

PREDICTING THE OUTCOME OF MILD CLOSED HEAD INJURY  
USING THE GLASGOW COMA SCALE-EXTENDED.

by

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## SUMMARY

Measures routinely used to assess the severity and outcome of closed head injury, that is the Glasgow Coma Scale (GCS) and the duration of post-traumatic amnesia (PTA), are of limited use in the case of mild closed head injury (MCHI). The present study investigated the sensitivity of a proposed alternative measure, the Glasgow Coma Scale-Extended (GCS-E), which is a combination of GCS and PTA measures. Twenty subjects who sustained MCHI were assessed with a brief battery of neuropsychological tests, six months after the injury. Correlations between the neuropsychological measures and GCS, duration of PTA and the GCS-E were not significant, possibly because of methodological limitations. Although statistical methods do not support the notion that the GCS-E is more sensitive than currently used measures in detecting the consequences of MCHI, some support is obtained from qualitative observations.

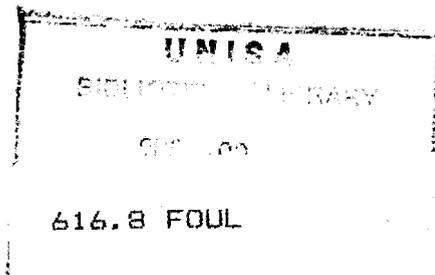
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## CHAPTER 1

### Rationale and Aims of the Study

Closed head injury can be described as trauma to the head without the integrity of the skull being compromised. An exact definition of what constitutes mild closed head injury (MCHI) has not yet enjoyed consensus (Bigler, 1990; Bohnen & Jolles, 1992). The reason for this appears to be the vast array of neurobehavioural sequelae to MCHI, as well as the large number of ways in which the brain can be injured (Bigler, 1990).

Authors such as Diamond, Barth and Zillmer (1988) and Teasdale and Jennet (1974) define MCHI as a non-penetrating cranial injury without loss of consciousness or, if consciousness is lost, it is for 20 minutes or less. MCHI is characterized by a Glasgow Coma Scale (GCS) score of 13 to 15 shortly after the incident, and hospitalization (due to the head injury, not concomitant injury) does not exceed 48 hours. Post-traumatic amnesia (PTA) is also routinely used as an indicator of severity of head injury, with PTA of one hour or less indicating MCHI (Lezak, 1995).

The incidence of MCHI is estimated to be 80% of all closed head injury cases (Bohnen & Jolles, 1992; Nell & Yates, 1998).

Traditionally the view has been that MCHI is a reversible process (for example, Blakely & Harrington, 1993). This view has recently been questioned, since long-term sequelae following MCHI have been documented (for example, Kay, 1996). Approximately 10% of

head injury cases that have been assessed as mild, do not recover fully a year after the injury (Ruff, Camenzulis & Mueller, 1996).

MCHI is often followed by a range of symptoms which have been labeled as postconcussion syndrome (PCS) (Youngjohn, Burrows & Erdal, 1995). The symptomatology of PCS includes cognitive impairment, behavioural changes and affective lability. Some authors (for example, Bohnen & Jolles, 1992) believe that the incidence of PCS can be as high as 80% of all mildly head injured persons.

The extent of head injury is currently routinely assessed by using the Glasgow Coma Scale (GCS) (Nell, 1997). This is unfortunate since the GCS was not developed for this majority category of head injury and the validity of the GCS in the mild range of closed head injury is low (Jennet, 1989). A head injury can thus be assessed as a mild, transient injury using the GCS, although the patient himself/herself may sense pervasive changes in his/her level of functioning due to the injury. A diagnosis of MCHI according to the GCS can thus lead to "cognitive dissonance" between the patient and the treating professional (Nell, 1997). Also, since the mildly head-injured patient often has only brief hospitalization (if any) and is usually discharged when other external concomitant injuries are healed, MCHI patients with persistent symptoms are often accused of malingering (McDonough, Mahalick & Greenberg, 1997).

The primary aim of this study was to investigate the Glasgow Coma Scale-Extended (GCS-E) as a tool for increasing the sensitivity in the detection of MCHI. Enhancing this sensitivity in the detection of MCHI (indirectly providing a more sensitive measure of outcome)

may prepare the injured individual, as well as his/her family, for the neurobehavioural impact of the injury. Also, the effect of expectations on the outcome of MCHI has been well documented (for example Mittenberg, DiGiulio, Perrin & Bass, 1992). More accurate prognoses in the event of MCHI will allow the practitioner to foster realistic expectations and to prepare the patient for rehabilitation.

More specifically, the aims of this study were to establish whether:

- the two GCS-E components, that of GCS scores and PTA scores, correlate with various measures of outcome of MCHI, six months post-injury.
- the GCS-E has stronger correlations and with more of the outcome measures of MCHI, six months post-injury, than either GCS or PTA alone.

## Preview

The chapters which follow cover the following topics:

Chapter 2 of this report explains the impact of trauma to the brain. Two types of injuries which typically co-occur, primary- and secondary injuries respectively, are described.

Chapter 3 describes the symptomatology associated with PCS. This is a disorder which often occurs subsequent to MCHI. The symptoms can be roughly categorized into physical symptoms, cognitive deficits, emotional deficits and changes in social behaviour.

Chapter 4 discusses some factors which have consistently been shown to have an effect on the outcome of MCHI, or the extent of PCS. These factors include the nature of the actual injury to the brain, age, gender, social support, premorbid personality of the individual and other factors.

Chapter 5 looks at measures currently used in the assessment of MCHI, the GCS and PTA. Both these measures have advantages and disadvantages. Chapter 5 also discusses the GCS-E as an indicator of the extent of brain injury, the basis on which predictions of the outcome of the injury can be made. The focus of the present study is whether this latter measure could overcome the disadvantages of the previously mentioned two measures (GCS and PTA).

Chapter 6 explains the hypotheses and method followed in investigating the sensitivity of the GCS-E, compared to the GCS and PTA, in detecting the presence of MCHI.

Chapter 7 presents the quantitative analyses of the results.

Chapter 8 discusses the quantitative results, sheds light on qualitative observations made during interactions with the participants of the study, and offers some final comments.

## CHAPTER 2

### Neuropathology of mild closed head injury

The neuropathology and sequelae associated with MCHI can be used as a basis for a discussion of the appropriateness of specific diagnostic tools for MCHI. This chapter aims to show that neuropathology is often associated with MCHI and that this pathology may not be as acute and transient as the presupposition of some diagnostic measures suggest.

The dynamics and neuropathology associated with MCHI (as with other closed head injuries), can be separated into two stages. These are usually referred to as the primary and secondary stages respectively (for example, Lezak, 1995). Each of these stages appear to have associated neurobehavioural deficits. (Chapter 4 describes the behavioural manifestations of the various categories of neuropathology.) In reality the distinctions drawn between the stages of injury and the associated deficits are artificial, since the manifestations of the stages typically co-occur. The distinction will however be perpetuated here for exposition purposes.

#### 2.1. Primary injury

This is the damage to the brain which occurs at the time of the incident and the effects of this type of injury are considered less reversible and less treatable than the later damage (Jansen, 1988). Primary injuries are further categorized into diffuse and localized injuries respectively.

### 2.1.1. Diffuse axonal injury

The brain has an inelastic, jelly-like consistency (Marieb, 1995). Should an adequate mechanical force be administered to this inelastic mass, the nerve fibers twist and stretch causing disruptions in the axonal cytoskeleton. A larger force will cause the shearing of the neurons, forming axonal retraction balls proximally. The distal detached segment of the axon disintegrates due to its supply of both oxygen and nutrients being interrupted. Such distal axonal disintegration is called Wallerian degeneration and ultimately causes faulty synapses. Such injuries to the neurons are known as diffuse axonal injury (DAI) and typically occur in MCHI: "Modern research has provided ample evidence from both animals and man that axons are diffusely injured throughout the brain in mild head injury" (Miller, 1996, p.17).

DAI often happens if the force which the head is subjected to, is a sufficiently large rotational force, as commonly found in whiplash injuries. A rotational injury occurs when the brain is subjected to a pendular motion due to a jolting force to the head on the flexible neck (imagine a lolly-pop on an unsupported stick). A type of violent shaking motion results where direct impact is not necessary to cause damage to the brain, but widespread "pushing and pulling" (often referred to as a flexion-extension injury) strains the delicate nerve fibres and blood vessels and causes the injury.

If DAI extends to the reticular activating system of the brain stem, consciousness is lost (Lezak, 1989). Loss of consciousness for more

than one hour, will lead to a diagnosis of more severe head injury. If the loss of consciousness is brief or manifests as confusion only, the injury is described as mild. However, Lezak (1995) argues that even when the injury is classified as mild and there is no loss of consciousness, but only concussion, the fibers of the reticular formation often suffer permanent damage.

The compromised or dead neurons throughout the brain may provide an organic basis for the behavioural deficits experienced after MCHI. However, this DAI in the MCHI patient may be undetected by scans and other direct assessment techniques, since the atrophy of brain substance may be too minor for the detection of ventricular enlargement, especially without a comparable premorbid MRI (Bigler, 1990; Levin & High, 1989). This low reliability of tests like MRI and CT scans for MCHI patients, together with their injury being considered transient and not life-threatening, results in these tests rarely being done for MCHI patients.

With severe closed head injury, DAI occurs throughout the brain and alternative pathways can often not develop to compensate for damaged areas (which happens in the case of localized injuries). In the case of MCHI, the damage is minor and it is thought that compensation occurs in most cases.

### 2.1.2. Localised injuries

Acceleration-deceleration forces can cause more localised cerebral lesions. This type of injury is typical in motor vehicle accidents. Since the bony skull is less dense than the brain, it moves at slower rate. During rapid deceleration, when the skull is suddenly

immobilized due to an impact, the brain continues to move (mainly horizontally) causing the outer cerebral tissue to slam against a suddenly stationary skull.

Compounding acceleration-deceleration type injuries, is the fact that the hard skull has bony ridges at some places. This can lead to localised shearing of the soft cerebral tissue where the brain hits the skull. Since the frontal and the temporal lobes form the areas of the greatest brain-skull interface and considering the jagged nature of the ethmoid and sphenoidal ridges which form this interface, these two brain structures are considered to be high-risk areas in the event of head injury. The hippocampus too has been identified as a high-risk structure.

#### 2.1.2.1. Hippocampus

Buried deep in the temporal lobe is the hippocampus. The hippocampus receives afferents from, and sends efferents to, the entorhinal cortex. Damage to the entorhinal cortex therefore also disrupts functioning of the hippocampus. The amygdala is positioned in close proximity to the hippocampus and is often damaged when the latter is damaged.

The hippocampus receives input from all the cortical areas and all sensory information from the environment passes through the hippocampus at some stage (Lezak, 1995). Neural pathways involving the hippocampus are reciprocal, forming feedback loops to the structures feeding it.

Apart from the position of the hippocampus rendering it a high-risk area, ischemia (the lack of blood supply) associated with secondary injury (section 2.1.3 discusses secondary injury) appears to have an especially devastating effect on the hippocampus.

#### 2.1.2.2. Temporal lobes

The temporal lobes are rich in afferent neurons from the sensory areas and receives major projections from the frontal lobes. The temporal lobes send efferents to the parietal frontal association regions, the limbic system and the basal ganglia.

Kolb and Wishaw (1990) identify three basic functions of the temporal lobes:

- The temporal lobes are concerned with sensory perception.
- The temporal lobes play a role in converting sensory input to long term memory storage.
- The temporal lobes play a role in determining affective tone.

Temporal lobe lesions have indicated that the temporal lobes also play an important part in the organization and categorization of information, showing that the temporal lobes also have a role in cognitive functioning (Kolb & Wishaw, 1990).

#### 2.1.2.3. Frontal Lobes

The frontal lobes comprise those parts of the cortical hemispheres which are situated anterior to the central sulcus. The frontal lobes are those structures in the brain which are the most likely to "produce ...a variety of symptoms....[and] a bewildering range of interpretations" if damaged (Kolb & Wishaw, 1990, p. 477).

.....

The frontal lobes can be divided into three major divisions; each involved with behaviour output.

- The precentral division is immediately anterior to the central sulcus and mediates muscle movement.
- The premotor division is anterior to the precentral area and is involved in the integration of movement.
- The prefrontal division has connections with major motor and sensory systems and integrates the components of complex behaviour. The prefrontal cortex is also involved in attention, memory and cognition.

Although a patient may suffer either diffuse *or* a more localized injury to the brain, these injuries typically co-occur, causing the manifestations of the injury to overlap (Lezak, 1995). In addition to this, the disconnection of brain areas, which are functionally hierarchically arranged, leads to an exacerbation of the injury. This means that the severing of a pathway between a sensory input area to a sensory integration area of the cortex, will manifest as a deficit associated with both those areas, even if only the pathway between the two areas is damaged. If, for example, disconnection occurs in a pathway that facilitates input to the visual cortex (leaving the visual cortex itself totally intact), the patient may be partially (or totally) blinded.

Primary injury is sometimes followed by secondary injury.

## 2.2. Secondary damage

This type of injury occurs after the initial insult on the brain.

The acute postconcussive state may result in intracranial swelling and bleeding leading to an increase in the intracranial pressure. Secondary damage primarily comprises oedema (swollen brain tissue) together with haematomas (blood masses), due to the shearing of blood vessels during DAI, exerting pressure on the neurons and the arteries and veins which serve them. This pressure may give rise to permanent damage to neural tissue by acting on the neurons and blood vessels in a diffuse manner (Blakely & Harrington, 1993). Apart from being exposed to extreme pressure (the skull cannot "give way" so therefore the brain becomes compressed), the neurons are deprived of blood. Neurons are especially vulnerable to such alterations since they have high metabolic rates, do not store nutrients and rely on blood supply for nutrients and oxygen (Stambrook, Kowalchuk, Kassum, Peters, McClarty & Hawryluk, 1990). In addition to this sensitivity to nutrients and oxygen, is their non-regenerative property - neurons, unlike other somatic cells, do not continuously divide and regenerate.

Blakely and Harrington (1993) mention another phenomenon which can be described as secondary injury, that of cortical depression. Cortical depression is a laboratory phenomenon which refers to the transient depression of electrophysical activity following the application of potassium chloride to the surface of the cerebral cortex. The result of this application is the depression of the cortex in a concentric pattern. In vivo, the high levels of intracellular potassium leaking out on to the extracellular space can cause such a depression in cortical functioning, when neurons are damaged.

Secondary insult can be minimized or even avoided with appropriate intervention (Jansen, 1988).

### 2.3. Organic recovery

The brain tries to heal itself by means of various neuroplastic processes. These include collateral axon sprouting and dendritic arborization. This axonal spreading and sprouting takes between three and twelve months. If this structural compensation of the brain is not optimal, faulty synapses result (Miller, 1996).

### Conclusion

This chapter described the neuropathology of MCHI. Primary injury occurs at the time of the injury and secondary injury occurs 12 or more hours later. In addition to this, the brain tries to structurally compensate for the insult it has incurred, by axonal spreading and sprouting. This structural compensation takes three to twelve months or longer, and can cause faulty synapses. The neuropathology associated with MCHI is thus diverse and can be chronic.

## CHAPTER 3

### Postconcussion syndrome

Deficits and symptoms which arise from MCHI have been found to be relatively uniform (Bohnen & Jolles, 1992; Levin, Eisenberg & Benton, 1989). So much so, that the concept of postconcussion syndrome (PCS) has been formulated (Kay, 1996). The incidence of PCS after MCHI is reportedly as high as 80% (for example, Bohnen & Jolles, 1992)

#### 3.1. Etiology of PCS

The high frequency of PCS after MCHI has led many researchers to investigate the etiological basis for the syndrome. Mittenberg *et al.* (1992) state that the etiology of this resistant syndrome is controversial. Where some investigators argue that the primary cause is that of organic pathology (for example Sekino in Bohnen & Jolles, 1992), others argue that purely psychological features cause the syndrome (Lishman, 1988). Still other researchers argue that PCS begins on an organic basis, but persists on a psychological basis (for example Binder, 1993; Lishman, 1988).

#### 3.2. Course of PCS

Kelly and Rosenberg (1997) divide the symptomatology of PCS into two distinct categories - early onset symptoms and late onset

symptoms. Early onset symptoms, which include headaches, dizziness and diminished awareness, occur immediately after the concussion and continue for a few hours. Late symptoms occur within days or weeks of the injury and include irritability, memory dysfunction, poor concentration, light and noise sensitivity and mood disturbances. This period coincides with the incidence of secondary damage (as explained in section 2.2).

In more than 50% of MCHI individuals, symptoms manifest immediately after the injury (Binder, 1986). It appears that these symptoms persist in varying degrees, depending on several factors (these factors are discussed in chapter 4). In most cases the symptoms associated with PCS fade within 3 to 6 months as the person gradually moves toward the level of premorbid functioning, provided enough time for recovery is allowed (Mittenberg, Zielinsky & Fichera, 1993).

