The analysis revealed that gender and age at testing were non-significant, but age at injury and age at testing were significant. Future research is required in this field in order to validate these results and contribute to the existing and growing body of literature on Mi-TBI.



*Keywords: Mild traumatic brain injury (Mi-TBI), speed of processing (SP), Low Socio-Economic, Polyglot Society*

## Declaration

I declare that this research project is my own, unaided work. It has not been submitted before for any other degree or examination at this or any other university.

Kajol Nair 16-03-2020

Kajol Nair

## Dedication

In dedication to my father, Ravi Nair, my sister, Sajel Nair and my brother Kischel Nair.

They have endlessly motivated me and tirelessly supported my goals and ambitions.

## Acknowledgements

I would like to take the opportunity to thank the following people:

- Foremost, this research report would not have been attainable without my supervisor Enid Schutte. I thank her for continuously supporting me throughout this process, and offering invaluable contributions and critiques to improve my work. She is my guide, friend and academic support.
- Secondly, I would like to thank the Principal Investigator of the THINK Study, Dr Vered Lack. This study would not have been possible without her support and allowing me to use the data collected by the THINK Study project.
- Thirdly, I would like to thank Laila Jeeboth Desai for being a continuous motivation and inspiration to me.
- Fourthly, I would like to thank Sahil Ramdin for being my pillar of strength.
- Lastly, I would like to thank my friends and family for supporting me throughout this process.

**Table of Contents**

**List of Tables**



**List of Figures**

# Chapter 1

## Introduction

The prevalence of traumatic head injuries (TBIs) are poorly documented in the South African context, with a particular paucity of research addressing the cognitive sequelae of Mild Traumatic Head Injury (Mi-TBI) in South Africa. Whilst there is a lacuna of statistics to be found on traumatic head injuries (both TBIs and Mi-TBIs) nationally, there seems to be a particular shortage of data addressing the frequency of head injuries in a low-socio-economic polyglot township population. Netcare South Africa estimates that there are approximately 89 000 reported cases of TBIs in South Africa per year (News Hub, 2016). The lack of research on the long-term cognitive sequelae of Mi-TBIs may preclude medical professionals from addressing the manifestations of Mi-TBI (Rodriguez & Thomas, 2017). TBI can be classified into three categories: mild, moderate and severe (Sheedy, Geffen, Donnelly & Faux, 2006). This classification is important as this determines the treatment and follow up sessions for the patient (Bijur, Haslum, & Golding, 1990). Many patients who suffer from cognitive sequelae's symptoms following Mi-TBI may be undetected which in turn could lead to lifelong social and cognitive deficits that may affect the individual's quality of life (Bijur et al., 1990). A study conducted by Rodriguez and Thomas (2017) found that children who had suffered a TBI were told to "tough it out" (Rodriguez & Thomas, 2017, pg. 528), Mi-TBI cases may be discharged within 24 hours, with no follow-up consultations (Babikian et al., 2011; Cassidy et al., 2004; Emery et al., 2016; Rees, 2003; Schretlen & Shapiro, 2003).

Some of the main causes of Mi-TBI documented in South Africa include a child falling, vehicle accidents and pedestrian accidents, amongst others (Naidoo, 2013). It has been suggested by Richter, Mathews, Kagura and Nonterah (2018) that overcrowding may relate to comparatively high rates of TBI in the region. In South Africa, residents of townships may be particularly vulnerable to overcrowding. Soweto, a township to the South West of

Johannesburg, comprises 10% of the Johannesburg surface area but houses 40% of the population (Findley & Ogbu, 2011). A study done by Rabinowitz and colleagues (2015) deduced one of the main predicting factors of weak recovery after three months of sustaining a Mi-TBI was low socioeconomic status (Rabinowitz et al., 2015). Further predictors of poor recovery from Mi-TBI are a result of lack of treatment, rehabilitation resources and poor education around Mi-TBI.

The majority of the international literature suggests that there may be no long-term cognitive sequelae following Mi-TBI effects (Babikian et al., 2011; Cassidy et al., 2004; Rees, 2003). However, there is contradictory literature which suggests that there are cognitive sequelae which may follow Mi-TBI (Benton, 1989; King, 2011; Segalowitz & Brown, 1991). The reduction in the speed of processing (SP) is an essential aspect of the possible consequences of Mi-TBI (O'Jile et al., 2006). The focus of the present study is to determine if there may be a possible impact on the SP from a Mi-TBI in children by using the Wechsler Intelligence Scale for Children IV (WISC IV). The present study is nested within the THINK study project headed by Dr Vered Lack with a focus on "Examining Neurocognitive, psychological and psychiatric sequelae following mild traumatic brain injury: a potentially significant impact in a low socioeconomic population." (Lack, 2016). The objective of this current study is to determine whether Mi-TBI affects the SP, and if so, to what extent. O'Jile et al. (2006) suggests that a reduction in SP may be a consequence of Mi-TBI, the population in the study did not yield from a low-socio economic polyglot society who yield from a township and this paediatric cohort seems to be absent in the literature. As such, the present study aims to contribute to the existing body of literature on the consequence of Mi-TBI in a low socio-economic polyglot society.

## Aims

The focus of the present nested study is to address the lacuna in the literature, as to whether long term effects of paediatric Mi-TBI may contribute to a reduced SP in a polyglot society which yields from a low socioeconomic background. This study hopes to set up the groundwork for developing guidelines to identify cases of Mi-TBI that may require a referral or medical follow-up.

## Rationale

International literature suggests that Mi-TBI does not lead long term sequelae (Babikian et al., 2011; Cassidy et al., 2004; Emery et al., 2016; Rees, 2003; Schretlen & Shapiro, 2003), and Cassidy et al. (2004) suggests that many children recover from paediatric Mi-TBI within two to three months post-injury. There is a body of literature pertaining to the full recovery of children with Mi-TBI which brings these findings into question by suggesting that there may very well be cognitive sequelae as a consequence of a Mi-TBI (King, 2011; & Segalowitz & Deborah, 1991). SP may affect higher cognitive functioning and this may affect cognitive and consequently neurological development. Identifying cognitive sequelae in children is vital as Mi-TBI may impact and limit both their cognitive and neurological development (Holdnack et al., 2015).Mjoli and Fieggen (2013) suggest that pathophysiologic changes may be more evident in the brain of a child as the brain is immature and still undergoing development (Rodriguez & Thomas, 2014). SP is essential to efficiently process and respond to incoming information, and as such may further impact on other areas of higher cognitive functioning (Rodriguez & Thomas, 2014).

As proposed earlier in this report, a reduction in SP may under lie cognitive deficits following Mi-TBI. SP is an ability to respond to visual and oral information. It is a primary measure of

how efficiently a child can process new information and make decisions (Rodriguez & Thomas, 2014).

SP is influenced by other areas of cognition such as multilingualism (Grant & Dennis, 2016). Multilingualism is an important consideration when examining Mi-TBI, as it may affect the SP and therefore this is a factor to consider in Mi-TBI (Grant & Dennis, 2016). Chris Hani Baragwanath Academic hospital is a catchment area for the multilingual patients of Soweto. Of particular relevance to a polyglot society such as Soweto, Multilingualism is influenced by culture, educational resources and amenity availability may compromise the applicability of international norm scores used on South African children (Eckert, Keren, Roberts Calhoun, & Harris, 2010). Marrero, Golden and Espe-Pfeifer (2002) raise the possibility that multilingualism and an altered cytoarchitecture may increase the susceptibility to the brain to injury and as such, the long term effects of the injury.

The debate around norm groups in a multidiverse settings is addressed by Shuttleworth (2016) and Talyor (2016). Shuttleworth suggests that unitary norms of an IQ tests may not be valid within a cross cultural context, as SP is a component of IQ testing. Taylor (2016) states that while unitary group norms may not be denied, however the adaption of these norms to the general population is not advised. Misclassification can occur when practitioners dispense the population norm without scientific evidence (Taylor, 2016). It is important to note that the norm sample for each country is stratified according to demographic variables such as age, sex, race/ethnicity, parent education level, and geographic region, as determined by the most recently available census data for that country (Foxcroft & Roodt, 2013). As such the norms for one population may not prove appropriate for another. For this reason, in the present study, any inference to reduced cognitive functionality in the Mi-TBI group is based on a comparison with a neurotypical sample from a similar demographic background.

Chris Hani Baragwanath Academic Hospital may treat approximately 1200 paediatric trauma related cases on average per year. Approximately half of these cases are Mi-TBI (Lack, 2016). In Soweto, there may be a high rate of caregivers who may be unemployed or may fall into the low-income bracket. An example of this is Doornkop in Soweto, where over 80% of the households receive a social grant and earn below R2500 per month (Patel, Hochfield, Moodley, & Mutwali, 2012). Low-income societies may have a higher rate of pedestrian and vehicle accidents of road traffic accidents, which may result in a higher rate of TBIs **(**Birken & MacArthur, 2004) which may impact the rate of paediatric Mi-TBI in Soweto, as this may be a high risk area for Mi-TBI's. Low-income societies have a large population in a small geographical area, and children may walk to a local school or play outside.

Lallier and Colleagues (1999) suggests that unsupervised play inside or outside of the home may lead to a Mi-TBI in children as parents may not be available to watch over their children or be able to afford a caregiver (Lallier, Bouchard, Vil, Dupont, & Tucci, 1999).The possibility of identifying and understanding the cases at risk for cognitive sequelae can only be achieved through extensive research of Mi-TBI. Follow up consultation and intervention may be implemented if risk patients are correctly identified. Mi-TBI may lead to a slower SP in children (O'Jile et al., 2006). If a correlation between the predictor variables and SP is found in the present study, this relationship may be documented in medical files and children who present with slower SP may be considered as a risk group. The objective of the study is to determine if a Mi-TBI affects the SP, and if so, to what extent

# Chapter 2

## Literature review

## 2.1 Paediatric Mild Traumatic Brain Injury (TBI)

The World Health Organization (WHO) suggests that Mild Traumatic Brain Injury (Mi-TBI) may be the most common type of TBI (Ruff, Iverson, Barth & Broshek, 2009). There are approximately 2.5 million individuals in the United States of America with brain injuries, and 70-90% of these individuals sustained a MI-TBI (Prince & Bruhns, 2017). Traumatic Brain Injury (TBI) is an injury that is inflicted to the head, via a violent action by an object or person (Naidoo, 2013). An individual may suffer a TBI as a consequence of falls, vehicle-related collisions, violence, sports injuries amongst others (Naidoo, 2013). TBI may cause penetrating and non-penetrating injuries which vary in severity (McGinn & Povlishock, 2016). The classification of mild through to severe TBIs is determined by the Glasgow Coma Scale (McGinn & Povlishock, 2016). The severity of a TBI will determine the consequence of damage to the neurons and glial cells (Silver et al., 2011). TBI may cause the death of neurons and glial cells and destroy the connections between them (Pekna & Pekny, 2012). Neurons and glial cells are responsible for organizing actions and transmitting signals in the central nervous system and the parasympathetic nervous system (Silver, McAllister &Yudofsky, 2011). Damage to the glial cells and neurons could influence learning and cognition (Fields et al., 2014).

Damage to brain cells and brain tissue from TBI may lead to long term consequences and possibly death. The consequences of TBI on neurological functioning would be contingent upon the severity of the TBI (Hamilton & Keller, 2010). Overall mortality and morbidity may be determined by the location, size and progression of the TBI. Examples of this would be: secondary injury from oedema, raised intracranial pressure, disruption of the blood-brain barrier and metabolic cascade of the injury (Kaur & Sharma, 2018).

The pathophysiology symptoms of a Mi-TBI in children are: change in eating patterns, unusual or easily irritable, crying inconsolably, inability to pay attention, sleeping patterns have changed, the child may have seizures, they may have a sad or depressed mood and loss of interest (Laskowski, Creed & Ragupathi, 2015). Ruff and colleagues (2009) suggest that Mi-TBI may be difficult to diagnose as the mildest of injuries may be difficult to detect by professionals.

Although TBI is not well documented in South Africa (Naidoo, 2013), Dr Vered Lack (Paediatric Registrar at Chris Hani Baragwanath Academic Hospital) has gathered and continued to keep a data bank for South African children with Mi-TBI. The main aetiology of TBI children in South Africa seem to be related to violence and motor vehicle accidents (Levin, 2004). A study conducted by Naidoo (2013) in Kwa Zulu Natal province reported that road traffic incidents cause 52 % of pedestrian injuries. These pedestrian victims of road traffic accidents may sustain TBIs (Naidoo, 2013). Severe TBI seems to be more common in South Africa due to the high motor vehicle accident rates (Mjoli, 2013).

Mi-TBIs are often confused with a concussion, however, they are not the same (Hamilton & Keller, 2010). Generally, Mi-TBI is diagnosed according to set diagnostic criteria quoted below:

"1. Any period of loss of consciousness

2. Any loss of memory for events immediately before or after the accident

3. Any alteration in mental status

4. A focal neurological deficit that may or may not be transient

Mi-TBI may not exceed the following criteria: a loss of consciousness for more than 30 minutes, a Glasgow Coma Scale score between 15-13, and post-traumatic amnesia not greater

than 24 hours (Head, 1993, p86). In a study conducted by Munivenkatappa and collegues (2016), the Glasgow coma scale scores were different for males and female patients, as females TBI patients seemed to be more prone to Mi-TBI and males more prone to moderate and severe TBI.

Clinical studies suggests that there are gender based differences in the functional outcome of TBI (Munivenkatappa et al., 2016 & Collins et al., 2012) . This is suggested as to be a result of endogenous hormone production differences between girls and boys which suggests boys may be more inclined to riskier behaviour (Arambula et al., 2019). It is suggested that gender may be relevant consideration in a study for Mi-TBI (Collins et al., 2012). Collins and colleagues (2012) explored the representation that gender may have for MI-TBI with a sample of 342 patients. The main reports for injury were falls from risky behaviour (Collins et al., 2012). It was suggested that males seem more prone to risky behaviour, as a consequence, they have a higher probability to sustain a Mi-TBIs than females. This may be the reason for a higher male to female ratio of Mi-TBIs. A review conducted by Arambula and colleagues (2019) mirror these findings as they suggest that there is abundant literature which supports the differences between girls and boys with paediatric Mi-TBI (Arambula et al., 2019).

### 2.2 The Glasgow Coma Scale and Mi-TBI

The Glasgow Coma Scale is commonly used by clinical practitioners to classify the severity of a TBI (Teasdale & Murray, 2014). The Glasgow Coma Scale may be a reliable and robust tool in evaluating patients who are experiencing an altered state of unconsciousness (Teasdale & Murray, 2014). The scoring of the Glasgow Coma Scale ranges from 3-15, and it is divided into three distinct sections: best eye response, best verbal response and best motor response (Teasdale & Murray, 2014). This test can be used on children as early from the age of 5 years

old. The reliability score of the Glasgow Coma Scale is $r = 0.74$ (Cohen, 2009) and for the four dimensions of the scale, the reliability score is $r = 0.95$ (Cohen, 2009). This is a robust measure on which to base classification as it is valid and reliable to use.

Despite its reputation as a strong measure, the Glasgow Coma Scale may be limiting as the score can be altered. It may not give a holistic view of the patients' TBI. The score of the Glasgow Coma Scale may be affected by factors such as: oedemas, differences in cultures and language, baseline psychological issues and age external factors (Dong & Cremer, 2011).

In addition, a study done by Chung & Khan (2015) observed a Mi-TBI patient with a Glasgow Coma Scale score of 14-15. The score of 14-15 is the highest score of the scale, which means the patient has the somewhat of the ideal eye responses, verbal responses and motor responses (Chung & Khan, 2015). But after 24 hours of overnight observation, the patient showed intracerebral, subdural and subarachnoid haemorrhages. The Glasgow Coma Scale remained 14-15 throughout observation (Chung & Khan, 2015). Upon testing the patient 6 months post Mi-TBI it was found that the patient demonstrated cognitive impairments. (Andrade et al., 2011; Chung & Khan, 2009)

### 2.3 Primary and Secondary Injuries following TBI

Furthermore, TBIs are categorized into primary injuries (which occurs at the time of impact), and secondary injuries. As discussed, secondary injury could potentially worsen as a consequence of raised intracranial pressure (Naidoo, 2013). Secondary injuries may occur within hours of the TBI leading to cellular and vasogenic fluid which collects in the brain resulting in a cerebral oedema, increased intracranial pressure and a reduction in blood flow and oxygen to the brain (McKee & Daneshvar, 2015). According to Hammell and Henning (2009), the primary impacts which may cause Mi-TBI occurs on the impact of the injury. Secondary impact occurs from additional 'insults' to the brain, which may further cause injury

and complications to the brain (Hammell & Henning, 2009). Mi-TBI cases may have a risk of delayed intracranial haemorrhage which is a secondary impact (Chung & Khan, 2015). The underlying mechanisms for both TBI and intracranial haemorrhage may be the early reduction rate of the cerebral metabolic rate of oxygen without ischemia (Dringer, Zazulia & Powers, 2011). Intracranial haemorrhage and TBI are suggested to share barotrauma from waves of pressure that propagate through intracranial contents as a mechanism of injury (Powers, 2011). Intracranial haemorrhage and other damages may occur to the brain after a Mi-TBI which may lead to cognitive sequelae (Powers, 2011).

### 2.4 Cognitive sequelae of Traumatic Brain Injury (TBI)

As discussed previously there are different classifications of TBI's which range from mild, moderate to severe. The type of TBI severity is categorized according to: loss of consciousness, depth and the duration of the loss of unconsciousness, as well as, the length of pre and post-traumatic amnesia (Bijur et al., 1990). The unique anatomy of children may make them more susceptible to develop an intracranial lesion due to head trauma. Children may have a larger head to body ratio. They have a thinner cranial bone, and they may have less myelinated neural tissue (Farrell, 2013). Patients with paediatric Mi-TBI may be more vulnerable to develop diffuse axonal injury and secondary oedema (Farrell, 2013). The aetiology of diffuse axonal injury includes the shearing of the white matter tracts in the brain (Rajagopalan, Kamer & Cohen, 2017) Diffuse axonal injury occurs at the corpus colosseum and brainstem (Rajagopalan et al., 2017). There are microscopic and gross damage to the axons at junctions of grey and white matter (Rajagopalan et al., 2017). Secondary oedema relates to the structural damage or water imbalance induced by a secondary injury (Werner & Engelhard, 2007).

The affected cognitive factors of Mi-TBI are memory, attention, SP and executive functioning. The aetiology may remain unclear although the frontotemporal, callosal regions and functional pathways are parts susceptible to be injured (Bijur et al., 1990).

Treatment of paediatric Mi-TBI includes hospitalization for 24 hours, where the patient is monitored (Satz, 2001). This is done in order to determine if the secondary injury may result in a change of classification to Moderate TBI or worse (Farrell, 2013). A CT scan can be used to identify neural deficits found in the brain, if any occurs (Chen et al., 2003). High water content in the brain may be one of the adverse effects in paediatric Mi-TBI, which may result in a higher detection rate of Mi-TBI (Rodriguez & Thomas, 2014).

Hessen, Nestvold and Anderson (2007) conducted a 23 year longitudinal study on 24 paediatric patients and 74 adults patients who had suffered a Mi-TBI. Participants underwent neuropsychological assessment the results of which concluded that paediatric participants had a significant result (Hessen et al., 2007). The significant result suggested that children with Mi-TBI may be more vulnerable to develop a neuropsychological dysfunction than adults who had sustained similar injuries (Hessen et al., 2007). The conclusion was paediatric patients with Mi-TBI may be more vulnerable to neuropsychological dysfunction than adult participants (Hessen et al., 2007).

Prasad, Swank and Cobbs (2017) assessed participants with mild, moderate and severe TBI. They concluded that ten years post Mi-TBI the participants in their study continued to manifest delayed scholastic milestones (Prasad et al., 2017). Impaired abilities included reading and writing amongst others. There were increasingly high academic challenges over time for those who had mild and moderate TBI. Therefore TBI's may increase the vulnerability of development and academic functioning in children (Prasad et al., 2017). Konrad et al. (2011) also suggests that Mi-TBI may impact on a child's cognitive functioning.

