Neuropsychological, functional and behavioural outcome and predictors of outcome in a sample of traumatic brain injury litigants.

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To my father, Pieter, and mother, Marietjie *(In memoriam: 1940-2003)*.

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Abstract

Objective: Generally, this study aimed to explore whether financial settlement in litigation influences outcome and recovery from closed head injury in a sample of traumatic brain injured (TBI) litigants who were tested and interviewed both during litigation (at time 1, or T1) and 1 year or more after case settlement (at time 2, or T2). More specifically, my major goals were to assess (a) changes between T1 and T2 on outcome variables such as neuropsychological test scores and self-and other-reported cognitive function, behaviour, activities of daily living (ADL), and physical dependency (PD), and (b) the impact of demographic (e.g., years of education, employment status) and clinical (e.g., severity of injury, degree of post-traumatic amnesia, Glasgow Coma Scale score) variables on the aforementioned outcome variables. **Participants:** Forty individuals with mild to severe TBI, each with a significant other who would complete a series of questionnaires, were recruited. **Design:** This study was in part a repeated-measures design (neuropsychological test data were collected at both T1 and T2) and in part a longitudinal design using retrospective data. Data were collected using a battery of standard neuropsychological tests and the Head Injury Family Interview. **Data Analysis:** Differences between outcome variables at T1 and T2 were assessed by using Bonferroni-corrected Student's t-Test. Reliable Change Index analyses further investigated relevance of the changes in neuropsychological test scores. Canonical Correlation Analysis assessed relations between sets of outcome variables. Multiple regression analyses assessed the extent to which demographic and clinical variables predicted outcome variables. Finally, a multiple case-study approach was used to assess whether any differences were present between a group of individuals defined as giving poor effort at T1 and a similar good effort group. **Results:** No real change between T1 and T2 was evident in neuropsychological test scores and everyday functioning. This finding was supported by the multiple case study analysis. Based on self- and other-report interviews, the outcome variables were predicted by, primarily, indices of PD and cognitive function. Regression analyses suggested the following: education accounted for much of the variance in neuropsychological test scores; months since injury accounted for much of the variance in ADL scores; months since injury and employment status accounted for much of the variance in self-reported PD; PTA and GCS accounted for much of the variance in self-reported behaviour; years of education accounted for much of the variance in significant other-reported behaviour, cognition, and PD. **Conclusion:** In this sample of TBI litigants, there was no clinically significant change in outcome over the long term. One might conclude, then,

that patients at the severe end of TBI spectrum are, despite clear secondary gains potentially being in place, not inclined to malinger, or deliver poor effort, during neuropsychological evaluations taking place in the context of litigation. Furthermore, the data strongly suggest that global assessment of patients is needed when assessing and making predictions about long-term outcome in TBI patients.

Introduction

Background

Organic brain damage resulting from traumatic brain injury (TBI) manifests in a similar manner across the world. However, socioeconomic circumstances and access to rehabilitation facilities vary greatly from country to country. South Africa, for instance, has a large population of individuals with low socio-economic status, most of whom rely on the state for health care and rehabilitation. Unfortunately, given economic, travel and other constraints, these individuals (both adults and children) typically have inadequate access to medical care and rehabilitation (Levin, 2004). Thus, South Africa has a large unrehabilitated population of TBI individuals, many of whom suffered their injury in the course of motor vehicle accidents (MVA).

Neuropsychologists who assess these TBI victims of MVAs as part of forensic cases are often pressured by attorneys to give predictions, based on test data, about the vocational potential of the brain-injured patient. Relatively recent neuropsychological research (e.g., Hoofien, Vakil, Gilboa, Donovick & Barak, 2002; Willemse-van Son, Ribbers, Verhagen, & Stam, 2007) has established, however, that accurate predictions of future outcome cannot be made based on test data alone. Instead, in order to be able to predict long-term outcome, neuropsychological test data need to be considered alongside demographic, functional and behavioural factors (Hammond, Grattan, Sasser, Corrigan, Rosenthal, Bushnik et al., 2004).

Rationale

Developing a better, more accurate understanding of how these factors work together to influence long-term outcome is essential in developing effective rehabilitation programs and

a system of compensation that benefits all justly, and is important in helping to reintegrate TBI individuals into society.

Although TBI outcome studies conducted in other countries are informative, long-term outcome in these studies is usually assessed in the context of rehabilitation, and samples are typically drawn from rehabilitation programs. Due to the dismal state of the South African public health sector (Goosen, Bowley, Degiannis, & Plani, 2003), rehabilitation for TBI is largely only available to those who have the economic means for access to private sector facilities. Partly as a result of these factors, research on long-term outcome after TBI in South Africa is lacking and there is no data on outcome after litigation in South Africa (Brown & Nell, 1991; Nell & Brown, 1991). Further, the use of data from rehabilitated samples (which are often used in TBI outcome studies from developed-world countries) limits the ability to draw conclusions from the unrehabilitated TBI population (which is by and large the case in South Africa and other developing-world countries).

One possible gateway to researching TBI outcome in South Africa is the Road Accident Fund (RAF). This body compensates individuals who were injured in an MVA, and who, by laying a claim, become litigants. A database is compiled on each patient from the files of expert witnesses who assessed that individual. The database includes family interviews, the history of the accident, clinical impressions, background information, education, employment history, social history, history of substance use, complaints at the time of assessment, neuropsychological test findings, prognosis, information regarding loss of amenities, and recommendations. This database therefore comprises a thorough medical and social history of the subject up until 2 to 4 years after the accident, largely depending on when the last expert assessment was conducted.

The present study uses the RAF database to investigate cognitive, behavioural and functional recovery from closed head injury (CHI) in a group of TBI individuals tested both during litigation (T1) and 1 year or more after case settlement (T2). As in some previous studies within the field (e.g. Millis, Rosenthal, Novak, & Sherer, 2001), the emphasis of this study is on change within the group over the long term as opposed to differences between groups. Because participants serve as their own controls, the need for a control group is negated. As noted earlier, in order to holistically assess outcome following TBI, the complex relationship between patient background, behaviour and functional status must be considered. Many studies outside of South Africa have been conducted exploring the relationship between TBI, litigation and pre-compensation recovery, and fewer studies have assessed long-term recovery after TBI in the context of litigation (e.g., Engberg & Teasdale, 2004; Hammond et al., 2004; Millis et al., 2001). The question of actual outcome and factors influencing outcome during and after compensation, which is the focus of this dissertation, has not been adequately addressed by previous work.

In brief, the primary objectives of this study are to: (a) describe the demographic characteristics (years of education, employment, relationship status) and severity of injury of a sample of South African TBI litigants; (b) assess changes in neuropsychological test scores (NTS), subjective cognition, behaviour, activities of daily living (ADL), and physical dependency (PD) between T1 and T2 as reported by both the head injured person and a significant other in order to assess what influence litigation may have on long term outcome in TBI; and (c) assess the impact of age at the time of the accident, months since injury, years of education, employment, post-traumatic amnesia (PTA), and Glasgow Coma Scale (GCS) scores on the aforementioned outcome variables. This study will provide the first data on

long-term outcome in TBI in South Africa, and even though the conclusions of this study may be limited it serves as a starting block for further research in this field.