A significant number of cases do however not regain their previous level of functioning. Ruff *et al.* (1996) refer to the group of individuals (approximately 10% of all MCHI cases) who do not regain premorbid functioning within 12 months, as the "miserable minority".

It is also frequently reported that patients appear to function adequately until premorbid home, work or school demands resume. The handling and organizing of tasks which were previously considered simple, become problematic and efficiency decreases (Kay, 1996). This seems to suggest that the deficits associated with PCS have been present since the injury, but the environment may not have required a level of functioning which elicited the

deficits. Lezak (1995) also states that the chronic residual dysfunction associated with MCHI becomes so subtle with passing time (yet the deficits are present), that the detection thereof may be problematic. This author mentions that even professional assessments may fail to detect deficiencies since the assessment environment is typically quiet and without interference, rendering it an artificial context in which routine challenges of living are not represented.

Miller (1996) states that the apparent worsening of symptomatology with time (weeks after the injury has occurred), may be due to faulty reafferentation of the synaptic pathways. Chapter 4 discusses other factors that can lead to the worsening of symptomatology. These include psychological distress, reinforcement of the sick role by significant others, and other factors.

### 3.3. Symptomatology of PCS

PCS comprises a constellation of somatic and psychological symptoms.

#### 3.3.1. Physical manifestations

These symptoms typically occur soon after the MCHI (Miller, 1996). Headaches, dizziness, fatigue, hypersensitivity to noise, photophobia, insomnia and fatigue are some of the general somatic symptoms which often present in mildly injured patients (Kay, 1996; Lishman, 1987; Youngjohn *et al.*, 1995). Alexander (in Bigler, 1990)

found MCHI patients to have a significantly higher prevalence of chronic pain than did more severely injured subjects.

### 3.3.2. Cognitive, memory and executive deficits

These deficits usually involve diminished cognitive speed and an impaired capacity to process information. Attention, concentration and other complex cognitive functions also become problematic. For example, memory deficits arise due to the attention deficits (Lezak, 1995). Incidental memory appears to be especially at risk, and patients often report postmorbid changes like the chronic misplacement of keys.

Executive functioning, which can be described as goal directed behaviour (volition) and motivation, is often compromised. Also planning and monitoring of purposeful activities can be affected because of the involvement of the temporal and frontal lobes.

### 3.3.3. Emotional deficits and behavioural changes

Spouses and significant others of head injured patients, often report labile affect or loss of emotional reactivity and other behavioural changes in the patient. These changes include increased irritability, anxiety, and hypochondriasis (Kay, 1996) and are generally the late (approximately three months post injury) occurring symptoms of PCS (Miller, 1996).

The emotional deficits can compound cognitive deficits which resulted from the injury and patients feel frustrated, incompetent and often think and fear that they are going crazy. Kay (1993) calls

this a "shaken sense of self", and mentions the devastating effects the shaken sense of self can have on the confidence level of the individual.

Investigators such as Alexander (in Bigler, 1990) found MCHI patients to have a significantly higher prevalence of depression than more severely injured subjects.

#### 3.3.4. Social functioning

PCS also often manifests as a reduced desire for social interaction and/or inappropriate socialization (Kolb & Whishaw, 1990) which may be due to, or exacerbated by, cognitive decline. Significant others, colleagues and other people who have dealings with the patient, are likely to report the person as being egocentric, interpersonally inappropriate and generally a changed person in comparison with premorbid functioning.

The changes described above can have dire consequences for relationships and social functioning. These negative effects on interpersonal functioning can be tragic since studies show a positive relationship between social support and outcome of MCHI (for example Wagner, Williams & Long, 1990).

#### 3.3.5. Interactive sequelae

The deficits associated with PCS as described above can recursively exacerbate one another. Some authors (for example Richardson, 1990) argue that the primary deficit of PCS is altered cognitive processing, and other deficits are secondary to this. For example an

injured person may become aware of his/her cognitive decline and become uncomfortable socially and eventually avoid social interaction. Such an individual may be labeled as socially withdrawn, which is considered a frequent manifestation of head injury.

Miller (1996) suggests that the fatigue so common in PCS, is due to the "inefficiently focused, but effortfully sustained concentration." (p. 11). The experience of the patient will thus be that of an overload of stimuli on a compromised brain.

Other investigators (like Mittenberg *et al.*, 1992) argue that memory deficits are due to anxiety or expectations. According to this argument, memory is impaired due to either the anxiety which is inherent in physical trauma, or due to the expectation that the individual may have of memory impairment. The effect of expectations is discussed further in chapter 4.

Perhaps the higher prevalence of depression and chronic pain in MCHI cases (than in more severe closed head injuries) which Alexander (in Bigler, 1990) found, is partially due to the interaction of the factors described above.

## Conclusion

The symptomatology of PCS is diverse and presents differently in different individuals. PCS patients usually report a degree of confusion since they feel (despite being told otherwise) that they have not regained their premorbid level of functioning. The course

of PCS is such that the full onset of the syndrome is not always experienced immediately. This confuses the PCS sufferer further. In addition to this, the etiology of PCS is controversial. There is no consensus whether the etiology of PCS is organic, psychogenic or both. There are however various factors which are associated with the outcome of MCHI (or the extent of PCS). Some of the factors that affect the outcome of MCHI will be discussed in the next chapter.

## CHAPTER 4

Factors affecting the outcome of mild closed head injury.

Various factors have been associated with the outcome of MCHI. These factors include organic, psychogenic, interpersonal and social factors. Although some factors (like the organic factors) may have a more prominent part in the onset of the syndrome, the factors all appear to interact and reciprocally influence one another in determining the persistence and severity of the syndrome.

### 4.1. Organic nature of the injury

Bach-Y-Rita (1989) states that magnetic resonance imaging (MRI) shows that microscopic lesions are present in the majority of mild head injured cases. Others agree that it is "...inescapable that even mild head trauma may be associated with some pathology." (Kolb & Whishaw, 1990, p. 819).

Neuropsychological deficits based on neuropathology are well documented. The argument which supports the organic etiology of PCS, implies that predominant factors affecting outcome of mild head injury, involve the physical nature of the injury. Where chapter 2 described the dynamics of mild head injury, this section aims to explore neuropsychological deficits associated with brain damage according to those dynamics and discrete brain areas. The concordance of the deficits according to neuropathology with the symptomatology of PCS (see chapter 3), should be noted.

#### 4.1.1. Primary Injuries

##### 4.1.1.1. Diffuse axonal injury

Manifestations of this type of injury are not specific, but widespread and pervasive. Since there is a depletion in the number of functional neurons, cerebral resources become limited. The general efficiency and speed of information processing, execution of functions and the integration of mental processes are compromised (Bigler, 1990; Kay, 1996). This could possibly be due to the DAI affecting the functioning of the brain in a generalized manner.

##### 4.1.1.2. Localized injuries

For many decades now, various aspects of behaviour and cognition have been associated with discrete brain areas. Investigators who argue in favour of organic bases for PCS, consider the site and depth of localized injuries as important factors affecting the outcome of MCHI. The site of the contusion largely determines the type of postmorbidity deficit. The depth of the contusion is also important, since deeper damage has more severe consequences. Joseph (1990) states that localized neurological deficits are present in 1% to 5% mildly injured patients.

#### Hippocampus

The hippocampus is essential for the formation of memory and damage to this structure has consistently been associated with memory loss. Since the amygdala plays a major part in the affective aspects of memory, the damage of the amygdala can

further damage memory functioning (Gronwall & Wrightson, 1980). The seat of this memory impairment is however a contentious issue (as is the basis for PCS in general) and authors like Kolb and Whishaw (1990) make clear the fact that there is no one region in the nervous system which can be identified as the seat of memory. Lesion studies have revealed that although lesions to various areas disturb memory, these regions do not house memories. Some regions, and especially the hippocampus, are however more involved in memory than others. For example, Bigler and co-workers (1996) found a statistically significant relationship between hippocampal atrophy and the impairment of various memory tasks. Still, the processing of memory is best seen as a process of neuronal connectivity throughout various areas in the brain.

Emotional manifestations of hippocampal disruption include impulsivity, disinhibition, irritability and sudden and severe mood swings. These symptoms are however also manifestations of frontal lobe dysfunction. Carpenter (1991) puts this overlap of symptomatology down to the pathways between the hippocampus, the thalamic structures and various cortical areas, including the frontal lobes. Hippocampal damage typically ultimately manifests as social withdrawal. The social withdrawal is often followed by depression (Ruff *et al.*, 1996).

### Temporal lobes

According to Kolb and Whishaw (1990), there are eight major categories of symptoms associated with temporal lobe dysfunction:

1. Sensation and perception are disturbed.
2. Attention to auditory and visual input is disturbed.

3. Visual perception is disrupted.
4. Categorization and organization of verbal input are disturbed.
5. Language comprehension diminishes
6. Long-term memory diminishes
7. Behaviour and affect changes, with the control over emotions being especially problematic.
8. Sexual behaviour changes.

Although the location of the damage within the temporal lobe (and/or its connections) will determine the focus of the deficit (verbal/auditory or visual or both), the nature of deficits typically associated with temporal lobe injuries primarily revolve around language and cognitive functioning, especially memory (Kay, 1996; Kolb & Wishaw, 1990). Patients with temporal injuries experience difficulties when they are confronted with complex information which is rapidly presented and is in competition with other recently presented information. It appears that one area of memory, incidental memory, is mostly affected in these patients. Incidental memory is that part of memory which is not deliberate (for example remembering where one had put one's purse). Also, the deficits in storing and retrieving new information are detrimental to learning new material (Kay, 1996). Generally old information is left intact, so that such injuries can present as a person being able to remember his own history, but forget where he placed his wallet five minutes ago.

Kolb and Wishaw (1990) name irritability and hostility as additional typical symptoms of temporal lobe syndrome. Again, the pitfalls of generalizations are to be borne in mind.

## Frontal lobes

Deficits associated with frontal lobe damage revolve primarily around executive functioning, but other manifestations of this type of injury are often present.

- **Executive Functioning:** This can be described as the ability to deal with novel situations and the volition to do so. Executive functioning thus involves behavioural and emotional control or regulation. It concerns planning, organizing, taking initiative, monitoring and adjusting thinking and behaviour to a situation. Executive deficits can be described as both the lack of drive to begin goal setting of a task, as well as the lack of task completion. The lack of completion is often due to repeating incorrect responses to a problem. This lack of mental flexibility (trying different options), is usually highly evident in psychometric tests. Also, self-monitoring is sometimes compromised, so that awareness of the cognitive and behavioural deficits is unavailable to the patient (and therefore there is an inability to initiate corrective activities).
- **Attention and Concentration:** This is a major function of the frontal lobes (Levin, Culhane, Mendelsohn, & Lilly, 1993). Attention can be described as the brief focus on a task and concentration is the quality of that focus. Injury here manifests as distractibility and tangentiality (jumping from idea to idea in a disorganized fashion). Complex material is often described as being boring within a short period of time.
- **Motor control** appears to be associated with the frontal lobes. Firstly, the precentral division sends input to the spinal motor neurons. The type of movement controlled by this area is mainly

finer motor co-ordination (for example fine hand, finger and facial movements). Lesions in this region manifest as loss of fine movement, strength, speed and control.

The premotor area forms synapses primarily in the red nucleus and the basal ganglia. This area controls limb and other body movements and lesions may cause a loss of complex coordinated motor function.

The prefrontal cortex receives input from the tertiary zones (which are responsible for combining all sensory information) and sends information to cortical neurons, giving it a more generalized motor control and co-ordinating function. It is also the area which allows sudden motor adaptability and flexibility. Lesions here may manifest as stereotypical, inflexible, inappropriate emotional and social behaviour.

- Memory loss does not often show up in tests when damage is associated with frontal lobes only (Kolb & Wishaw, 1990). Still, patients with frontal lobe damage often present with disturbances in certain memory functions especially interference, where certain things can be omitted and others included in a sequence. These disturbances are probably due to an important short-term memory component which is controlled by the frontal lobes.
- Affective disorders are associated with frontal lobe damage. This could be due to the range of connections which the prefrontal cortex has with the limbic system. A main function of the limbic system is that of controlling emotions.
- Behavioural changes are often reported by significant others. Kolb and Wishaw (1990) list the following personality manifestations of frontal lobe damage (depending on the area of the frontal lobe involved):

apathy regarding social interaction or a reduced desire therefor, inappropriate interaction socially (disinhibition of behaviour typically occurs), altered facial and bodily expression and finally, reduction of spontaneous social vocalization.

The frontal lobes have been described as the regulators of behaviour (Carpenter, 1991).

Kolb and Whishaw (1990) mention frontal syndromes (rather than one frontal syndrome). These syndromes typically manifest as lack of foresight and concern, irresponsibility and a loss of insight. These authors do however warn of the dangers of such generalizations, and emphasize that each case should be considered in light of its own complexities. For example, attention deficits do not necessarily mean that frontal lobe damage has occurred, since other structures, like the brainstem, can also cause attention deficits. Although these frontal deficits are usually related to focal frontal injuries, they often present after MCHI (Miller, 1996).

It appears that anterior temporal lesions produce milder versions of the cognitive, affective and behavioural manifestations of frontal lobe injury, due to the rich connections between the frontal and temporal areas. If both the frontal and anterior temporal lobes are damaged, these deficits may be exacerbated. In addition to this, the limbic system, of which the hippocampus is part, is accepted as being crucial in emotional behaviour. Since all three of the "high risk" structures are implicated in emotional functioning, organic damage may well explain the high frequency of emotional lability after MCHI.

#### 4.1.2. Secondary damage

Since secondary damage essentially comprises an increase in intracranial pressure due to bleeding and swelling within the confinements of the skull, the manifestations of this type of injury are diffuse and have a more delayed presentation.

#### 4.1.3. Organic recovery

Authors like Miller (1996) argue that if the reafferentation of the brain (as explained in section 2.3) is in any way imperfect and faulty synapses form, typical delayed onset symptoms of PCS occur (for example depression and irritability), three to twelve months post-injury.

Kolb and Wishaw (1990) categorize the organic effects of MCHI on general behaviour into the following categories (which can, and often do, overlap):

- There can be the loss of previous functioning.

This is the most common effect of brain injury. Loss of function is generally and mostly associated with the area of dysfunction, although other effects may also be seen due to secondary effects of injury. The size of the area affected also generally presents with a positive correlation to the outcome. For example, insult to the visual cortex will primarily lead to major loss of vision and to a less severe extent, other deficiencies (for example personality changes) may be evident.

- There can be the release of a new function.

This is when, after a brain injury, the incidence of a behaviour is increased, or a new behaviour novel to premorbid behavioral repertoire appears. Such a postconcussive, acquired behaviour can include compulsive rituals.

- There can be the disorganization of function.

In this instance an aspect of behaviour becomes inappropriate. Although the behaviour is not lost, it occurs at the wrong time and place. For example, the patient may show an inability to make tea due to getting the sequence of the activities wrong.

Organic factors which have been associated with the outcome of MCHI, are discussed above. Accordingly, head injuries, which may be defined as mild, due to brief (or no) loss of consciousness, can result in severe deficits (Lezak, 1995). This usually happens if areas damaged are at sites distant from the brain sites which regulate consciousness (Kay & Lezak in Corthell, 1990). The manifestations of such organic damage correspond significantly with the presentation of PCS.

PCS can develop without evidence of organic damage (Lishman, 1988). Authors like Ruijs, Keyser and Gabreels (1994) concur that head injuries which initially appear to be mild, occasionally give rise to severe complications, even in the absence of specific neurological signs. In these instances PCS is often associated with various other factors (which include psychogenic, social and demographic factors). Deb, Lyons and Koutsoukis (1999) found that these risk factors are more influential in the event of MCHI than when the injury is moderate or severe.

## 4.2. Age

Findings like those of Stambrook and coworkers (1993) suggest a negative correlation between age and measures of outcome following head injury. Youthfulness is generally associated with better outcome. Mittenberg *et al.* (1992) found that children have fewer cognitive deficits following MCHI. An exception to this may be infants. Injury during infancy can often lead to generalized deficits, most of which may only become evident in later life (Watts-Runge, 1993).

Teuber (in Kolb & Whishaw, 1990) found that the outcome of head injured soldiers was better in the age group 17 to 20, when compared to 21 to 25 year old soldiers. The latter group, in turn showed better outcome than soldiers 26 years and over. Kolb and Whishaw (1990) suggest that being over 40 years old negatively affects the individual's prognosis. Richardson (1990) also associates poorer outcome with older age. According to Stambrook *et al.* : "In the aged, even a high GCS on admission may be associated with death or poor outcome" (1993, p. 100). These authors ascribe this poor outcome of MCHI in the aged to increased vulnerability of the brain and the probable presence of premorbid cerebral pathology. Also associated with older age is less cognitive flexibility and generalized neuronal loss, making this age group more susceptible to the potentially detrimental effects of MCHI.

From the above it appears that age *is* a variable to be considered when assessing the impact of MCHI. It appears that the prognosis of young adults is better than that of older adults, and that the

effects of MCHI on children (especially infants) are more difficult to assess.