They discovered that participants who had sustained a Mi-TBI revealed impairments in different cognitive domains such as Attention, Working Memory, Learning, Recall and Executive Functioning 6 years post injury (Konrad et al., 2011).

On the other hand, majority of international literature suggests that there are no long term cognitive sequelae that follow Mi-TBI. Mi-TBI was considered to have minimal effects on cognitive abilities (Babikian et al., 2011; Cassidy et al., 2004; Rees, 2003). Patients are generally discharged within 24 hours as Mi-TBI has a rapid recovery rate. A patient recovers within a few days or weeks (Cassidy et al., 2004). Majority of patients with Mi-TBI may not exhibit intracranial pathology, and the symptoms will be resolved quickly (Farrell, 2013). A patient is expected to return to their baseline premorbid function within 1- 3 months (Schretlen & Shapiro, 2003). A study was conducted by Macciocchi et al., (1996), concluded that college students who suffered from a Mi-TBI recovered between 5-10 days. After a meta-analysis of 39 studies regarding Mi-TBI, Schretlen and Shapiro (2003) concluded that individuals may recover completely within 2-3 months post-Mi-TBI injury (Schretlen & Shapiro, 2003). In another study the cognitive functionality of a sample of athletes was assessed after three months post- Mi-TBI (Iverson, Gaetz, Lovell & Collins, 2014). It was noted that they had returned to typical cognitive functioning, post- Mi-TBI suggesting no cognitive sequelae. The multilingual brain has a unique cytoarchitecture, and may respond differently to cognitive sequelae after TBI.

### 2.5 Mi-TBI and the impact of Multilingualism

As mentioned previously, the test sample for the present study is drawn from a predominantly multilingual society. Language may be a powerful tool which may shape cognition, behaviour and possibly brain function (Hayakawa & Marian, 2019). The bilingual or multilingual child may experience some difficulties when presented with too many words

(Costa & Galles, 2014). Bilingual infants must learn two linguistic codes instead of one. Both linguistic codes need to be achieved in the context of reduced exposure to each of the two languages (Costa & Galles, 2014). Learning two or more languages systems may run parallel with the need to sort and compute information for each language (Costa & Galles, 2014). Cognitive and neural processes may be influenced when individual interchanges between two or more different languages (Hayakawa & Marian, 2019). Bilingual children's ability to switch in between languages optimises their mental flexibility. In studies conducted by Bialystok and colleagues (2009), speaking more than one language was found to have cognitive advantages as language and cognition may not be processed separately in the brain. Bilingualism may enhanced metalinguistic awareness and improved cognitive control (Woumans & Duyck , 2015). Also, it appears that individuals who can speak more than one language may have more effective cognitive control, and better executive functioning skills in areas such as "decision making, planning, monitoring, set-switching and attending" (Higby, Kim, & Loraine, 2013, pg79). Bilinguals may perform better than monolinguals on executive tasks measuring different aspects of cognitive control (Woumans, Ceuleers, Van Der Linden, Szmalec & Duyck, 2015). Bilingualism may be associated with greater plasticity. Due to greater plasticity, the Bilingual brain may recover better after TBI in comparison to Monolinguals.

Grey matter is predominantly found in the cerebral cortex (Amunts et al., 2007). Grey matter density increases for individuals who speak more than one language in comparison to monolinguals and grey matter is further increased. The increase in grey matter is particularly evident in the right hemisphere of the multilingual brain when comparing multilinguals to bilinguals (Higby et al., 2013). Thus, multilingualism may increase the neural network of the cortex. Experience promotes plasticity similar to the way in which multilingualism promotes

plasticity as multilingualism increases neural networks in various areas of the brain (Higby et al., 2013).

Cytoarchitecture is the arrangements of cells in the tissue, and it reflects the internal arrangement of cortical areas (Amunts, Schleicher, Zilles., 2007). Korbinian Broadman divided the cerebral cortex into different areas based on the "density, shape and size of cell bodies" (Amunts & Zille, 2015, pg. 1086). Broadman believed each cortical area served a different and critical function in a more extensive neural network (Amunts & Zille, 2015). As an example: cytoarchitecture correlates with Broca's region and damage to this area may impact speech (Amunts & Zilles, 2012).

Further, and relevant to the present research, grey matter increases in different areas of the brain, which may lead to a greater development of neural networks which may positively impact the SP (Eckert et al., 2010). TBI may affect bilinguals differently by having an unpredictable effect on one or both of their spoken languages (Marrero, Golden & Espe-Pfeifer, 2002). This may depend on if the individual was bi or multilingual individual, how many languages do they speak, when they learned to speak more than one language, the proficiency of each spoken language amoung others may impact TBI (Costa & Galles, 2014).

In a case study written by Kong, Abutalebi, Lam, and Weekes (2014), a multilingual patient who had sustained a TBI. Lesions were found in the left frontal lobe and left temporal-parietal lobe (Kong, Abutalebi, Lam, & Weekes, 2014). As a result, executive functioning was impacted, and the patient interchanged between all three of their spoken languages (Fabbro, 2001). The sample from the current study was predominantly multilingual and may have a unique cytoarchitecture.

From the literature above, it can be seen multilingual children are a unique group possibly with a unique cytoarchitecture. Multilingualism may imply that they may be uniquely

vulnerable to the effects of paediatric Mi-TBIs. In order for the brain to recover after a TBI, neuroplasticity needs to takes place. Neuroplasticity may occur differently within the bilingual and multilingual brain after TBI due to unique cytoarchitecture. Structural neuroplasticity may occur in an individual's brain as a result of bilingualism and multilingualism (Li, Legault & Litcofsky, 2014).

### 2.6 Mi-TBI and Neuroplasticity as a possible Recovery Trajectory

The basis for recovery from a Mi-TBI may lie in the possibility of neuroplasticity. Plasticity may occur after insult to an infant's brain, and this may act as a recovery mechanism (Anderson, Smith & Wood, 2011). Neuroplasticity may be the brain's ability to adapt and change as a result of reception and the environment (Dennis, 2010). The possibility of neuroplasticity is an intrinsic component of the central nervous system, including the ability to reorganize and form synapses (Anderson et al., 2011). The mechanisms for neuroplasticity include growing new connections and growing new neurons (Mundkur, 2005). Neuroplasticity may underlie the brain's ability for neural circuits to make adaptive changes on a neural structural and functional level (Anderson et al., 2011). These changes range from molecular to global networks (Dennis, 2010). The brain of a young individual may develop in a systematic order with different critical periods. Neural development naturally occurs over a lifetime (Dennis, 2010).

Neuroplasticity may occur in the developing brain in three stages (Su, Veeravagu & Grant, 2015). The first stage may occur immediately after the Mi-TBI (Su et al., 2015). The cell dies and there seems to be a diminish in cortical inhibitory pathways for approximately one or two days. This process may reveal secondary neural networks (Su et al., 2015). The second phase occurs when the cortical pathways change to excitatory from inhibitory (Su et al., 2015). Neuronal proliferation and synaptogenesis follows after the change in pathways. Cells are

recruited to revascularise, replace damaged cells and facilitate gliotic scar tissue (Su et al., 2015). The third phase occurs following the injury, there may be new synaptic markers, and axonal sprouting. Remodelling and cortical changes are essential for brain recovery in children (Su et al., 2015).

Neuroplasticity may assist brain recovery from insults and injuries. As an individual gains experience by means of repetition or exposure the synapses (Mundkur, 2005). The Kennard Principle explores the possibility that injury in the early stages of development may not be as threatening as injury in later development (Dennis, 2010). After injury, the Kennard Principal suggests that the developing paediatric brain may be more capable of significant reorganization and recovery (Bennet et al., 2013).

The type of injury may play a critical factor in the recovery trajectory. A study done by Berger and colleagues (1985) recruited a sample of 37 children under the age of 17 with TBIs. The study found that these children had functionally recovered after 6 months. Other studies suggest that age is not a critical factor in determining functional outcome and capacity for recovery following Mi-TBI (Su et al., 2015). Neuroplasticity may depend on the behaviour of the individual post injury. Neuroplasticity may be considered beneficial and can facilitate adaptive changes in response to environmental stimuli and enrichment (Su et al., 2015).

Children may have a better chance of recovery in comparison to adults (Su et al., 2015). This may be a possibility in this study as neuroplasticity may impact the cytoarchitecture development of the brain (Su et al., 2015). Engaging in cognitively stimulating tasks may improve cognitive functioning and tap into multiple domains (Lindsey & Voelbel , 2014). Neural efficiency of cortical structures can be enhanced by repetition targeting multiple sensory systems, which includes SP (Lindsey & Voelbel, 2014).

## 2.7 Speed of processing (SP) information and Mi-TBI

SP is an ability that underlies the efficiency of many other higher cognitive abilities (Bowling & Mackenzie, 1996). SP is the speed at which a person completes a mental task, understand and read the information in the absence of motor retardation (Bowling & Mackenzie, 1996). Processing capacity is the number of operations the brain may be able to carry out simultaneously (Kay, Newman, Cavallo, Ezrachi, & Resnick, 1992). SP is one of the critical developmental tools required to enhance academic performance; it forms part of intellectual development and develops reasoning and experience (Bowling & Mackenzie, 1996). If an organic pathology impacts negatively on the SP, this may interfere with the executive functioning of the brain (Kail, 2000).

Age-related changes impact the development speed of neural communication (Lindley et al., 1998). The speed of neural communication increases in childhood and decreases in old age (Kail, 2000). The higher the SP of the individual, the more efficiently they are able to process information (Bowling & Mackenzie, 1996). A child with a comparatively reduced SP may take longer to complete tasks or chores, and they can often leave out or forget important information (Adubasim, 2018). Reduced SP may be typical among cases of TBI (O'Jile et al., 2006). Slowed SP is associated with deficits in working memory which may be impacted by a Mi-TBI (O'Jile et al., 2006).

It is suggested that the SP develops throughout childhood. Grey and white matter seem to increase the development of effective neural networks related to the SP (Kail, 1992). These networks are comparable to brain processes. SP may add to an integrated network, as many nodes are interconnected (Kail, 2000). Nodes may be the individual neurons or connected cell-assemblies. Nodes may be connected to each other by pathways which may correspond

to the axonal processes (Rypma & Prabhakaran, 2009). Greater neural activity may be achieved through greater intermodal transmission but this may lead to slower SP. Faster SP may be achieved when fewer nodes are transferred. When the processing paths are more direct, it may lead to faster SP (Rypma & Prabhakaran, 2009). This may be linked to working memory. Working memory capacity may be facilitated by excessing amounts of SP resources (Rypma & Prabhakaran, 2009). Chunking information as a learning strategy may reduce the demand on working memory and which increases working memory capacity and SP (Rypma & Prabhakaran, 2009).

McNeil's (2009) observed that the SP might be linked to arithmetic ability. She assessed 87 children between grade 2 and 3 from five schools. The results of the study concluded that children with arithmetic disabilities had a slower SP (McNeil, 2009). This is important to note that children who struggle in mathematics may have a slower SP, which may link to executive functioning (Diamond, 2013). In the study conducted by Kail (2000), it was observed that some of the tasks done by the sample of children were more difficult than other tasks, such as reading, listening and taking notes. It was suggested that the children who had greater difficulty with tasks had slower SP (Kail, 2000). The reduced capacity in information processing may be the outcome of diffuse damages from TBIs (O'Jile et al., 2006).

### 2.8 White matter, neural networks and speed of processing

The Digit Span test positively correlates with the white matter in the parietal and temporal lobes, and in the frontal gyrus (Grieve et al., 2007). Many 3D reconstructions of the brain show that these regions are consistent with the superior and inferior Fasciculi (nerve fibres in the central nervous system) (Turken, Whitfield, Bammer, 2008). The performance on the Digit Span test is related to the integrity of white matter tracts in the parietal and temporal

cortices. The Digit Span test and Coding subtest measure the same trait. The Symbol Search subtest and the Coding subtests in the Wechsler Intelligence Scale for Children IV (WISC IV) measure SP (Baron, 2005). There is a long transmission in white matter pathways of information across neural networks (Turken et al., 2008). The brain has connectivity patterns which are accounted for by white matter fibre systems (Turken et al., 2008). The speed of neural signals is directed across the myelinated axons in the central nervous system. The thicker the myelinated axons, the stronger and faster the signal (Turken et al., 2008). The lengthy associations serve as a functional integration between the frontal, temporal and parietal lobes. White matter tracts are closely associated with SP (Turken et al. 2008).4.4

### 2.9 Executive functioning and speed of processing

Executive functioning is part of a very intricate set of higher-order abilities (Baudouin, Clarys, Vanneste, & Isingrini, 2009). Executive functioning is an essential function in the frontal lobe (Baudouin et al., 2009). Children who have poor executive functioning have many difficulties with planning and organizational skills, communication, attention, memory and social problem solving (Baudouin et al., 2009; Diamond, 2013; Winardi, 2004). It will take more time to act on information if the SP is slow. Due to slower skills in processing information, it may compromise attention and working memory. Attention refers to the ability to hold information for short amounts of time and manipulate it (Tunnermann, Peterson & Scharlau, 2015). SP may compromise this functioning, and it may lead to forgetfulness as information cannot be processed fast enough, and or the individual will easily be distracted (Tunnermann et al., 2015). Selective memory may enhance SP, as an attended stimulus is processed faster than when attention is drawn away from a stimulus. When a child focuses on a task, their SP is enhanced (Tunnermann et al., 2015). Mi-TBI may impact the individual's attention and memory, which in turn impact their SP (Tunnermann et al., 2015).

The executive control mechanism is usually studied by assessing working memory (Mccabe et al., 2010). Mi-TBI may disrupt executive functioning processes (Gorman et al., 2016). A similar finding was observed in a study done by Adubasim (2018), as deficit SP may impact working memory. The sample of students that were assessed took more extended amounts of time to complete classwork. This may infer that more information may be held for an extended period of time (Adubasim, 2018). This may have occurred due to the SP of the individual, as it may be directly impacted by working memory. Limited capacity of information can be stored for short periods in working memory (Adubasim, 2018). Too much information in a short period of time may lead to loss of information (Adubasim, 2018).

### 2.10 Speed of processing and the Wechsler Scale of Intelligence for Children IV (WISC IV)

The WISC IV uses two subtests to measure the SP of a participant, these are the Coding and Symbol Search. The Coding and Symbol Search subtests may also measure working memory, psychomotor abilities, visual discrimination and attention (Ebaid et al., 2017). The WISC IV is age-graded and appropriate for all children between the ages of 6 and 16 years. Cultural biases may limit the use of norms cross culturally. The current study interpreted the data from the current Mi-TBI group and Neurotypical group rather than relying on published norms. The Coding and Symbol Search subtests of the Processing Speed Index (PSI) are practical tests with practice items which reduced the language concerns. Only the instructions were needed to be translated, and there are practical practice examples.

# Chapter 3

# Method

## 3.1 Research design

The current study adopted an ex-post facto design (quasi experimental where the independent variable (Mi-TBI) had a standing inclusions characteristic of the test sample) (Fields, 2009), cross sectional (data analysis from a single specific point in time without casual implications)( Fields 2009). The current study was quantitative in nature (where the dependent variable is measured using statistical techniques) and within a positivist paradigm (the role of the researcher was limited to the analysis and objective interpretation of retrospective data from a broader clinical trial) (Fields, 2009). The participant sample was derived from the non-probability sample identified by the principal investigator of the THINK study trial.

## 3.2 Research questions

This study was guided by the following research questions and their respective hypothesis:

1. What was the performance of the Mi-TBI population in the SP on the Coding Test?
2. What was the performance of the neurotypical population in the SP on the Coding Test?
3. What was the performance of the Mi-TBI population in the SP on the Symbol Search Test?
4. What was the performance of the neurotypical population in the SP on the Symbol Search Test?
5. Were there are any differences in the SP between the group of children with Mi-TBI and the children without Mi-TBI?

Based on the survey of the literature, the study hypothesised that Mi-TBI may result in a slower SP (O'Jile et al., 2006; Ozen, & Fernandez, 2012; Bernstein, 2002).

And

No= 20

No was the sample size of the test group with Mi-TBI. This sample group had 20 participants.

Ny= 20

Ny was the sample size of the Control group without Mi-TBI; this group had a sample size of 20 participants.

Level of significance = 0.05

The variances were assumed to be equal.

### 3.3 Sample

Twenty cases of children who had suffered Mi-TBI and were at least 12 months post-injury, and 20 cases of comparable children who had not suffered a Mi-TBI (neurotypical), and for whom comprehensive psychometric data was available, were included in the study. The Principle Investigator had developed a database of Mi-TBI participants and the sample of participants for this were based according to a stipulated criteria.

The participants of this study were identified by the principal investigator having suffered a Mi-TBI at least 12 months prior to psychometric assessment. They were invited by the clinic's administrative manager. The invited individuals were selected to participate in the umbrella THINK project. Inclusion/exclusion for the umbrella study was based on medical and non-medical requirements as stipulated in the approved protocol for the registered

clinical trial. The specific inclusion criteria for the present study are discussed in sections 5.4.2 and 5.4.3 and were verified based on the completed demographic questionnaire. The control participants and their guardians were approached and invited to participate in the study while waiting for a consultation for general and treatable disorders that required no surgery or medical treatment which compromise neurological functioning. In the write up of this study, the control group was referred to as the neurotypical group. The test sample (HI) comprised 20 cases between the ages of 6-10 who were identified by the principal investigator of the THINK trial. The 20 neurotyipical contrast participants (control) were drawn from attendees at the Paediatric Outpatient Department (POPD) who met the inclusion criteria of the THINK clinical trial. The sample of 20 participants that were selected for analysis in the present test sample were drawn from the larger cohort identified by the principal investigator. The demographic questionnaire was per the hospital records further screened the neurotypical group based on age, gender, language proficiency, socioeconomic status and medical history.

### 3.3.1 Assumptions regarding the Socio-Economic Status of the participants from Chris Hani Baragwanath Academic Hospital

Certain assumption were made based on the fact that all participants were drawn from a cohort of attendees at the Chris Hani Baragwanath Academic Hospital. Usage of the same governmental public medical facility for routine assistance implies they were from Soweto hospital catchment area and of similar socio-economic status. Within this cosmopolitan polyglot geographical area they would have experienced similar exposure to multiple languages, be emerged in similar cultural practices, have experienced access to similar amenities and scholastic opportunities.

3.3.2 **Inclusion criteria for participant:**

**3.3. 2.1 Inclusion Criteria for the THINK study:**

For the test (Mi-TBI) group:

1) Clinical records supporting the classification of Mi-TBI

2) Participants must have a minimum recovery period for no less than 1-year post-injury.

3.3.2.2 **Inclusion Criteria for the current study**

1) The participants (Mi-TBI) are between the ages of 6-10 years.

2) Participants data from the PSI

**3.3.3 Contrast group/ Control Sample**

**3.3.3.1 Contrast group/Control group for the THINK Study:**

1) Participants are assumed to be from a similar demographic, given that they use the same primary health care provider, Chris Hani Baragwanath Academic Hospital.

2) The participants must have no history of a TBI or other conditions that may impact on neurological functioning. The typical participant of the control group would be a child attending the clinic for a pre-surgical consultation for pre-surgical patients attending the clinic for circumcision or umbilical hernia.

**3.3.3.2 Contrast group/ Control group for participants in the current study**

1) Participants between the ages of 6-10

2) Participants with no history of Mi-TBI or other conditions which may impact neurological functioning.

**5.3.4 Exclusion criteria for participants**

#### 5.3.4.1 Exclusion criteria for participants in the THINK study

1) Individuals who have multiple head injuries of any classification, such as moderate and severe head injuries.

2) Cases of head injuries associated with social issues such as abuse or violence, as this may add complications to the study.