For the purposes of this study, *TBI* is defined as a head injury that is (a) caused by an MVA, (b) diagnosed by objective neurological findings, and (c) results in loss of consciousness (LOC) and posttraumatic amnesia (PTA),. *T1* refers to the first litigation-related neuropsychological assessment following the MVA; *T2* refers to a post-settlement assessment that occurred in the context of the current research. Furthermore, in this dissertation the term *cognitive status* refers to a self-report score related to the experience of fatigue and difficulties experienced in the domains of, amongst others, memory, concentration and word finding (see Appendix A, Subscale 1). The terms *functional status* and *activities of daily living* (*ADL*) are used interchangeably and refer to the ability to perform self-care, self-maintenance and physical activities (see Appendix A, Subscale 2). *Behaviour* refers to affective behaviour, for example, mood swings, irritability, complaining, depression, anxiety/tension headaches and temper outbursts (see Appendix A, Subscale 3).*Physical dependency* (*PD*) refers to physical difficulties (e.g., poor vision) and dependency on others (e.g., a need for supervision in daily activities; see Appendix A, Subscale 4).

Literature Review

Injury statistics and the Road Accident Fund

South Africa has one of the highest rates per capita of MVAs. In 2006 there were 12 454 fatal accidents, an increase of 6.12% over 11 736 from fatalities during 2005 (Traffic Road Management Corporation, 2007). The last comprehensive set of statistics released by the RAF indicates that the majority of drivers involved in road accidents between 1994 and 1998 were in the 20-29 year age group (33.7%), followed by the 30-39 year age group (28%). The majority of pedestrians who were injured in road accidents during that time were in the same age groups. Approximately 70% of road accident victims are men (Ministry of Transport, 2002).

Between 1935 and 1998, fatalities due to road accidents increased from less than 1 000 per year to more than 9 000 per year. Injuries increased from less than 20 000 to approximately 130 000 per year during the same period. Unsurprisingly, many of these resulted in head injuries. The total number of people who were injured in road accidents in the period 1988-2000 varied between 126 000 to 147 000 per annum. Of these injuries, 33% constituted head and neck injuries (Van Zyl, 2002).

The majority of those injured in road accidents are drivers of motor vehicles, followed by passengers, then pedestrians. Passengers were the largest group (44%) to receive compensation from the RAF, followed by pedestrians (28%), drivers (25%) and cyclists (3%). Most victims were economically active at the time of their accidents. Furthermore, 52% of those injured were employed in the formal sector of the economy, whereas only12% were employed in the informal sector. A further 12% were unemployed, and of those who

were not economically active, 8% were students, 3% were homemakers and 3% were retired (Ministry of Transport, 2002).

During accidents, the head and neck were most commonly injured part of the body (33.5%), followed by lower limbs (27.5%). Injuries to the back, trunk, abdomen and upper limbs made up a further 30%, 15% and 14% respectively. According to an independent report cited in the Report of the Road Accident Fund Commission, causes of disability due to car accidents were cited as 37% in the lower extremities, 22% brain injuries, 12% spinal injuries, 12% upper extremities, and the balance allocated to "other" (De Beer, in Ministry of Transport, 2002).

Time taken for compensation payments from the RAF to claimants may vary from as little as a few days after the date of accident to in excess of ten years, with an average of approximately 2.6 years. The first neuropsychological assessment usually occurs 2 years plus after the injury (F. Hemp, personal communication, March 4, 2005).

Long-term functional, behavioural and neuropsychological outcome in closed head injury

A coherent interpretation of outcome studies is complicated and difficult. The overall findings among such studies show no consistent direction, with some studies detecting meaningful change while others do not (Hammond, Grattan et al., 2004; Oddy, Coughlan, Tyerman, & Jenkins, 1985; Olver, 1995). This variety in outcome studies may be due to several factors: different criteria used to establish severity of injury (e.g., GCS scores, duration of PTA, and/or duration of coma) and the predictive validity of such measures (Sherer, Sander, Nick, High, Malec & Rosenthal, 2002; Sherer, Struchen, Yablon, Wang &

Nick, 2008); different populations used for study (e.g., admissions to in-patient rehabilitation centres, community-dwelling samples, or consecutive admissions to a trauma centre); and different standards of care and rehabilitation provided in different countries, at different times post-injury and at different time periods (Sherer, Madison, & Hannay, 2000). Comparisons across studies are further complicated by the use of different instruments for measurements of, for example, activities of daily living, behaviour difficulties and self-reported cognitive function.

Despite these methodological concerns, in the TBI literature it is generally accepted that most significant recovery occurs within 1 year post-injury, that the patient is stabilised at 2 years, and that there will be no more significant cognitive and functional improvement after this period (Alexander, 1995; Hammond et al., 2004). However, not all patients follow the same pattern. Recent research confirms that there is varying symptom presentation and length of symptom presentation in patients with similar injuries (Hammond, Grattan, et al., 2004). Furthermore, all cases of mild head injury do not necessarily present in the same manner, and the same can be said for moderate and severe cases. To make matters even more complex, there is also an overlap in neuropsychological and clinical symptoms across the severity of the injury (Millis et al., 2001).

These complexities in symptom presentation led to early research and clinical lore suggesting that TBI symptom presentation was of a 'non-specific' type (i.e., that there is no discrete set of symptoms associated with closed head injury). More recently, however, this line of thinking has been disputed. For instance, Gordon et al. (2000) compared the number of symptoms reported by patients with and without TBI 9.5 years post-injury, using 135 mild TBI (mTBI) and 275 moderate to severe TBI (mod/s TBI) participants. They found that

cognitive symptoms, followed by physical and behavioural/affective symptoms, were most commonly reported by both mild and moderate/severe TBI patients. Cognitive symptoms were more homogenously endorsed than physical and behavioural symptoms.

Recent research, then, has attempted to describe the most common symptoms, and patterns of symptoms, associated with different severities of TBI. The most frequently reported problems in TBI are mental fatigue, memory difficulties, depressive mood, lack of initiative and motivation, difficulty in mental flexibility, poor planning, slowed information processing, disruption of complex integrative functions and reduced capacity for new learning (Engberg & Teasdale, 2004; Haddad, Brown, Hibbard, & Sliwinski, 2000). In mTBI, expectations of symptoms may result in benign emotional, physiological, and memory difficulties being reattributed to the head injury, thus resulting in circular reinforcement of expectations about symptoms leading to persistent report of symptoms (Alexander, 1995; Mittenberg, DiGuilio, Perin, & Bass, 1992). In addition, mild/moderate TBI may also be associated with symptoms of anxiety, lability of mood, and emotional withdrawal, while severe TBI may, in addition, lead to conceptual disorganisation (Mazaux, Masson, Levin, Alaoui, Maurette & Barat, et al., 1997; Millis et al., 2001) (For a review on personality, emotional and motivation disturbances associated with TBI, see Prigatano, 1992).