#### 4.3. Lateralization, gender and handedness

The ideas of lateralization involve the association of various functions to specific sides of the brain. For example, logical reasoning and language are considered to be functions performed predominantly by the left hemisphere. Damage to a particular hemisphere may therefore have more severe behavioural consequences, depending on the aspect of functioning discussed. For example, emotional processes are dominant in the right hemisphere, and injury to this hemisphere will probably result in marked labile affect. Generally however, the other hemisphere will compensate for a loss of function to some degree.

Kolb and Wishaw (1990) state that females and left-handed people have better outcome in the event of head injury. The possible reason provided for this is that both females and left handed people are less "lateralized". They tend to rely more on both cerebral hemispheres, than do males and/or right handed people. In the event of injury to a particular site in a hemisphere, the opposite hemisphere will absorb that function more readily, since the intact hemisphere is already "fit" to a particular function. Loy and Milner (in Kolb & Wishaw, 1990) found that axonal sprouting in female rats was more vigorous than that of male rats. Kolb and Wishaw (1990) state that one explanation for this may be that female hormones facilitate axonal sprouting more readily than do male hormones.

Richardson (1990) states that good outcome for *all* head injured patients is facilitated if damage is confined to one hemisphere of the brain. Single hemisphere injury leaves the other hemisphere to compensate for the structures affected by the injury.

#### 4.4. Premorbid personality

Kolb and Whishaw (1990) state that post-injury changes in affect and behaviour exhibit much more intersubject variability than changes related to cognitive functioning. It appears that a major determinant of this variance is that of premorbid personality functioning.

According to Kolb and Wishaw (1990), the pre-injury behavioral repertoire almost certainly interacts with the severity and length of the symptoms. Optimistic and extroverted individuals have better outcomes following head injury (Kolb & Whishaw, 1990). Kay and Lezak (in Corthell, 1990) believe that although a typical behavioural repertoire may be altered by the head injury, dominant personality characteristics usually persist post-trauma. These dominant traits then have an effect on the outcome of the injury. Personality traits which include fighting spirit, motivation and resilience, together with the acceptance of assistance or guidance from others, are traits which facilitate the recovery process (Kay & Lezak in Corthell, 1990).

People who have perfectionistic tendencies benefit from the motivation component of their personality, but suffer due to the

high standards they set for themselves. The general outcome for such individuals is generally mixed (Kay & Lezak in Corthell, 1990).

Poorer outcome appears to correlate with dysfunctional premorbid personality traits. Lishman (1988) states that neurotic personalities and histories of psychiatric illness are possibly important in determining the emotional outcome of CHI.

Kay (1996) also states that PCS is prolonged in individuals who were described as neurotic or anxious prior to the injury. Perhaps this is because they are more concerned, and for longer, about the deficits which they are experiencing. The fact that others are telling them that they have no deficits may only add to their concerns.

Kay and Lezak (in Corthell, 1990) describe the personality types which often correlate with poorer outcome from MCHI, as those who are chronically depressed, those easily overwhelmed by stress and those who refuse to accept the help of others. Ruff *et al.* (1996) report on a case study of four MCHI patients with the following pre-morbid personality traits; grandiosity, perfectionism, borderline traits with depression and unmet childhood needs. According to these authors, people with these pre-morbid character traits are more likely to become one of the "miserable minority" (the 10% in whom complaints persist after 12 months post-injury). Joseph (1990) found that many head injured patients with poorer outcome, suffered a bout of depression or other emotional disturbances (for example, they fought with a significant other) immediately prior to the injury.

Rutter, Chadwick, Shaffer and Brown (1980) found that children with MCHI who present with prolonged behavioural disturbances, have premorbid histories of impulsivity and erratic behavior. Ponsford and coworkers (1999) found that children "at-risk" for problems after MCHI commonly have pre-existing learning problems, psychiatric, neurological or family problems.

Problems with findings relating to premorbid personality, include difficulties associated with measuring premorbid personality, as well as the difficulties associated with the head injury actually affecting the personality (Kolb & Wishaw, 1990). For example, ascribing a post-injury lack of volition (as typically found in compromised executive functioning) to a premorbid trait, could be vastly off the mark.

Binder (1986) states that although various pre-injury characteristics may predispose an individual to lingering symptoms post-injury, many high functioning premorbid individuals *do* develop the PCS symptomatology.

#### 4.5. Intelligence and education

Premorbid intelligence can be an indicator of outcome (Lezak, 1989). Individuals with higher intelligence have been found to recover better from head injury, than those with lower intelligence (Kay & Lezak in Corthell, 1990; Kolb & Wishaw, 1990). Kolb and Wishaw (1990) caution that this phenomenon may be *totally* due to the higher premorbid functioning that such individuals have, rather than truly enhanced recovery. Joseph (1990) argues that head

injury has a worse effect on less intelligent individuals, since they have fewer capabilities to fall back on, so that a highly educated individual, who has a greater pool of resources with which to compensate, may experience a loss of functioning, yet still function at a much higher level than a less educated individual.

Deb *et al.* (1999) found a statistically significant relationship between premorbid formal education and outcome of head injury after one year. In addition to this, Joseph (1990) found that fifty percent of head injured individuals have poor premorbid intellectual functioning suggesting a reciprocal effect between premorbid intelligence and the incidence of head injury, both of which negatively effect the outcome of MCHI. (Repeated head injury is associated with successively poorer outcome.)

Dickerson-Mayes, Pelco and Campbell (1989) found a positive correlation between preinjury IQ (obtained from educational records) and IQ point loss, suggesting that more intelligent individuals suffer more from the effects of head injury than do those with lesser intelligence (even if they do eventually stabilize at a higher base line than lesser intelligent individuals).

In general it appears that the effect of intelligence on the outcome of MCHI is controversial, but that higher premorbid intellectual functioning is associated with better post-injury functioning.

#### 4.6. Insight and acceptance

The head injured person's capacity for becoming aware of his/her own limitations and accepting the reality of the new self, may be compromised with the injury. In the case of MCHI, this may be seen when the frontal lobes are damaged and a diminished capacity for self-monitoring results. For example, failure to perform a task does not result in the reasoning and planning to perform the task on a following occasion. One can expect outcome to be negatively affected, in that such an individual does not have the capacity to check him/herself, and his/her progress. In addition to this, the probability of benefiting from psychotherapy is limited if insight is poor.

#### 4.7. Malingering

Since the MCHI patient often has only brief hospitalization (if any) and is usually discharged when other external concomitant injuries are healed, MCHI victims are often accused of malingering when they present with PCS (Mittenberg, Azrin, Millsaps & Heilbronner, 1993a).

Since the etiology of PCS is debatable, professionals are wary of "compensation neurosis" or "compensationitis" (Binder, 1986; Nell & Yates, 1998). This is the malingering of symptomatology due to the prospects of compensation via litigation. Confounding this argument is that the process of litigation is stressful and can contribute to the behavioral deficits displayed (Binder, 1986).

Nell and Yates (1998) also warn that "cognitive dissonance" can develop between the treating professional and the patient when

there are disparities between the parties' respective perceptions of the impact of the MCHI. It seems reasonable to assume that this dissonance can pervade many of the patient's relationships and can lead to the suspicion of malingering.

Joseph (1990) states that less than 1% of mildly injured patients are involved in litigation, and therefore do not have reason to malingering. It appears that purposeful malingering for the purpose of compensation is not likely among most MCHI patients. There may however be sick role enactment due to such behaviour being reinforced by others.

#### 4.8. Family system

Whether PCS occurs immediately after the injury or only some time thereafter, patients and their families are often not prepared for the consequences of MCHI with which they are confronted.

"Head injury happens to the entire family, not just the injured person" (Kay & Lezak in Corthell, 1990, p 57). According to these authors, a head injury to any one member of a family system instantly disturbs the homeostatic balance of that family system.

The relationships among all family members (not just between the head-injured and others) are adjusted after a head injury, in an effort to restore an equilibrium. Families differ in their ability to negotiate this new equilibrium (Kay & Lezak in Corthell, 1990). Peters, Stambrook and Esses (1990) found that PCS is associated with social difficulties, especially when significant others become

frustrated with the complaints in the absence of physical symptoms. Stambrook, Moore, Peters and Zubek (1991) found that head injuries especially (rather than other physical injuries like spinal cord injuries) caused alterations in the perception of significant others of the injured individual.

The context in which a head injured individual functions has a great impact on the outcome of the injury (Bergland & Thomas, 1991). Factors within the family which can foster a good outcome are the extent to which the family can balance hope and reality, the family's provision of adequate structure and the ability of the family to provide guidance and protection without encouraging dependence (Kay & Lezak in Corthell, 1990). These factors are in turn affected by the expectations of the family, where realistic expectations following the injury are more conducive to good outcome (Mittenberg *et al.*, 1992).

Kay and Lezak (in Corthell, 1990) estimate that the impact of the family on the outcome of the head injury is predictable on the basis of the way they coped with previous crises. A family which was inflexible and showed difficulties in dealing with developmental issues and a low stress tolerance, will more than likely display the same inflexibility and inappropriate coping mechanisms toward head injury.

The effect which the family has on the outcome of the individual, is not unidirectional. Also important are the *patient's* behaviour and dependence and the effect that these have on the support that the family is prepared to give. There is thus a recursive pattern of interaction between the members of the family system.

Should a family system be unable to cope with the head injury and the individual with the injury decide to move out, such a change in environment can either cause spurts of improvement in functioning, or severe setbacks. Should such change in environment lead to increased social involvement, the outcome of the injury can be greatly enhanced (Kay & Lezak in Corthell, 1990).

#### 4.9. Lifestyle

The life-style of some individuals predisposes them to a high risk for head injuries. According to Joseph (1990), thirty percent of head injured individuals have had previous head traumas. Repeated head injury, in turn, is associated with successively poorer outcome (Naugle in Bigler, 1990).

Regular alcohol abuse also correlates with both the incidence and poor outcome of head injury. This is due to alcohol abuse increasing the incidence of both violence and accidents, as well as causing neurological damage, which compromises the brain prior to the insult (Joseph, 1990).

#### 4.10. Socioeconomic status

Socioeconomic status has been related to the period of persistent PCS. A study done by Rimel, Giordani, Barth, Boll and Jane (1981) found that 100% of managerial level patients who presented with PCS returned to work within three months after MCHI. On the other

hand, just over half the unskilled labourers in the study with similar injuries had returned to work after three months. Perhaps the personality type typical of managers also affected the outcome of this study (rather than socioeconomic standing only).

Although the period of persistence of PCS correlates negatively with socioeconomic status, there appears to be no correlation between socioeconomic status and the type of symptoms of MCHI - different socioeconomic groups do not present with significantly different permutations of the PCS symptoms described in chapter 3. This has led investigators like Miller (in Binder, 1986) to speculate that lower socioeconomic groups find their jobs less desirable and rewarding, and have less motivation to resume their duties than do those in higher income groups (who will probably perceive themselves as having more control over their working environment). Perhaps the likely link between lower socioeconomic status and lower levels of intelligence also affects the persistence of PCS, in that the lower socioeconomic groups will experience greater cognitive decline due to lower premorbid levels of intelligence (the effect of intelligence on PCS is reviewed in section 4.5).

Most studies that investigated socioeconomic status and MCHI together, have supported the relationship between these two variables from the angle that socioeconomic status correlates negatively with the *incidence* of head injury (for example Parkinson, Stephenson & Phillips, in Bigler, 1990). Reasons for the direction of this relationship include fights and falls, which appear to be more prevalent in the low socioeconomic group (Parkinson *et al.*, in Bigler, 1990).

When considering the higher incidence of MCHI in lower socioeconomic groups, it should be kept in mind that individuals who have sustained repeated head injuries will have poorer outcome and that MCHI victims in this socioeconomic group will generally have fewer resources to deal with the problem. In addition to this, it is thought that the additional stress of low socioeconomic status may also negatively affect the outcome of MCHI. The effect of stress on the epidemiology of psychopathology is well documented (for example, Barlow & Durand, 1995).

In the case of children, social status appears to be a major predisposing factor to head injury. Rutter *et al.* (1980) found that lower socioeconomic status correlates positively with the lack of adult supervision and the incidence of head injury. These children then also have inadequate social support post injury, which may very well manifest as prolonged PCS.

#### 4.11. Community and employer support

The availability of therapy and other programs, as well as support groups within a community, can have a positive effect on the outcome of head trauma (Oddy, Humphrey & Uttley, 1978).

The work environment can also affect the outcome of MCHI. Work superiors who foster good outcome of head injury, show interest in the injury. Accordingly, the superior will act in a manner to find out about the injury and the prognosis. Such an attitude will possibly permeate to the injured person's co-workers, enhancing the support which he/she enjoys.

If the work superior is also flexible regarding work expectations from the head-injured individual, it will probably correlate with better outcome (Kay & Lezak in Corthell, 1990). A flexible superior is one who is facilitative and does not constantly look out for "slip-ups" with the aim of dismissing the worker.

#### 4.12. Expectations

Mittenberg *et al.* (1992) adds the role of expectations to the list of general predictors of MCHI outcome. The rationale behind this variable affecting the onset and persistence of PCS, is that of self-fulfilling prophecy. A controlled study conducted by Mittenberg *et al.* (1992) hypothesized that symptoms following MCHI are related to symptoms which individuals would *expect* in the event of a head injury. The result of the study suggests that PCS is indeed also a manifestation of expectations. Mittenberg *et al.* (1992) further verifies this finding by stating that children have fewer expectations of deficits following MCHI, and also are less prone to PCS.

Bohnen and Jolles (1992) argue that the anxiety provoked by considering the possible consequences of the head injury is sufficient to cause a psychogenic etiology of PCS. It appears that this fits in with the findings of Mittenberg *et al.* (1992). If one experiences anxiety due to the expectation of compromised functioning, the anxiety may well cause the PCS. This, the above researchers argue, should not be seen as malingering. The actual physical changes due to the injury may also cause anxiety, exacerbating the symptoms of PCS.

Accurate information during the diagnosis of MCHI may ultimately enhance the outcome of the injury. This is because individuals will know what to expect, and thus realistically suspect which symptoms may be due to the injury, rather than some spontaneous personal incompetence. For example, those MCHI patients who experience a "shaken sense of self" often report that they feel they are "going crazy" (Kay, 1996, pp. 10-11). These patients and their support systems will benefit simply by knowing that this is a symptom of PCS, and will be better equipped with coping strategies.

Nell and Yates (1998) talk of "cognitive dissonance" which can develop between the professional and the patient if these two parties have contrasting expectations regarding the outcome of the injury. Naturally this dissonance can also manifest between the patient and his/her significant others if the former is not behaving according to the prognostic guidelines provided by the professional. This dissonance in itself can affect the outcome of the injury. The most obvious way of alleviating or minimizing the cognitive dissonance between the patient and others is if the prognosis of the patient is valid. Unfortunately the predictive validity of the most commonly used current assessment technique for MCHI (the GCS) is low (chapter 5 elaborates on this). One reason for the low validity is that assessment occurs in the acute phase only.

#### 4.13. Timing of assessment/s

Because the term "mild" generally implies transience, routine prognostic procedures typically involve the assessment and diagnosis of a head injured individual in the acute phase only. The

patients are usually discharged from hospital when concomitant external injuries are healed. It is also common for a patient with a GCS score of 15 to be discharged and assumed recovered from concussion, without regard for the level of psychological functioning.

Many behavioural manifestations of MCHI can become evident once a premorbid level of functioning is required from the patient, when routine demands resume.

Suspensions of malingering or "compensationitis" (especially if the onset of PCS is delayed) may arise in both the treating professional and significant others. This cognitive dissonance may very well lead to anxiety in the patient and the withdrawal of support by significant others. This, together with the patient not being kept in the treatment loop, can severely affect the outcome of the injury.

Blakely and Harrington state that "...chronic post-concussive mental status can only be assessed through thorough examination which should be carried out about six or more months following injury." (1993, p. 235). These authors make explicit the low validity of acute morbidity indices on the long-term outcome of MCHI. A study by Anderson, Housley, Jones and Slattery (1993) showed similar results. Lezak (1995) concurs when she proposes that testing during the third to sixth month after injury, may give a better indication of the patient's ultimate mental condition, thereby fostering realistic expectations (see section 4.12).

Acute assessment appears incongruent with an injury that appears to have a progressive component, irrespective of whether this component is physiological or psychological. Acute phase

assessment disregards the secondary brain injury which may be developing, the structural reorganization of the brain, as well as progressive psychogenic factors which may affect the outcome of the MCHI. Acute phase assessments may lead to a patient not receiving any rehabilitation, even if this is needed.

## Conclusion

Various factors have been associated with the outcome of MCHI and PCS. Where some investigators (like Conzen, Ebel, Swart, Skreczek, Dette & Oppel, 1992) argue that PCS is an organic neurological disorder, other investigators argue that PCS is a psychological disorder. It appears that the distinction of these two etiologies guides the rehabilitation approach. Traditional psychotherapy methods may very well be successful in the event of psychogenic trauma, whereas they will be of little (if any) value in the event of neurological damage (Kay, 1996). Kay (1996) states that using psychotherapy with neurologically compromised individuals will probably worsen the problem in that encouraging such a person to explore his feelings of rage can lead to uncontrollable outbursts of rage. This author believes that neurologically compromised persons can benefit from a structured approach to helping them understand and control (rather than explore) their emotional and behavioural deficits.