3) Participants with any form of mental health diagnosis (previously diagnosed with any psychiatric or neurological disorders), endocrinological or autoimmune disorders: inclusive of anxiety, depression, ADHD, diabetes, HIV amongst others)

#### 5.3.4.2 Exclusion criteria for participants in the current study

1) Children below the age of 6 and above the age of 10 years old (this is appropriate as the WISC IV can be administered to children from the ages of 6-16 years).

2) Participant data relating to other subtest of the WISC IV such as the Verbal Comprehension Index, the Working Memory Index and the Perceptual Reasoning Index.

Outside of the above, to comply with the research question, there was no social exclusion for this study as it was part of a clinical trial looking at the hospital population. Due to this, participants were only excluded based on medical grounds that would impact the study.

### 3.4 Ethics

The THINK study is registered as a clinical trial at Chris Hani Baragwanath Academic Hospital. The ethical clearance for the umbrella project was based on the proposal (Examining Neurocognitive, psychological and psychiatric sequelae following Mi-TBI: a potentially significant impact in a low socioeconomic population) submitted to Wits Medical Ethics (Human Research Ethics Committee (Medical) (M1611113) by Dr Vered Lack. The ethical issues which were covered by the THINK Study project (M1611113) were: invitation

of participants, obtaining informed consent and assent, referrals of the participants (if necessary), withdrawals of participants, and translations of the information sheets and consent forms.

Participation in the study was voluntary. The informed consent and assent document was designed by the principal investigator and approved by the ethic committee (Appendix F) was presented to participants prior to data collection, read, explained and signed by the participant's guardian, the participant and the member of the research team was responsible for this process. This form guaranteed the right to withdraw or retire at any point of during the study without any consequences to the participant. Each participant had a consent form signed by a parent or guardian, and assent form where a member of the research team had explained the purpose, procedure and participant rights for the THINK study.

The demographic and psychometric data were collected at the Chris Hani Baragwanath Academic Hospital, Glaxo-Kline-Smith Paediatric Clinic under the auspices of the department of paediatrics and Surgeons for little lives, on the days which were suitable for the participant. There was minimal noise in this facility, and the test was completed during the weekday and between the times of 07h30 and 16h30. Identification of data files was coded by the principal investigator ensuring confidentiality and anonymity. Data collected was and will remain in storage, at Chris Hani Baragwanath Academic Hospital and locked in a cupboard in a doctors' boardroom.

Information regarding the study was available to the participants and their parents by contacting the administrative manager and Dr Vered Lack. The results of the study can be obtained from Dr Vered Lack at Chris Hani Baragwanath Hospital.

The THINK project had been systematically gathering data since 2017. The present researcher was granted access to archival data from this database. Facilitating this access, the

researcher had permission from the Head of Department of Paediatric Surgery to access patient data from the Chris Hani Baragwanath Academic Hospital database (Appendix D). The researcher signed a confidentiality agreement with the THINK project (Appendix E). The present researcher was linked to the project and is registered with Surgeons for Little Lives at the Chris Hani Baragwanath Academic Hospital.

Although the parent THINK study had been approved by the University of the Witwatersrand Ethics Committee and only archival data from the data bank generated in this research. Given the age and vulnerability of participants, the specific research protocol specific for the current study was also submitted for scrutiny and approved under medical ethics clearance details (M190909).

The Chris Hani Baragwanath Academic Hospital will receive the final report generated for the existing nested research project.

### 3.5 Procedure followed by the THINK Study research team

Data collection was conducted by the THINK study research team. The data collection procedure is described in the present study, however the researcher was not part of the testing process carried out by Dr Lack and her team. The potential participants were identified by the principal investigator, Dr Vered Lack's database. The participants were contacted by the clinic administrative manager, informed of the purpose of the study and invited to participate in the study. The ethical rights and procedure of the study were fully disclosed to the participant by the Clinic Manager. The Principal Investigator covered costs of the participant's transport to Chris Hani Baragwanath Academic Hospital, and they were provided with lunch.

The data collection took place at Chris Hani Baragwanath Academic Hospital Glaxo-Kline-Smith Paediatric Clinic under the auspices of the Department of Paediatrics and Surgeons for Little Lives. The data collection occurred over several days per week in a suitable room located within the building by the research team.

As per the approved protocol submitted by Dr Lack, on the day of testing the purpose and process was explained to caregiver and participant again. The contrast participants and their guardians were approached and invited to participate in the study while they were waiting for a consultation. Once the participants had agreed and understood the ethical issues relevant to confidentiality and the rights of the participant, they had signed an assent form. The caregiver had signed a consent to agree for their child to participate in the study.

A demographic questionnaire (Appendix G) was completed by the parent with assistance from a multilingual member of the research team. Once the demographic questionnaire was completed, and once again with assistance from a multilingual member of the research team, the caregiver completed the Vanderbilt Assessment Scale and the participant, the Hospital Anxiety and Depression Scale.

The psychometric test protocol was administered in accordance with a Latin Square Design to minimise the impact of test-wiseness, fatigue and test administrator/testee dynamic across participants within the sample. Specific tasks at each station were grouped to accommodate those tasks that incorporate a delayed recall element and to minimise the interference factor of tasks based on similar cognitive components. The tests used to answer the specific research questions for this study was drawn from the WISC IV battery and NEPSY. The NEPSY and WISC IV were batteries that formed part of the umbrella THINK Study project. Dr Lack and her research team had gathered all requisite data; however, if necessary, a multilingual translator, was trained in the test requirements and procedures, was available at

all stations to ensure that test requirements and instructions in accordance with the test manuals were understood in accordance with the test manuals. The multilingual translator was familiar with translating clinical and research environments and was available on site for the full THINK Study battery. The Multilingual translator followed with strict accordance with the Wechsler Scale of Intelligence for Children IV manual and translated the necessary instructions for the specific tests. The current study used retrospective data, and the data extracted from the umbrella study included whether the participant has Mi-TBI or they form part of the control group, gender of the participant, current age of the testing, date of birth, date tested, home language of the participant, time since injury, age at injury, language of testing, education level, Coding, Symbol Search and the PSI.

In order to answer the present research questions the Coding and Symbol Search subtests of the WISC IV were extracted from the main data set. The research team administered either the Coding A (6-7-year-olds) or Coding B (8-10-year-olds) subtest depending on the age of the participants. Both versions of the test include practice items (Wechsler, 2004). Once the participant had successfully understood the practice examples, they were allowed to start the test. In addition to the standard instruction provided in the test manual, for the present research, the researcher had used a stopwatch to record 15-second interval progress. These are 15 seconds, 30 seconds. 45 seconds, 60 seconds, 75 seconds, 90 seconds and 120 seconds. This increased the richness of the data beyond the "what" and into the "how". Although the quantitative score for the Coding tasks was based on the 120 second period, the participant was encouraged to continue with the task until they completed 4 of the digit-symbol rows to facilitate immediate and delayed incidental recall trials. The participant completed a minimum of 4 rows, regardless of the time limit.

After completion of either Coding A or Coding B, the research team had administered the Symbol Search A (6-7years old) or B subtest (8-10 years old) (Wechsler, 2004). The

participant was presented, and assisted by the test administrator, with the practice items. Once the participant understood the task, the participant was allowed to complete as many items of the task as possible within 120 seconds time limit Wechsler, 2004). After the testing was completed, the tests were collected by the research team and stored in a sealed box and locked in a cupboard in the paediatric surgery department of Chris Hani Baragwanath Academic Hospital boardroom. The testing process stated above was the same for the Mi-TBI sample and the Neurotypical sample.

Once all the data was gathered, appropriate data was accessed by the present researcher scored in accordance the WISC IV test manual by the current researcher, cleaned and coded using an excel spreadsheet. The performance of the test group scaled scores for both subtests as well as the composite PSI was compared to the neurotypical group.

### 3.6 Measuring Instruments

Demographic Questionnaire

The demographic questionnaire was dictated by THINK study clinical trial (project at Chris Hani Baragwanath Hospital, and approved by Principal Investigator Dr Vered Lack (Appendix G)). The demographic questionnaire was used to identify demographic variables which may have interacted with, and might possibly help predict, cognitive deficits such as a deficit in SP. Examples of variables that it was hypothesised may be of relevance to SP following Mi-TBI include age, age at injury, age at testing, period post-injury, and level of education.

**The Wechsler Scale of Intelligence IV (WISC IV).**

The WISC IV was developed in 2004, and this test is suited for children between the ages of 6-16 years old (Gomez, Vance, & Watson, 2016). The Wechsler Scale of Intelligence for Children IV is a test battery designed to assess cognitive function, general strengths and weaknesses and identify neuropsychological dysfunction. (Gomez et al., 2016). The WISC-IV is a norm referenced battery in which an individual child's performance is interpreted in the light of a demographically appropriate sample of children. A child must be compared to other children who are relatively similar to them in age, language and socioeconomic status (Gomez et al., 2016).

Each test in the WISC IV assumes the sample tested will have the same a norm score as international standards, as the tests rely on the idea that cognitive skills are normally distributed amongst the population (Gomez et al., 2016). These assumptions may not be met in South Africa and for this reason a suitable comparison sample rather than published test norms were used in understanding present data. Interpretation based on an inappropriate norm reference which may lead to misdiagnosis. For this reason although age corrected in accordance with the international standards. The interpretation of this study drew on from a comparative sample rather than standard scores. Otherwise, this compromises the tests the reliability of the results (Skuy et al., 2000).

There are four composite indices to the WISC IV which consist of specific subtests. Specified subtests from the WISC IV are utilised to calculate four different composite scores and these are: The Verbal Comprehension Index, the Perceptual Reasoning Index, The Working Memory Index and the Processing Speed Index (Wechsler, 2004). SP is assessed in the WISC IV by using two subtests in the battery, and these tests are the: Coding test (matching symbols to associated numbers) and the Symbol Search test (visual scanning and graph motor speed of matching symbols) (Gomez et al., 2016). These tests measure a child's ability to scan visual information, discriminate between information and solve problems in

their environment. There seems to be little cultural impacts on these specific tests (Gomez et al., 2016).

It is important to note that in South Africa language, education level as well as the quality of education may be crucial factors to consider when interpreting psychometric performance. The WISC IV has not been standardized for the South African population (Laher, Cockcroft, Amod, Bain & Bhabha, 2013). There does not seem to be evidence for reliability and validity for Coding and Symbol Search in the South African context. The performance on a test may be impacted upon by variables such as age, the quality and extent of the individual's education (Skuy et al., 2000). Educational level and age of the participants were statistically correlated to the performance on the psychometric measures. The age of the participant may not impact their level of education.

### 3.7 Instrument reliability and overall reliability of the psychometric measure

The Cronbach alpha for the WISC IV is 0.87. The reliability coefficient of the PSI index is 0.88, and the full-scale reliability for the entire WISC IV battery is 0.97.

Coding Test and Symbol Search Test

The Coding A and B subtests are subtests in the WISC IV to assess SP. The participant must copy simple symbols that are paired with their respective symbols (A) or numbers (B) (ages 6-16). The participant is scored on how many symbols or digit symbol combinations are correctly completed within 120 seconds (Wechsler, 2004). Regardless of the time limit, the child must complete four rows to ensure they are exposed to the digit combinations to validate recall (Brunnert, Naglieri, & Hardy-Braz, 2009). The research team was trained to conduct both the Coding A and Coding B test. Coding A was administered to participants between the ages of 6-7 and Coding B test was administered as it was designed for children between the ages of 8-10 years (Wechsler, 2004).

Similarly, Symbol Search subtests is a timed, non-verbal task with clear practice item to demonstrate an understanding of the requirements of the task before administration. As is the case for the Coding subtest, the Symbol Search subtest has two different versions A for children aged 6-7, and B for children aged 8-10. All members of the test administration team were trained to conduct both the Symbol Search A and Symbol Search B test. Either Symbol Search A or B was administered to the research sample (Wechsler, 2004). The test requires that the child marks yes or no in response to as many items as possible depending on whether the key items are identified among distractors (Sweet, 2011). Following discussion with Dr Nicola Taylor of JvR, so as not to disadvantage left-handed participants, the subtests were adapted the response sheet moving the "Yes/No" response block to the left-hand side of the page so that test stimuli will not be obscured during the administration of the test.

Categorically there is evidence of reliability for both the Coding and Symbol Search subtests. A study done by Raiford et al. (2016) administered the Coding and Symbol Search subtests to a sample of 329 children aged between 6 and 16 years on two occasions. They conducted test-retest reliability for the two tests on different occasions. The 6-7-year-old group had an initial score of "r = 0.74" and a second testing score of "r =0.77" (Raiford et al., 2016, pg. 10). The 8-16-year-old group had a first testing score of "r =0.85" and a second testing score of "r =0.78" (Raiford et al., 2016, pg. 10). The overall scores for the initial testing were "r =0.8" and the second testing was "r =0.78". As seen from these results, the reliability coefficients are similar for both occasions. Coding and the Symbol Search tests are stable over time, and the scores are high, which means these tests have a good reliability score. (Raiford, et al., 2016). Raiford and colleagues (2016), established the validity and checked the correlation score between the Coding Test and the Symbol Search test. Their research concluded that the correlations comparing the items in each test were statistically significant, and these subtests correlate to some degree with each other (Raiford et al., 2016).

The level of performance on both the Coding and Symbol Search tasks relies heavily on the SP and together, the standard scores from each were used to compute a PSI with higher scores associated with faster SP (Wechsler, 2004).

# Chapter 4

## Analysis

The results were then analyzed and documented focusing on the descriptive data such as the mean, standard deviation and the range. After the data was examined, it was found that there were missing variables of data. This reduced the number case per variables which could be analyzed in this study. This study measured performance levels have been age-corrected as per conversion from raw to standard scores. According to Fields (2009), the significance suggests the relevance of the variable as a predicting for the test variable (SP), if the significance is less than 0.05, then the item is significant as a predicating variable. Gender, age at testing, age at injury and time since injury have a significance level greater than 0.05, which indicates that none of the variables acts as covariates for the SP.

The collected data were entered into an excel spreadsheet to establish demographic comparability between the two samples. The data set was cleaned and decoded in order to determine which cases were viable for further analysis. According to Fields (2009), fewer case numbers may increase the probability of achieving a significant outcome. The most common method of dealing with missing data would be to delete the cases which have values missing for the dependent variable. This may reduce the sample size. There may be potential bias due to missing data (Jackobsen, Gluud, Wetterslev & Winkel, 2017).

When analysis was done, various tests were used to establish if the data was normally distributed in order to establish which tests would be suitable for analysis. An independent t-test was run to investigate if there is a difference in means between the test group and the neurotypical comparison group. Once the independent t-test was analyzed, a simple linear regression and correlation analysis was completed. A simple regression and correlation were completed on the characteristics of TBI: age at injury, time since injury, age at testing to establish if there were any predictor variables for a difference between the SP between the two groups.

### 4.1. Test Assumptions

It is essential to explore the test assumptions of normality. These assumptions are paramount and necessary to use in parametric tests. It is essential to discuss the test assumptions of normality to ensure that none of the assumptions had been violated.

#### 4.1.2 Normality

The assumption of normality was tested using a normality bell curve, as well as a skewness coefficient. The bell curve summarizes the data and represents the distribution of the samples. To be normally distributed, the data should be approximately a shape of a bell. The shape of the bell represents the distribution of the data. A bell shaped curve may indicate a perfect distribution and the skewness coefficient needs to be within the range of 1 and -1 (Foxcroft & Roodt, 2013). Data may be positively or negatively skewed. The Shapiro Wilk tests all show a significant value above 0.05, suggesting that there is no deviation from normality.

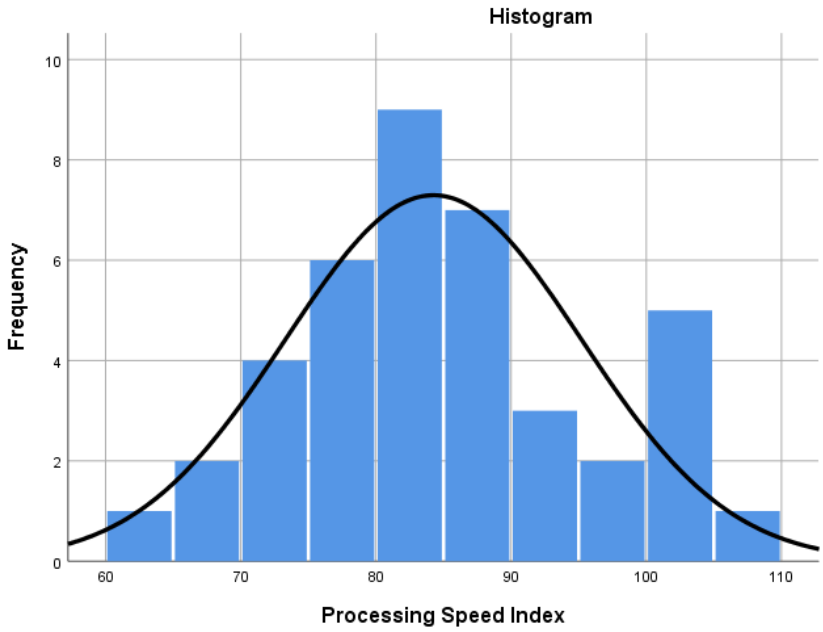
Table 1

*Tests for the Kolmogorov-Smirnov and Shapiro Wilk tests for Normality of Data for Coding, Symbol Search and Speed of Processing.*

| | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Coding | CO | .195 | 20 | .044 | .921 | 20 | .105 |
| | HI | .162 | 20 | .181 | .935 | 20 | .195 |
| Symbol Search | CO | .135 | 20 | .200* | .954 | 20 | .426 |
| | HI | .150 | 20 | .200* | .930 | 20 | .153 |
| Speed Of Processing | CO | .176 | 20 | .106 | .940 | 20 | .235 |
| | HI | .171 | 20 | .128 | .943 | 20 | .277 |

**Figure 1**

*The distribution curve of the Processing Speed Index*




### 4.1.3 Homogeneity of variance

The homogeneity of variance was determined using the Levene's test of homogeneity. In an independent t-test, it is assumed that the variances are equal for both independent groups. The variances of the groups are not equal when the null hypothesis has been rejected. This will violate the assumption of homogeneity of variance. Coding, Symbol Search, and SP had equality of variance.

### 4.1.4 Independent observations

The independent group (participants) are categorical as there are two separate individual groups (Control and Mi-TBI Group).

### 4.1.5 Outliers, linearity and scale of measure

The raw data on the Excel Spreadsheet was examined and cleaned. Given the potential impact on statistical validity, outliers were identified and removed from the sample before further analysis. Inclusion of outliers may allow for biased estimates and invalid conclusions (Kang, 2013). Once outliers and missing data were identified from this sample, and they were removed from the sample.

As discussed, the raw scores delivered for the Coding and Symbol Search subtests are age-corrected when converted to standard scores. Thereafter the sum of the two standard scores is converted in to a PSI as per the table provided in the WISC IV manual. As is the case for IQ, the PSI is normed to a standard bell curve with a mean of 100 and a standard deviation of 15. The PSI scores were compared to the psychometric conversion scale, which compares the score to a percentile rank. The purpose of categorisation of performance levels is the index score were converted to percentile ranks as per the table provided in the WISC IV manual. The percentile rank of a score is the percentage of scores in its frequency distribution that are equal or lower than it. An example is if the test score is greater than 75% of the scores of people taking the test is said to be at the 75th percentile, where 75 is the percentile rank. As indicated in the categories that follow, a percentile of 75 falls at the upper limit of the average range. A percentile of <1 would indicate a profound deficit, a percentile of 2, impaired, a percentile of between 2 and 8 would classify as borderline impaired, 9 – 24 Low average, 25-75 as falling with the average range, 77-91 falls within the high average range, 92-97 is falls within the superior range and 98-<99.9 falls within the very superior range.