Variation in these symptoms in terms of presence and length of symptom presentation has yet to be explained medically, and psychological and social explanations are similarly wanting (Hammond, Grattan, et al., 2004; Millis et al., 2001). Several recent long-term outcome studies have attempted to address these issues. For instance, Hammond, Grattan et al. (2004) found that, in their sample of 301 TBI individuals (mean age 36.6 years), outcome as measured at 1 year and 5 years after the head injury were largely the same, and in both cases

were worse than pre-morbid functioning. More specifically, most individuals in their sample (76%-79%) did not, over the follow-up period, present with functional level changes in the domains of attention, behavioural arousal, emotion, motivation, and information processing; there were no level of employability changes over the follow-up period either. Similarly, Whitnall, McMillan, Murray, and Teasdale (2006) measured outcome in cognitive impairment, psychological wellbeing, health status and social factors in a sample of 360 young people and adults with TBI. They found that the overall rate of disability observed in adults at 1 year post-injury was very similar to that observed at 5-7 years after hospital admission. Disability remained frequent and similar from 1 year to 5-7 years (53%-57%) post-injury. Further, 29% of participants improved and 25% deteriorated.

These reports of no real change in long-term outcome across multiple functional domains (i.e., stabilisation in cognitive and physical function after initial recovery; Hammond, Grattan, et al., 2004; Oddy, Coughlan, et al., 1985; Whitnall et al., 2006) are, however, not consistent with data reported by other researchers. For instance, some studies show evidence of increasing problems in cognition and behaviour over time (Dikmen, Machamer, & Temkin, 1993; Jennett & Bond, 1975; Lezak & O'Brien, 1988; Olver, 1995; Sander, Kreutzer, Rosenthal, Delmonico, & Young, 1996; Thomsen, 1984). Although the latter is not generally expected to be typical of cognitive recovery in uncomplicated TBI, it can be the case in individuals with strong affective complications (e.g., psychological factors such as chronic pain and depression; Alexander, 1995), or due to environmental change post-injury, a concomitant progressive neurodegenerative process, a history of physical injuries sustained during the TBI event (Hammond, Grattan et al., 2004), chronic fatigue and greater alcohol use post-injury (Draper et al., 2007).

With specific regards to long-term outcome in terms of employment status, TBI results, in many instances, in the affected individual not being able to return to the same level of employment as before or not being able to return to work at all. Olver et al. (1995) reported a 32% decline in actual employment. Some studies, however, present a more optimistic picture with regard to the capacity to return to work. For instance, Draper et al. (2007) did not find significant changes in employability between year 1 and year 5 post-injury. A small minority (5% - 7%) of TBI patients became less employable over a 4-year period after the injury. In a study that reported changes in levels of functioning and employability over a 5-year follow-up period (e.g., Millis et al., 2004), the authors cautioned that those changes were small and probably not of clinical significance.

Interestingly, the changes in employability noted by Hammond, Grattan, et al. (2004) were mostly in a positive direction (i.e., increased as opposed to decreased employability). The reasons for such increased capacity are not entirely clear, but it has been suggested that it may be ascribed to societal and other issues, such as vocational assistance, job retraining, and return to driving (Oddy et al., 1985; Sander et al., 1996). These studies did not examine factors that influenced recovery, but speculated that a variety of reasons such as "true neurological recovery, receipt of intensive outpatient therapies, socialization, adaptation, or better manipulation of the environment" may play a role in improvement in employability over the long term in TBI patients (Hammond, Grattan et al., 2004, p. 31).

With regard to long-term neuropsychological sequelae of TBI, relatively few studies have been conducted. This fact is in stark contrast to work on the immediate and short-term neuropsychological sequelae of TBI, which extensively documents what one might expect in adults (see, e.g., Dikmen et al., 1983, 1995; Formisano, Carlesimo, et al., 2004; Levin, 2000;

Tabaddor, Mattis & Zazula, 1985). Several recent studies have, however, attempted to redress this imbalance (see, e.g., Draper et al, 2007; Hammond, Grattan, et al., 2004; Hammond, Hart, et al., 2004, Millis et al., 2004). For instance, comparing outcome at 2 and 7 years following severe head injury, Oddy et al. (1985) found little improvement in cognitive function. Similarly, Millis et al. (2001), studying a sample of individuals with head injuries ranging from mild to severe, found that neuropsychological recovery was not uniform across two testing occasions (at one year post-TBI and five years post-TBI). More specifically, as a group, moderate to severe TBI patients improved across the follow-up period on six out of 15 neuropsychological test scores – in the domains of attention, cognitive speed, verbal fluency, verbal memory, and visuo-constructional skills – suggesting that recovery may continue beyond the 6 to18-month period suggested by Dikmen et al. (1983) and Levin (1995). Millis and colleagues (2001, p. 343) therefore summarized one implication of their findings thus: "For a subset of persons with moderate to severe TBI, neuropsychological recovery may continue several years after injury with substantial recovery. For other persons measurable impairment remains five years after injury."

Millis et al. (2001) cautioned, however, that although statistically significant improvements on neuropsychological testing were found from year 1 to year 5, the magnitude of change was so small that it appears, from a group perspective, to be of little clinical significance. In a subsample of patients whose performance changed significantly on two tests as judged by the reliable change index, 15 patients declined, 22 improved and 62 exhibited no change. The cognitive deficits that were present 5 years after injury were mostly in the areas of memory functioning, attention and processing speed. Improvement was most likely to have occurred on measures of cognitive speed, and visuo-construction. Verbal memory was still 'impaired' at 5-year post-injury when compared to norm-referenced cohorts, but it was significantly

improved when compared to memory functioning at 1 year post-injury. The most pronounced declines from year 1 to year 5 were on tests that required rapid performance and cognitive flexibility.

In addition to the factors discussed above, patients' personal and social relationships are often affected. Patients frequently do not successfully re-integrate into society (Bond & Godfrey, 1995; Oddy, 1978; Olver, Ponsford, & Curran, 1996; Thomsen, 1974). For instance, Schalén, Hansson, Nordström, and Nordström (1994), in their study of severe head injured patients 4-8 years after injury, found that 40% reported problems in personal and social relationships, specifically in terms of the degree of dependence upon their families and partners. The decline in social interaction is also associated with decreases in social and behaviour problems after injury (Hammond, Hart et al., 2004).