It seems more appropriate to adopt a holistic approach and consider *all* factors affecting the onset and persistence of PCS when making a prediction of outcome of MCHI. These factors range from the physical impact of the insult to the brain, to personal factors and the

social context. Although each of these factors can be studied individually, the interaction between the contributing factors is important, as well as what the patient and his/her social network *expect* will result from the injury. Such a holistic approach to the assessment (and impact) of MCHI can only be done if the timing of the assessment of the patient is not limited to the acute phase only.

The following chapter discusses established techniques for assessing MCHI, each of which have advantages and disadvantages, as well as a new technique, the GCS-E, which was developed with the aim of overcoming the disadvantages of the more traditional measures (Nell, 1997).

## CHAPTER 5

### Measures indicating severity of brain injury

Various tests can be administered when assessing the extent of brain injury in head injured patients. Currently the most common of these are the Glasgow Coma Scale (GCS) and the duration of post-traumatic amnesia (PTA). This chapter discusses the GCS, PTA and finally the Glasgow Coma Scale-Extended (GCS-E) as indicators of the severity of head injury. This final measure (the GCS-E) is the focus of investigation in this study. It is currently not yet routinely used in the assessment of MCHI.

#### 5.1. Glasgow Coma Scale

The most common measure of severity of brain injury is the GCS. The GCS is a well-accepted, brief and uncomplicated technique. Although the title of this test suggests that it is used when the patient is unconscious, it is generally used even when the patient is conscious, to determine the level of awareness. The GCS measures levels of consciousness from mild confusion to deep coma, on the basis of eye, verbal and motor response on a scale from 3 to 15 (see Table 5.1). Low scores indicate low levels of consciousness and suggest poorer prognoses and vice versa.

The GCS has been criticized for its lack of suitability for the full spectrum of closed head injury patients. Critics state that the GCS does not provide a diagnostician with an accurate measure when

TABLE 5.1.

## The Glasgow Coma Scale

Eye Opening	Spontaneous	4
	When asked	3
	To pain	2
	Does not open	1
Verbal	Coherent	5
	Disorientated	4
	Nonsensical	3
	Sounds	2
	None	1
Motor response	Follows commands	6
	Pushes examiner away on pain	5
	Pulls away on pain	5
	Flexes inappropriately on pain	3
	Decerebrate posture	2
	None	1

used in MCHI cases specifically. This argument is augmented by the developers of this scale who explicitly state that the scale is unsuitable for MCHI cases: "[GCS] ...not intended [for] ...milder injury." (Jennet, 1989, p.24). The developers of the GCS argue that a high GCS score immediately after injury, is often not a true representation of the injury, in that the assessment of eye opening, verbal response and motor response does not recognize the subtleties associated with mild injury (Jennet, 1989). This criticism of the GCS is supported by authors like Blakely and Harrington (1993), who state that there is a high incidence of severe sequelae to apparently mild head injuries.

It appears that the GCS may be useful in that the extent of involvement of the reticular activating system and cortical arousal can be determined. The GCS will reflect a high score if the reticular activating system is not compromised but largely disregards other subtler deficits. The effects of secondary injury and organic recovery (as explained in 2.2 and 2.3 respectively) as well as non-organic factors (as explained in 4.2. to 4.13) are also not taken into account when the GCS is used in isolation.

Critics of the use of the GCS in MCHI further argue that the unsuitability of the technique is exacerbated by the few points on the scale corresponding to mild injury, as opposed to a greater number for more severe injuries. A GCS score of 3 to 8 indicates severe head injury (about 10% of all cases), 9 to 12 for moderate injury (again about 10% of all cases) and 13 to 15 (three points) for mild injury, which makes up 80% of the reported cases. The proportion of MCHI could be much higher if one considers that many MCHI victims never report their injuries. According to Miller

(1996), it is estimated that between 20% to 40% of MCHI cases in the United States are unreported.

## 5.2. Post-traumatic amnesia

Head injury is often accompanied by memory loss. A distinction between two types of memory loss is generally drawn; these are retrograde amnesia and post-traumatic amnesia (PTA), or anterograde amnesia. The former is the forgetting of events immediately prior to the trauma and the latter is the memory loss for events that occur after the accident.

PTA is frequently used in the assessment of the severity of head injury, in that the duration of PTA is considered to be an important indication of the severity of CHI (Bishara, Partridge, Godfrey & Knight, 1992; McMillan, Jongen & Greenwood, 1996). PTA is defined as the period of amnesia from the accident until continuous memories are laid down. PTA of 1 to 7 days is typically associated with severe head injury and 1 to 24 hours with moderate head injury. A head injury can be described as mild only if PTA is limited to a period of one hour or less (Kolb & Whishaw, 1990).

PTA, it is thought, reflects DAI and/or disrupted hippocampal and temporal lobe functioning (for example, Carpenter, 1991).

Some authors consider PTA to be superior to other measures of CHI (even sophisticated techniques such as MRI): "Post-traumatic amnesia is considered to be the best single indicator of the severity of closed head injury" Mc Millan *et al.* (1996, p. 422).

Haslam, Batchelor, Fearnside, Haslam, Hawkins and Kenway (1994) found that the relationship between PTA and cognitive outcome is such that a slight increase in the length of PTA is associated with a significant decrease in cognitive functioning. Various earlier studies reported similar findings (Brooks (in Wood, 1990); Haslam *et al.*, 1994; Stambrook *et al.*, 1993; Teasdale & Jennet, 1974; Wood, 1990). Other authors, such as Oddy *et al.* (1978) and Richardson (1990) report statistically significant relationships between the length of PTA and other specific (non-cognitive) outcome variables (such as return to work).

Critics of the use of PTA as diagnostic tool for the assessment of CHI, state that establishing the length of PTA is usually done retrospectively. This, they say, could lead to distortions of the length of PTA.

The retrospective assessment of PTA has been researched and findings like that of Mc Millan *et al.* (1996) show the retrospective assessment of PTA to be a valid method in the assessment of severity of brain injury and the outcome thereof.

During recovery, the progressive shrinkage of amnesia and enhanced learning ability typically presents (Malec, Goldstein & McCue, 1991) and PTA ends when continuous memories are laid down.

Establishing whether complete recovery from PTA has occurred or not, can be problematic. This difficulty can be due to the interference of island memories (Nell, 1997; Gronwall & Wrightson,

1980), or due to PTA assessment in the acute phase of the injury only (Nell, 1997).

Island memories refer to the recall of isolated events during the amnesic period. Gronwall and Wrightson (1980) warn that arousal and stimulation of specific events shortly after the trauma, may result in a vivid island memory for the event. Importantly, these island memories do not mark the end of PTA. These authors suggest that there are two phases in which island memories are probable. The first phase of island memory coincides with short-term recovery and stabilization of the insult to the brain. This typically occurs within an hour of the accident. The second phase, these authors speculate, occurs when the secondary effects (oedema, hemorrhage and biochemical changes) of the incident have stabilized (secondary injury is discussed in chapter 2).

Another problem regarding the assessment of amnesia is that what may appear as amnesia, may be drug induced memory dysfunction. Patients who arrive at the hospitals may either have surgery, or be given morphine or other potent analgesics and/or sedatives. These medical interventions will depress awareness and artificially prolong PTA.

A further problem associated with the assessment of PTA is that it often increases with passing time (Nell, 1997). This means that a MCHI patient may recall waking up at the scene of the accident when he/she arrives at hospital (thus presenting with little or no PTA during the acute phase assessment). However, the next day the same patient may say that he/she remembers nothing up to

waking up in the ward (presenting with amnesia for a longer period).

The two measures of MCHI (GCS and PTA) discussed here are routinely used in emergency rooms. Their advantages include their ease of use and the familiarity which comes with years of use. A disadvantage associated with both these techniques revolves around the timing of assessments.

Although the GCS and PTA scores can guide prognoses, the assessment of MCHI patients should not be limited to the acute phase only. Acute assessments may be deceiving in that secondary damage may be present and organic reorganization may still occur. Also, the psychological and social effects of the injury (which are not assessed by GCS and PTA) can also affect the presentation and/or onset of the PCS.

Another problem associated with the acute phase measurement of PTA and GCS is that a patient in the acute post-injury phase may be in an "automatic awareness" stage (Hagen, in Corthell, 1990). In this instance the patient appears to be alert and talking, but functions on an automatic level, not having conscious awareness. This lack of conscious awareness is generally not observable, since the patient appears appropriate and oriented. Such a patient will thus be awarded a GCS score of 15 without PTA (if the latter is done at all) in the emergency room.

These disadvantages of the GCS and PTA have led to the development of the GCS-E.

### 5.3. The Glasgow Coma Scale-Extended

The GCS-E is a scale developed especially for MCHI cases. The unsuitability of the GCS and acute phase PTA measures (as discussed earlier), was the impetus for the development of this scale.

The GCS-E, as the name suggests, is an extension of the GCS with the added component being that of amnesia assessments. PTA according to the GCS-E is assessed on a scale from 0 to 7 (see Table 5.2) at fixed intervals, over six months (see Table 5.3). The GCS score is applied as is customary.

The appearance of continuous, consecutive memories indicate the absence of amnesia. A score of 7 will be indicative of no memory loss and 0 will indicate amnesia for period of greater than three months.

Problems associated with acute phase assessment only of MCHI is addressed by the GCS-E by 4 administrations of the measure in about 6 months. The intervals of these administrations are set out in Table 5.3.

The GCS-E is reported in a format whereby the amnesia score appears behind the conventional GCS score, separated by a colon as in the following example, indicating a GCS of 13 and PTA of 5.

GCS-E = 13:5.

TABLE 5.2

Evaluation of PTA according to the GCS-E.

Score	Period of amnesia
7	No amnesia
6	30 minutes or less.
5	30 minutes to three hours.
4	3 to 24 hours.
3	1 to 7 days.
2	8 to 30 days.
1	31 to 90 days.
0	Longer than 3 months.
X	Indeterminable.

TABLE 5.3

Time intervals of administration of the GCS-E

Administration	Timing
1	As soon as possible post-injury
2	24 hours post-injury (no sooner)
3	1 week post-injury (no sooner)
4	6 months post injury (no sooner)

Importantly, a study by Nell and Yates (1998) shows that the GCS-E can be reliably applied by emergency staff.

The technique, developed by Nell (1997), allows for a more chronic assessment of MCHI in that a patient is assessed regularly for at least six months post-injury. It is thought that the GCS-E would provide a more valid prediction for the outcome of MCHI than the GCS. Patients with a high GCS, but low amnesia score in the GCS-E, can be identified as being at a higher risk of developing PCS.

A sensitive MCHI measure can possibly enhance the ultimate outcome of the injury. This is possible by keeping the patient in the treatment loop for an adequate amount of time. Also, rehabilitation strategies can be adapted to suit the expected outcome. Secondly, the patient may experience less anxiety due to knowing what symptoms to expect. Thirdly, significant others will have more congruent and realistic perceptions and expectations regarding the outcome of the injury. This can affect the social support which the patient receives, thereby enhancing outcome. The enhanced prognostic validity of the GCS-E (if proven) may not only equip a MCHI victim and his/her support system with coping strategies, but it can also affect the legal claims of MCHI patients (by negating "compensationitis").

## Conclusion

This chapter initially looked at the two most common techniques for the assessment of the full range of closed head injuries. Both the GCS and PTA have advantages and have proven their respective

utility during many years of use. Yet both of these techniques also have disadvantages, especially when used in the MCHI range. It thus appears that a more sensitive technique for the assessment of the large proportion of MCHI cases is desirable. The GCS-E may offer this enhanced sensitivity, and is the subject of the latter part of this chapter. This study aims to investigate the possibility that the GCS-E is a more sensitive measure of the effects of MCHI than GCS and PTA.

## CHAPTER 6

### Methodology

In the event of head injury, GCS and length of PTA are the indices most frequently used to assess level of consciousness and amnesia respectively. The outcomes of these assessments are, in turn, considered to be of prognostic value to clinicians, in that high GCS scores and short periods of amnesia (or no amnesia) are thought to be associated with good outcome and vice versa. (The theoretical bases for these associations are discussed in chapter 5). The aim of this study is to establish whether the GCS-E is a more sensitive instrument in the assessment of the level of MCHI (and thus a better predictor of outcome) than the GCS and PTA respectively.

In order to assess the value of the GCS-E in comparison to the GCS and PTA respectively, individuals who had sustained MCHI, were assessed to establish whether measures of psychosocial status six months post-injury, correlate better with GCS-E scores (done retrospectively) than either GCS or PTA.

This chapter sets out the hypotheses, the data collection and the method followed in this study.

#### 6.1. Hypotheses

##### 6.1.1. Hypothesis one

There is positive correlation between GCS scores and measures of outcome, six months after MCHI.

Rationale for hypothesis one.

The GCS is a measure routinely used for the assessment of level of consciousness in all instances of head injury, whether it is mild, moderate or severe. It is generally accepted that there is a relation between GCS scores and outcome. This measure is used despite the low validity of the GCS in for MCHI cases (Teasdale & Jennet, 1974). Hypothesis one investigates whether statistically significant correlations exist between GCS scores and measures of outcome of MCHI, for the participants in this study.

6.1.2. Hypothesis two

There is positive correlation between PTA scores and measures of outcome, six months after MCHI.

Rationale for hypothesis two.

Length of PTA has constantly been found to be a sensitive indicator of outcome following head injury (for example, Mc Millan *et al.*, 1996). It is therefore expected that the length of PTA will correlate with the outcome measures in this study, which involves head injury in the mild range only.

6.1.3. Hypothesis three

The GCS-E (which is a combination of GCS and PTA scores) correlates with more outcome measures and more strongly, than either the GCS or PTA used alone.

Rationale for hypothesis three.

High GCS scores, such as the ones obtained in the event of MCHI, do not necessarily accurately reflect the extent of the brain injury (Teasdale & Jennet, 1974), yet the GCS is routinely used for this type of injury. (Section 5.1. of this document reports on the inappropriateness of using the GCS in the event of MCHI).

The length of PTA, on the other hand, has been shown to be more closely related to outcome within the full range of head injury (from mild to severe).

It is however possible that different psychometric test results (the measures of outcome in this study) may correlate with either GCS and PTA respectively. Should this be the case, it can be argued that GCS and PTA are associated with different deficits due to MCHI. Consequently, both GCS and PTA may have some value (albeit different value) in predicting the outcome of MCHI, six months post-injury. It is expected that combining the two measures (GCS and PTA) would make the GCS-E more sensitive in the detection of the consequences of MCHI, and thus a better predictor of the outcome of the injury.

## 6.2. Procedure

### 6.2.1. Subjects

The participants of the study were sourced mainly from three private hospitals in the Johannesburg area. These were: Sandton Clinic, Sunninghill Hospital and Carstenhof Clinic. Permission was granted by these hospitals, to view hospital records of all patients who were diagnosed with concussion within the previous six months. Suitable candidates were identified. Their trauma reports, contact details, some biographical data and, in most instances, GCS scores were obtained.

### 6.2.2. Criteria for inclusion

The participants in this study were obtained on the basis of availability. They were twenty individuals who met the following criteria:

- They were older than 18 years of age and represented both genders. An age floor of 18 was decided on to control for ongoing, normal cognitive development, which is associated with younger ages. It was argued that a cut-off age of 60 should control for cognitive decline associated with aging.
- Their GCS score was between 13 and 15. This is the range which traditionally classifies a head injured patient as being mildly injured (Teasdale & Jennett, 1974).
- They were fluent in English. This criterion was set with regard to the validity of the psychometric instruments used in the present study, which were standardized for English speaking testees. Comparisons with norms or intragroup comparisons could be distorted by language deficiencies. For example, a

participant who is not completely fluent in English may perform poorly on the similarities subtest (see 6.2.3.3) due to problems in comprehending the subtleties in the language, rather than problematic abstract reasoning (which is what this subtest aims to measure).

Most of the recovery after head injury occurs within the first six months (Mittenberg *et al.*, 1993b). In view of this, the present study aimed to assess the effects of MCHI, six months after the trauma.

### 6.2.3. Appointment protocol

Potential participants were contacted telephonically approximately 5,5 months after they sustained the MCHI, in order to set an appointment date for as close to six months post-injury as possible.

During the telephonic contact, participants were offered a brief background to the purpose of the study (a Masters thesis) and their participation in the project was requested. Appointments with those patients who were prepared to participate in the study were then set up.

The appointments started off with an introductory phase during which the researcher attempted to put participants at ease. This introductory phase proved valuable in that the participants often felt suspicious and had many questions which they had not thought of during the initial telephonic contact. Putting the participants at ease also aided to minimize the effects of anxiety on the responses of the examinees.