## Results

The statistical analysis was conducted by the researcher using the Statistical Package for Social Science version 25 and G Power 3.1. Analysis of the data interrogated whether there was a difference in SP between the test group who had suffered a Mi-TBI and the

neurotypical comparison group. Further, this study aimed to determine which variables of pediatric Mi-TBI patients such as age, age at injury, age at the time of psychometric testing and gender act as predictors for SP. The data gathered from the Mi-TBI test sample was examined in an attempt to identify the class of patient most vulnerable to the slower SP.

### 4.2.1 Power Analysis

A power analysis was calculated before the data was collected. The power analysis was used to determine the smallest sample size which would detect the effect of a specific test at a specific level of significance. The power analysis calculated a sample of 40 participants at a 5% level of significance to detect a true difference between the test group and the contrast group using a power calculation on the Statistical Package for the Social Science. The probability of a type two error or β determines the probability of the power analysis aimed to assess the type 2 error. The PSI score was used to determine the power statistic. The sample size is 40 and the p-value is 0.022 with an effect size of 0.130. The observed power statistic is 0.643. This means there is a 64.3% chance of detecting a difference in the sample for that specific sample size and the specific effect size. There is a 36% chance of a type 2 error occurring. After the power statistic calculation had occurred, the power was calculated using the G power 3.1.9.4 statistical tool. The power revealed to be 1- Beta (β) = 0.7762071. There is a 77.6% chance of correctly rejecting H1 when H1 is false.

### 4.2.2 Descriptive Statistics

The hypothesis of this study was investigated through comparison of 2 groups of participants, namely a Mi-TBI group and a neurotypical control group. A sample exclusion based on factors such as outliers and missing data where only one of the testing variables was

completed. The SP was not calculated for some variables due to some missing results either from Coding or Symbol Search. There are 20 control participants and 20 Mi-TBI participants that met the criteria for inclusion in the final statistical analysis.

The WISC IV for PSI scores operates similar to an IQ score with all the same standardization procedures and criteria. The WISC IV (2004) manual indicates that scores obtained from the Coding and Symbol Search subtests are raw scores. A raw score is an item score. The raw score was converted into a standard scores as per the Wechsler Intelligence Scale for Children IV manual. Each page of the normative tables presents a 4 months age span. Standard scores offer a 20 point scale with a mean of 10, a standard deviation of 3 and a normal distribution appropriate for age. Scaled or standard scores are thus comparable across age ranges. The collected data was cleaned in an excel spreadsheet. Summation of the scaled score for the two contributing subtests, Coding and Symbol Search (active non-verbal tasks that require minimal higher-level thinking) is converted to an index score indicative of SP. The means of the Coding, Symbol Search and SP were calculated for the test group and the control group. After these groups were then compared to each other. An independent t-test was used to calculate and compare the significance of the test group and the control groups. The data was further interrogated using regression and correlation analysis.

Table 2 describes the sample as 67.50% male and 32.50% female.

Table 2 below provides an overview of the demographic characteristics of the participants. Some participants did not indicate their home language.

Table 2

*Demographic descriptive statistics for the Mi-TBI group and Control Group (Categorical Variables) N=40*

| | | Percentage of total sample | Number of Mi-TBI sample | Number of Control sample |
|---|---|---|---|---|
| Gender | | | | |
| Male | | 67.50% | 13 | 14 |
| Female | | 32.50% | 7 | 6 |
| Current School | | | | |
| Not in School | 1 | 2.5% | 0 | 1 |
| Grade R | 1 | 2.5% | 1 | 0 |
| Grade 1 | 6 | 15% | 3 | 2 |
| Grade 2 | 10 | 25% | 4 | 6 |
| Grade 3 | 6 | 15% | 5 | 1 |
| Grade 4 | 8 | 20% | 2 | 6 |
| Grade 5 | 5 | 12.5% | 3 | 2 |
| Grade 6 | 2 | 5% | 1 | 1 |
| Grade 7 | 1 | 2.5% | 1 | 0 |
| Grade 8 | 1 | 2.5% | 0 | 1 |
| Home Language | | | | |
| Sesotho | 10 | 28.6% | 4 | 6 |
| Zulu | 14 | 40.0% | 9 | 5 |
| Sepedi | 3 | 8.6% | 2 | 1 |
| Ndebele | 1 | 2.9% | 0 | 1 |
| Tswana | 6 | 17.1% | 2 | 4 |
| Xhosa | 1 | 2.9% | 0 | 1 |

Figure 2

*Bar graph representing the home languages of the Test group (Mi-TBI N= 17) and the Control group (Control N=18).*

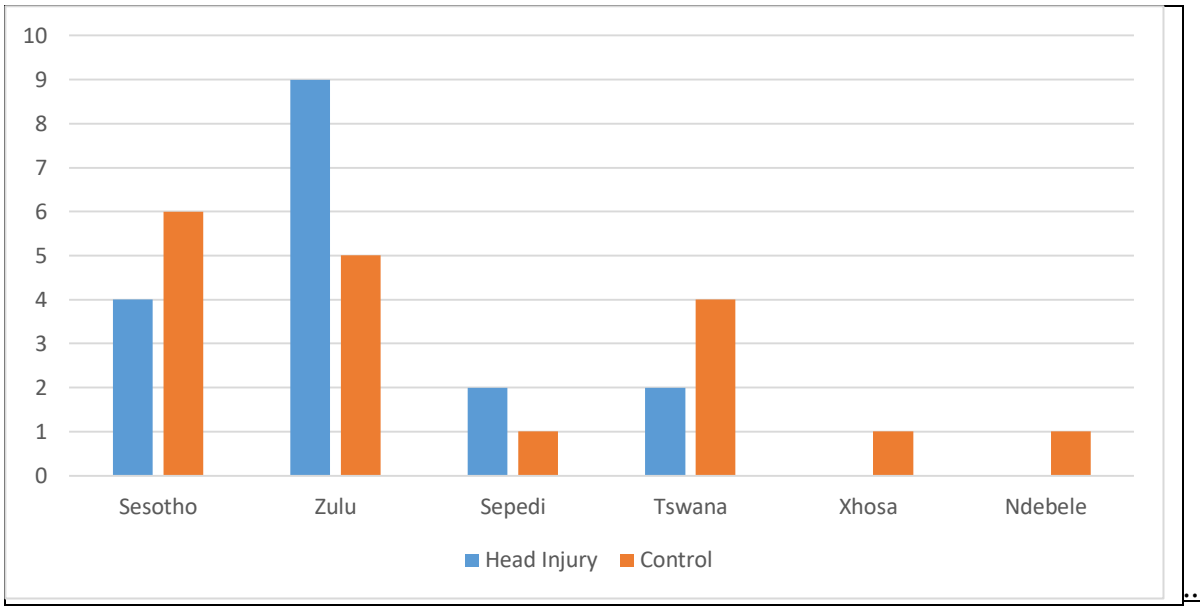
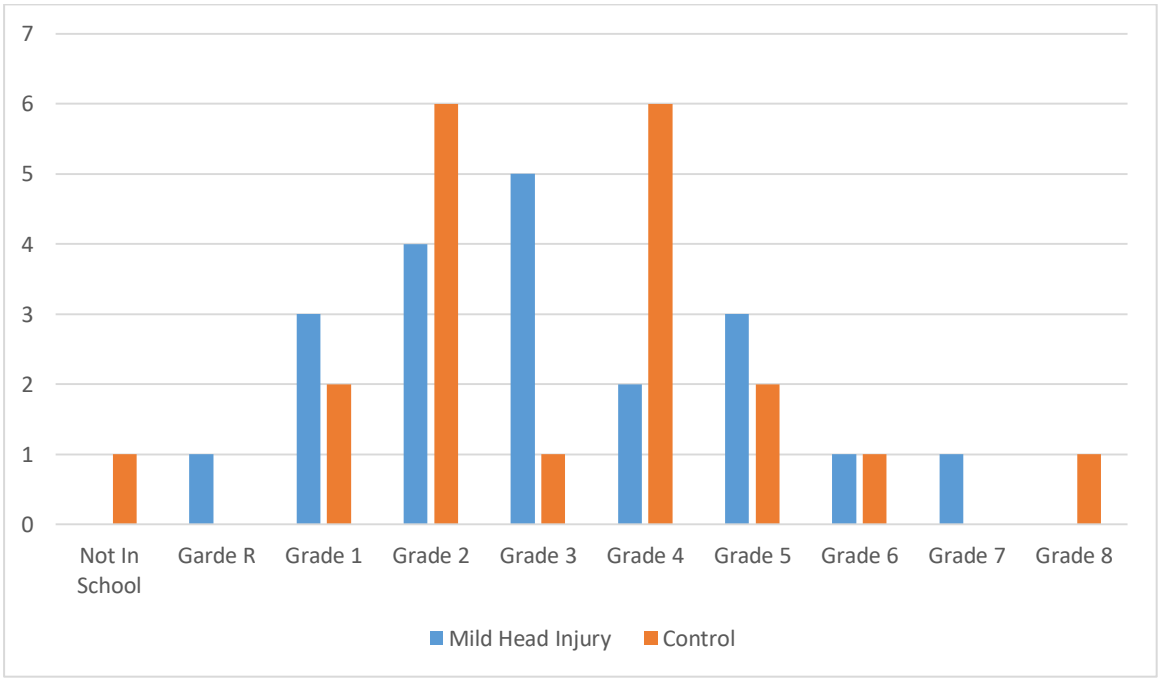



Figure 3

*Bar graph representing the Level of Education of the Test group (Mi-TBI N= 20) and the Control group (Control N=20)*



### 4.2.3 Demographic statistics of the Test group (Mi-TBI) and Control group (Control).

The sample above consisted of 40 participants. A higher proportion of males than females in the test sample reflects the gender distribution of Mi-TBI in the population at large (Arambula et al., 2019; Collins et al., 2012). The current study found that there was a higher percentage of boys than girls who had sustained a Mi-TBI Table 2 describes the sample as 67.50% male and 32.50% female. Also, Collins et al. (2012) found a difference between genders in the occurrence of Mi-TBI through a longitudinal observational study. Their study found a difference in gender distribution, and this is similar to the finding in the current study.

Table 2 shows that a large percentage of participants (97.89%) attended school. The grades of the participants ranged from grade R – grade 8. It is seen that the target sample of this study is the school-going age. Primary and Secondary education is compulsory for children between the ages of 7 (grade 1) -15 (grade 9). This indicates the age range chosen for this study is appropriate, for the WISC IV may assess children from the age of 6 – 16yrs 11 months. The education level of the test group and control group were age-appropriate

Table 3

*Demographic descriptive statistics of the Mi-TBI and Control group (interval variables) N=40*

| | Mi-TBI | | Control | | Overall | | Range |
|---|---|---|---|---|---|---|---|
| | Mean | STD | Mean | STD | Mean | STD | |
| Age at testing | 8.87 | 1.97 | 8.66 | 1.77 | 8.71 | 1.86 | |
| Age at injury | 5.77 | 1.71 | - | - | - | - | 7.08 |
| Time since injury | 3.40 | 0.99 | - | - | - | - | 2.91 |

*Note: *=p<0.05, Blank spaces are representative of a mean and standard deviation that could not be generated for that variable because it is not relevant for the group.*

The age-related data was first converted from years into months. The scores were then calculated and then converted back into years. Table 3 indicates the average age at testing for the combined Mi-TBI sample and the neurotypical sample was 8.71 years and the standard deviation is 1.86 years. The average age of the test group was 8.87 years, and the average age for the control group was 8.66 years. The average of the test group and the control group are very similar in age, which allows the groups to be compared. The test group was approximately 5.77 (average years) at time of injury with approximately 2.91 (average) years between the time of injury and time of testing.

### 4.2.4 Inferential Statistics of the Test group (Mi-TBI) and the Control group (Control).

Table 4 below indicates the differences between the paediatric Mi-TBI group and the control group.

Table 4.

*Independent t-test to investigate the differences between the Mi-TBI (HI) and control (CO) group. N=40*

| | Mean | Standard Deviation | Independent t-test | | | | |
|---|---|---|---|---|---|---|---|
| | | | F | T (two tailed) | df | p | Std. Error Difference |
| Gender | | | | 1.454 | 37 | 0.908 | 0.791 |
| Coding | | | 0.735 | 1.54 | 38 | 0.154 | 0.791 |
| Control | 7.28 | 2.73 | | | | | |
| HI | 6.65 | 2.25 | | | | | |
| Symbol Search | | | 0.271 | 2.237 | 38 | 0.031 | 0.805 |
| Control | 8.10 | 2.69 | | | | | |
| HI | 6.30 | 2.38 | | | | | |
| Processing Speed Index | | | 0.588 | 2.388 | 38 | 0.02 | 3.267 |
| Control | 88.15 | 11.40 | | | | | |

| | | |
|---|---|---|
| HI | 80.35 | 9.13 |

Regarding the research question, an independent t-test was used to compare the means between the two groups, at a 0.05 significance level. The hypothesis tested to determine if the test group was slower than the control group for SP.

Table 4 indicates the Independent t-test results when comparing the test group and the control group. Despite a 0.63 difference between the mean performance level, for the Coding subtest, the analysis did not meet the criteria for statistical significance at the 5% level of significance. On the other hand, there was a significant difference between the groups for the symbol search subtest and the overall PSI ($p<0.05$). A one-tailed independent t-test was calculated for the PSI. The result of the one-tailed t-test is $t(38)= -47.80895$ , $p= < .00001$. This indicates that the control group had a significantly higher score than the test group. This result suggests that the test group were slower compared to the control group for their overall PSI.

### 4.3 Regression and Correlation coefficients

A linear regression was computed to determine whether a relationship exists between two variables (Field, 2009). As one variable deviates from the mean, the other variable will also deviate from the mean. All the variables below (independent variable) were measured against the SP variable (dependent variable).

Predictor variables are independent variable which may be linked to a specific outcome (Fields, 2009). The figure below represents the tests for normality of the suggested predictor variables for the SP deficit in children with Mi-TBI. Age at injury and time since testing only included the Mi-TBI group and age at testing and gender included both the Neurotypical group and Mi-TBI group.

Table 5

*Tests of Normality for Age at injury (Months), Time since injury (Months) and Age at testing (Months).*

| | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | Participants | Statistic | df | Sig. | Statistic | df | Sig. |
| Age at injury (Months) | 0 | - | 18 | . | . | 18 | . |
| | 1 | .091 | 18 | .200* | .977 | 18 | .916 |
| Time Since injury(Months) | 0 | - | 18 | . | . | 18 | . |
| | 1 | .207 | 18 | .041 | .853 | 18 | .009 |
| Age at testing Mi-TBI and Controls (months) | 0 | .144 | 18 | .200* | .929 | 18 | .189 |
| | 1 | .136 | 18 | .200* | .945 | 18 | .353 |

The above Shapiro Wilk test suggests that the suggested predictor variables: age at injury and age at testing have a normal distribution (Fields, 2009). A Pearson Correlation Coefficient was used to interrogate this data. However, time since injury suggests that the data seemed to not be normally distributed. This variable used a Spearman's Correlation Coefficient. Age at testing includes both the test (M-TBI) and control samples.

Table 6

*Correlation table representing the Test group (Mi-TBI) and the Control group (Control).*

| | Test statistic (sig.) | Correlation Coefficient |
|---|---|---|
| Gender | 0.13 | 0.24 |
| Age at injury | 0.024 | -0.35 |
| Time Since injury | 0.017 | -0.37 |
| Age at testing | 0.25 | -0.20 |

Table 7

*Regression table representing the Test group (Mi-TBI)*

| | Test statistic (sig.) | Regression Unstandardized Coefficients | Regression Standardized Coefficient |
|---|---|---|---|
| Gender | 0.024 | A=-0.126<br>B=89.67 | -0.35 |
| Age at testing | 0.017 | A=0.187 | -0.37 |

B=89.68

Table 8

*Regression and Correlation table of gender and age at testing for the test group (Mi-TBI) and control group (Neurotypical)*

| | Test statistic (sig.) | Regression Unstandardized Coefficients | Regression Standardized Coefficient |
|---|---|---|---|
| Gender | 0.13 | A=82.22<br>B=2.45 | 0.24 |
| Age at testing | 0.25 | A=-0.123<br>B=99.59 | -0.20 |

A linear regression was computed to determine whether a relationship exists between two variables (Field, 2009). As one variable deviates from the mean, the other variable will also deviate from the mean. All the variables below (independent variable) were measured against the SP variable (dependent variable).

Table 6 displays that gender, age at testing have an insignificant, weak positive correlation to the SP. However, age at injury and time since injury had relatively weak correlation coefficients but they were significant predicting variables for a deficit in SP in participants with Mi-TBI. Age at injury had a significance level of 0.024 and time since injury had a significance level of 0.017 which is below the significance level of 0.05. The results for age

at injury and time since injury are congruent with the literature of this report. Children who have sustained a TBI may exhibit long term cognitive difficulties (Karver et al., 2012). If there is a lapse in time from the day the individual sustained a Mi-TBI to the age at testing, there is a suggested decrease in cognitive abilities over time (Karver et al., 2012). Injuries sustained at different ages may impact critical periods (Mundkur, 2005). The Kennard principal suggests that injury at an early age may not be as threatening as injury in the later years of life. The paediatric brain may be able more capable of synaptic reorganization, and neuroplasticity may influence the recovery trajectory (Su et al., 2015).

The regression coefficients suggest that every one unit increase for the predictor value; the outcome variable will increase by the unstandardized coefficient (B). If the coefficient is negative, for every one-unit increase in the predictor, the unstandardized coefficient will decrease. Also, if the standardized beta is negative, then as the predictor increases, the standard deviation beta coefficient will decrease. If the standard beta coefficient is positive, the predictor will increase as well as the standard deviation beta coefficient (Field, 2009). The regression model is Y=A+bX. A is the constant and b is the beta coefficient/ slope of the graph. The line of best fit is a straight line which is drawn best represents the data in a scatter plot. The line may represent the general trend between the variables. The figures below represent the line of best fit for the variables in table 6.

Figure 4.

*Regression Residual of Age at Injury*

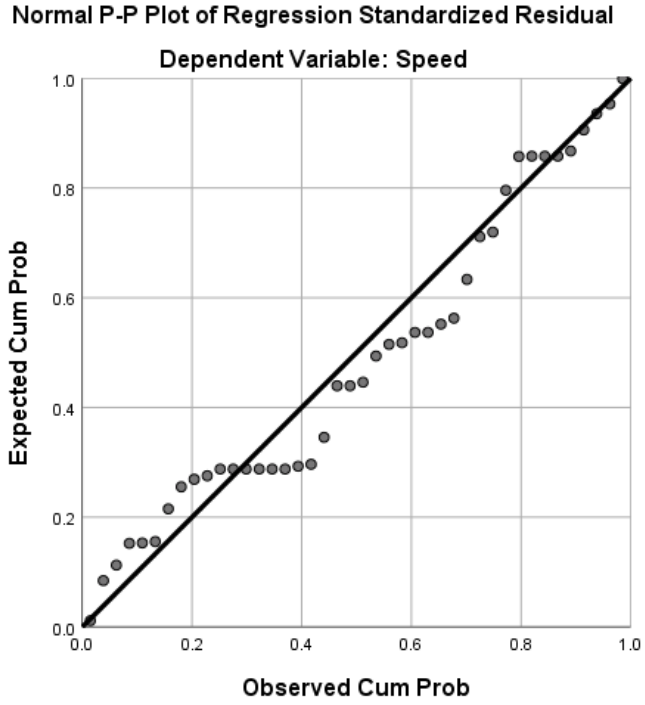



Figure 5.