The literature reviewed above makes it clear that, across multiple functional domains, there can be significant individual differences in long-term outcome. Numerous studies, including some of those reviewed earlier, have attempted to account for those individual differences by investigating the role of demographic factors and injury severity in long-term outcome. In studies where TBI occurred 10 or more years earlier, demographic factors seem to be relatively weak predictors. For instance, Hoofien et al. (2002) found that age of injury did not predict long-term cognitive, psychiatric, vocational, and social/familial functioning, and that severity of injury was predictive of only independence in daily functioning. Across most studies, however, measures of injury severity (e.g., GCS) seem to be predictive of short-term outcome (up to 1 year) but not of long-term outcome (more than 5 years) (Asikainen et al., 1996). Amongst all demographic factors, education shows the most consistent and significant association with outcome (Dawson & Chipman, 1995; Draper, Ponsford, & Schönberger,

2007; Hoofien et al., 2002; Tate, Broe, Cameron, Hodgkinson & Soo, 2005; Kesler, Adams, Blasey & Bigler, 2003; Wood & Rutterford, 2006a). For instance, Wood and Rutterford (2006a) found that years in education made a significant contribution to the prediction of community integration. Asikainen et al. (1996) suggested that non-injury variables such as age and education level increase in importance with time as predictive factors of outcome and that the predictive weight of injury factors decreases over time. (For a review of prognostic factors of long-term functioning and productivity after TBI, see Willemse-van Son et al., 2007).

In summary, the literature indicates that generally, across multiple outcome variables, there is not much change in TBI individuals over the long term. The literature also indicates that organic and demographic factors (such as severity of the head injury and age) play a role in long-term outcome – that is, increased injury severity and relatively late age at the time of injury are associated with poorer prognosis (Asikainen, Kaste, & Sarna, 1998; Draper et al., 2007; Hammond, Grattan, et al., 2004; Hammond, Hart, et al. 2004; McMillan, Jongen, & Greenwood, 1996; Millis et al. 2001). Other factors may also be influential in long-term outcome; however, the list of these possible other factors is almost as long as the list of TBI outcome studies. Various authors have proposed that return to driving, true neurological recovery, receipt of intensive outpatient therapies, socialization, adaptation, better manipulation of the environment, pre-morbid personality, stability of family background, pre-injury occupation, environmental changes, and/or medical issues, may be important to determining the long-term degree of recovery following TBI. Overall, one must simply recognise that outcome following TBI is a multidimensional construct and that continuing post-injury cognitive, behavioural and emotional problems have a complex association with global psychosocial outcome.

Financial compensation and long-term outcome in TBI

In contrast to the voluminous literature on long-term outcome in TBI that does not take into account the presence of litigation, there is limited literature on the relationship between long-term outcome and seeking financial compensation. The question of whether or not head-injury patients who are seeking compensation generally tend to embellish symptoms has not, as yet, been answered definitively due to the fact that few studies compare litigant and non-litigant groups who have suffered similar injuries (Lishman, 1999). The research that has been conducted to investigate the relationship between litigant status and long-term outcome following head injury tends to suggest that, after mTBI, there is a positive association between seeking financial compensation and the likelihood of poor outcome (Binder & Rohling, 1996; Evans, 1994; Reynolds, Paniak, Toller-Lobe, & Nagy, 2003). Although these studies indicate that mTBI patients appear to present with a greater tendency toward malingering than do moderate/severe TBI patients, definite malingered neurocognitive dysfunction has also been documented in the latter group (Bianchini, Greve, & Love, 2003; Boone & Lu, 2003). The clinical characteristics regarding this presentation have been well established but there is no biological, epidemiological, or even empirical data to support "accident neurosis" (i.e., the picture of exaggerated symptoms often associated with litigation) as a distinct diagnostic specificity (Alexander, 1995). Mittenberg et al. (1992) argued that the consistency of the symptom cluster across patient populations indicates that one underlying common denominator, cerebral dysfunction, is the principle aetiology; however, selective attention, symptom expectations, and anxiety can under certain circumstances interact to produce syndromes that essentially mimic any pathological process.

Binder and Rohling's (1996) meta-analytic review of outcome in mTBI patients engaged in litigation concluded that those with financial incentives performed more poorly on outcome

variables such as symptom reports, neuropsychological testing, clinician rating, and return-to-work capacity than did those without such incentives. Based on these data, the authors postulated that mTBI individuals who present with severe cognitive deficits for many months after their head injury, and who might potentially be financially compensated for ongoing impaired function, might be suspected of malingering or of other non-organic explanations for their impairments.

Both the findings presented and conclusions drawn by Binder and Rohling (1996) have, however, been contested. Over a period of 10 years, Wood and Rutterford (2006a), for instance, assessed 31 individuals with mild head trauma who were involved in litigation, and found that there were no long-term effects of the litigation process on cognitive and psychosocial outcome. McKinlay, Brooks, and Bond (1983) found similar results in a severely head-injured sample of 21 litigants and 21 non-litigants. Specifically, they found few differences between the groups in terms of post-concussional symptoms and cognitive reports, among other outcome variables. Interestingly, although collateral reports of changes in the TBI individuals were similar across groups, litigants self-reported slightly more symptoms than did non-litigants. McKinlay et al. (1983) therefore concluded that the penchant to fake low scores in severe head injury cases is rare.

In similar vein, Suhr, Tranel, Wefel, and Barrash (1997) studied the contributions of malingering, litigation status, psychological factors (e.g., affect and mood), and medicine use to memory performance after mTBI. They found that "several memory tests were useful in distinguishing *probable* malingerers from the other groups" (p. 500; emphasis added). However, there was a complex interaction between the above-mentioned non-neurological factors in the prediction of memory test results; litigation status alone was not a predictor.

The authors emphasised the need to take such non-neurological factors into consideration when interpreting poor memory performance in forensic cases.

Clearly, then, the role of malingering, or, more broadly, non-neurological factors, in functional outcome and neuropsychological test performance after head injury is a matter of ongoing concern. Estimates of the number of plaintiffs manufacturing psychological deficits over the years have varied greatly, from 1% (Keiser, 1968) to 64% (Heaton, Smith, Lehman, & Vogt, 1978). Malingering is reportedly also often present in workers' compensation cases, with an estimated 47% of claimants involved in feigning deficits (Youngjohn, 1991). A possible explanation for this phenomenon could be lack of effort on cognitive and neuropsychological tests. Allen, Richards, and Green (1997) found that 30% of a sample of 1752 individuals who were involved in workers' compensation cases failed an effort test. Green, Rohling, Lees-Harley, and Allen (2001) replicated this startling finding and noted that (a) patients from all diagnostic groups failed effort tests, but that (b) effort test failure occurred more frequently in less severely injured participants.