Subsequent to the introductory phase, participants were requested to sign a consent form (see Appendix 6.1). Following this, biographical data was obtained (as set out in 6.2.3.1), semi-structured interviews were conducted (as set out in 6.2.3.2) and a battery of psychometric tests was administered (as set out in 6.2.3.3.).

#### 6.2.3.1. The biographical questionnaires

The complete biographical questionnaire, designed to guide the researcher to elicit demographic and background information, is available in the appendix of this document (Appendix 6.2).

Chapter 4 of this study reported on factors which have been associated with the outcome of MCHI. Some of these factors, which are considered nuisance variables in this study, were obtained from the biographical questionnaire and were quantified as follows:

- Level of education

Premorbid intelligence is one of the factors associated with the outcome of MCHI (see section 4.5 of this document). Since the establishment of premorbid intelligence is often not possible, level of education is generally used as an indication of intelligence (for example, Deb *et al.*, 1999).

The present study also regarded level of education as an indication of premorbid intelligence. The level of education was quantified by summing the number of years of formal education which the

respondent had received. For example, someone with a BA degree was allocated an education score of 15.

- Socioeconomic status.

Associations between socioeconomic status and the outcome of head injuries are well documented (for example Rimel *et al.*, 1981), where higher socioeconomic status consistently relates to better outcome following head injury. In an effort to estimate participants' socioeconomic status, participants were requested to indicate their level of income.

Authors like Breakwell, Hammond and Fife-Shaw (1995) caution researchers against requesting research participants for their income level directly, due to the sensitive nature of this information. Breakwell *et al.* (1995) suggest a scale based on income bands to alleviate some of the sensitivity around revealing income levels. With this in mind the present study devised an income scale which divides income levels into five separate income bands. The respective bands were derived by estimating the range of income bands expected at the beginning of the study.

As it turned out, these derived bands did not reflect the range of income bands in the present study. Broadly speaking, the participants in the present study all originated from a higher socioeconomic group (they were all sourced from private hospitals). The income bands used on the biographical questionnaires however, represent a wide range of income levels, which includes very low-income levels. Soon after the commencement of this study it became evident that these very low-income bands were unlikely to

be selected by the sample and that a different income scale might have been more appropriate.

Although it was expected that no participants would tick the lowest two income bands as being relevant to them, these low-income bands were not omitted, and it was thought that these may act as a "check". It is possible for someone from a very low-income group to be taken to a private hospital after an injury (especially when the patient is concussed or unable to supply medical aid or payment details).

The different income bands were allocated scores for 1 to 5, where a score of 1 indicates a very low monthly income and a score of 5 a high monthly income.

The income scale is presented in Table 6.1.

TABLE 6.1

Income scale

<u>SCORE CODE</u>	<u>INCOME (per month)</u>
1	Less than R 1000
2	R 1 000 - R 4000
3	R 4 000 - R 8 000
4	R 8 000 - R 12 000
5	More than R 12 000.

Many participants were not yet in a position of full-time employment (for example, university students), thus showing a level of income equivalent to their monthly allowance. The true socioeconomic status of such participants was estimated by their home environments and living conditions. This estimated income level of the patients was used in the present study.

- Age

The inclusion criteria of this study (see 6.2.2) can only partially control for the effects of age on cognitive functioning. Since the age range of 42 years (from 18 to 60 years of age) is large, the effects of age may still influence the findings. For this reason, age was considered an extraneous variable in this study.

Subsequent to completing the questionnaires, participants participated in semi-structured interviews.

#### 6.2.3.2. The interviews

The aims of the semi-structured interviews included putting the participants at ease for the psychometric tests and eliciting information relating to factors relevant to MCHI outcome (see chapter 4), spontaneously. This information provided qualitative data for the study. The interviews were recorded (with the patients' permission), to facilitate later analysis.

In cases where the information offered was limited, more specific questions (especially regarding PCS symptomatology) were

included. The questions were formulated to cover the following levels of functioning:

- On an emotional level - irritability, aggression, anxiety, depression, mood swings and social functioning.
- On a cognitive level - memory, attention and concentration, motivation and persistence.
- On a physical level - headaches, fatigue, sleep disturbances, sensory disturbances, dietary changes (not deliberate changes) and changes in alcohol tolerance and alcohol consumption.

Other information also obtained during the interview, included issues regarding occupation, achievement of siblings and general social functioning. This information served as a source of qualitative data and control for the biographical data.

The interviews also supplemented the information pertaining to the independent variables (especially PTA) of this study.

- GCS

This information was obtained from the hospital records of the participant. According to the definition of MCHI, this value should range between 13 and 15. However, the GCS values obtained from the hospital records did not reflect this range.

No GCS scores other than a score of 15 were indicated on the hospital records. In eight cases the diagnosis was concussion, and in 10 cases a GCS score of 15 was given. Five cases had no GCS score but the hospital records either stated that the patient had

suffered a concussion, whiplash or a brief period of loss of consciousness. Various reasons for this homogeneous GCS score can be given:

Firstly, patients typically do not always go to the hospital immediately after the injury (since the injury is not life threatening). Hospitalization in all of the cases occurred within a minimum of a few hours only. This delay in hospitalization and assessment of the patient probably contributed to a GCS score of 15 being allocated. A lower GCS score may have been allocated had the assessment occurred within an hour post-injury.

The second problem, which is related to the first one, is that the trauma units (when the patient *does* arrive) have no need to accurately assess the immediate post-injury GCS score of the patient. This, one can assume, is mainly because the staff aim to establish a diagnosis, rather than establish a score for research purposes. Once the diagnosis of concussion is evident, a fine distinction between a GCS score of 13 or 14 or 15 is presumably no longer required.

The above issues caused a problem in the present study because one of the aims was to compare the sensitivity of the GCS and GCS-E respectively, in assessing the outcome of MCHI six months post-injury. In order to overcome this problem and to offer more valid acute post-injury GCS-E assessments, this study *derived* an acute phase GCS score. This retrospective GCS evaluation was done by the researcher, based on the set criteria for a GCS score (see Table 5.1.) and inferring the state of the patient within an hour post-injury

from the hospital records, the participant interviews and significant other reports.

- PTA

PTA was assessed retrospectively in this study. Investigators like McMillan *et al.* (1996) have found the retrospective assessment of PTA to be a valid indicator of the original amnesia. These researchers assessed PTA retrospectively up to six years post-injury and found the correlation between prospective and retrospective assessment of PTA to be  $r=0,87$ .

The retrospective assessment of PTA was done on a scale from 1 to 7. The PTA scale used in this study, as compiled by Nell (1997), is presented in Table 5.2.

In order to allocate PTA scores, participants were asked questions which were an indirect assessment of the period of PTA. Some examples of these questions are: "At what point and in which ward were you when they stitched up your head/put a cast on your arm?", "Who was the first doctor to attend to you?" and "Please tell me exactly what happened as you remember it - not what others told you". The answers to these questions were then compared to hospital records and information from significant others, in order to estimate the period of amnesia.

- GCS-E

GCS-E scores were obtained by combining GCS and PTA scores (as described earlier) for each participant. It is important to note that

the PTA score at the end of a conventional GCS score does not represent a decimal of the GCS. When reporting a GCS-E score, the combination of the two scores is shown as a GCS and PTA score separated by a colon. As illustration, a GCS-E score of 15:4 means that an individual has a GCS score of 15 and a PTA score of 4. The latter score indicates that retrograde amnesia lasted for 3 to 24 hours.

#### 6.2.3.3. Measures of outcome variables

The outcome variables of this study are the constructs which are associated with PCS (Chapter 3 sets out the symptomatology of PCS). These include cognitive abilities, executive abilities, emotional functioning and behavioural regulation. These constructs were measured using psychometric tests.

The materials used for the psychometric testing were selected according to various areas of functioning affected by PCS. These are summarized in Table 6.2.

TABLE 6.2

Tests administered to investigate functioning in particular domains.

<i>Domain</i>	<i>Test</i>
Attention and concentration	<ul style="list-style-type: none"> <li>• Digits forwards</li> </ul>
Mental flexibility	<ul style="list-style-type: none"> <li>• Digit backwards</li> <li>• Trail making tests parts A and B</li> </ul>
Motor co-ordination	<ul style="list-style-type: none"> <li>• Grooved pegboard</li> </ul>
Visuo-construction	<ul style="list-style-type: none"> <li>• Block design</li> <li>• Rey Complex Figure Test copy</li> </ul>
Visuo-motor skills	<ul style="list-style-type: none"> <li>• Coding</li> </ul>
Mathematical reasoning	<ul style="list-style-type: none"> <li>• Number problems</li> </ul>
Memory	<ul style="list-style-type: none"> <li>• Rey Complex Figure Test recall</li> <li>• Rey Auditory Verbal Learning Test</li> <li>• Digits backwards</li> <li>• Coding recall</li> </ul>
Executive functioning	<ul style="list-style-type: none"> <li>• Mazes</li> </ul>
Abstract thought	<ul style="list-style-type: none"> <li>• Proverbs</li> <li>• Similarities</li> </ul>
Perception of postmorbidity functioning	<ul style="list-style-type: none"> <li>• Semantic differential</li> </ul>

*(It is important to note that the pairings of domain and tests above may overlap. The performance on any one of the various tests may depend on more than one domain of functioning. An effort was however made to categorise the tests according to the domain which it primarily measures.)*

#### Attention and concentration.

Attention can be described as the "...selective aspects of perception...so that...an organism focuses on certain features of the environment, to the...exclusion of other features." (Reber, 1985). Attention underlies higher order cognitive processes, suggesting pervasive cognitive deficits in the event of attention being compromised. Concentration is the quality of that exclusive focus on that selected feature of the environment.

### Auditory attention

- Digits forwards

The digit forward subtest requires the testee to repeat an increasingly larger number of digits back to the tester. The testee needs to attend to, and concentrate on, the information presented, in order to be successful. It is thus a measure of the examinee's ability to attend to the task at hand rather than longer-term memory (Van Eeden, 1992). The subtest thus mainly assesses auditory attention. Lezak (1995) agrees that digits forward performance is more closely related to freedom from distractibility than to memory. Lezak (1995) reports on test-retest reliability of this subtest ranging from 0,66 to 0,89.

Various intelligence tests use this subtest for the assessment of attention and concentration (for example the SSAIS-R and SAWAIS). The required ability to mentally track information, is often low in people with MCHI (Lezak, 1995), which makes this subtest suitable for this study.

The digits subtests from the South African Wechsler Adult Individual Scale (SAWAIS) was used in the present study. The raw scores obtained for each participant (that is, the number of digits correctly recalled), was reported as the participant's score on this subtest.

### Mental flexibility

- Digits backward

During the administration of this subtest, examinees are requested to reverse an increasingly larger series of digits presented to them. The information has to be stored in memory and this consolidated information needs to be manipulated. This subtest therefore

assesses attention, concentration, mental tracking, memory and manipulation of information.

Whereas digits forward assesses attention and concentration rather than memory, successful performance on the digit backward subtest requires both working memory and mental flexibility.

Like digits forward, digits backward is also a standard subtest in South African test batteries (for example SSAIS-R and SAWAIS). Although Lezak offers no validity coefficients, she states that: "...the more severe the lesion, the fewer reversed digits can be recalled" and "This test is very vulnerable to...diffuse damage..." (1995, p. 368).

Deficits in memory and mental flexibility are complaints often associated with PCS (refer to section 3.2).

The number of digits in the longest series correctly repeated in a reversed order by each participant, represented the score obtained on digits backward in this study.

- Trail making test part A

During the administration of this subtest, testees are requested to connect sequential numbers which are randomly arranged on an A4 sheet of paper, without lifting the pencil.

Sustained attention, visual scanning and motor ability are the major determinants of outcome on this test (Lezak, 1995). It is part of the Halstead-Reitan battery where it is considered to be a valid indicator of attention and visuo-motor functioning. Individuals with MCHI

typically perform slower on this subtest than normal control groups, with performance decreasing with the increased severity of the head injury (Lezak, 1995). Lezak (1995) reports that although reliability coefficients range from 0,60 to 0,90, most of these are around 0,80.

In the present study, the speed in seconds in which the participants were able to do this task, represented their raw score on this test. The obtained raw scores were converted to age appropriate percentile scores. Since South African norms were not available at the time of this study, English norms cited in Spreen and Strauss (1998), were used. It is generally accepted by neuropsychologists in practice that the performance of white South Africans is comparable to that of British subjects.

- Trail making test part B:

The test is similar to the Trail making test part A test in that the testee is to connect sequential numbers on an A4 sheet. The Trail making test part B test however includes the first [12] letters of the alphabet and the testee is requested to alternate between the digits and the letters when drawing connecting lines.

Mental flexibility and double mental tracking are required for success on this test. As with Trail making part A, the performance of individuals with MCHI on this subtest is consistently slower than that of control subjects (Leininger, in Lezak, 1995). Lezak (1995) reports on reliability coefficients for this subtest usually being in the region of 0,80.

Trail making test part B performance in this study was assessed as follows: A raw score was obtained by timing the participant and a

percentile score was obtained from age appropriate norms cited in Spreen and Strauss (1998).

#### Motor coordination

- Grooved pegboard

Administration of this subtest typically involves examinees inserting [25] grooved pegs into a slotted plate.

Lezak (1995) states that performance on the grooved pegboard is sensitive to general motor slowing. This instrument is thought to validly assess motor speed, coordination and manipulation ability with good test-retest reliability ( $r=0,82$ ) (Kelland *et al.*, in Lezak, 1989). Motor slowing is commonly found in MCHI.

Scoring this subtest involves adding the number of pegs placed in the plate, the time in seconds for the pegs to be placed in the plate as well as a point for each peg that was dropped. This subtest was thus negatively scored in that a high score indicates poorer performance.

#### Visuo-construction ability

- Block design

Administration of this test involves presenting testees with blocks and requesting them to construct designs depicted on cards.

Non-verbal concept formation, problem solving and perceptual organization as well as spatial orientation and visuo-motor

coordination are the main abilities tapped by this test (Van Eeden, 1992). This subtest is regularly found within the non-verbal reasoning component of intelligence tests, where it is considered a valid indicator of visuospatial organization. Lezak (1995) reports on reliability coefficients of this subtest ranging from 0,83 to 0,89.

The block design subtest of the SAWAIS was used as an estimate of visuo-construction ability in this study. Participants' raw scores were converted to standard scores according to age appropriate conversion tables of the SAWAIS.

- Rey Complex Figure Test - copy

According to standard procedure, participants in the current study were requested to copy the Rey Complex Figure. The copy component of the Rey Complex Figure Test (RCFT) assesses perceptual and visuospatial ability. Poor performance on visuospatial tasks (assessed on the RCFT - copy by repeating or omitting elements of the drawing) have been associated with parietal deficits (Lezak, 1995). Poor performance on the organisational component of this task (for example copying the figure in a fragmented format and failing to see the whole) may suggest frontal deficits.

Points were allocated for correct components and the points were summated to derive the participant's score for the subtest. Since appropriate norms are not available, this is one of the subtests in this study which did not make use of norms to derive scaled scores, but comparisons among the participants within the group, were made.

## Visuomotor skills

- Coding

Performing this subtest involves testees' substituting digits for symbols according to a key visually presented and available during the full course of the subtest.

This test assesses attention, visual scanning, tracking and motor speed and co-ordination. Lezak (1995) reports test-retest reliability coefficients ranging from 0,82 to 0,88. Lezak (1995) also reports on findings which show that coding is resistant to practice effects. This is valuable in this study where some participants were subjected to neuropsychological testing at an earlier stage post-injury. The coding subtest is highly sensitive to even minimal brain damage, regardless of the locus of the lesion (Lezak, 1995), enhancing its value for this study.

In the present study, the SAWAIS subtest was used and the raw scores obtained (by counting the number of correctly substituted digits within 90 seconds) were converted to age appropriate standard scores.

## Mathematical reasoning

- Verbal number problems

In the present study mathematical ability was estimated by verbally administering a mathematical problem to examinees. The actual question was the following: "If you have 18 books which you wish to pack on two shelves and you want twice the number of books on

the top shelf. How many books will be on each shelf?" This item is similar to items proposed by Luria (in Lezak, 1995) for testing mathematical ability.

Logical reasoning, attention and mathematical ability can be estimated by performance on mathematical problems. Since logical reasoning and complex attention are frontal lobe functions, one aspect of the competence of frontal lobes can be assessed with verbal number problems.

The time for a correct response (in seconds) was documented as the respondent's score on this test. An incorrect response was allocated a maximum score of 100. This item is not part of a published test and as such does not have a standard scoring procedure and norm tables. The quantification of performance on this subtest was however thought to be suitable for the present situation, which compares performance among members of a group.

## Memory

### Auditory memory

- Rey Auditory Verbal Learning Test:

Auditory memory was assessed with the Rey Auditory Verbal Learning Test (RAVLT). The test consists of 15 nouns, which are read out loud and followed by a request to recall these nouns over five trials. The number of correctly recalled words represents the score for each trial.