*Regression Residual of Time Since Injury*

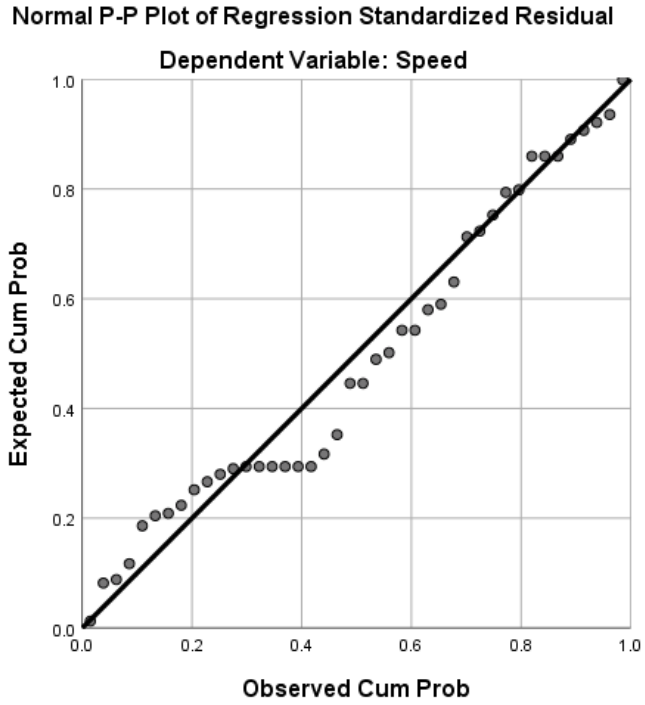


Figure 6.

*Regression Residual of age at testing*

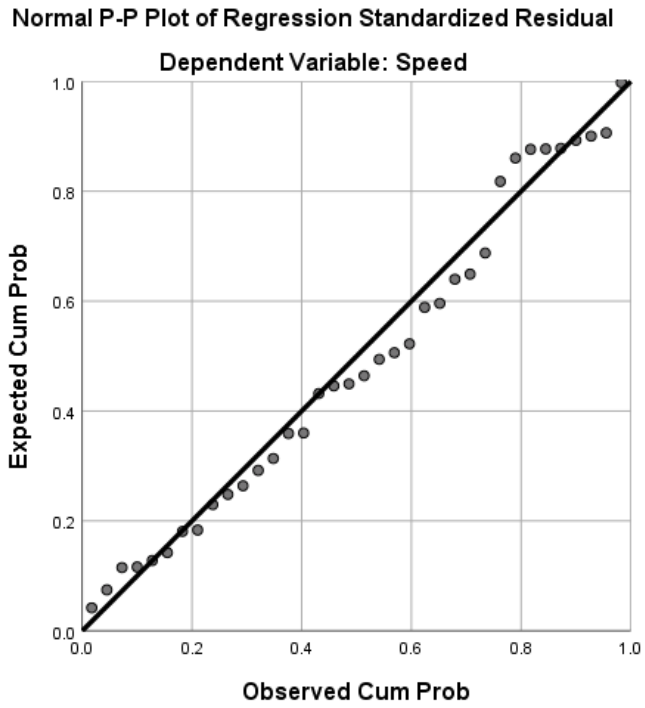



*Figure 6. Regression Residual of age at testing*

### 4.4 Mi-TBI and the speed of processing (SP)

Paediatric Mi-TBI is a categorical variable. A simple linear regression and correlation were conducted to determine whether Mi-TBI or not is a predictor of the SP. Regression describes how the independent (test group and the control group) variable is numerically related to the dependent variable) (SP) (Fields, 2009). Correlation is used to represent the linear relationship between two variables (Fields, 2009). The model for the test group shows that

the correlation is r =0.338 and r2 =0.114. The coefficients table reveals that beta= -0.338 and t(40) = -2.270 with a p=0.029. The result is significant. This suggests that Mi-TBI may predict the SP. The p-value was significant as it is below 0.05 level of significance. This may be difficult to determine as there may be gaps in knowledge regarding the effects of preexisting conditions which may a TBI (Institute of Medicine, 2011). The correlation coefficient is between paediatric Mi-TBI, and SP is r=0.338, which suggests a positive medium correlation.

# Chapter 5

## Discussion

The primary aim of this research was to explore the effects of paediatric Mi-TBI on the SP of South African Children within a polyglot society, at Chris Hani Baragwanath Academic Hospital. The test group and control group were either bilingual or multilingual. This study was initiated by analyzing the differences between mean scores for the paediatric Mi-TBI group and the Neurotypical group to assess the relative PSI for these groups. An independent t-test was conducted that assessed the test group and the control group at a one-tail distribution, and this revealed that the control group had a higher score in comparison to the test group. An independent t-test with a two-tailed distribution was conducted between the independent means of the two groups for the Coding and Symbol Search subtest.

The results from the current study's test group displayed lower PSI scores than the Neurotypical group. This indicated that the test group had an overall slower SP than the Neurotypical group. The GM states two specific frameworks which suggest that SP is limited with age differences and SP increases with age. The test group SP development may have been interrupted by the Mi-TBI. The population of this current study age range between 6-10 years old. It can be suggested that the developmental cascade has occurred and SP has increased within each age group. The GM framework will also apply as the older a child becomes the performance will be increasingly better than the previous age. The evidence of this study suggests that the increase of SP may have not occurred for the test group due to the Mi-TBI. Therefore, it can be suggested that a Mi-TBI may act as a precursor of a deficit in SP.

Kail (2000) hypothesised that SP increased during the periods of childhood and adolescence. The development of SP, in turn, is linked to overall neural development and functioning. SP

can be limited by age differences, which is referred to as the Global Hypothesis. The Global Mechanism (GM) may limit the speed at which children and adolescents process information (Kail, 2000). One approach to measuring for basic parameters of mental functioning may correspond with the global mechanism (Kail, 2000). An example of this is that cognitive theories may depict the mind as a network of many nodes with interconnecting links. Neural networks are thought to be analogous to brain processes and neural networks. As stated in the literature review on page 23, there are typically limited nodes in the neural network which can be active at any time. In this framework, SP would correspond to the rate of propagation from one node to another (Kail, 2000). The development of SP should cascade between the ages of 7-9 years old and 12-13 years old as important neural changes may occur during this period of development. If this development is interrupted, this may impact important development of neural functions and cognitive abilities such as SP (Kail, 2000).

During childhood and adolescence, it is suggested that there are dramatic changes which impact SP. SP acts as a parameter, if cognitive functioning which may change as development occurs (Rose, Feldman & Jankowski, 2002). Kail (2000) and Rose and Colleagues (2002) suggest that SP, memory and reasoning should typically improve with age and these functions may be interdependent on one another. Both Kail (2000) and Rose and colleagues (2002) discuss SP as a central limiting factor which increases with age, rather than simply to the acquisition of distinct task specific skills. The study conducted by Kail (2000) displayed that there were age related increases in SP which were associated with higher scores on a fluid intelligence test. Children who had processed information rapidly were able to use working memory more effectively, which enabled them to solve problems on fluid intelligence tests accurately (Kail, 2000). The Symbol Search and Coding subtests of the WISC IV measures fluid intelligence (Weschler, 2004).

### 5.1 Mi-TBI and the WISC IV

The WISC IV has a four composite indices and these are: The Verbal Comprehension Index, the Perceptual Reasoning Index, The Working Memory Index and the Processing Speed Index. The four factor scoring structure, within which the subtests measure multiple abilities may show possible cross-loadings in factor analysis. A factor analysis was conducted for the core subtests of the WISC IV for all ages and by age group. The primary loading of each subtest fell on its corresponding factor. The factor loading of all ages for Coding on PSI was 0.68 and Symbol Search on the PSI was 0.65 (Weschler, 2004). For ages 6-7, the factor loading for Coding on PSI is 0.58 and Symbol Search on PSI is 0.45 (Weschler, 2004). Including ages 8-10, the factor loading for Coding PSI was 0.66 and Symbol Search on PSI was 0.59. For ages 11-13, the factor loading for Coding on the PSI was 0.69 and Symbol Search is 0.68 (Weschler, 2004). This means that Coding subtest loads heavier onto the PSI than the Symbol Search subtest.

A cross-validation procedure replicated the factor loadings. This was tested using a sample of 440 children (40 children from 11 age groups) from the original standardization sample of 2200 children. Factor scores were calculated from these 440 children in a cross-validation sample (Weschler, 2004). Each child had seven-factor scores for each of the four WISC IV factors. These factor scores are then inter-correlated for each child in the cross-validation sample. The median (mean) correlations among the target factor score for PSI was 0.99. This result demonstrates the stability of the PSI scores across samples and supports a factor structure (Weschler, 2004). Coding seems to load more than Symbol Search. This was relevant to this study as Coding and Symbol Search are both characteristics of SP. Coding may not have had a significant result in the independent t-test. On the other hand the mean scores of the test group and control group were different. This meant that the result for Coding is still an indicator for SP between the test group and control. The control group has a

higher mean score for Coding than the test group, which suggests that the control group completed the Coding faster and with more accuracy.

The comparison between the test group and the control group demonstrated comparative differences in SP. The mean level of performance was seen in Table 4; the results between the control group and the test group suggested a difference in performance in Coding, Symbol Search and PSI. The control group had a higher mean score in Coding, Symbol Search and PSI. This suggested that the control group had scored a higher overall result for the PSI and its subtests. It can be inferred that the SP of the test group was slower than the control group. Although the Mi-TBI sample performed at an inferior level to the comparative sample, only the Symbol Search subtest and PSI suggested a statistically significant difference between the test and control group. Coding and Symbol Search tap into different abilities which contribute to SP. The result from Symbol Search test displayed that the test group were slower than the control group in rapid differentiation of abstract symbols. Symbol Search may have had less emphasis on the motor output of the participant, but it did require rapid differentiation of abstract symbols and possibly rapid eye movements (Raiford et al., 2016). Difficulty in visual scanning and tracking may leave the participant less time and mental energy for the complex task of understanding material that is new (Holdnack, et al., 2013). The overall PSI score included the scored from both the Coding and Symbol Search subtests. The statistically significant result indicates that the overall PSI score of the test group was lower than the control group, suggesting that the test group was slower in comparison to the control group. According to Jacobson and Colleagues (2011) children with Mi-TBI have shown to have slower SP. The most common reported cognitive dysfunction reported is a slower SP. As previously discussed in the literature review, Gorman et al (2015) concluded in their study that Mi-TBI disrupts core cognitive abilities such as SP. The current study had similar results to both studies as the test group displayed an overall slower PSI than

the comparison group. The outcome of this test may have been influenced by the fine motor skills of the individual such as handwriting and hand-eye coordination of the participant. Further research may be required on the impact of fine motor controls and viso-spatial differentiation.

The participants in this study had an average of 2. 9 years between the time they sustained a Mi-TBI and the time of testing. They have performed worse than the control group for SP. The test group performed worse than the control group for SP, and the finding in this study was in line with the research conducted by Gorman and colleagues (2016). Their study compared the performance on the Coding task of 37 children who had suffered Mi-TBI and 40 who had not suffered a Mi-TBI. Furthermore, and once again, their study is in agreement with the present finding as they concluded that this reduced SP was not mediated by gender. Also, the group differences were primarily seen in the Coding subtest. SP may mediate the effects of Mi-TBI on working memory. The findings of the study conducted by Gorman and colleagues (2016) showed that children with TBI performed poorly on SP in comparison to the control group, which is similar to the findings from the current study.

In comparison, the test group of the current study performed poorly on Coding, and this is shown by comparing the averages for the Coding subtest between the test group and the control group. The mean Coding result of the test group was CO =7.28, and the test group mean for Coding was HI =6.65. The test group average for Coding is lower than the control group average for Coding, and the overall score for the PSI was significant between the two groups. Gender and age at testing did not differentially make any impact on the results from the current study.

The results from the current study show that the control group performed better on both subtests than the test group on Coding, Symbol Search and the overall PSI. Sweet (2011)

suggests that the Symbol Search was designed to assess information of SP and Visual perception. Symbol Search was not limited to handwriting or the ability to draw the symbols as participants are simply required to tick yes or no with a pencil (Sweet, 2011). It can be suggested that the higher the score for symbol search, the better their SP and Visual Perception. Higher scores on symbol search may require more rapid and accurate processing of non-verbal information (Sweet, 2011). This was seen in the factor analysis in the test manual and the above paragraph where factor loading of Coding and Symbol search was discussed. This may explain the reason for the control group performing better than the test group for the overall performance on the PSI. Participants with Mi-TBI were slower than the control group. However, their accuracy when completing the codes and symbols was not impacted. The findings of the current study was mirrored in the study by Struss et al., (1985) which found that children who experienced Mi-TBI showed slower SP when tested, however they observed no reduction on the accuracy of performance.

Interestingly, Table 4 indicates that gender and age at testing (months), have non-significant values. On the other hand age at injury (months) and time since Injury (months) have significant values and this supports the literature as these are suggested predictive variables (Rabinowitz et al., 2015; Helstrom et al., 2017; Olsson, Lloyd, Lebrocque, Mckinlay, Anderson, & Kenardy, 2013) This may have occurred due to the limited sample size (Laskowitz & Grant, 2016). This may require future research.

### 5.2 Correlation and Regression of the SP

The results from this study show that gender and age at testing are non-significant as per their test statistic (Fields, 2009). Their scores for correlation and regression are weak correlation scores as predictors for the PSI. This could be due to the small sample size as correlation may be sensitive to a type 1 error. According to Fields (2009) a study with a small sample size

may have a weak statistical power to detect any real difference or significant hypothesis between the test and control groups. A small sample size may increase the bias of data (Fields, 2009). This was contradictory as the literature suggests that these variables predict the SP (Brickler, Morton, Hazy & Theus, 2018). According to Bickler and Colleagues (2018), Age at Injury is an essential contributor to IQ post-injury. On the other hand, Age at Injury and time since injury have significant values. These may act as significant predicting values for deficits in SP for children with Mi-TBI.

The average PSI percentile rank score for the test group is 80.35, which indicates a low average score. The means the average scaled score is higher than approximately 9 out of 100 on tasks which require quick and accurate judgments on different codes and symbols. The average PSI percentile rank score for the control group is 88.15, and this score is within the average range. The control population had a scaled scored higher than 27 out of 100. Both groups fell below the 50th percentile. The control group had a higher percentile than the test group. The difference in index scores seems to be much more pertinent as children are performing between low average to average on the PSI subtests.

## Limitations

A limitation of this study was the small sample size. Irrespective of the small sample size, the sample was sufficient in order to assume normality according to the Central Limit Theorem, as well as the power calculation. A comparison group for this study was used to ensure the participant cultural background, access to amenities and education was similar as may impact their test scores and the administrator's interpretation of the test. There might be pre-existing neurological problems with a patient before the study, which resulted in the accident. There might be a pre-existing deficit inability in this area that may have contributed to the event responsible for the TBI. It may be a possibility that as a result of already having a reduced SP

resulted in the Mi-TBI. They may have processed the environment too slowly to avoid danger. In an article written by Walshe and Colleagues (2019) found that working memory may be essential to hazard awareness. SP may be related to the working memory cognitive ability, as those who are able to process information quickly may not hold as much information in their working memory. According to the study, SP may be related to the rate of reading, the faster the individual was able to read, and increases in memory span (Nicolson, 1981; Towse, Hitch, Horton & Harvey, 2010). This is may be limiting as slower SP which is undetected may lead to slower detection of environmental dangers which can be suggested to lead to a TBI. It is suggested that future research would need to be conducted into pre-accident scholastic performance. In addition to this, the researcher used archival data for this study. Hence, data had already been collected by the research team that formed part of the umbrella THINK study project. Some of the Coding and Symbol Search tests were not fully completed and therefore, could not be used. This added to the limitations of the small data size.

## Recommendations

The findings from this study can suggest that patients with a Mi-TBI will need to follow up with medical professionals and hospital staff. There seems to be a difference between the test group and the neurotypical group for SP. The Mi-TBI group had performed poorly overall compared to the control group. These individuals may require follow up sessions longitudinally with their respective medical professionals in order to assess the shortfalls in their development. Medical professionals may require further guidence and specialized training around sensitive tools used to identify Mi-TBI as a whole in order to better assist their patients for future follow up consultations. Other professionals may be required for remedial assessments for screening purposes as there may be underlying preconditions which

may have preceded the paediatric Mi-TBI such as investigating the pre-accident scholastic performance.

It would be advisable that medical professionals refer patients with paediatric Mi-TBI with a slower SP to the most appropriate treatment as early intervention may assist recovery (Prince & Bruhns, 2017).

Another recommendation would be for future research to be done with a larger sample size as well as in more hospitals around South Africa. This would enable more extensive research, and include more communities to investigate similarities and/or differences in comparison to this study.

## Conclusion

Mi-TBI may lead to long term consequences or be indicative of the pre-existing condition. Nevertheless, either way, this might prove to be sufficient reason to follow-up with psychometric screening. This study aimed to explore the effects of paediatric Mi-TBI on the SP on South African children in polyglot societies, at Chris Hani Baragwanath Academic Hospital. It focused on exploring the differences in SP in children with a paediatric Mi-TBI and those who do not have a paediatric Mi-TBI. The test group was compared to the control group, and the results from the study revealed that there was a significant difference between both the test group and the neurotypical group on SP, with the control group performing better than the test group. The mean scores indicate that the test group performed weaker than the control group in the Coding and Symbol Search subtests and the overall SP. Paediatric Mi-TBI may occur due to a wide variety of factors and given the hypothesis of pre-existing condition maybe relate to long term cognitive implications such as the impaired SP. By administering the Coding and Symbol Search the SP was assessed in each of the participants.

A simple regression and correlation were performed at gender and age at testing were non-significant. This may have occurred due to a small sample size. However age of injury and time of injury were significant.

There are other factors which may contribute to Mi-TBI and the possible lack of treatment. According to an audit done on Chris Hani Baragwanath Academic Hospital by Landman, Mouton, & Nevhutalu (2001), 72% of patients from Chris Hani Baragwanath Academic Hospital indicated they had communication difficulties with doctors as several doctors spoke primarily just English. However, 62% of patients were able to communicate effectively with multilingual nurses (Landman, Mouton, & Nevhutalu, 2001). More research may need to be conducted on how this may impact paediatric Mi-TBI patients and relevant health care professionals.

This study shows that paediatric Mi-TBI may impact the cognitive ability of SP as the sample from this study is at least 1-year post-injury. Compromised SP may impact executive functioning and other spheres of cognition. The above results may require replication and a larger body of knowledge to contribute to this area specifically. This must be completed in order to answer any unanswered questions highlighted in this study, correct research and controversies. The current research acknowledges shortfalls in its own attempt to contribute to research although the present study is not without its limitations, it highlights areas for further research.

## Chapter 6

## References

The following references have adhered to APA 6th edition:


Adubasim, I. (2018). Improving Working Memory and Processing Speed of Students with Dyslexia in Nigeria. *Journal of Education & Enterprise, 5*(2), pg. 103-123.

Anderson, V., Smith, M., S., & Wood, A. (2011). Do children really recover better? Neurobehavioural plasticity after early Brain insult. *Journal of Neurology 134*, 2197-2221.

Amnuts, K., Schleicher, A., & Zilles, K. (2007). Cytoarchitecture of the cerebral cortex-More than localization. *NeuroImage 37*, pg. 1061-1065.

Amnuts, K. & Zilles, K. (2012). Architecture and organizational principles of Broca's region. *Trends in Cognitive Sciences, 16*(8), pg. 418-426.

Amnuts, K. & Zilles, K. (2015). Architectonic Mapping of the Human Brain beyond Broadman. *Neuron 88 (6*), 1086-1107. Doi: 10.1016/j.neuron.2015.12.001.

Andrade, F. A., Paiva, S. W., Soares, S. M., Amorim, D. L. R., Tavares, M. W., Teixeria. (2011). Classification and management of Mild Head trauma. *International Journal of General Medicine 4*, pg. 175-179. Doi: 10.2147/IJGM.S13464.

Arambula, S. E., Reinl, E. L., Demerdash, N. E., Mccarthy, M. M., & Robertson, C. L. (2019). Sex differences in pediatric Traumatic Brain Injury. *Experimental Neurology, 317*, 168–179. Doi: 10.1016/j.expneurol.2019.02.016

Babikian, T., Satz, P., Zaucha, K., Light, R., Lewis, R.S., & Asarnow, R.F. (2011). The UCLA Longitudinal Study of Neurocognitive Outcomes Following Mild Pediatric Traumatic Brain Injury. *Journal of the International Neuropsychological Society,*17, pg. 886-9.