Notwithstanding the findings from the above studies, it should be noted that the claim that disability is motivated by financial gain was recognised, more than 30 years ago, as grossly oversimplifying a complex phenomenon (Linn, 1974). Some authors have suggested that 'learning' of symptoms may occur when TBI individuals are placed in the context of litigation and repeated evaluation. Walsh (1985) called this phenomenon 'role enactment': repeated assessment leads to the individual deducing the type of behaviour expected from him, and therefore experiencing onset of the symptoms. Others have stated that, in the process of litigation and repeated evaluation, undue focus is placed on symptoms, resulting in the symptoms (a) becoming part of the testee's self-image, and (b) gradually growing worse,

regardless of the underlying aetiology (Cullum, Heaton, & Grant, 1991). With specific regard to this role enactment in cases of mTBI, Suhr et al. (1997, p. 511) stated:

> Results suggest that patients with mild head injury (based on the facts of the case) may be treated as though they in fact have a significant brain injury, to a significantly greater extent than other patients with more severe brain injury. Patients 'treated' in such a manner may experience an exacerbation of symptoms over time, rather than the expected recovery in symptoms.

In summary, although the literature alludes to possible explanations, the mechanisms driving the relationship between financial incentives and poorer outcome are not clear. In recent years, one potential explanation has been malingering (Binder & Rohling, 1996). Additionally, researchers have also suggested that social, emotional, and psychological factors (e.g., stressors due to litigation, victimisation, feelings of guilt and emotional adjustment), as well as environmental factors and educational level may contribute to the relationship between financial incentives and poor outcome in litigants (Hofman et al., 2001; Reynolds et al., 2003). There are only two studies, however, that explore whether severe TBI individuals who have been part of a litigation process necessarily improve *after* the litigation process is concluded (the assumption being that that improvement is due to lack of effort during initial assessment while litigation is ongoing and optimal effort during post-settlement assessment; McKinlay et al., 1984; Wood & Rutterford, 2006a). Both of these studies, however, compared litigants to non-litigants. The current research aims to extend this research so as to focus on the nature of this post-litigation change (if there is any), and on what factors might be predictive of outcome after litigation.

Problem statement

Different mental and emotional reactions to the trauma of an MVA, as well as to the process of litigation and to the social environment in which the TBI individuals find themselves following the accident, influence recovery and long-term outcome (Miller & Donders, 2001). As noted in the literature review above, it is therefore important to document and to understand factors (e.g., marital status, education, employment status, psychiatric history, alcohol use, environmental circumstances, social support and interaction, and return to work) that may influence recovery during and after litigation. Furthermore, researchers and clinicians have to be aware that, other than malingering, there may exist a variety of clinical possibilities that could explain illness behaviour.[1]

As reviewed above, numerous studies have shown that there is a correlation between poor outcome (in terms of neuropsychological testing, symptom reports, and ability to return to work) and litigation; that is, greater symptom complaints are present in those individuals seeking compensation (Binder & Rohling, 1996; Evance, 1994; Green, Rohling, Lees-Harley, & Allen, 2001; Mittenberg, Patton, Canyock, Condit, 2002; Paniak et al., 2002; Suhr et al., 1997). However, none of these studies present a convincing case as to why this correlation may exist. Additionally, several studies present data that dispute these findings (e.g., Kelly & Smith, 1981; Lishman, 1999; Mendelson, 1995; Wood & Rutterford, 2006a).

At the clinical level (i.e., outside the research context), neuropsychologists may hold the impression that a percentage of patients involved in litigation may be more functional at the time of settlement than they present themselves to be, and generally do not improve until the

[1] Neuropsychologists who focus mainly on the administration and scoring of psychometric tests may overlook alternative diagnoses and syndromes that their education and training have ill-prepared them to recognise, resulting in misdiagnosing malingering (Miller, 2001).

compensation claim has been finalised (Binder, Rohling, & Larrabee, 1997; Evans, 1994; F. Hemp, personal communication, 20 January 2005; Mayou, 1995; S. Parker, personal communication, 21 January 2005; L. Tucker, personal communication, 20 February 2005). This dissertation argues that if tendencies toward lack of effort are present in this population, it will be evident in differences in outcome measures between T1 and T2. Should T1 and T2 measures be significantly different, then some kind of non-neurological factors may be at play.

Another complicating factor in judging the veracity of the TBI individual's claimed functional status during litigation is that experts appearing for the plaintiff and the defendant during the trail period often disagree. For example, with regard to employability, experts for the defendant often feel that the claimant has some residual earning capacity, whereas experts for the claimant typically express the view that the claimant is unemployable and therefore has no residual earning capacity. Similarly, there is often discord between experts regarding impressions of the claimant's social functioning (in terms of relationships with families and friends, as well as in terms of their abilities to interact in social environments). Consequently, a higher than warranted emphasis may be placed on rooting out fraudulent behaviour or malingering, resulting in the danger of less objective evaluation of cognitive status.

To summarise, there is no present agreement on whether there is a change in outcome in a cohort of TBI victims involved in litigation. There is, however, some evidence that this might sometimes be the case (e.g., Reynolds et al., 2003), which in turn has led to speculation about simple malingering, which in further turn sometimes results in uncharitable interpretations of the litigants. Understanding the psychological impact that an MVA and subsequent TBI have on an individual is of the utmost importance in answering questions relating to later outcome

and compensation. Understanding long-term neuropsychological, cognitive, behavioural, psychosocial and physical outcomes will help predict future development in the patients and inform their rehabilitation. However, it is not possible to make these predictions purely on grounds of neuropsychological test results (Alexander, 1995). Clinical understanding of the individual's behavioural, physical, and psychosocial functioning play an additional critical role in outcome. In South Africa especially, there is a dearth of long-term outcome studies (Digby & Nell, 1991; Nell & Digby, 1991), and no local studies have been conducted to address long-term outcome in TBI litigants. Although generalisation from research in other countries is helpful, it is not optimally useful due to different socio-economic circumstances obtaining in South Africa and because North American and Western European studies are often conducted in the context of rehabilitation following head injury. The current research will, I hope, contribute to the future development of a *local model* that will better serve accurate prognosis within this difficult clinical and medico-legal arena.

Hypotheses

In light of the above-stated problem and research objectives, I hypothesise that:

1. a. If there are no significant differences within the sample in terms of injury severity, level of education, or other demographic variables that impact on neuropsychological test performance, there will be no significant variation in neuropsychological test scores across participants at T1. This lack of variation might be interpreted either as underachievement by all participants in an attempt to ensure maximum compensation, or as optimal achievement (i.e., no malingering or lack of effort) by all participants. The more likely interpretation would be revealed at T2, when the participants, assessed in a research context and outside of the litigant role enforced by their medico-legal case, would perform

significantly better on the neuropsychological test battery than they did at T1 if and only if they had delivered less-than-optimal effort at T1 but genuine effort at T2.

b. If there are significant differences within the sample in terms of injury severity, level of education, or other demographic variables that impact on neuropsychological test performance, there might be significant variation in neuropsychological test scores across participants at T1. This variation might be accounted for by those differences in injury severity, level of education, or other demographic variables, or it might be accounted for by underachievement in some participants in contrast to genuine effort by others. The more likely interpretation would be revealed at T2, when each participant, assessed in a research context and outside of the litigant role enforced by their medico-legal case, would perform significantly better on the neuropsychological test battery than he/she did at T1 if and only if he/she had delivered less-than-optimal effort at T1 but genuine effort at T2.