The RAVLT assesses immediate memory span, new learning, resistance to interference and long term memory. Lezak (1995) cites good validity and test-retest reliability (up to  $r=0,77$ ) for this subtest. The homogeneous range of language proficiency and education of the participants within this study, renders the RAVLT highly suited to assessing memory functioning in this study.

In this study learning ability was estimated by the summation of the number of correctly recalled nouns over all five trials. A RAVLT post-interference score was also obtained by asking the testee to repeat the 15 nouns (from memory) subsequent to administration of a new (interference) list of 15 nouns.

- Digits – Scaled Scores

The digits subtests routinely used in South Africa are found in the SAWAIS and SSAIS-R. The subtest is scored by summing the scores obtained for digits forward and digits backward. (Digits forward and digits backward were also used separately in this study, as explained earlier in this section). The obtained score is then converted to age appropriate norms and considered to be an indication of general memory functioning and especially auditory short-term memory (Van Eeden, 1992). Performance on this subtest does however also depend on attention and concentration and mental control (Van Eeden, 1992).

In this study, the scores obtained from summing the digits forward and digits backward for each participant, were converted to scaled scores according to the SAWAIS norms, which were standardised on 3 000 cases.

## Visual memory

- Coding recall

The coding recall subtest follows directly after the coding subtest. During the coding recall subtest examinees are requested to recall the symbol-digit pairs from the test. In the present study a score was obtained by counting the number of correct digit-symbol pairs recalled.

The coding recall subtest is thought to assess incidental learning and visual memory. Although this subtest is often used by neuropsychologists (Lezak, 1995), information regarding the validity and reliability of this technique is not readily available. Still, the ease of availability of the participant scores (due to the speed of the administration of this subtest) and the domains thought to be assessed by it, made this an economic and potentially useful addition to the test protocol.

- Rey Complex Figure Test - recall

In the RCFT-recall subtest, the figure is firstly copied from a drawing presented to the participant (as described under RCFT-copy). Following this testees are requested, on two occasions, to reconstruct the drawing from memory. The first request is usually made about three minutes after copying the drawing and the second, approximately 30 minutes later. In the present study the reconstructions were labeled RCFT I and RCFT II respectively.

Test-retest reliability of this subtest which assesses visual memory, ranges from 0,60 to 0,76, and interrater reliability is high at 0,91 to

0,98 (Lezak, 1995). The rationale for including the RCFT recall pivots on its sensitivity to frontal lobe deficits (Lezak, 1995), and that the frontal lobes are at high risk of damage in the event of MCHI (please see section 2.1.2.3). Lezak (1995) does however caution that education can have a significant effect on the performance of this subtest.

In this study a score was obtained according to a standardized procedure as explained by Lezak (1995). This scoring procedure involves awarding points for correct aspects of the drawing. The summation of these points represents the score of this subtest. According to Lezak (1995) this scoring system shows an interrater reliability of up to 0,91.

#### Executive functioning

##### Planning

- Mazes

During the administration of this subtest participants were requested to commence from the centre of each maze and work their way out of it, adhering to certain rules.

"Maze test scores have successfully predicted the severity of brain damage" (Lezak, 1995, p. 657). Mazes are thought to assess executive functioning specifically, since performance is related to both prior planning and volition to perform. The test can also be an indication of problem solving ability. Lezak (1995) reports a

correlation of  $r=0,77$  between maze performance scores and other valid executive function measures (such as driving tasks).

In this study points were subtracted for each incorrect move (for example "going up the wrong path", "going through walls" or lifting the pencil). Standard scores were derived by converting the raw scores according to the norm tables from the Individual Scale for Northern Sotho-speaking pupils. (Although the scaled scores were derived from a younger Sotho-speaking norm group, the scoring of this subtest was considered suitable for the present study which performed within group comparisons.)

#### Abstract ability

- Proverb interpretation

Since no South African tests currently incorporate proverbs, the present study selected proverbs which were thought to be appropriate due to the varying degree of familiarity of the proverbs to the South African population. The four selected proverbs, which became progressively more difficult, were presented to the participants for interpretation. The presented proverbs were:

1. Don't count your chickens before they are hatched.
2. Let sleeping dogs lie.
3. A rolling stone gathers no moss.
4. All's fair in love and war.

The interpretation of proverbs is an effective method of assessing quality of thinking on a concrete-abstract continuum (Lezak, 1995).

Lezak (1995) does however caution that performance on the proverbs subtest may be more a function of familiarity with the proverbs among older testees, thereby diminishing the validity of this test in older people. In young adults the proverbs subtest is considered a valid indicator of abstract thought which, in turn, is an indication of one aspect of frontal lobe functioning.

A maximum score of 2 was given for each correct response, and intermediate score of 1 was given for a concrete, yet feasible interpretation of the proverb. A score of zero was given for a concrete, unfeasible response.

- Similarities

During the administration of this subtest, respondents are asked to describe how two concepts, for example an apple and an orange, are similar. This subtest is a standard inclusion in South African intelligence tests, where it is considered valid in assessing concept formation (for example the SSAIS-R, Van Eeden, 1992) and reliable.

Although she offers no reliability or validity coefficients, Lezak (1995) reports the similarities subtest to be sensitive to left temporal and frontal deficits. The subtest assesses the ability to engage in logical, abstract verbal reasoning and concept formation. Long term memory also plays a role in the successful performance of the test. Abstract reasoning is typically compromised in individuals with injured frontal lobes and thus the inclusion of the similarities subtest in this study.

The present study used the similarities subtest from the SAWAIS. Raw scores and standard scores were obtained according to the scoring procedure in the manual of the SAWAIS.

#### Perception of post-morbid functioning

- Semantic differential

The semantic differential subtest which was included in this study consists of 37 pairs of dichotomous words or phrases. Participants were requested to mark their perceived functioning on the dimensions, first premorbidly and then postmorbidly.

A common sequel of MCHI is emotional upheaval. Patients report that they have changed and feel that they are "going mad". (Section 3.3 of this document reports on this "shaken sense of self" phenomenon.) The aim of the semantic differential was to compare examinees' perceptions of premorbid functioning with their perceptions of postmorbid functioning, mainly on emotional and behavioural levels.

The bipolar phrases from the semantic differential used in the present study were sourced partially from an unpublished report by Jansen (1988) and partially from discussions with neuropsychologists. The semantic differential subtest is available in the appendix of this document (Appendix 6.3).

The subtest was scored by summing the differences in values allocated to premorbid and postmorbid functioning for each item. A large value on the semantic differential would thus indicate a

large disparity between the individual's perception of pre- and postmorbidity functioning. An individual who perceives the MCHI having no impact on his/her life, would allocate the same score to each item, giving such an individual a semantic differential score of zero.

- Semantic differential - significant other

The present study set out to obtain a semantic differential score from the significant other of the participant. The same set of dichotomies as set out in the semantic differential were to be presented to each participant's significant other, with the aim of scoring it in the same way as that of the participants, and then comparing the scores.

The perceptions of significant others regarding the premorbid and postmorbidity differences in functioning of head injured individuals may be valuable in verifying the reports of participants. Large discrepancies between the reports of head injured sufferers and those of their significant others, can be indicative of malingering or what Nell (1997) calls "compensationitis". The semantic differential of significant others may also reveal the level of support the participant has.

Administering the semantic differential to the significant other of each participant proved to be problematic. On no occasion were significant others able to accompany the examinees to the appointments with the researcher. Telephonic administration of the subtest proved to be long, cumbersome and difficult for the significant other to follow. The significant other typically also regarded the semantic differential to be low in face validity and thus

lacked the motivation to take part. A full significant other semantic differential was successfully done on one occasion only. This test was thus omitted from further analysis.

The scores obtained for some psychometric tests (for example digits forward and proverbs) as well as the measures of level of education and socioeconomic status, are not norm-referenced. Such a scoring procedure was thought justified in that this study sought within-group comparisons, or intragroup variations of participants' scores in relation to the various independent variables. Comparisons to the general population or a norm group on a scientifically derived scale are thus not necessary.

### 6.3. Statistical manipulation

Pearson Product Moment Correlations and regression analyses were performed on most of the variables described above (GCS, PTA, outcome variables and some extraneous variables).

#### 6.3.1. Correlations between independent variables and actual dependent variables.

The correlations initially obtained in this study, were based on the independent variables (which are GCS and PTA respectively in this study) and the *actual* scores obtained for the outcome measures (psychometric tests) of this study.

#### 6.3.2. Derivation of residual dependent variables

There are various ways in which the extraneous variables of this study may influence the correlations between the independent variables and the actual measures of outcome. For example, it is likely that someone who is socioeconomically more privileged and who is better educated, will perform better on various psychometric tests than an individual who is of a lower socioeconomic and/or educational level. Lezak (1995) states that higher socioeconomic level is associated with better numerical ability especially, with socioeconomically privileged individuals generally performing better on test which assess numerical ability than socioeconomically disadvantaged individuals.

The actual outcome scores obtained in this study are a function of both the participants' true abilities in a particular domain *plus* the effects of various extraneous variables. An equation like the one below serves to summarize this view:

Obtained score = True score + extraneous variables scores

So: True score = Obtained score - extraneous variables scores

For the purposes of the current research it was thus desirable to obtain true scores or scores as close to that of the participants' true abilities on a specific domain, as possible. From the above equations it is evident that the observed score can give one this true score if the effect of the extraneous variables are known. However, knowing the effect of *all* extraneous variables is unlikely.

The present study did however obtain some data on variables that are likely to affect the obtained scores and can thus be considered

extraneous variables. The extraneous variables which this study investigated were age, education and socioeconomic standing (these were identified as possible extraneous variables in section 6.2.3.1).

In an effort to control for the effect of the extraneous variables (age, income and education) on the various outcome variables, each of the outcome measures were subjected to regression analyses. In these analyses the outcome variables were treated as dependent variables, and the true scores and the various extraneous variables, as the independent variables.

These regression analyses thus determined the influence of the true ability of the individuals *and* the effects of the extraneous variables on the obtained scores. In this manner a residual score, thought to be a closer representation of the true score of the relevant variable, was obtained for each of the outcome measures.

#### 6.3.3. Correlations between independent variables and residual dependent variables.

Pearson Product Moment Correlation coefficients were obtained between the independent variables and the residual dependent variables (as defined above) in this study.

#### 6.3.4. Regression analyses

This study made use of regression analyses for determining the contribution of extraneous variables on test performance and thus for determining the residual dependent variables as described in

7.2.2. Regression analyses were also used for the testing of hypothesis three.

#### 6.3.5. Significance levels

This study considered correlation coefficients which showed p-values of 0,05 or less, as statistically significant. Since the associations between GCS and PTA respectively (considered the independent variables in this study) and the outcome measures (considered the dependent variables) are directional, the actual p-values obtained for the significant correlations can be halved to see the directional probability of the correlation obtained.

A p-value of 0,05 was also set for the regression analyses.

#### 6.4. Qualitative investigation

The sample size of the present study was relatively small, which prohibited further quantitative analyses. To supplement the quantitative testing of each of the three hypotheses, some qualitative observations, associated with each hypothesis, are also discussed.

Qualitative information in this study was obtained from three sources:

Firstly, the responses to the semantic differential indicated which areas of functioning were problematic for the participant after the accident. For example, in this study pre- and postmorbid

differentials were most often reported in the areas of memory, concentration and anxiety.

Secondly, information about postmorbidity distress was often spontaneously given by the participants during the interviews (when this qualitative information was *not* given spontaneously, carefully worded questions were posed as set out in 6.2.3.2 of this document, so as not to lead the participants).

Finally, observations by the interviewer during interviews also provided qualitative data.

A discussion of the qualitative findings is integrated into chapter 8 which also discusses the quantitative findings.

## Conclusion

This chapter outlined the aim of the study which is mainly to investigate whether the GCS-E is a more sensitive indicator of deficits due to MCHI, than GCS or PTA. The procedures followed in this study, which includes using various measuring instruments, were also discussed. The following chapter provides the quantitative results of the study as well as qualitative observations.

## CHAPTER 7

### Results

This study primarily aimed to establish whether a retrospective GCS-E measure is a better indicator of the consequences of MCHI (according to various neuropsychological tests and participant self-report) six months post-injury, than GCS and PTA respectively. This chapter discusses the quantitative results of investigating this aim, in the following sequence:

1. Descriptive statistics of the various variables.
2. Correlations between the independent (GCS and PTA) and dependent variables (psychometric test scores) in the study (as described in hypotheses one and two).
3. Correlations between the independent and dependent variables, when the latter are controlled for the effects of certain extraneous variables, which are known to affect the outcome of MCHI. These "extraneous variable controlled" dependent variables are called *residual* dependent variables in this study (since they represent the remaining score after the effects of extraneous variables are deducted). These correlations between the independent variables and the residual dependent variables are discussed under hypothesis one and two respectively.
4. Finally, this chapter reports on the results of the regression analyses associated with the testing of hypothesis three.

#### 7.1. Descriptive statistics

### 7.1.1. The participants

There were 20 participants in this study. Information on biographical data of the participants was derived from the biographical questionnaire (refer to section 6.2.3.1).

TABLE 7.1

Participants' age, gender, education and income

	Mean	Standard Deviation
Age	27,9 years	10,22
Education	13,95 years	1,9
Income	3,75 (see table 6.1)	1,12
n=20: 11 males, 9 females		

- Age and gender

The aim, regarding age, was to obtain an even distribution within the set range (18 to 60 years). However, since the high-risk population of this type of injury is young males (Miller, 1996), this age group was also most represented in this study.

The mean age of the participants was 27,9 years (SD: 10.22). There were 11 males and nine females. The age and gender distribution of this study corresponds with that of Nell and Brown (1990) who cite incidence rates of head injury based on the 1986 census. These investigators divided the ages of head injured individuals into four categories and report 41,2% to be in the 25 to 44 year age range, with a slightly higher proportion of males (51,21%).

- Education

The participants had a mean education level of 13,95 years. Accordingly, the participants, on average had close to 2 years tertiary education. The standard deviation of 1,90 suggests 68% of the participants were at an educational level of between the commencement of post-matric study and four year post-matric study.

The participants of this study were all sourced from private hospitals, suggesting that they come from a higher socioeconomic group than that of the general South African population. This stratified sampling explains the high mean and low standard deviation found in the level of education of the participants in this study.

- Income

The income distribution was such that a mean of 3,75 and a standard deviation of 1,12 were obtained, using the scale shown in table 6.1. This obtained mean places the average participant of this subject at an income level of around R 7 000 per month. According to the standard deviation, approximately 68% of the participants earn between R 3 000 and R 9 000.

The high mean and low standard deviation of income, is not representative of the general South African population, but is due to the stratified sampling.

- Language

All the participants were fluent in English and thus sensitive to the linguistic subtleties inherent in some of the tests.

- Etiology

The injuries were sustained from motor vehicle accidents and motorcycle accidents (13), rugby injuries (3), horse riding accidents (3) and other accidents (1).

### 7.1.2. GCS

Section 6.2.3.2 of this document explains the difficulties encountered in obtaining GCS scores for each of the participants. The GCS scores had to be derived from various sources of information (hospital records, participant interviews and significant other reports).

Since the GCS defines MCHI as a score of 13 to 15, an approximately even distribution of such GCS scores was desirable in this study. Table 7.1. illustrates the frequency with which each of these scores was obtained in this study.

TABLE 7.2

Frequency table of the GCS scores

GCS score	Frequency	Cumulative Frequency
13	8	8
14	6	14
15	6	20

The GCS values obtained had the desired distribution, with a similar number of cases falling into each category.

### 7.1.3. PTA

PTA is another independent variable in this study. PTA, in this study, can be allocated a score from 0 to 7 (or X, if indeterminable). Refer to Table 5.2 regarding the evaluation of PTA. As with GCS, the aim was to obtain a heterogeneous sample regarding PTA.

Table 7.3 shows the frequencies with which each of the PTA scores were obtained.

TABLE 7.3

Frequency table of the PTA scores

PTA score	Frequency	Cumulative Frequency
7	4	4
6	4	8
5	5	13
4	4	17
3	1	18
2	2	20

Table 7.3 shows that most participants had either no PTA, or PTA for a brief period only. Few participants (3) had PTA for a day or longer. Scores within the lower range of the PTA scale were not obtained since extended periods of PTA do not typically co-occur with MCHI. Low PTA scores are more typical in the event of a more serious head injury.

#### 7.1.4. Outcome measures

In this study the level of functioning six months after MCHI was quantified by scoring the participants' performance on psychometric

tests. Table 7.4 offers some descriptive statistics on the participants' performance on the psychometric tests. The unusually large standard deviations for the number problems and semantic differential subtests are due to the scoring methods employed for these subtests (see section 6.2.3.3).

## 7.2. Results

### 7.2.1. Hypothesis one

There is positive correlation between GCS scores and measures of outcome, six months after MCHI.

- Correlations between GCS and actual outcome scores

Table 7.5 shows the full table of Pearson Product Moment Correlation coefficients between GCS scores and each of the outcome measures.