Baron, I. S., (2005) Test review: Wechsler intelligence scale for children-fourth edition (WISC-IV). Child Neuropsychology, 11(5), pg. 471-475. https://doi.org/ 10.1080/09297040590951587.Baudouin, A., Clarys, D., Vanneste, A., & Isingrini, M. (2009) Executive functioning and Processing Speed in age-related differences in memory: contribution of coding task. *Brain and cognition, 71(3)*, pg. 240-245.

Bennet, L., Van Den Heuij, L., M Dean, J., Drury, P., Wassink, G., & Jan Gunn, A. (2013). Neural plasticity and the Kennard principle: does it work for the preterm brain? *Clinical and Experimental Pharmacology and Physiology*, *40*(11), 774–784. https://doi.org/10.1111/1440-1681.12135

Berger, M. S., Pitts, L. H., Lovely, M., Edwards, M. S. B., & Bartkowski, H. M. (1985). Outcome from severe Head Injury in children and adolescents. *Journal of Neurosurgery*, *62*(2), 194–199. Doi: 10.3171/jns.1985.62.2.0194

Bernstein, D. M. (2002). Information processing difficulty long after self-reported concussion. *Journal of the International Neuropsychological Society*, *8*(5), 673–682. https://doi.org/10.1017/s1355617702801400

Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition, 12*(1), 3–11. https://doi.org/10.1017/s1366728908003477

Bijur, P. E., Haslum, M., & Golding, J. (1990). Cognitive and behavioural sequelae of Mild Head Injury in children. *Paediatrics, 86(3*), pg. 337-344.

Birken, C. S., & MacArthur, C. (2004). Socioeconomic status and Injury risk in children. Journal of Paediatrics Child Health, 9(5), pg. 323-325.

Bowling, A. & Mackenzie, B. (1996). The relationship between the Speed of information Processing and cognitive ability. *Personality and Individual Differences, 20(6)*, pg. 775-800.

Brickler, T., Morton, P., Hazy, A., & Theus, M. H. (2018). Age-Dependent Responses Following Traumatic Brain Injury. *Traumatic Brain Injury - Pathobiology, Advanced Diagnostics and Acute Management*. doi: 10.5772/intechopen.71344

Brunnert, K. A., Naglieri, A. K., & Hardy-Braz, S. T. (2009). Essentials of WNV Assessment, John Wiley & Son Inc. Hoboken, New Jersey. ISBN 979-0-470-28467-4

Cassidy, J. D., Carroll, L., Peloso, P., Borg, J., Von Holst, H., Holm, L, & Coronado, V. 1 (2004). Incidence, risk factors and prevention of Mild Traumatic Brain Injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *Journal of rehabilitation medicine*, 36, 28-60

Chen, S. A., Kareken, D. A., Fastenau, P. S., Trexler, L. E., & Hutchins, G. D. (2003). A study of persistent post-concussion symptoms in Mild Head trauma using positron emission tomography. *Journal of Neurology, Neurosurgery & Psychiatry, 74*(3), 326-332.

Chung, P., & Khan, F. (2015). Mi-TBI presenting with delayed intracranial haemorrhage in warfarin therapy: a case report. *Journal of Medical Case Reports, 9*(173). Doi: 10.1186/s13256-015-0652-2

Cohen, J. (2009). Interrater Reliability and Predictive Validity of the FOUR Score Coma Scale in Paediatric Population. *Journal of Neuroscience Nursing, 41(5),* pg. 261-267.

Collins, N. C., Molcho, M., Carney, P., Mcevoy, L., Geoghegan, L., Phillips, J. P., & Nicholson, A. J. (2012). Are boys and girls that different? An analysis of Traumatic Brain Injury in children. *Emergency Medicine Journal*, *30*(8), 675–678. Doi: 10.1136/emermed-2011-200496

Costa, A., & Gallés, N. (2014). How does the bilingual experience sculpt the brain? *Nature Reviews Neuroscience*, *15*(5), 336–345. doi: 10.1038/nrn3709

Diamond, A. (2013). Executive Functions. *Annual review of psychology, 64,* pg. 135-168.

Dennis, M. Spieglor, B. J., Juranek, J. J., Bigler, D. E., Snead, C. O. & Fletcher, J. M. (2003). Age, Plasticity, and Homeostasis In Childhood Brain Disorders. *Neuroscience Biobehavioural Review, 37(1002*), pg. 1-32.

Dennis, M. (2010). Margaret Kennard (1899–1975): Not a 'Principle' of brain plasticity but a founding mother of developmental neuropsychology. *Cortex*, *46*(8), 1043–1059. https://doi.org/10.1016/j.cortex.2009.10.008

Dong, P., & Cremer, O. (2011). Limitations of the use of the Glasgow Coma Scale in intensive care patients with non-neurological primary disease: a search for alternatives. *Critical Care*, *15*(Suppl 1). Doi: 10.1186/cc9926.

Diringer, M. N., Zazulia, A. R., & Powers, W. J. (2011). Does Ischemia Contribute to Energy Failure in Severe TBI? *Translational Stroke Research*, *2*(4), 517–523. https://doi.org/10.1007/s12975-011-0119-8

Ebaid, D., Crewther, S. G., Maccalman, K., Brown, A., & Crewther, D. P. (2017). Cognitive Processing Speed across the Lifespan: Beyond the Influence of Motor Speed. *Frontiers in Aging Neuroscience, 9*. Doi: 10.3389/fnagi.2017.00062.

Eckert, M. A., Keren, N. I., Roberts, D. R., Calhoun, V. D., & Harris, K. C. (2010). Age-related changes in Processing Speed: Unique contributions of cerebellar and prefrontal cortex. *Frontiers in Human Neuroscience, 4*(8), pg.1-1. Doi 10.3389/neuro.09.010.2010

Emery, C. A., Barlow, K. M., Brooks, B. L., Max, J. E., Villavicencio-Requis, A., Gnanakumar,V., &Yeates, K. O. (2016). A systematic review of psychiatric, psychological, and behavioural outcomes following Mi-TBIin children and adolescents. *The Canadian Journal of Psychiatry*, 61(5), 259-69.

Fabbro, F. (2001). The bilingual Brain: cerebral representation of languages. *Brain and Language 79(2*), pg. 211-22.

Ferrell, A. C. (2013). Management of the paediatric patient with acute Head trauma. *Paediatrics & Child Health, 18*(5), pg. 253-258.

Field, A. P. (2009). *Discovering statistics using IBM SPSS statistics: And sex and drugs and rock 'n' roll*. Los Angeles: Sage.

Findley, L., & Ogbu, L. (2011, November 01). South Africa after Apartheid: From Township to Town. Retrieved August 28, 2020, from https://placesjournal.org/article/south-africa-from-township-to-town/

Foxcroft, C., & Roodt, G. (2013) *Introduction to Psychological Assessment in the South African Context*. Oxford University Press.

Gomez, R., Alasdair, V., & Watson, S. (2016). Structure of the Wechsler Intelligence Scale for Children- Fourth Edition in a Group of Children ADHD. *Frontiers in Pschol, 7(*737). Doi:10.3389/fpsyg.2016.00737

Gorman, S., Barnes, M. A., Swank, P. R., Prasad, M., Cox, C. S., & Ewing-Cobbs, L. (2016). Does Processing Speed mediate the effect of pediatric Traumatic Brain Injury on working memory? *Neuropsychology*, *30*(3), 263–273. Doi: 10.1037/neu0000214

Grant, A., & Dennis, N. (2016). Increased processing speed in young adult bilinguals: evidence from source memory judgments. *Bilingualism: Language and Cognition*, *20*(2), 327–336. doi: 10.1017/s1366728916000729

Grieve, S. M., Williams, L. M., Paul, R. H., Clark, C. R., & Gordon, E. (2007). Cognitive aging, executive function, and fractional anisotropy: a diffusion tensor MR imaging study. *AJNR Am. J. Neuroradiol, 28* (2), pg. 226–235.

Hale, S., Fry, A. F., & Jessie, K. A. (1993). Effects of practice on Speed of Processing in children and adults: Age sensitivity and age invariance. *Developmental psychology, 29(5*), pg. 880-892.

Hamilton, N.A., & Keller, M.S. (2010). Mild Traumatic Head Injury in participants. *Seminars in Paediatric Surgery*, 19, pg. 271-8.

Hammell, L. C. & Henning, J. D. (2009). Prehospital management of severe Traumatic Brain Injury. BMJ 388(1683). Doi: 10.1136/bmj.b1683

Hayakawa, S., & Marian, V. (2019). Consequences of multilingualism for neural architecture. *Behavioral and Brain Functions, 15*(1). Doi: 10.1186/s12993-019- 0157-z

Head, J. (1993). Definition of Mild Traumatic Head Injury. *J Head Trauma Rehabil, 8(3)*, pg. 86-7.

Hellstrøm, T., Kaufmann, T., Andelic, N., Soberg, H. L., Sigurdardottir, S., Helseth, E., Westlye, L. T. (2017). Predicting Outcome 12 Months after Mild Traumatic Brain Injury in Patients Admitted to a Neurosurgery Service. *Frontiers in Neurology*, *8*. Doi: 10.3389/fneur.2017.00125

Hessen, E., Nestvold, K., & Anderson, V. (2007). Neuropsychological function 23 years after Mild Traumatic Brain Injury: A comparison of outcome after paediatric and adult Head injuries. *Brain Injury*, *21*(9), 963–979. Doi: 10.1080/02699050701528454

Higby, E. Kim, J & Obler, L. (2013). Multilingualism and the Brain. *Annual Review of Applied Linguistics (33*), pg. 68-101. Doi: 10.1017/S0267190513000081

Hoffman, N. (2000). Novel Learning Abilities After Traumatic Head Injury in Children. *Archives of Clinical Neuropsychology*, *15*(1), 47–58. doi: 10.1016/s0887-6177(98)00156-5

Holdnack, J. A., Drozdick, L., Weiss, L. G., & Iverson, G. L. (2013). *WAIS-IV, WMS-IV, and ACS: Advanced Clinical Interpretation (ISSN)* (1st ed.). Texas, USA: Academic Press.

Holdnack, J. A., Prifitera, A., Weiss, L. G., & Saklofske D. H. (2015). *WISC-V and the Personalized Assessment Approach*. Elsevier: Academic Press.

Holdnack, J. A., Prifitera, A., Weiss, L. G., & Saklofske, D. H. (2019). WISC-V and the Personalized Assessment Approach. *Wisc-V,* 447–488. Doi: 10.1016/b978-0-12-815744-2.00013-6

Institute of Medicine. 2011. *Cognitive Rehabilitation Therapy for Traumatic Brain Injury: Evaluating the Evidence*. Washington, DC: The National Academies Press. https://doi.org/10.17226/13220.

Iverson, G. L., Gaetz, M., Lovell, M.R., & Collins, M.W. (2014). Cumulative effects of concussion in amateur athletes. *Brain Injury*, *18*(5), 433-443.

Jakobsen, J. C., Gluud, C., Wetterslev, J., & Winkel, P. (2017). When and how should multiple imputation be used for handling missing data in randomised clinical trials – a practical guide with flowcharts. *BMC Medical Research Methodology*, *17*(1). Doi: 10.1186/s12874-017-0442-1

Jacobson, L. A., Ryan, M., Martin, R. B., Ewen, J., Mostofsky, S. H., Denckla, M. B., & Mahone, E. M. (2011). Working memory influences processing speed and reading fluency in ADHD. *Child Neuropsychology*, *17*(3), 209–224. https://doi.org/10.1080/09297049.2010.532204

Kail, R. (1992). Processing Speed, Speed rate and memory. Developmental Psychology, 28, 899-904.

Kail, R. (2000). Speed of information Processing: Developmental change and links to intelligence. *Journal of School Psychology, 38*(1), pg. 51-61.

Kang, H. (2013). The prevention and handling of the missing data. *Korean Journal of Anesthesiology, 64*(5), 402. https://doi.org/10.4097/kjae.2013.64.5.402

Karver, C. L., Wade, S. L., Cassedy, A. G., Taylor, H. O., Stancin, T. C., Yeates, K. undefined, & Walz, N. undefined. (2012). Age at injury and long-term behavior problems after traumatic brain injury in young children. *Rehabilitation Psychology*, *57*(3), 256–265. doi: 10.1037/a0029522

Kaur, P., & Sharma, S. (2018). Recent Advances in Pathophysiology of Traumatic Brain Injury. *Current Neuropharmacology*, *16*(8), 1224–1238. Doi: 10.2174/1570159x15666170613083606

Kay, T., Newman, B., Cavallo, M., Ezrachi, O., & Resnick, M. (1992). Toward a neuropsychological model of functional disability after Mild Traumatic Brain Injury. *Neuropsychology*, *6*(4), 371–384. Doi: 10.1037/0894-4105.6.4.371

King, N. (2011). Mild Head Injury: Neuropathology, sequelae, measurement and recovery. *British Journal of Clinical Psychology*, *36*(2), pg. 161-184.

Kong, A. P.-H., Abutalebi, J., Lam, K. S.-Y., & Weekes, B. (2014). Executive and Language Control in the Multilingual Brain. *Behavioural Neurology*, *2014*, 1–7. Doi: 10.1155/2014/527951

Konrad, C., Geburek, A. J., Rist, F., Blumenroth, H., Fischer, B., Husstedt, I., & Lohmann, H. (2011). Long-term cognitive and emotional consequences of Mild Traumatic Brain Injury. *Psychological medicine*, *41*(6), pg. 1197-1211.

Laher, S., Cockcroft, K., Amod, Z., Bain, K., & Bhabha, F. (2013). *Psychological Assessment in South Africa: Research and applications*. Wits University Press.

Lallier, M., Bouchard, S., St-Vil, D., Dupont, J., & Tucci, M. (1999). Falls from heights among children: A retrospective review. *Journal of Pediatric Surgery, 34*(7), 1060–1063. Doi: 10.1016/s0022-3468(99)90564-x

Landman, W. A., Mouton, J., & Nevhutalu, K. H. (2001). *Chris Hani Baragwanath Hospital Audit.* Unpublished Audit Report. Ethics Institute of South Africa

Laskowski, R., Creed, L., & Raghupathi, R. (2015). Pathophysiology of Mild TBI: Implications for Altered Signalling Pathways. *Brain Neurotrauma Frontiers in Neuroengineering Series*, 35-42. Doi: 10.1201/b18126-6

Laskowitz, D., & Grant, G. (2016). *Translational research in Traumatic Brain Injury*. Boca Raton: CRC Press.

Lack, V. (2016). *Examining neurocognitive psychological and psychiatric sequelae following Mild Traumatic Brain Injury: A potentially significant impact in a Low socio-economic population*. Unpublished doctoral dissertation. The University of Witwatersrand. Johannesburg.

Levi, H.S., Eisenberg, H. M., & Benton, A. L. (1989). *Mild Head Injury*. New York: Oxford University Press.

Levin, K. (2004). Paediatric traumatic brain injury in South Africa: some thoughts and considerations. *Disability and Rehabilitation, 26*(5), 306–314. https://doi.org/10.1080/0963828032000174089

Li, P., Legault, J., & Litcofsky, K. A. (2014). Neuroplasticity as a function of second language learning: Anatomical changes in the human brain. *Cortex, 58*, 301–324. https://doi.org/10.1016/j.cortex.2014.05.001

Lindley, R. H., Smith, W. R., & Thomas, T. J. (1988). The relationship between Speed of information Processing as measured by timed paper-and-pencil tests and psychometric intelligence. *Intelligence, 12*(1), 17–25. Doi: 10.1016/0160-2896(88)90020-7

Lindsey, H., & Voelbel, G. (2014). Effects of Neuroplasticity-based Auditory ProcessingSpeed Training in Adults with Traumatic Brain Injury. Unpublished doctoral dissertation. The University of New York. New York.

Macciocchi, S. N., Barth, T. J., Alves, W., Rimel, R. W., & Jane, J.A. (1996). Neuropsychological functioning and recovery after Mild Head Injury in collegiate athletes. Neurosurgery, 39(3), pg.510-514.

Marrero, M.Z., Golden, C. J., &Espe-Pfeifer, P. (2002). Bilingualism, Brain Injury, and recovery: Implications for understanding the bilingual and for therapy. *Clinical Psychology Review, 22 (3*), pg.463-478.

Mccabe, D. P., Roediger, H. L., Mcdaniel, M. A., Balota, D. A., & Hambrick, D. Z. (2010). The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology*, *24*(2), 222–243. Doi: 10.1037/a0017619

McGinn, M., J., & Povlishock, J,. T. (2016). Pathophysiology of Traumatic Brain Injury. *Neurosurgery Clinics of North America, 27(4*), pg. 397-407.

Mckee, A. C., & Daneshvar, D. H. (2015). The neuropathology of traumatic brain injury. *Handbook of Clinical Neurology Traumatic Brain Injury, Part I*, 45–66. doi:10.1016/b978-0-444-52892-6.00004-0

McNeil, A. (2009). Processing Speed Impairments in Children with Arithmetic Disabilities. Unpublished masters' thesis. The University of Mount Saint Vincent University. Halifax, Nova Scotia, Canada

Mjoli, N & Fieggen, G. (2013). Minor head trauma – when does it become a major headache? *Continuing Medical Education, 31(3),* pg. 91-95

Mundkur, N. (2005). Neuroplasticity in Children. *Indian Journal of Pediatrics, 72(10*), pg. 855-857.

Naidoo D. (2013). Traumatic Brain Injury: The South African landscape. *The South African Medical Journal, 103*(9), pg.613-614. Doi: 10.7196/SAMJ.7325

News Hub. (2016). Retrieved from https://www.netcare.co.za/News-Hub/Articles/Traumatic-Head-injuries-one-of-the-leading-causes-of-disability-in-south-africa

Ngo, H.L., Inouye, K. S., Jones, N. R., Travison, G. T., Libermann, A. T., Dillon, T. S., Kuchel, A. G., Vasunilashorn, M. S., Alsop, C. D., & Marcantonio, R. E. (2017). Methodologic considerations in the design and analysis of nested case-control studies: association between cytokines and postoperative delirium. *BMC Medical Research Methodology, 17*(88), pg. 1-1.

Nicola, A. F. D., Labombarda, F., Deniselle, M. C. G., Gonzalez, S. L., Garay, L., Meyer, M., Schumacher, M. (2009). Progesterone neuroprotection in traumatic CNS injury and motoneuron degeneration. *Frontiers in Neuroendocrinology*, *30*(2), 173–187. doi: 10.1016/j.yfrne.2009.03.001

O'Jile, J., Ryan, L., Betz, B., Levy, J., Hilsabeck, R., Rhudy, J. & Gouvier, D. (2006). Information Processing following Mild Head Injury. *Archives of Clinical Neuropsychology, 21(4*), pg. 293-296.

Olsson, K. A., Lloyd, O. T., Lebrocque, R. M., Mckinlay, L., Anderson, V. A., & Kenardy, J. A. (2013). Predictors of child post-concussion symptoms at 6 and 18 months following Mild Traumatic Brain Injury. *Brain Injury*, *27*(2), 145–157. Doi: 10.3109/02699052.2012.729286

Ozen, L.J., & Fernandez, M.A, (2012). Slowing Down after a Mild Traumatic Brain Injury: A Strategy to Improve Cognitive Task Performance? Archives of Clinical Neuropsychology, 27(1), pg. 85-100. Doi: 10.1093/arclin/acr087.

Patel, L., Hochfield, T., Moodley, J., & Mutwali, R. (2012). *The gender dynamics and impact of the child support grant in Doornkop, Soweto*. Johannesburg: University of Johannesburg.

Pekna, M. & Pekny, M. (2012). The Neurobiology of Brain Injury. *Cerebrum, 9,* pg. 1-10.

Prasad, M. R., Swank, P. R., & Ewing-Cobbs, L. (2017). Long-term school outcomes of children and adolescents with Traumatic Brain Injury. *The Journal of Head trauma rehabilitation*, *32*(1), E24.