2. Because most previous studies indicate that symptom presentation tends to stabilise at around 2 years post-injury, ADL, cognition, behaviour and physical dependency measures will not be significantly different from T1 (2 years plus post-injury) to T2 (3 years plus post-injury).
3. Neuropsychological test scores at T1 will be predictive of no T2 outcomes other than neuropsychological test scores. The same will be true for self- and other-reported behaviour, cognition, ADL and physical dependency from T1 to T2. Otherwise stated, each measured predictor/outcome variable will account for only a portion of overall long-term multidimensional psychosocial functioning

following head injury, implying that one must adopt a holistic approach in order to develop the most effective treatment and rehabilitation models.

4. Because severity of injury measurements do not appear to predict long-term outcome, (based on previous studies), GCS and PTA in the current sample will not be predictive of outcome measures at T2. On the other hand, age at the time of the accident, months since injury, years of education and employment status at T1 will be predictive of outcome at T2.

Method

Participants

Two-hundred and thirty-five potential participants were identified by scanning the files of two neuropsychologists in private practice who receive patient referrals from both plaintive and defence counsel in near equal numbers (i.e. both neuropsychologists will have a more or less equal number of defence as plaintive cases on file).[2] All of these potential participants had been assessed by those neuropsychologists for medico-legal purposes; all assessments occurred at least 2 years after the potential participant had sustained a head injury in a MVA. With regard to the MVA, potential participants were either pedestrians who had been struck by a motor vehicle, or who were (a) the driver of a vehicle, (b) being transported in a vehicle, (c) driving a motorcycle, (d) being transported by a motorcycle, or (e) riding a bicycle. The participants were tested in a litigation context at T1 and research context post litigation at T2. As previously noted, a major difference between these two contexts may be that, at T2, participants did not have any incentive to exaggerate symptoms.

The following inclusion criteria were applied to this pool of potential participants: they had to (1) have at least conversational English language ability; (2) be aged 16 years or older at the time of the MVA; (3) have no history of TBI or neurological dysfunction before the MVA; (4) have undergone their first neuropsychological assessment within 5 years of the MVA; (5) have undergone their second neuropsychological assessment at least 1 year after case settlement and within 11 years of the MVA. After application of these inclusion criteria, 95 potential participants remained.[3]

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[2] Two hundred and twenty-five from Dr F. Hemp and 10 from Ms M. Coetzee.

[3] Ninety from Dr F. Hemp and 5 from Ms. M. Coetzee.

Contact details for this group of 95 potential participants were gleaned from the neuropsychologists' medico-legal folder, and participants were subsequently contacted by telephone. Where contact information was out of date, lawyers were contacted for updated information or curator information. As a last resort, the potential participants' place of employment or a family member was called and asked for updated contact information. Thirty-two of the 95 potential participants could not be traced.

Potential participants who were traced were informed about the study and were asked whether they would be able and prepared to come to Groote Schuur Hospital for an initial interview lasting approximately 3 hours. At this point, seven of the remaining pool of 66 participants declined to participate.[4]

As a result of participants experiencing financial or transport difficulties, researchers travelled between 30 and 500 km in nine instances to assess participants. Nine other participants lived farther than 500 km from Cape Town, three were living in inaccessible areas, and four did not keep their scheduled appointments, despite repeated scheduling attempts. Ultimately, then, a sample of 40 participants was successfully interviewed.[5] Given that impairment of self-awareness has been frequently documented in TBI, it was thought appropriate to get the perspective of both the injured person and a significant other (Draper et al., 2007); thus, one well acquainted significant other (SO) of the participant also participated in the study.

[4] The most common reasons participants gave for declining participation was that they did not want to return to the trauma of the accident, or that they were not prepared to be subjected to neuropsychological testing again.

[5] Thirty-eight from Dr F. Hemp and 2 from Ms M. Coetzee.

Although I went to great lengths to get as large a sample size as possible from local psychologists, there were, as already mentioned, some constraints on recruiting efforts. For instance, many potential participants in rural areas were not contactable by phone. Additionally, despite considerable effort, some participants missed appointments, were not available, or did not want to be tested again. The final sample size, however, compares well to previous studies done with TBI litigants (e.g., Wood and Rutterford (2006a) had a sample of 31 litigants and 22 non-litigants, and McKinlay, Brooks and Bond (1983) had a sample of 42 participants).

Sample characteristics

The sample consisted of 62.5% (25) males and 37.5% (15) females. The home language of the majority of the sample, 60% (24), was Afrikaans; 35% (14) had a home language of English, and 5% (2) a home language of isiXhosa. The latter number is low because, typically in the case of the neuropsychologists from whom cases were taken, an interpreter is used for assessment of isiXhosa speakers, and because most potential isiXhosa participants did not meet the requirement of being conversational in English at T2. Further demographic and clinical characteristics of the sample are shown in Tables 1-4.

The sample characteristics for age at time of injury are presented in Table 1. The mean age of the sample was 38 years. The mean age at which the injury occurred was 32 years. The mean period since injury was 7 years, ranging from 3 to 11 years. Table 1 also shows that 35% of participants had completed high school (12 years of education), while 15% had 15 years or more of education. This makes it a relatively well-educated sample, with an average of more than 11 years of formal education. A reason for this bias toward high levels of education in the sample may be that such levels of education are associated with greater socio-economic

stability, and therefore making it easier to trace such individuals and to invite them to participate in research.

Table 1.

Demographic Characteristics of the Sample

	Mean	Standard Deviation	Range
Age (years)	38.97	11.09	24-65
Age at injury (years)	32.27	11.64	16-58
Years since injury (at T2[a])	6.87	2	3.33-10.9
Age at T1 (years)	35.35	11.65	19-63
Years between T1 and T2	3.69	1.83	1.24-7.92
Years since settlement (at T2)	2.41	1.28	1-6.59
Years of education	11.3	3.46	4-17
Glasgow Coma Scale[b]	7.71	3.53	2-15

Note: [a] T1 refers to the first neuropsychological assessment following the MVA; T2 refers to the post-settlement assessment. [b]Refers to GCS score upon admission to hospital immediately following the MVA. A GCS of ≤ 8 is severe, 9-12 is moderate and ≥ 13 is mild (Lezak, 2004). The majority of participants have a GCS score of ≤ 8, falling in the severe head injury range. This bias toward lower GCS scores may be a result of payment for severe injury from RAF being generally larger and a longer case settlement period, resulting in these participants being easier to trace due to a more stable socio-economic situation post settlement.

Table 2.