*At a significance level of  $p=0,05$ , none of the Pearson Product Moment Correlation coefficients between GCS and the measures of outcome were significant.*

According to Table 7.5, the RCFT-copy correlates strongest with GCS. Although this correlation is not significant ( $r=0,40$ ;  $p=0,08$ ), a directional p-value of 0,04 is obtained.

TABLE 7.4

Means and standard deviations of outcome measures six months post-injury.

Test	n	X	SD
Digits Forward	20	6,95	0,94
Digits Backward	20	5,25	1,16
Trail making test part A			
(time in sec) (SS)	20	35,95	25,62
Trail making test part B			
(time in sec) (SS)	20	51,30	27,01
Number Problems	18	25,89	34,59
Blocks (SS)	18	13,50	2,58
RCF Copy	20	35,05	1,10
Coding (SS)	20	13,68	1,80
Pegboard dominant (SS)	19	91,16	15,45
Pegboard non-dom (SS)	19	96,84	13,32
RAVLT	19	54,79	11,47
RAVLT Interfere	19	12,11	3,09
Digits (SS)	20	11,78	1,77
Coding Recall	18	6,56	2,85
RCF I	20	22,90	6,25
RCF II	20	24,35	5,43
Mazes (SS)	20	13,20	3,27
Proverbs	19	4,79	2,04
Similarities (SS)	19	11,5	1,55
Semantic differential	18	25,83	27,36
Key: SS = Scaled Score			

TABLE 7.5

Correlations between GCS and outcome measures

	n	Pearson r with GCS	p-value
<u>Measures of outcome</u>			
Digits Forward	20	-0,14	0,56
Digits Backward	20	0,03	0,91
Trail making test part A	20	0,03	0,89
Trail making test part B	20	0,07	0,75
Pegboard dominant	19	-0,16	0,51
Pegboard non-dominant	19	0,11	0,65
Block design	18	-0,01	0,96
RCFT Copy	20	0,40	0,08
Coding	20	0,11	0,63
Number problems	18	-0,01	0,97
RCFT I	20	0,06	0,81
RCFT II	20	0,10	0,68
RAVLT	19	0,03	0,92
RAVLT interfere	19	0,11	0,64
Digits (SS)	20	0,10	0,71
Coding recall	18	-0,12	0,63
Mazes (SS)	20	-0,03	0,90
Proverbs	19	0,04	0,86
Similarities	19	-0,02	0,93
Semantic differential	18	-0,38	0,12

TABLE 7.6  
Correlations between GCS and residual outcome measures.

	n	Pearson r with GCS	p-value
<u>Residual measures of outcome</u>			
Digits Forward	20	-0,09	0,71
Digits Backward	20	0,33	0,15
Trail making test part A	20	0,05	0,82
Trail making test part B	20	0,28	0,24
Pegboard dominant	19	-0,24	0,32
Pegboard non-dominant	19	0,03	0,91
Block design	18	0,08	0,77
RCFT copy	20	0,38	0,09
Coding	20	0,23	0,33
Number problems	18	-0,06	0,80
RCFT I	20	0,18	0,44
RCFT II	20	0,21	0,39
RAVLT	19	0,24	0,32
RAVLT interfere	19	0,29	0,23
Digits (SS)	20	0,13	0,58
Coding recall	18	0,30	0,23
Mazes (SS)	20	0,01	0,96
Proverbs	19	0,10	0,69
Similarities	19	0,24	0,32
Semantic differential	18	-0,30	0,23

The correlation matrix in Table 7.6 shows the correlations between GCS and the various residual outcome measures (which controls for age, income and education). The definition and derivation of the residual scores are explained in chapter 6.

*At a significance level of  $p=0,05$ , none of the Pearson Product Moment Correlation coefficients between GCS and the residual measures of outcome were significant.*

Table 7.6 indicates that when the demographical variables of age, education and income were controlled for, even the RCFT - copy subtest, which correlated fairly strongly with GCS before controlling for demographic variables, did not correlate significantly.

The present study thus finds no significant correlation between GCS and measures of outcome of MCHI, six months post-injury.

The null hypothesis associated with hypothesis one can thus not be rejected.

#### 7.2.2. Hypothesis two

There is positive correlation between PTA scores and measures of outcome, six months after MCHI.

- Correlations between actual scores and PTA

Pearson Product Moment Correlation coefficients were also calculated between PTA and measures of outcome. The full correlation report can be seen the Table 7.7.

TABLE 7.7

Correlations between PTA and outcome measures.

	n	Pearson r with PTA	p-value
<u>Measures of outcome</u>			
Digits forward	20	-0,29	0,22
Digits backward	20	-0,03	0,90
Trail making test part A	20	0,38	0,10
Trail making test part B	20	0,13	0,57
Pegboard dominant	19	-0,29	0,23
Pegboard non-dominant	19	-0,17	0,49
Block design	18	-0,10	0,69
RCFT copy	20	0,12	0,61
Coding	20	0,03	0,91
Number problems	18	-0,01	0,98
RCFT I	20	-0,15	0,52
RCFT II	20	-0,17	0,48
RAVLT	19	0,14	0,55
RAVLT interfere	19	0,11	0,66
Digits (SS)	20	-0,11	0,71
Coding recall	18	-0,16	0,54
Mazes	20	-0,27	0,25
Proverbs	19	0,01	0,97
Similarities	19	0,07	0,79
Semantic differential	18	-0,42	0,08

*At a significance level of  $p=0,05$ , none of the Pearson Product Moment Correlation coefficients between PTA and the measures of outcome were significant.*

Table 7.7 shows that the semantic differential correlates strongest of all the outcome measures, although not significantly ( $r=-0,42$ ;  $p=0,08$ ).

- Correlations between residual scores and PTA

The correlations between the various outcome measures and PTA were also investigated by controlling for the extraneous effects of the biographical variables identified in section 6.2.3.1 (income, education and age).

Table 7.8 shows the full correlation matrix of residual outcome measures (which controls for age, income and education) and PTA.

*At a significance level of  $p=0,05$ , none of the Pearson Product Moment Correlation coefficients between PTA and the residual measures of outcome were significant.*

According to table 7.8, residual scores of the Trail making test part A and the pegboard showed the strongest (but not significant) correlations with PTA ( $r=0,42$ ;  $p=0,07$  and  $r=-0,39$ ;  $p=0,09$  respectively). Controlling the demographical variables caused the correlation coefficient between PTA and the semantic differential to weaken (from  $r=-0,42$ ;  $p=0,08$  to  $r=-0,37$ ;  $p=0,14$ ).

TABLE 7.8

Correlations between PTA and residual outcome measures

	n	Pearson r with PTA	p-value
<u>Residual measures of outcome</u>			
Digits forward	20	-0,26	0,27
Digits backward	20	0,14	0,56
Trail making test part A	20	0,42	0,07
Trail making test part B	20	0,23	0,33
Pegboard dominant	19	-0,39	0,09
Pegboard non-dominant	19	-0,29	0,22
Block design	18	-0,02	0,93
RCFT copy	20	0,10	0,67
Coding	20	0,12	0,59
Number problems	18	-0,12	0,65
RCFT I	20	0,04	0,86
RCFT II	20	0,01	0,98
RAVLT	19	0,34	0,15
RAVLT interfere	19	0,21	0,40
Digits (SS)	20	-0,06	0,81
Coding recall	18	0,13	0,61
Mazes	20	-0,25	0,29
Proverbs	19	-0,07	0,76
Similarities	19	0,20	0,41
Semantic differential	18	-0,37	0,14

The present study thus finds no significant correlation between PTA and measures of outcome of MCHI six months post-injury.

The null hypothesis associated with hypothesis two can thus not be rejected.

### 7.2.3. Hypothesis three

The GCS-E (which is a combination of GCS and PTA scores) correlates with more outcome measures and more strongly, than either the GCS or PTA used alone.

This study primarily aimed to investigate the utility of the GCS-E in comparison with either PTA or GCS.

The lack of significant correlations associated with hypotheses one and two shows that, in this study, none of the various outcome variables can be associated with either GCS and PTA. GCS and PTA themselves did also not correlate with one another significantly ( $r=0,32$ ;  $p=0,09$ ).

Although there were no statistically significant Pearson Product Moment Correlation coefficients in this study, regression analyses were performed to address whether some of the stronger correlations were due to GCS or PTA, or *both* of GCS and PTA. If the regression analyses show that GCS and PTA separately and significantly contribute to the outcome variables, then their unique contributions to that particular outcome variable is evident. If both GCS and PTA uniquely contribute to the various outcomes, there may be some support for hypothesis three, in that a combination of

the two (as the GCS-E does) provides a better indication of outcome of MCHI than either GCS or PTA used in isolation.

Since the aim was to see the individual effects of PTA and GCS respectively on each outcome variable, the regression analyses considered each of the outcome measures (the psychometric tests) as a dependent variable and GCS and PTA as the explanatory (predictor) variables.

**TABLE 7.9**  
Significant Stepwise regression of outcome measures and GCS and PTA

Summary of Stepwise Procedure for Dependent Variable RTRAILA				
Variable	R**2	C(p)	F	Prob>F
PTA	0.2142	1.0405	4.3622	0.0531
No other variable met the 0.1500 significance level for entry into the model.				

Table 7.9 shows that at (or below) the significance level of  $p=0,05$ , only one regression analysis is significant. According to this significant regression, PTA loads highly on the subtest; Trail making test part A ( $p=0,05$ ). However, it should be borne in mind that although PTA may significantly load on predicting Trail making test part A, that these two variables did not correlate significantly in this study.

The present study thus finds no significant correlation between GCS-E and measures of outcome of MCHI, six months post-injury. The

study shows very slight evidence that PTA contribute toward the performance on one subtest more significantly than GCS.

The null hypothesis associated with hypothesis three can thus not be rejected.

### Conclusion

This chapter presented the results of the study. The testing of hypotheses one and two showed that the null hypotheses associated with each of these respective hypotheses, could not be rejected. Since the testing of hypothesis three involved the analysis of the significant correlations drawn from the earlier two hypotheses, the testing of this hypothesis was greatly limited. According to the quantitative results of this study, neither the GCS nor PTA can significantly predict the outcome of MCHI.

In terms of the rationale followed in this study, the GCS-E does not statistically significantly correlate with the outcome of MCHI and is thus not sensitive in the detection of MCHI.

## CHAPTER 8

### Discussion and Conclusion

The previous chapter described the quantitative results found in this study. This chapter commences with an overview of the rationale behind this study and then offers a discussion of the quantitative results and offers some qualitative observations. Finally, the chapter offers some limitations and implications of the present study.

#### 8.1. Overview

The term "mildness", in general terms, implies transience. MCHI is therefore often assumed to be transient and associated with good outcome. Lezak (1995) defines "good outcome" as the regaining of employment abilities in young adults and the premorbid degree of independence for older people.

Good outcome however, does not always occur in the event of MCHI. Patients who have sustained MCHI sometimes show a variety of persistent, impaired neurobehavioral sequelae (Bohnen & Jolles, 1992; Joseph, 1990). These sequelae have been grouped and labeled PCS. Patients who present with such symptoms are often discharged from hospital and assumed to be capable of resuming normal activities, when concomitant injuries have healed. Ironically the patients themselves often are unable to monitor themselves due to accompanying frontal lobe incompetence.

Reasons for the premature discharge of patients with PCS is often attributed to the assessment of MCHI occurring in the acute phase only, before the full onset of PCS (Nell, 1997), or the unsuitability of the assessment technique. Chapter 5 of this document discusses the most common techniques in the assessment of MCHI and the criticism that these techniques have evoked.

Considering the apparent multiple etiology and persistent nature of PCS, as well as the proven low validity of acute assessment for MCHI, the development of an assessment technique more sensitive to MCHI appears to be in the interest of all MCHI patients, their families and their employers. It was thought that the GCS-E would be an assessment technique which may offer a more sensitive prediction of the outcome of MCHI, in part because it involves assessing the patient over six months (rather than in the acute phase only).

Whether the inclusion of an amnesia component into an established prognostic measure, the GCS, provides a higher level of sensitivity in predicting the outcome of MCHI six months post-injury, was the question which this study addressed. The aim of this study was thus to compare the value of the GCS-E to the GCS and PTA respectively, as predictive tools for the onset of PCS.

## 8.2. Discussion of results

The quantitative testing of the three hypotheses of this study showed virtually no significant results. There was a single significant result which needs to be interpreted with caution.

*Hypothesis one* was tested to investigate whether GCS is a good indicator of what the outcome of MCHI will be six months after the injury. This study found that a GCS score of 13, 14 or 15 (indicating that an individual has sustained MCHI) does not differentiate between the levels of outcome six months after the injury, on a statistically significant level.

The findings associated with hypothesis one are consistent with that of other studies: Various authors have reported on the unsuitability of the GCS for MCHI cases (for example, Nell, 1997; Teasdale & Jennett, 1974).

The aim of testing *hypothesis two* was to investigate PTA as a indicator of the outcome of MCHI, six months after the injury. The results showed slightly higher Pearson Product Moment Correlation coefficients between PTA and measures of outcome than between GCS and measures of outcome, but none of the correlations were statistically significant.

The results from testing hypothesis two are in contrast to those which claim that PTA is "the best yardstick we have" (Editorial in McMillan *et al.*, 1996, p. 422). The reason for the lack of significant results in this study is unknown, but speculated on in section 8.3 of this document.

It is however noteworthy that the Pearson Product Moment Correlation coefficients associated with hypothesis two are generally higher, than those associated with hypothesis one. Table 7.6 shows that two of the correlation coefficients between GCS and

the residual outcome measures are below p-values of 0,15. Table 7.8 shows that four of the correlation coefficients between PTA and the residual outcome measures are associated with p-values of 0,15 or below.

The testing of *hypothesis three* was severely limited by the lack of significant results from hypotheses one and two. The regression analyses reveal a single significant result which shows that PTA alone (that is, without the GCS) significantly contributes to performance on the Trail making test part A subtest. The result of this regression analysis does however need to be approached with caution since the Pearson Product Moment Correlation coefficient between PTA and the particular subtest was not significant.

The lack of statistical significance associated with hypothesis three is not surprising given the results of hypotheses one and two, on which hypothesis three is built.

Although not statistically significant, there were more and stronger correlations between PTA and the residual outcome variables, than there were between GCS and the residual outcome variables. Also, the higher correlation coefficients ( $p < 0,15$ ) between the outcome variables and GCS and PTA respectively, were not between the same residual outcome variables. This may suggest that, had this study been more controlled, the GCS-E may have been shown to be more sensitive than GCS or PTA to the detection of MCHI.

Although the results of testing the three hypotheses of the present study may be due to GCS and PTA (and thus GCS-E) truly not being associated with deficits found after MCHI, the lack of significant

correlations may also be due other factors. For example, Lezak (1995) cautions that there is a possibility is that the quiet test environment, which is conducive to focusing on single tasks, may negate the deficits associated with MCHI (which are often subtle six months post-injury). Retrospective insights of the researcher of this study, also exposed limitations within the study, which are discussed in detail in part 8.3 of this document.

Qualitative observations associated with each of the hypotheses suggest that the limitations within the study may have had a large impact. The qualitative observations show some support for the respective hypotheses.

- Qualitative observations associated with hypothesis one

Three of the six participants who had a GCS score of 15 (representing 50% of these participants), had injuries which they considered to be slight and purely external. Two of these injuries were due to minor motor vehicle accidents and one was a "freak" type accident where a branch fell on the participant's head. These participants all reported that they were sent to hospital on the insistence of others rather than a personal concern for their injuries. All three of these participants replied negatively to the question of whether they were concussed. Should these participants be correct in their self-assessments, it may be that their injuries were so minor as to have no discernible effects.

Two of these three participants with a GCS score of 15 completed a semantic differential. One of these participants obtained a semantic

differential score of nil, and the other had a score of three (representing a very low score), reporting only pre- and postmorbidity differences in caution related concepts.

A fourth participant with a GCS of 15 performed poorly on virtually all of the psychometric tests. This participant had two other head injuries (one mild and one moderate) prior to the one relevant to this study. He sustained one more head injury (it is unclear if this injury was moderate or mild) subsequent to the one relevant to this study. The poor performance of this participant with a high GCS score may thus have been due to the most recent injury, or due to the accumulated effect of prior injuries. The compounding effect of prior injuries is well established (for example Naugle, in Bigler, 1990) and reported on in section 4.9 of this document.

Seven of the eight participants who were allocated GCS scores of 13 (the lowest in the MCHI range), reported that the injury had changed their functioning compared with that of their premorbid perception of self. (Although a semantic differential was not performed on the eighth participant, he too spontaneously reported this change within himself.) The most dominant themes were decreases in memory, increases in anxiety and signs of depression. According to Kelly and Rosenberg (1997) these are typical late onset PCS symptoms.

One of these individuals with a GCS score of 13, reported a type of emotional flattening subsequent to accident, which appeared consistent with the loss of emotional reactivity that Lezak (1995) associates with moderate head injury. The participant reported being calm and not easily upset by anything. This led to a

moderate semantic differential (32) for this individual who had questionable MCHI. (Perhaps her head injury would more accurately have been classified as moderate.)