Prince, C., & Bruhns, M. (2017). Evaluation and Treatment of Mild Traumatic Brain Injury: The Role of Neuropsychology. *Brain Sciences*, *7*(12), pg. 105. Doi: 10.3390/Brainsci7080105

Rabinowitz, A. R., Xiaoqi, L., McCauley, S. R., Wilde, A. E., Barnes, A., Hanten, G., Mendez, D., McCarthy, J. J., & Levin, H. S. (2015). Prevalence and Predictors of Poor Recovery from Mild Traumatic Brain Injury. *Journal of Neurotrauma 32(19*), pg. 1488-1496.

8.

Raiford, S., Zhang, O., Drozdick, W. L., Getz, K., Wahlstrom, D., Gabel, A., Holadnack, A. J., & Daniel, M. (2016). WISC –V Coding and Symbol Search in Digital Format Reliability, Validity, Special Group Studies, and Interpretation. Retrieved from https://images.pearsonclinical.com/images/Assets/WISC-V/Qi-Processing-Speed-Tech-Report.pdf

Rajagopalan, P., Kamer, A., & Cohen-Gadol, A. (2017). Diffuse Axonal (Shear) Injury (DAI). *Neurosurgical Atlas*. doi: 10.18791/nsatlas.v1.03.04.02.08

Rees, P. M. (2003). Contemporary issues in Mild Traumatic Brain Injury. *Archives of Physical Medicine and Rehabilitation*, 84(12), pg. 1885-94.

Richter, L. M., Mathews, S., Kagura, J., & Nonterah, E. (2018). A longitudinal perspective on violence in the lives of South African children from the Birth to Twenty Plus cohort study in Johannesburg-Soweto. *South African Medical Journal*, *108*(3), 181. Doi: 10.7196/samj.2017.v108i3.12661

Rodriguez, J. A. G., & Tomas, R. E. (2014). Office management of Mild Head Injury in children and adolescents. *Canadian Family Physician, 60(6*), pg 523–531.

Ruff, R. M., Iverson, G. L., Barth, J. T., Bush, S. S., & Broshek, D. K. (2009). Recommendations for Diagnosing a Mild Traumatic Brain Injury: A National Academy of Neuropsychology Education Paper. *Archives of Clinical Neuropsychology*, *24*(1), 3-10. doi:10.1093/arclin/acp006

Rypma, B., & Prabhakaran, V. (2009). When less is more and when more is more: The mediating roles of capacity and speed in brain-behavior efficiency. *Intelligence*, *37*(2), 207–222. https://doi.org/10.1016/j.intell.2008.12.004

Satz, P. (2001). Mild Head Injury in children and adolescents. *Current Directions in Psychological Science*, *10*(3), 106-109.

Schretlen, D. J., & Shapiro, A. M., (2003). A quantitative review of the effects of Traumatic Brain Injury on cognitive functioning. *Journal of International Review of Psychiatry*, *15*(4), pg. 341-349.

Segalowitz J.S., &, Brown, D. (1991). Mild Head Injury as a Source of Developmental Disabilities. *Journal of Learning Disabilities, 24(*9). https://doi.org/10.1177/002221949102400907.

Sheedy, J., Geffen, G., Donnelly, J., & Faux, S. (2006). Emergency Department Assessment of Mi-TBIand Prediction of Post-Concussion Symptoms at One Month Post Injury. *Journal of Clinical and Experimental Neuropsychology*, *28*(5), 755-772. doi: 10.1080/13803390591000864

Shuttleworth-Edwards, A. B. (2016). Generally representative is representative of none: commentary on the pitfalls of IQ test standardization in multicultural settings. *The Clinical Neuropsychologist*, *30*(7), 975–998. doi: 10.1080/13854046.2016.1204011

Silver, J. A, McAllister, T. W, & Yudofsky, S. C, (2011). *Textbook of Traumatic Brain Injury.* American Psychiatric Pub.

Skuy, M., Taylor, M., O'Carroll, S., Fridjhon, P., & Rosenthal, L. (2000). Performance of Black and White South African Children on the Wechsler Intelligence Scale for Children—Revised and the Kaufman Assessment Battery. *Psychological Reports*, *86*(3), 727–737. https://doi.org/10.2466/pr0.2000.86.3.727k

Stonnington, H. H., Uzzell, B. P., & Enriquez, G. (2014). *Recovery After Traumatic Brain Injury*. Lawrence Erlbaum Associates Incorporated.

Sweet L.H. (2011) Symbol Search. In: Kreutzer J.S., DeLuca J., Caplan B. (eds) Encyclopedia of Clinical Neuropsychology. Springer, New York, NY

Su, Y., Veeravagu, A., & Grant, G. (2015). Neuroplasticity after Traumatic Brain Injury. *Translational Research in Traumatic Brain Injury Frontiers in Neuroscience*, 163–178. doi: 10.1201/b18959-9

Taylor, N. (2016). Generally representative is generally representative: comment on Shuttleworth-Edwards. *The Clinical Neuropsychologist*, *30*(7), 1017–1022. doi: 10.1080/13854046.2016.1213884

Tesdale, G. & Murray, G. (2014). The Glasgow Coma Scale at 40 years: standing the test of time. *The Lancet Neurology 13(8)*, pg. 844-854.

Tunnermann, J., Peterson, A., & Scharlau, I. (2015). Does attention Speed up Processing? Decreases and increases of Processing rates in visual prior entry. *Journal of Vision, 15*(1), 1-1. Doi: 10.1167/15.3.1

Turken A., Whitfield-Gabrieli, S., Bammer, R., Baldo, JV. Dronkers, NF. & Gabrieli, JD. (2008). Cognitive Processing Speed and the structure of white matter pathways: convergent evidence from normal variation and lesion studies. *NeuroImage, 42(2)*, pg. 1032-1044.

Wechsler, D. (2004). *Wechsler Intelligence Scale For Children-Fourth UK Edition.* London, UK: Harcourt Assessment.

Werner, C., & Engelhard, K. (2007). Pathophysiology of traumatic brain injury. *British Journal of Anaesthesia*, *99*(1), 4–9. doi: 10.1093/bja/aem131

Winardi, W., Kwan, A.-L., Wang, T.-L., Su, Y. F., Yen, C. P., Pei, H. (2014). Predictors of Memory and Processing Speed Dysfunctions after Traumatic Brain Injury. *BioMed Research International*, *2014*, 1–7. Doi: 10.1155/2014/12979610.1155/2014/129796

Woumans, E., & Duyck, W. (2015). The bilingual advantage debate: Moving toward different methods for verifying its existence. *Cortex*, *73*, 356–357. https://doi.org/10.1016/j.cortex.2015.07.012

Woumans, E., Ceuleers, E., Van der Linden, L., Szmalec, A., & Duyck, W. (2015). Verbal and nonverbal cognitive control in bilinguals and interpreters. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *41*(5), 1579–1586. https://doi.org/10.1037/xlm0000107

# Chapter 7. Appendices

## 12.1 Appendix A


GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

**CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL**
**Directorate: Paediatric Surgery**
**Enquiries: Dr V. Lack**
**Tel. number: (011)933 8138; Email: veredlack@yahoo.com**

**Attention:** Human Research Ethics Committee (Medical)

**Re:** Clearance Certificate no M1611113

To whom it may concern

Update on protocol: "Examining Neurocognitive, psychosocial and psychiatric sequelae following mild TBI: a potentially significant impact in a low socio-economic population"

Project start date: 25 March 2017
End Date: 5 year prospective study; ongoing (goal is 300 test subjects and 300 controls)

Progress (March 2017- end November 2017):

- 68 head injured patients tested
- 41 "control" non-head injured patients tested
- Stats not yet run on this group's results however there is an overrepresentation of left handed children in the head-injured group, suggesting the possibility of dominance switching (this may be more evident in moderate and severely head injured children and needs to be be explored).

Challenges:

- HADS: difficult to administer to children under 8 years of age and those with poor command of English. The test concepts do not translate well into African languages due to the grading system used (terms such as sometimes, occasionally etc result in ambiguity).
- "Clocks" component of NEPSY II testing "Attention and executive functioning" has yielded erratic results, possibly dependent on school syllabus rather than inherent abilities of the children.

Amendments:

- We would like to include in our test batches all children who experienced head injuries presenting to CHBAH.
- Add the WISC V as a measure of processing speed and working memory. Requires few instructions, eastly translated and is diagram based. This test is suitable for children aged from 6 years old.
- HADS only to be used in children aged 8 years or above comfortable to communicate in English.
- Remove "clocks" component of the NEPSY II
- Add "hand dominance" as a question on the Data Collection sheet.


Thank you for your attention and consideration.
Kind regards,
Dr Vered Lack

**12.2 Appendix B**

R14/49 Dr Vered Lack et al

## HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

## CLEARANCE CERTIFICATE NO. M1611113

| | |
|---|---|
| **NAME: (Principal Investigator)** | Dr Vered Lack et al |
| **DEPARTMENT:** | General Surgery<br>Chris Hani Baragwanath Academic Hospital<br>Department of Paediatric Surgery |
| **PROJECT TITLE:** | Examining Neurocognitive, Psychosocial and Psychiatric Sequelae Following Mild TBI (Traumatic Brain Injury): A Potentially Significant Impact in a Low Socio-Economic Population |
| **DATE CONSIDERED:** | 25/11/2016 |
| **DECISION:** | Approved unconditionally |
| **CONDITIONS:** | |
| **SUPERVISOR:** | |
| **APPROVED BY:** | Professor P Cleaton-Jones, Chairperson, HREC (Medical) |
| **DATE OF APPROVAL:** | 20/02/2017 |

**This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.**

**DECLARATION OF INVESTIGATORS**

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in November and will therefore be due in the month of November each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

**PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES**

## 12.3 Appendix C

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Kajol Nair

### HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

### CLEARANCE CERTIFICATE NO. M190809

| | |
|---|---|
| **NAME: (Principal Investigator)** | Kajol Nair |
| **DEPARTMENT:** | Paediatric Surgery, Chris Hani Baragwanath Academic Hospital (CHBAH) and Neuropsychology, University of the Witwatersrand |
| **PROJECT TITLE:** | Investigating the effects of paediatric mild head injury on speed of processing of South African children, within a polyglot society, at Chris Hani Baragwanath Academic Hospital (secondary data analysis of M1611113). |
| **DATE CONSIDERED:** | 26/07/2019 |
| **DECISION:** | Approved unconditionally |
| **CONDITIONS:** | . |
| **SUPERVISOR:** | E. Schutte |
| **APPROVED BY:** | Dr CB Penny, Chairperson, HREC (Medical) |
| **DATE OF APPROVAL:** | 7/05/2020 |

**This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.**

**DECLARATION OF INVESTIGATORS**

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions.Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report.** The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **July** and will therefore be due in the month of **July** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical)

Principal Investigator Signature

7.05.2020
Date

**PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES**

**12.4 Appendix D**

Application for Permission Letter

27 February 2018

Chris Hani Baragwanath Academic Hospital: Department of Paediatric Surgery

R68 Old Potchefstroom Road

PO Bertsham

Johannesburg

2013

South Africa

| | | |
|---|---|---|
| RE: | Head of Department: | Prof Jerome Loveland |
| | Principal Investigator: | Dr Vered Lack |
| | (Larger Study): | Examining Neurocognitive, Psychosocial and Psychiatric Sequelae Following Mild TBI (Traumatic Brain Injury): A Potentially Significant Impact in a Low Socio-Economic Population |
| | Student Investigator: | Kajol Nair |
| | Title of Research Study | |
| | (Sub-study): | Investigating the Effects Paediatric Mild Traumatic Brain Injuries on Speed of Processing. |

To: Dr Vered Lack

My name is Kajol Nair, and I am a student enrolled in the Master of Arts by Coursework and Research Report in the field of Psychology programme. Enid Schutte, my supervisor, has informed me of your investigation titled: '*Examining Neurocognitive, Psychosocial and Psychiatric Sequelae Following Mild TBI (Traumatic Brain Injury): A Potentially Significant Impact in a Low Socio-Economic Population'.*

I am writing this letter to convey my interest in joining your research team. I would like to pursue a similar line of inquiry, specifically one which investigates speed of processing related sequelae following a mild traumatic Brain injury. I would like to enquire whether your research team would be able to accommodate me for the duration of my MA studies.

Yours Sincerely

Kajol Nair

## 12.4 Appendix E


### Research Data Access Permission Letter

Chris Hani Baragwanath Academic Hospital

Department of Paediatric Surgery

R68 Old Potchefstroom Road

Johannesburg

2013

South Africa

26/07/2019

RE: Principal Investigator: Dr Vered Lack

(Larger Study): Examining Neurocognitive, Psychosocial and Psychiatric Sequelae Following Mild TBI (Traumatic Brain Injury): A Potentially Significant Impact in a Low Socio-Economic Population

Student Investigator: Kajol Nair

Title of Research Study

(Sub-study) Investigating the effects of Paediatric Mild Traumatic Brain Injury on Speed of Processing of South African Children within a polyglot society, at Chris Hani Baragwanath Academic Hospital.

To: Kajol Nair

This letter is to convey that I/we have reviewed the proposed research study to be conducted by Kajol

Nair, Project Title: *Investigating the effects of Paediatric Mild Head Injury on Speed of Processing in*

*South African Children* within the parameters of Project Title: '*Examining Neurocognitive, Psychosocial and Psychiatric Sequelae Following Mild TBI (Traumatic Brain Injury): A Potentially Significant Impact in a Low Socio-Economic Population*' Protocol Number: M1611113.

Kajol Nair intends to access retrospective records containing the following patient/ clinical data:

1.1) Date of Admission

1.2) Gender

1.3) Age

1.4) Mechanism of Injury

1.5) Initial GCS.

1.6) Date of injury

1.7) Amount of time admitted to hospital

1.8) Whether CT brain scan was performed and where it was positive or negative for pathology

1.9) Handedness.

Access to utilize the following prospectively collected data (from the larger study):

2) Wechsler Intelligence Scale for Children IV (WISC IV)

- 2.1) Coding Test
  - 2.1.1) Coding Total Correct Scores
  - 2.1.2) Coding Commission Error Scores
  - 2.1.3) Coding Total Omission Error Scores
  - 2.1.4) Coding Total Inhibitory Error Scores
  - 2.1.5) Coding Correct Scores
  - 2.1.6) Coding Error Scores
  - 2.1.7) Coding Total Omission Scores
  - 2.1.8) Coding Total Inhibitory Error Scores

- 2.2) Symbol Search
  - 2.2.1) Symbol Search A and B
    - 2.2.1.1) Symbol Search Total Uncorrected Error Scores
    - 2.2.1.2) Symbol Search Total Self-Corrected Error Scores
    - 2.2.1.3) Symbol Search Total Error Scores

2.2.1.4) Symbol Search Total Time Scores

2.2.3.4) Symbol Search Total Time Scores

3) Background Questionnaire

3.1) Speed of Processing

Utilise the documentation provided by the larger study, namely:

3.1) Participant Information Sheet

3.2) Consent Form/Assent Form

To invite participants to take part in the study, inform them about the study, their participation, their rights and how their information will be used.

I/we give permission for the above investigator to access and analyse the above-mentioned data of research participant who wish to participate in the investigation at Chris Hani Baragwanath Academic Hospital: Department of Paediatric Surgery. Possible test sample participants should have been present at this site, as part of their follow up care. Possible contrast sample participants were selected from a list of patients awaiting umbilical/inguinal hernia surgery, they were present at this site.

If you have any question regarding site permissions, please contact Dr Vered Lack at veredlack@yahoo.com or on (011)933 8138

Principal Investigator:

Dr Vered Lack

**12.5 Appendix F**

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

**CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL**
**Directorate: Paediatric Surgery**
**HOD: Prof J Loveland**
**Enquiries: Dr V. Lack**
**Tel. number: (011)933 8138; Email: veredlack@yahoo.com**

## CONFIDENTIALITY AGREEMENT

**THINK Study: Traumatic Head Injury-Neurocognitive and Behavioural Assessment and Management in Kids**

**Human Research Ethics Committee (Medical)**

- Clearance Certificate No M1611113
- DOH Trial No: DOH-27-0617-5762

THINK Study is founded on many years of work and data collection by the Principal Investigator and HOD of the Department of Paediatric Surgery. This work forms the backbone of the clinical trial (and is the intellectual property of the department).

Although THINK aims to answer important and clinically relevant questions, confidentiality and patient autonomy are of paramount importance to the Department. To this end, clinical information used in the Study is highly protected, as per Ethics requirements of the Study.

As Principal Investigator of the above-mentioned, and holder of the Ethics Permissions it is incumbent on myself to enforce confidentiality prerequisites as stipulated by Ethics. To this end, I can only share clinical information relevant to your component of the study. This data is shared in confidence, and may only be shared with the student stipulated below and direct co-supervisor (stipulated below). Also, as Principal Investigator, and to ensure clinical information in accurately represented, myself and my supervisor are required to read all manuscripts that result from analysis of this data, and as PI, I am to be supervising author on all resulting publications.

Please sign below, to confirm acceptance of the above stipulations.

Kajol Nair DATE: 26/07/2019

Dr Vered Lack DATE 26/07/2019

Enid Schutte DATE: 26/07/2019

Prof Jerome Loveland DATE: 26/07/2019

**12.6 Appendix G**

INFORMED CONSENT FOR STUDY PARTICIPATION

- I confirm that I have been informed by the staff about the nature, conduct, benefits and risks of this study.
- I have received, read and understood the above written information regarding the study.
- I am aware that the results of this study, including personal details regarding my child's gender, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerized system.
- I can withdraw my consent and the participation of my child from this study at any time I wish, without prejudice.
- I have read sufficient opportunity to ask questions, and, of my own free will, declare that I allow my child to participate in this study.

Participant name and surname:

| Printed Name | Signature | Date and Time |
|---|---|---|

Parent/ Guardian's name (a copy of the consent form will be given to the parent/guardian)

| Printed Name | Signature | Date and Time |
|---|---|---|

Study Staff obtaining the Consent:

Printed Name Signature Date and Time

## 9. 7 Appendix H Reference Number


## Demographic questionnaire

## Section A

Background Questionnaire

Date: ……..

Information provided by: ……

Completed by: ……..

**Participant Demographic**

| | | | | |
|---|---|---|---|---|
| Name | | | | |
| Hospital number | | | | |
| Date of birth | | | | |
| Sex | | | | |
| Ethnic grouping/Race | | | | |
| Home language | | | | |
| Other languages/proficiency/taught by? | Language | Good/Okay/Weak | Home/school/other | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| Left or right handed | | | | |
| Primary caregiver | | | | |
| Mother's pregnancy with participant | Uneventful | Full-term | Delivery | Post-Natal |
| | | | | |
| Caregiving (mother, day-care, crèche, other) | 0-2 years | 2-4 years | 4 – 6 years | |
| | | | | |
| Present School Grade | | | | |
| School attended | | | | |

| | | | |
|---|---|---|---|
| General scholastic performance | Good | Average | Weak |
| Grades failed/repeated | | | |
| Concentration | Good | Average | Weak |
| Memory | Good | Average | Weak |
| Best Subject | | | |
| Worst Subject | | | |
| Favourite free-time activities | | | |
| Other problems the child has experienced? | | | |

| | | | | | |
|---|---|---|---|---|---|
| Rate the child's ability to concentrate from 1 to 5<br>1- Poor concentration<br>5- Concentrates well | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Does the child have trouble sitting still for a long time? | Yes | | | No | |
| If yes, when does the child have trouble sitting still? E.g. When doing homework | | | | | |
| Rate the child's ability to sit still from 1 to 5<br>1- Cannot sit still<br>5- Sits still very well | 1 | 2 | 3 | 4 | 5 |
| Does the child get distracted by sounds or movements when doing an activity? | Yes | | | No | |
| What distracts the child the most? | | | | | |
| Rate how much this thing/ these things distract the child<br>1- Not much<br>5- Very much | 1 | 2 | 3 | 4 | 5 |
| Does the child have trouble remembering instructions? | Yes | | | No | |
| Rate how good the child is at remembering instructions<br>1- Not good<br>5- Very good | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Does the child forget things at crèche/ school? | Yes | | | No | |
| Rate how often the child forgets things at crèche/ school 1- Not often<br>5- Very often | 1 | 2 | 3 | 4 | 5 |
| Does it take a long time for your child to make a decision? | Yes | | No | | |
| Please rate how long your child takes to make a decision from 1-5<br>1- Very slow<br>5- Very fast | 1 | 2 | 3 | 4 | 5 |
| Does it take the child a long time to finish their homework? | | | | | |
| Rate the how long the child takes to finish their homework from 1-5.<br>1-it takes the child a long time<br>5- it takes the child quickly | 1 | 2 | 3 | 4 | 5 |

| | | | | |
|---|---|---|---|---|
| **Caregiver's Information** | | | | |
| Relationship to participant | | | | |
| Ethnicity | | | | |
| Language of choice | | | | |
| Highest Educational Qualification | | | | |
| Employment status | | | | |
| Contribution to family income | | | | |
| Major health problems | | | | |
| Mother's pregnancy with the child | Uneventful | Full Term | Delivery | Post Natal |
| | | | | |

| | |
|---|---|
| Caregiving time for the child (Mother, day care, other) | |

## 12.8 Appendix I

# CODE OF CONDUCT
# FOR RESEARCHERS / APPLICANTS FOR ETHICS APPROVAL AND / OR RESEARCH ETHICS MEMBERS

This Code of Conduct is applicable to all University of the Witwatersrand, Johannesburg (University) researchers / applicants which includes staff and students of the University and third parties applying for ethics approval and research ethics members.