Length of Post-Traumatic Amnesia (PTA)

PTA Duration	Severity of injury	Number of participants
< 5 minutes	Very mild	1
5 – 60 minutes	Mild	3
1 – 24 hours	Moderate	2
1 – 7 days	Severe	8
1 – 4 weeks	Very severe	15
> 4 weeks	Extremely severe	11

Note. Scale adapted from Lezak et al., 2004

Table 3.

CT Abnormalities and Focal Lesions

	Yes	No	Data Unavailable
CT abnormalities	80%	15%	5%
Swelling	45%	55%	
Frontal lobe	57.5%	40%	2.5%
Temporal lobe	22.5%	72.5%	5%
Parietal lobe	20%	77.5%	2.5%
Occipital lobe	10%	87.5%	2.5%
Cerebellum	2.5%	95%	2.5%
Other injuries	95%	5%	

Table 3 shows that the majority of participants (80%) had abnormalities on a CT scan reported as either DAI or as a focal lesion. Additionally, 95% of participants had also sustained other orthopaedic injuries.

Table 4 shows that all except 2 participants were employed pre-morbidly. Most professional/office workers remained in that sector (pre-morbid = 15, T1 = 12, T2 = 13), however, at a lower than pre-morbid level. Note that informal assistance employment

remained the same from T1 to T2. Data suggests that the greatest employment fallout occurred in the secondary sector where 18 participants were employed before injury, three at T1 and four at T2. There was an increase in informal assistance, that is, work without payment, from three participants at T1 to eight at T2. Olver et al. (1996) found a decrease in employment when they assessed outcome at years two and years five after TBI. The small increase in employment in this specific population may be as a result of litigants being discouraged to work during the litigation process, in an attempt not to negatively influence the amount of monetary compensation they may receive from the RAF.

Table 4.

Employment and Relationship Status Pre-accident, at T1, and at T2.

	Pre-accident	T1	T2
Marital status			
Single/widowed	15% (6)	35% (14)	35% (14)
Married/co-habiting	80% (32)	62.5% (25)	52.5% (21)
Divorced	5% (2)	1% (1)	12.5% (5)
Employment			
Employed	95% (38)	62.5% (25)	75% (30)
Unemployed	5% (2)	37.5% (15)	25% (10)
Financially gainfully employed	95% (38)	55% (22)	55% (22)
Type of employment			
Professional/office work	37.5% (15)	30% (12)	32.5% (13)
Secondary sector[a]	45% (18)	7.5% (3)	10% (4)
Homemaker	1% (1)	1% (1)	1% (1)
Student	12.5% (5)	5% (2)	
Retired	0	0	5% (2)
Informal assistance	0	7.5% (3)	20% (8)
Manual labour	0	12.5% (5)	5% (2)

Note: [a] Secondary sector refers to service industry, for example, factory and security guard work. Informal assistance refers to unsalaried casual assistance to others.

Table 4 also shows that participants who were single or widowed at T1 tended to remain the same at T2. However, more participants were divorced at T2 than at T1, and those who were married or co-habiting declined from 32 pre-morbidly to 25 at T1 and 21 at T2, suggesting a breakdown in personal relationships over time. This, however, is not conclusive as rates in relationship breakdown have to be contrasted with the normal population to make a meaningful conclusion. This question may be addressed in a study with a control group.

Table 5 shows that the mechanism of injury in this sample is, by and large, representative of the mechanism of injury as reported by the RAF (Ministry of Transport, 2002).

Table 5.

Mechanism of Injury for Current Participants Compared to Road Accident Fund Litigants

Category	Present study	RAF
Driver	20%	25%
Passenger	37.5%	44%
Pedestrian	22.5%	28%
Motorcycle	15%	3%
Bicycle	5%	Not reported

Materials and sources of data

There were four sources of data from which information about independent variables and outcome measures were derived: (a) medico-legal files, which included neuropsychological testing at T1; (b) neuropsychological testing at T2; (c) interview with the participant; and (d) interview with a significant other of the participant.

Medico-Legal Files

The medico-legal files consist of information (i.e., ambulance notes, hospital notes, and medical expert reports) related to the MVA. The hospital notes typically include, but are not limited to, GCS scores, the nature of the injury, results of CT or MRI scans if either was done, medication administered, type of injury, and treatment of injury. The medical expert reports typically include, but are not limited to, reports from neurologists, neurosurgeons, occupational therapists and psychologists. Comment in these reports covers the nature of and

recovery from the injury, as well as documentation of the injured party's socio-economic status, education and psychological status.

Neuropsychological Tests

A full neuropsychological report, based on testing completed in the aftermath of the MVA for medico-legal purposes, was available for each participant. I gathered the T1 neuropsychological test scores from the testing session and this report. The neuropsychological tests that were most frequently administered at T1 (numbering 14) and a test of effort were chosen to be administered at T2. This consistency in testing is an improvement on Wood and Rutterford's (2006a) study, where different tests were administered at their Time 1 and Time 2 sessions. In the current study, the test battery covered the domains of memory, executive functioning and attention, language, visuo-spatial function, and motor function. One effort test was also administered. If the tests were administered in Afrikaans at T1, the same was done at T2. The outcome variable *Neuropsychological status* was derived from scores on the neuropsychological tests administered at T1 and T2. Separate composite scores for T1 and T2 were derived by adding the individual test scores at each session and dividing the sum by the number of tests administered at that session.

The SA-WAIS is the South African version of the WAIS-R. It is different from the WAIS-R only in that South African norms are available for the test and that it is available in the original English as well as in Afrikaans translation. There is, as yet, no South African version of the WAIS-III. Because performance correlations between the WAIS-R and WAIS-III are high, which suggests that essentially the same constructs are measured in both tests, there is no reason to suspect that the SA-WAIS measures any different constructs from either the

WAIS-R or WAIS-III. Due to the timeframe over which patients were tested, some participants (n = 21) were administered SA-WAIS subtests and others (n = 19) WAIS-III subtests. All participants were, however, administered only three Wechsler subtests: *Block Design, Digit Span,* and *Digit Symbol-Coding.*

The *WAIS Block Design* subtest (Wechsler, 1981) is an assembly and building task that involves spatial perception both on the conceptual level and in motor execution. Test-retest reliabilities are good and over intervals of 2 to 12 weeks range from .80 to .88 (Lezak et al., 2004). The SA-WAIS version of this subtest includes seven designs and has a maximum score of 42 points. The WAIS-III version includes 14 designs and has a maximum score of 68 points. This discrepancy in the raw scores between the two versions of the subtest does not affect the study because (a) differences between participants were only assessed in terms of scaled scores, and (b) participants were administered the same version of the subtest at T2 as at T1.