Although participants with GCS scores of 13 allocated to them mostly considered their own pre- and postmorbidity levels of functioning to be disparate, the psychometric tests often did not show impaired functioning. This may be due to the premorbidity level of intellectual functioning of the individuals or, as one participant stated, her highly cognitively challenging work environment "keeps [her] mind fit". It is also possible that the measuring instruments used in the present study were not sufficiently sensitive for the detection of subtle deficits.

- Qualitative observations associated with hypothesis two

Four participants had PTA scores of 7, indicating that there was no amnesia present. Of these four, three of them questioned the hospital diagnoses of concussion. These were the same three participants who had full GCS scores who believed that they had external injuries only (as reported under the qualitative observations associated with hypothesis one).

The fourth participant with a PTA score showing no amnesia, showed very little distress associated with the accident. He reported that the only difference between his pre- and postmorbidity functioning is in the area of caution. He is more cautious now.

Intermediate PTA scores (5 and 6) were mostly associated with intermediate levels of distress and cognitive deterioration after the incident (seven of the 10 cases), with one reporting increased irritability only. Two participants within this range perceived the head injuries to be insignificant events in their lives.

One of the individuals within the moderate PTA score range had previous neurosurgery performed on him to remove two cerebral tumours. He also has had at least one other head injury, at least within the moderate range. These events also had complications associated with them. Notwithstanding these cerebral insults, the participant completed a post graduate degree and two other diplomas subsequent to his surgery and injury. Perhaps this individual perceived the head injury relevant to this study as insignificant in his life since he has been, to some extent, desensitised by his prior experience with cerebral insults. This participant also appears to have extraordinary psychological hardiness.

The second participant within the moderate PTA score range came across as very relaxed during the interview and reported that the MCHI had virtually no impact on his functioning. This participant was eighteen years old, had just completed his matric exams and was the only participant to report (on the semantic differential) that he is sillier and more out of touch than before the accident. Perhaps a lack of insight together with both the excitement associated with finishing school and youth, could explain his overall low semantic differential score.

Very low PTA scores (2 to 4) were mostly associated with higher disparities in pre- and postmorbidity functioning, mainly in the areas of increased irritability, decreased memory, less need for social interaction and more general confusion. These symptoms are all very typical of PCS (for example Kay, 1996).

One of the participants within this range of low PTA scores, had a perception of very low differentials in pre- and postmorbidity functioning. This participant reported only increases in caution due to the accident. The low differentials in the case of this participant could be due to a combination of her high level of premorbidity functioning and the cognitively challenging environment in which she works (information technology). In addition to the former this respondent reported remarkable support in her domestic and work environments. This finding is consistent with that of Oddy *et al.* (1978) who report on the mediating effects of social support on the outcome of head injury.

- Qualitative observations associated with hypothesis three

Participants who showed a maximum GCS score together with a maximum PTA score, showed little changes in pre- and postmorbidity functioning. The only aspect of functioning that did change for this category, was that there was an increase in caution. One of the four participants who fell within this range of GCS and PTA scores felt that the injury has a positive impact in his life in that he evaluated his personal priorities and made various changes, for the better, to his life.

One of the participants, who had a GCS score of 15 and PTA score of 6 (showing a high level of consciousness shortly after the injury and a short period of amnesia), showed marked pre- and postmorbid differentials in emotionality and some physical complaints (postmorbid nausea especially). During the interview she mentioned that she had not thought of these changes before they were discussed in the present study. This participant telephoned the researcher a week later to report that she had just learnt that she was in the first trimester of pregnancy. The differentials shown in her pre- and postmorbid levels of functioning could have been due to the pregnancy rather than the MCHI.

Six respondents were allocated GCS scores of 14, of which five showed a PTA score of 5. This category marks the midpoint of both GCS and PTA range of scores. It also coincides with the median range of participants:

Eight GCS scores fell below a score of 14 and 6 fell above a score of 14.

Eight PTA scores fell above a PTA score of 5 and seven fell below a score of 5.

These individuals reported the impact of their injuries ranging from an "empowering experience", to having a pervasive negative impact on their lives. It is however noteworthy that the person who reported the pervasive negative effect is involved in litigation regarding the accident. The individual who found the incident to be empowering, had broken off a long standing relationship just prior to the accident, and felt empowered by managing the pragmatics of the arrangements associated with the motor vehicle accident without having to rely on her ex-partner.

There were two individuals who had the lowest PTA scores (PTA=2). One had a GCS score of 14 and the other's GCS was 15. These individuals reported moderate anxiety due to the injury. Their semantic differential scores were 38 and 24 respectively, also showing moderate pre- and postmorbidity differentials in their perceptions of the impact of the injury.

Eight participants had the lowest possible GCS scores of this study (GCS=13). Six of these had PTA scores of 4, 5 and 6. These participants showed moderate differences in pre- and postmorbidity perceptions of their functioning, with semantic differential scores ranging from 6 to 42.

Four of these participants reported that they did not know themselves and were not the same person. For example one of the participant's stated "I feel so stupid". This is congruent with the notion of MCHI being associated with a "shaken sense of self" (Kay, 1996). During the interviews such participants often appeared fatigued, which is consistent with what Miller (1996) reports. (Cognitive deficits make attention effortful, which, in turn causes fatigue.)

The lowest overall GCS-E score within this study was that of 13:3. This individual also had the highest semantic differential score within the study (116), suggesting that he perceived the accident as having more profound effects on his life. Both the participant and his fiancée reported that his temper had become a problem and that his drinking, which was controlled before the accident, is now a problem. His fiancée is considering leaving him since "...he is no longer the man I once knew". Six months post-injury he was still

experiencing dizzy spells and fatigue. This participant's semantic differential reveals that the major changes (all for the worse) occurred in the areas of memory, concentration, affect (much more depressed) and sociability. The participant's performance on most of the cognitive test did not show major deficits. This may be due to practice effects, since he had undergone extensive testing and was familiar with many of the tests administered for this study. He also had serious concomitant injuries which may affect his psychosocial functioning. Six months after the injury he still limped and walked with the aid of a cane.

Qualitative observations largely support hypothesis three, in that individuals with lower GCS-E scores reported poorer outcomes of MCHI, due to the injury, six months post-injury. Those participants who showed either high GCS scores and low PTA scores, or high PTA scores and low GCS scores, showed better psychosocial adjustment six months post-injury, than did those participants who had both low GCS and low PTA scores. It should be borne in mind that the psychosocial adjustment may be due to (or may be affected by) the nature of concomitant injuries, which is usually more serious in the lower GCS and PTA scores within the range of MCHI.

In the current study the quantitative results do not support the hypotheses which revolve around the GCS-E being a sensitive indicator of MCHI. The qualitative observations provide more support for the hypotheses. This disparity may well be due to the limitations of this research.

### 8.3. Limitations of this research

The primary limitation of this research is caused by the unpredictability of head injury. This made the availability of premorbid measures impossible. The research therefore necessarily had to rely on ex post facto data, and on making inferences.

When one of the variables within a correlation analysis is homogeneous or restricted in its range, the derived correlation coefficients are low (Anastasi & Urbina, 1997). In the present study, such a restriction of range is evident in that GCS scores which indicate MCHI are within the 13 to 15 range. This may have contributed to many of the low Pearson Product Moment Correlation coefficients obtained in this study. This same restriction of range may also be the reason why Teasdale and Jennett (1974) state that the GCS is unsuitable for predicting the outcome of MCHI.

Another limitation of this research was the lack of true random sampling, due to the reliance on an availability sample. This affects the external validity of the findings.

In addition to the reliance on an availability sample, the sample size, which this research is based on, is too small for more powerful statistical manipulations. For example, the initial proposal of this research based the statistical manipulation on a canonical correlation. Although the results of such a correlation may have been more valuable than that of Pearson Product Moment Correlation coefficients, it would have required a sample size of over 200, which is beyond the scope of the present study. Some statisticians may also argue that the sample size of twenty within

this study is too small for the regression analyses which was performed. For example, Hammond (in Breakwell *et al.*, 1995) questions the reliability of multiple regression results if the such results were obtained using a sample size of smaller than 200.

Related to the small sample size, is that the correlations which did not show significant coefficients need to be approached with caution, in order to avoid a Type 2 error. This caution is necessary because although there may truly have been no correlation between the variables, it is possible that other factors could have caused the emergence of non-significant results.

Richardson (1990) cautions about the effects of alcohol use on the acute assessment of MCHI. The impact of this extraneous variable could be significant, since head injury is often accompanied by alcohol and/or drug abuse. An attempt to control this extraneous variable was done by including questions about alcohol intake in the questionnaire. However, the actual extent of intoxication, and the effect of alcohol on the GCS and PTA scores obtained, is difficult to establish with certainty. The hospital records of one of the participants in this study stated that alcohol was smelt on the individual upon admission to the hospital. However, during the interview, the participant reported that he had not been drinking.

Also other drugs may have affected the results. Although the present study aimed to exclude individuals who were heavily sedated, the effects of medication on those who participated in the study, may have affected the PTA scores obtained. Two participants mentioned that they did not recall family members visiting them a number of hours after admission to the hospital, but

they also said that they had been sleeping so well they thought that they had been sedated or that the analgesics were so potent that it affected their level of awareness.

Section 4.4 of this document reports that personality types which include optimism and resilience lead to more favourable outcomes of head injury (Kolb & Whishaw, 1990). The various aspects of premorbid personality functioning were not assessed in this study, and may have affected the results obtained. Intrapsychic modalities which may have affected the results include anxiety and even the presence of posttraumatic stress disorder due to the accident. Also the motivation of the patient to regain premorbid functioning (which was perhaps negatively affected by the reinforcement behaviour of significant others) is a variable which could have affected the outcome of this study. Perhaps the semantic differential of the participants' significant other would have shed some light on this. (As explained in 6.2.3.3, administering the semantic differential to significant others had pragmatic problems which lead to the abandonment of this test.)

It was apparent during the interviews and testing of the participants, that those participants who had particularly mild injuries (GCS-E of 15:7) had less motivation to perform well on the tests. This sub-group of participants appeared not to have seen any point in the investigation. Ironically those who had the more severe injuries also showed distorted functioning on many tests. This happened because these individuals often were familiar with the tests (which formed as part of their assessments with other psychologists). This was especially evident in subtests like block design.

A surprising finding within this study was the lack of significant results between the semantic differential and GCS and PTA respectively. It was thought that patients whose injuries were on the more serious side of MCHI, would show more subjectively perceived differentials in their functioning. However, a common sequel to head injury is a loss of emotional reactivity and insight (Lezak, 1995). Emotional flattening was seen in two of the participants who, contrary to the hypotheses, showed small pre- and postmorbidity differentials. In retrospect, the use of the semantic differential, which requires insight, was probably inappropriate in the quantitative analysis of this study. In her study, Jansen (1989) also found only two significant correlations (in a set of 28 correlations) between the length of PTA and differentials in pre- and postmorbidity functioning, although changes in functioning were described by relatives.

Gregory (1996) explains that older adults enter a stage of post-formal thought (or wisdom) during which the ecological validity of traditional tests is questionable. This author mentions a case where a digits backward subtest is administered to an older individual and the testee's response to the standard request of repeating the digits in the reverse order, is "What for?" One of the participants in this study (whose performance should have been good according to hypothesis three) was an older gentleman and the attitude of "What for?" was highly evident during testing.

Two of the participants in this study were in the process of submitting third party claims for the injuries sustained in motor vehicle accidents. Nell (1997) refers to "compensationitis" as a

motivation to perform on a level below true potential, due to expecting compensation because of litigation brought on by the accident. It is a possibility that "compensationitis" may have been a factor in this research. It was however made clear to the participants that the information obtained for this study would be totally confidential, and not affect any claims they are considering, or in the process of making.

#### 8.4. Implications of this study for further research

The limitations of this study are associated with comparing the results between individuals who are very different to one another on various levels. Also, the present study relied on ex post facto data. This research design caused limitations which affected the results of the study. Perhaps further research can identify a high-risk, accessible, population without previous head injury to facilitate a true experimental design, where within-subject comparisons (that is, comparing each individual's before and after injury scores) may provide more meaningful information.

The current study included all available cases of MCHI, irrespective of etiology. However, specific neurobehavioral deficits are associated with different types of insult to the brain. (As reported on in chapters 2 and 3 of this document). For example, DAI caused by whiplash is associated with deficits in attention and concentration. Perhaps further studies should investigate MCHI according to single etiologies.

The category of closed head injury, MCHI, appears to lend itself to subcategorization. For example, Lezak (1995) distinguishes between mild concussion and classic concussion. Ruff *et al.* (1996) talks about the miserable minority in terms of MCHI. This miserable minority comprises 10% of MCHI cases and these are the individuals who have most difficulties after the concussion. Considering that 80% of all head injuries are MCHI (Nell, 1997), such a subcategorisation seems necessary. The present study did not distinguish between types or categories of concussion, or specifically consider those individuals who are having difficulties six months post-injury. For example, if Ruff *et al.*'s (1996) statistics apply to the South African environment then two individuals within this study would be part of the 10% which comprise the "miserable minority". Perhaps a study that correlates subcategories of MCHI with GCS-E scores, will shed more light on the utility of the GCS-E.

South Africa has a diverse population in terms of ethnicity. In addition to this, various ethnic groups and subgroups are in various stages of westernization. The present study included participants from only one group; white, westernized South Africans. The external validity of the results of this study is thus low in the broader South African context. A South African study which has a much larger sample size which is representative of the South African population, may shed more light on using the GCS-E to predict the outcome of MCHI.

## 8.5. Conclusion

The quantitative findings of this study do not support the view of Nell (1997) that the GCS-E is sensitive in the detection, and thus the prediction of outcome, of MCHI. This conclusion is based on the fact that, in the present study, neither of the components of the GCS-E (GCS and PTA) correlates significantly with measures of outcome of MCHI.

The lack of statistically significant findings between measures of outcome on MCHI and GCS is not surprising since various authors have commented on the unsuitability of the GCS in the detection of MCHI (for example, Teasdale & Jennet, 1974). The lack of significance between the correlations of PTA and measures of outcome is more surprising and suggests that extraneous effects (such as the small sample size, individual differences and the lack of sensitivity of the measures) played a role in the quantitative results of this study.

Qualitative observations within this study suggest that low GCS-E scores are associated with more disparities in pre- and postmorbid functioning after MCHI, than high GCS-E scores. This corresponds with the findings of Nell and Yates (1998). It is suggested that future investigations into predicting the outcome of MCHI consider the methodological limitations of the present study.

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APPENDIX 6.1

Consent form

CONSENT FORM

Date: \_\_\_\_\_

I \_\_\_\_\_ hereby agree to be a participant in the study of mild closed head injury, being undertaken by Christa Foulis (the Researcher). I understand the purposes and extent of my involvement, which have been described and explained by the Researcher. I also consent to her having access to my hospital records relevant to this study, should the need arise.

Signed \_\_\_\_\_

Printed Name \_\_\_\_\_

If patient is a minor, signature and name of guardian.



## APPENDIX 6.3

## Semantic differential

- Cannot concentrate \_\_\_\_\_ Concentrate well
- Impatient \_\_\_\_\_ Patient
- Restless \_\_\_\_\_ Calm
- Discouraged \_\_\_\_\_ Enthusiastic
- Anxious \_\_\_\_\_ Relaxed
- Forgetful \_\_\_\_\_ Remember well
- Lonely \_\_\_\_\_ Sociable
- Sloppy \_\_\_\_\_ Neat
- Drinking more \_\_\_\_\_ Drinking same
- Distracted \_\_\_\_\_ Focused
- Insomnia \_\_\_\_\_ Sleeps a lot
- Remembers recent events \_\_\_\_\_ Forgets recent events
- Remember remote events \_\_\_\_\_ Forget remote events
- Considerate \_\_\_\_\_ Inconsiderate
- Kind \_\_\_\_\_ Cruel
- Happy \_\_\_\_\_ Unhappy
- Reasonable \_\_\_\_\_ Unreasonable
- Warm \_\_\_\_\_ Cold
- Rational \_\_\_\_\_ Irrational
- Calm \_\_\_\_\_ Excitable

Likes Company \_\_\_\_\_ Dislikes company

Cautious \_\_\_\_\_ Impulsive

Talkative \_\_\_\_\_ Quiet

Energetic \_\_\_\_\_ Lifeless

Generous \_\_\_\_\_ Mean

Mature \_\_\_\_\_ Childish

Charming \_\_\_\_\_ Rude

Confident \_\_\_\_\_ Unsure of self

Sensitive \_\_\_\_\_ Insensitive

Intelligent \_\_\_\_\_ Unintelligent

Sensible & down to earth \_\_\_\_\_ Silly & out of touch

Clear thinking \_\_\_\_\_ Confused

Relaxed \_\_\_\_\_ Tense

Creative \_\_\_\_\_ Unimaginative

Attentive \_\_\_\_\_ Inattentive

Stable \_\_\_\_\_ Changeable

Self-reliant \_\_\_\_\_ Relies on others