This Code of Conduct must be read in conjunction with the University's Code of Conduct document HRG/26 approved by Council, C2006/482.

As a member of the University Community, I agree and commit to the rules and regulations of the University as well as all national and international laws and regulations applicable to my field of study. Furthermore, I agree and commit myself to abide by the ethical principles and responsibilities as set out in the Singapore Statement on Research Integrity dated 22 September 2010, in any and all research endeavours that I undertake as a researcher or applicant of the University or research ethics member.

I acknowledge and agree that I have read the Terms of Reference and the Standard Operating Procedures for the relevant research ethics committee that I am applying for ethics approval and agree to follow them.

**The four major values of research integrity to which I will agree to adhere to and that will guide my research are:**

· Honesty and integrity in all facets of my research or decisions that I make as a researcher and/or ethics committee member;

· Accountability in the conduct of my research or decisions that I make as a researcher and/or research ethics member;

· Professional courtesy and fairness in working with other people; and

· Good stewardship of research on behalf of other people.

**Therefore I will further agree to adhere to the following ethical responsibilities:**

1. I will take responsibility for the originality and trustworthiness of my research.
2. I will stay abreast of and adhere to all institutional, national, and international laws, regulations, rules and policies applicable and related to my research.
3. I will at all times employ appropriate research methods, base my conclusions on critical analysis of the evidence and report my findings and interpretations fully and objectively.
4. I will keep clear and accurate records of all research that I have conducted in a manner that will allow verification and replication of my work by others, if applicable.
5. I will, where applicable, share my data and findings openly and promptly, in line with external funding rules. This will be done as soon as possible after I have had an opportunity to establish priority and ownership claims.
6. I will take responsibility for my own contributions to publications, funding applications, reports and other
representations of my research. I will also and only include authors who meet valid authorship criteria which is set out in the University's Authorship Policy.
7. I will acknowledge the names and roles of those who made significant contributions to my research in publications, including writers, funders, sponsors, and others, but do not meet authorship criteria.
8. In my peer reviews, I will provide fair, prompt and rigorous evaluations and I will respect confidentiality when I review others' work.

9. I will disclose all conflicts of interest (financial and other) that could compromise the trustworthiness of my work in research proposals, publications, public communications, and in review activities.
10. When I publically address a community in the spirit of academic freedom, I will in all stages base my professional comments on research findings, if applicable, and my expertise. I will distinguish between professional comments and opinions based on personal views.
11. Should any irresponsible research practices and/or research misconduct become known to me or brought under my attention, I will report such irresponsible research activities to the appropriate University representatives, Research Ethics Committee and in line with the University's Research Integrity Policy.
12. I will respond to any irresponsible research practices or conduct, by taking prompt actions as set out in the procedures of the University. I will also protect those who report misconduct in good faith, to the best of my abilities.
13. I will endeavour to create and sustain an environment that encourage research integrity through education of students, research teams and peers, as well as abide by policies, and reasonable standards for advancement.
14. I will at all times weigh societal benefits against the risks inherent in my research.

The absence of a specific guideline in this Code of Conduct does not relieve and individual of the responsibility of applying the highest ethical standards when reacting to a situation. Ethical, respectful, responsible and diligent conduct of all members of the University community are essential for maintaining and enhancing the position of the University of the Witwatersrand, Johannesburg as a leading university in the Republic of South Africa, Africa and the world.

Researcher / Applicant / Research Ethics Member Name: _____Kajol Nair_____

Signature: ____Kajol Nair_____

Date: _____25.04.2019_____

Place: _____University of Witwatersrand_____

## 12.9 Appendix J

DATA SHEET

BLUNT HEAD INJURY SEQUELAE ASSESSMENT

| PATIENT INFORMATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| RESEARCH NUMBER | | | | | | | | | |
| DATE OF ADMISSION | __ __/ __ __/ 20 __ __ | | | DATE OF DISCHARGE | __ __/ __ __/ 20 __ __ | | | | |
| AGE: | | | | | | | | | |
| | | | GENDER | MALE | FEMALE | | | | |

| CLINICAL INFORMATION | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| MECH OF INJURY | PENETRATING | | | GUNSHOT | STAB | OTHER | | | |
| | BLUNT | | | MVA | PVA | FALL | ASSUALT | NAI | |
| | INITIAL GCS | | | __/15 | | | | | |
| | LOC | Y | N | DURATION | | | | | |
| | SEIZURE | Y | N | VOMITING | N | Y | | | |
| | AMNESIA | Y | N | 0 | <3 | >3 | | | |
| | SCALP HAEMATOMA NOTED | Y | N | | | | | | |
| | INCIDENT WITNESSED | Y | N | BY WHO | | | | | |
| TRANSPORT | PRIVATE | | | EMS | | | | | |
| IF EMS | INTUBATION | Y | N | IF YES | COMPICATED | UNCOMPLICATED | | | |
| IF COMPLICATED - SPECIFY | | | | | | | | | |
| RESUS(TIME OF ARRIVAL TO RESUS) | | | | | | | | | |
| INTUBATED ON ARRIVAL | YES | | | NO | | | | | |
| | GCS | | | | | | | | |
| RX | INTUBATION | Y | N | VENTALATION | Y | N | | | |
| | CVP | Y | N | | | | | | |
| INITIAL REPORT & WORKING DX | | | | | | | | | |
| CT BRAIN (TIME PERFORMED) | NAD | SAH | SDH | ICB BLEED/CONTUSION | RAISED ICP/DAI | #BOS | | | |
| REVIEWED REPORT | | | | | | | | | |
| CT BRAIN | NAD | SAH | SDH | ICD BLEED / CONTUSION | RAISED ICP/DAI | #BOS | | | |
| FRACTURE | SIMPLE LINEAR | | DEPRESSED | | COMPLEX | | | | |
| NEURO SURGERY CONSULT | YES | | NO | | | | | | |
| IF YES | VERBAL | | PHYSICAL CONSULT | | | | | | |
| OUTCOME | | | | | | | | | |
| SOCIAL WORKER CONSULT | YES | | NO | | | | | | |
| IF YES: RECOMMENDATION | | | | | | | | | |
| ALLIED MEDICAL PROFESSIONS CONSULTED (SPECIFY) | | | | | | | | | |
| SX INTERVENTION | Y | N | IF YES SPECIFY | | | | | | |
| ICU ADMISSION | Y | N | IF YES | ICP MONITORING | DEFINITIVE SURGERY | | | | |
| FOLLOW UP | 6 WEEKS | | 12 WEEKS | | | | | | |
| COMMENTS (IF ANY) | | | | | | | | | |

**12.10 Appendix K**

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE
CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

**PERMISSION TO CONDUCT RESEARCH**

Date: 21 Oct 2016

TITLE OF PROJECT: Examining neurocognitive, psychosocial and psychiatric sequelae following mild TBI: a potentially significant impact in a low socio-economic population

UNIVERSITY: Witwatersrand

Principal Investigator: V Lack

Department: Surgery

Supervisor (If relevant):

Permission Head Department (where research conducted): Yes

Date of start of proposed study: October 2016
Date of completion of data collection: December 2018

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Hospital. The CEO /management of Chris Hani Baragwanath Hospital is accordingly informed and the study is subject to:-

- Permission having been granted by the Human Research Ethics Committee of the University of the Witwatersrand.
- the Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- the MAC will be informed of any serious adverse events as soon as they occur
- permission is granted for the duration of the Ethics Committee approval.

.....
Recommended
(On behalf of the MAC)
Date: 21 October 2016

.....
Approved/Not Approved
Hospital Management
Date: 27/10/16

12.10 turn it in report

# 1054711:turn_it_in_draft.docx

ORIGINALITY REPORT

| 15% | 3% | 7% | 11% |
|---|---|---|---|
| SIMILARITY INDEX PAPERS | INTERNET SOURCES | PUBLICATIONS | STUDENT |

PRIMARY SOURCES

| | | |
|---|---|---|
| 1 | Submitted to University of Witwatersrand<br>Student Paper | 4% |
| 2 | "Encyclopedia of Clinical Neuropsychology", Springer Science and Business Media LLC, 2018<br>Publication | 1% |
| 3 | Submitted to Universiti Sains Malaysia<br>Student Paper | <1% |
| 4 | Submitted to Jacksonville University<br>Student Paper | <1% |

5 "Final Program Forty Fifth Annual Meeting International Neuropsychological Society", Journal of the International Neuropsychological Society, 2017 <1%
Publication

6 Submitted to Thornton Township High School District 205 <1%
Student Paper

7 Submitted to Argosy University <1%
Student Paper

8 "Encyclopedia of Clinical Neuropsychology", Springer Science and Business Media LLC, 2011 <1%
Publication

9 Submitted to University of Nottingham <1%
Student Paper

| | | |
|---|---|---|
| | "Final Program Forty Second Annual Meeting 10 International Neuropsychological Society February 12–15, 2014 Seattle, Washington, USA", Journal of the International Neuropsychological Society, 2014<br>Publication | <1 |
| 11 | Submitted to Queen's University of Belfast<br>Student Paper | <1 |
| 12 | "Final Program, Abstracts Presented at the<br>Thirty–Fifth Annual International Neuropsychological Society Conference, February 7–10, Portland, Oregon, USA", Journal of the International Neuropsychological Society, 2007<br>Publication | <1 |
| 13 | Submitted to University of Birmingham<br>Student Paper | <1 |
| 14 | Submitted to Walden University<br>Student Paper | <1 |

| | | |
|---|---|---|
| 1. | "Abstracts Presented at the Thirty–Fourth 15 Annual International Neuropsychological Society Conference, February 1–4, 2006, Boston, Massachussetts, USA", Journal of the International Neuropsychological Society, 2006<br>Publication | <1% |
| 16 | Submitted to University Of Tasmania<br>Student Paper | <1 |
| 17 | "Final Program, Thirty-Sixth Annual Meeting International Neuropsychological Society, February 6-9, 2008, Waikoloa, Hawaii, USA", Journal of the International Neuropsychological Society, 2008<br>Publication | <1 |
| 18 | Submitted to University of Huddersfield<br>Student Paper | <1 |
| 19 | livrepository.liverpool.ac.uk<br>Internet Source | <1 |
| 20 | Submitted to Albany State University<br>Student Paper | <1 |

| | | |
|---|---|---|
| 21 | Submitted to Colorado Technical University<br>Online<br>Student Paper | <1 |

2. "XXIIst CINP Congress: Brussels, Belgium, 9-13

| | | |
|---|---|---|
| 2.1 | 22 July 2000", The International Journal of Neuropsychopharmacology, 2007<br>Publication | <1% |

| | | |
|---|---|---|
| 23 | "Final Program, The International Neuropsychological Society, Federation of Spanish Societies of Neuropsychology, Spanish Neuropsychological Society, Spanish Psychiatry Society Joint Mid-Year Meeting, July 4-7, 2007 Bilbao, Spain", Journal of the International Neuropsychological Society, 2007<br>Publication | <1 |
| 24 | Submitted to South University<br>Student Paper | <1 |
| 25 | Submitted to Acadia University<br>Student Paper | <1 |

| | | |
|---|---|---|
| 26 | blog.galvanize.com<br>Internet Source | <1% |
| 27 | www.pearson.com<br>Internet Source | <1% |
| 28 | Christopher M. Bailey. "SLAM on the Stand",<br>Journal of Head Trauma Rehabilitation, 03/2009<br>Publication | <1% |
| 29 | www.cup.ualberta.ca<br>Internet Source | <1% |
| 30 | Submitted to University of Sydney<br>Student Paper | <1% |
| 31 | Submitted to Southridge High School<br>Student Paper | <1% |
| 32 | Submitted to Murdoch University<br>Student Paper | <1% |

| | | |
|---|---|---|
| 33 | Submitted to Mahidol University<br>Student Paper | <1 |
| 34 | epdf.pub<br>Internet Source | <1 |
| 35 | Submitted to University of Ulster<br>Student Paper | <1 |
| 36 | Submitted to University of South Australia<br>Student Paper | <1 |
| 37 | Submitted to University of Surrey<br>Student Paper | <1 |
| 38 | Submitted to Carlos Albizu University<br>Student Paper | <1 |

| | | |
|---|---|---|
| 39 | Emmaline Kate Falconer, Gina Malke Geffen, Sara Louise Olsen, Ken McFarland. "The rapid screen of concussion: An evaluation of the nonword repetition test for use in mTBI research", Brain Injury, 2009<br>Publication | <1 |
| 40 | A McKinlay. "Long term psychosocial outcomes after mild head injury in early childhood",<br><1% Journal of Neurology, Neurosurgery & Psychiatry, 2002<br>Publication | |
| 41 | Submitted to Texas A&M International University<br>Student Paper | <1 |
| 42 | www.workout-routines-that-work.com<br>Internet Source | <1 |
| 43 | Submitted to University of East London<br>Student Paper | <1 |
| 44 | Submitted to University of Hull<br>Student Paper | <1 |

| | | |
|---|---|---|
| 45 | Submitted to Adelphi University<br>Student Paper | <1% |
| 46 | journals.sagepub.com<br>Internet Source | <1% |
| 47 | Navid Ghavi Hossein-Zadeh, Mohammad Golshani. "Comparison of non-linear models to describe growth of Iranian Guilan sheep", Revista Colombiana de Ciencias Pecuarias, 2016<br>Publication | <1% |
| 48 | etheses.whiterose.ac.uk<br>Internet Source | <1% |
| 49 | Submitted to Bond University<br>Student Paper | <1% |
| 50 | Submitted to University College London<br>Student Paper | <1% |

| | | |
|---|---|---|
| 51 | www.iiste.org<br>Internet Source | <1% |
| 52 | Pengyun Wang, Rui Li, Bei Liu, Cheng Wang, Zirui Huang, Rui Dai, Bogeng Song, Xiao Yuan, Jing Yu, Juan Li. "Altered Static and Temporal Dynamic Amplitude of Low-Frequency Fluctuations in the Background Network During Working Memory States in Mild Cognitive Impairment", Frontiers in Aging Neuroscience, 2019<br>Publication | <1% |
| 53 | www.hdinjurylaw.com<br>Internet Source | <1% |
| 54 | Submitted to University of Central Lancashire<br>Student Paper | <1% |
| 55 | scholar.sun.ac.za<br>Internet Source | <1% |

| | | |
|---|---|---|
| 56 | edpsychassociates.com<br>Internet Source | <1% |
| 57 | Daryl Greaves. "The educational uses of the WISC- III", Australian Journal of Learning Disabilities, 1997<br>Publication | <1% |

**3. Submitted to University of Cape Town**

| | | |
|---|---|---|
| 58 | Student Paper | <1% |
| 59 | P McCrory. "Commentary", British Journal of Sports Medicine, 2001<br>Publication | <1% |
| 60 | Submitted to Northcentral<br>Student Paper | <1% |
| 61 | Submitted to Tarleton State University<br>Student Paper | <1% |
| 62 | www.nap.edu<br>Internet Source | <1% |

| | | |
|---|---|---|
| 63 | jamanetwork.com<br>Internet Source | <1 |
| 64 | Submitted to Aston University<br>Student Paper | <1 |
| 65 | Submitted to University of Johannsburg<br>Student Paper | <1 |
| 66 | studylib.net<br>Internet Source | <1 |
| 67 | link.springer.com<br>Internet Source | <1 |

3.1 **BRENDA D. TOWNES, ISABEL PAVAO**

68 MARTINS, ALEXANDRE CASTRO-CALDAS, <1% GAIL ROSENBAUM, TIMOTHY DEROUEN.

3.2 **"REPEAT TEST SCORES ON NEUROBEHAVIORAL MEASURES OVER AN EIGHT-YEAR PERIOD IN A SAMPLE**

**OF PORTUGUESE CHILDREN", International Journal of Neuroscience, 2009**
Publication

69 Acta Neurochirurgica, 2002
Publication

<1

70 Submitted to The Maldives National University
Student Paper

<1

71 M Juan-Espinosa. "Age dedifferentiation hypothesis Evidence from the WAIS III", Intelligence, 2002
Publication

<1

72 Submitted to University of Glamorgan
Student Paper

<1

73 Valerie A McCormack, Maureen Joffe, Eunice van den Berg, Nadine Broeze et al. "Breast cancer receptor status and stage at diagnosis in over 1,200 consecutive public hospital patients in Soweto, South Africa: a case series", Breast Cancer Research, 2013
Publication

<1

Submitted to Whitireia Community Polytechnic 74
Student Paper
<1%

Elizabeth L. Moore, Lori Terryberry-Spohr, 75
Debra A. Hope. "Mild traumatic brain injury and anxiety sequelae: A review of the literature", <1% Brain Injury, 2009
Publication

76
" 46 Congress of the International Society of Paediatric Oncology (SIOP) 2014 ", Pediatric Blood & Cancer, 2014
Publication
<1%

77
www.e-sciencecentral.org
Internet Source
<1%

Maria J. Hennessy, Gina Geffen, Gerard Pauley, 78 Tim Cutmore. "The Assessment of Executive Functioning Following Mild Traumatic Brain Injury", Brain Impairment, 2012
Publication
<1%

79
lifecyclejourneys.com
Internet Source
<1%

<1%

80 Rafael E. Oliveras-Rentas, Lauren Kenworthy, Richard B. Roberson, Alex Martin, Gregory L. Wallace. "WISC-IV Profile in High-Functioning Autism Spectrum Disorders: Impaired Processing Speed is Associated with Increased Autism Communication Symptoms and Decreased Adaptive Communication Abilities", Journal of Autism and Developmental Disorders, 2011

Publication

3.3 **Ralph M. Reitan, Deborah Wolfson. "The Influence of Age and Education on Neuropsychological Performances of Persons With Mild Head Injuries", Applied Neuropsychology, 1997**

81 <1%

Publication

82 "National Academy of Neuropsychology. Abstracts from the 26th Annual Meeting, San Antonio, Texas, October 25-28, 2006", Archives of Clinical Neuropsychology, 2006

<1%

Publication

83 Submitted to Reykjavík University

<1%

Student Paper

| | | |
|---|---|---|
| 84 | Submitted to Arkansas Tech University<br>Student Paper | <1 |
| 85 | Submitted to Southampton Solent University<br>Student Paper | <1 |

| | | | |
|---|---|---|---|
| Exclude quotes | On | Exclude matches | < 5 words |
| Exclude bibliography | On | | |