The *WAIS Digit Span* subtest (Wechsler, 1981) consists of *Digits Forward* and *Digits Backward* sections. It is most commonly used for measuring span of immediate verbal recall and working memory. Digits Forward is thought to be primarily a measure of attention, that is, freedom from distraction, whereas Digits Backwards is a measure of working memory (Strauss et al., 2006). Practice effects are negligible over a period of 2 to 12 weeks (ranging from .75 to .85 between the ages of 16 to 74 years; The Psychological Corporation, 1997). The SA-WAIS and WAIS-III versions of this subtest are identical. T1 and T2 data from this test were both scored according to WAIS-III guidelines.

The *WAIS Digit Symbol-Coding* subtest (Wechsler, 1981) is a test of psychomotor performance and processing speed. The SA-WAIS version of this subtest has a maximum raw score of 67, whereas the WAIS-III version has a maximum raw score of 133. Again, this discrepancy in raw scores between the two versions of the subtest does not affect the study because (a) differences between participants were only assessed in terms of scaled scores, and (b) participants were administered the same version of the subtest at T2 as at T1.

The *Purdue Pegboard* test (Lafayette Instrument Company, 1999) measures uni-manual and bi-manual finger and hand dexterity. The task taps not only motor ability but is also demanding of cognitive speed and attentional control, thus making it a useful predictor of functioning in every day life (Strauss, Sherman, & Spreen, 2006). Although some empirical studies have noted the presence of practice effects on repeated testing, with scores improving with each consecutive trial in individuals who were tested over eight test sessions at 2 to 4 week intervals (Feinstein, Brown, & Ron, 1994), it is unlikely that such practice effects would apply in the current longitudinal study design.

The *Rey-Osterrieth Complex Figure* test *(ROCF;* Meyers & Meyers, 1995) assesses a variety of cognitive processes: visuo-spatial constructional ability and visual memory, planning, organisational skills, problem solving strategies and perceptual and motor functions (Lezak et al., 2004; Meyers & Meyers, 1995). Only the Copy and Immediate Recall trials were administered in the current study. The decision to not administer either the Delayed Recall or the Recognition trials was based on concerns about patient fatigue and time constraints. One potential point of difficulty in the current study is that the ROCF was not consistently administered at T1. In some instances, the Rey-Osterrieth Complex Figure Test: Form B (Taylor alternate version) was administered. In contrast, the standard version of the ROCF

was administered to all participants at T2. When the ROCF and the alternate Taylor figure are compared to one another, reliability coefficients are in the moderate range (Strauss et al., 2006). Women tend to perform slightly better than men on the Taylor Figure copy trial, and immediate recall of the ROCF appears to be somewhat more difficult (Strauss, et al., 2006). Although some comparison between the tests is possible, it is not optimal for research purposes and results should thus be interpreted with caution.

The *Rey Auditory Verbal Learning Test (RAVLT*; Lezak, 2004) assesses verbal learning and memory (Strauss et al., 2006). Over 1-year intervals, the test has adequate test-retest reliability with scores on Trial 5 and the delayed recall trials being particularly reliable (r = about .60 to .70; Mitrushina & Satz, 1991; Utchiyama et al., 1995). The RAVLT was administered in either Afrikaans or English, depending on the participant's home language. The Afrikaans version used is the one commonly used in South African clinical practice, although, again, no normative data exist for this administration. Nonetheless, because a primary aim of this study was to assess change within the same participants and not differences between participants, the language-based differences that might be found in between-participant comparisons are of only passing interest.

The *Trail Making Test (TMT*; Reitan, 1955) measures attention, processing speed, and mental flexibility. In normal adults, 11-month test-retest reliability is adequate for Part A (.79) and high for Part B (.98; Dikmen, Heaton, Grant, & Tempkin, 1999).

The *Controlled Oral Word Association Test (COWAT*; Lezak, 2004), also called *Verbal Fluency*, assesses spontaneous production of words under restricted search conditions. In recent years the COWAT has also been found to have utility in examining executive

functions. Test-retest correlations are typically above .70 for letter and semantic (category, typically animal naming) fluency, over short as well as long (5 years) intervals (Levine, Miller, Becker, Selnes, & Cohen, 2004; .Strauss, 2006). When testing verbal fluency, *F*, *A*, and *S* are the most commonly used letters, although other letter combinations are also used (Strauss et al., 2006). The letter *F* is not, however, appropriate for use in Afrikaans.[6] Although for Afrikaans participants the letters *M*, *A*, and *S* are most commonly used in the clinical setting, there are no normative data for this administration. Regardless of which letters were used in the administration, however, the same letters that were used for testing at T1 were used at T2. Again, because this study was primarily interested in assessing change within the same participants and not differences between participants, the differences that might result in the scores as a result of the different letters used should not influence the results. In the *Semantic Fluency* test, 'animals' was used for both Afrikaans and English speaking participants.

The *Forced-Choice Test* (Hugo et al., 2001) is a 21-item instrument that detects simulated memory impairment. It is argued that those who fake will "perform significantly worse than chance as they use their recognition of the correct stimulus to choose an incorrect response" (Theron et al., 2001, p. 97). The free recall task is insufficient as a test of malingering but the recognition test is effective, even at a cut-off score of 15.5, higher than the 50% cut-off point (Theron et al., 2001).

[6] It is easily confused with the use of the letter V and therefore not appropriate, especially for individuals with a low education level.

Other Assessment Instruments

The *Head Injury Family Interview, Version 2.0 (HI-FI*; Kay, Cavallo & Ezrachi, 1995)[7] is a well researched and validated tool, and was administered verbally to the participants. This tool was developed to comprehensively and systematically gather information regarding specific issues relevant to TBI in order to be useful to the clinician who wants to assess the impact of a head injury on both the client and the family. Information is gathered by asking structured questions, using check lists and rating scales. Participants respond to the same content area in a highly structured manner, assuring that all report on the same content areas. The format is easily codable and scorable for data analysis and applicable to both research and clinical work (Kay, Cavallo, & Ezrachi, 1995). It consists of four distinct interviews. For the purposes of this study, only two of those interviews were utilised: a) Interview for the Person with the Head Injury Problem Check List, and b) Significant Other Interview, which includes as a sub section a questionnaire on Activities of Daily Living.

The *Interview for the Person with the Head Injury Problem Checklist* (Kay, Cavallo & Ezrachi, 1995) assesses a head-injured person's perceptions about his/her own deficits. The person rates him- or herself on 42 items (problem areas) common to TBI (e.g., irritability, fatigue, memory and personality change). For each item, the person with the head injury (PHI) is asked whether or not the symptom was experienced at T1. If the response is yes, the person is asked to rate the degree (severity) to which the symptom affected his/her daily life on a scale of 1 to 7. The person is then asked whether the symptom has changed, and, if yes,

[7] The "N.U.Y. Head Injury Family Interview" (HI-FI) was developed under funding from the National Institute on Disability and Rehabilitation Research, U.S. Department of Education (Grant No. H133B0028) to New York University Medical Centre. Use, modification, or translation of the HI-FI requires permission of the authors: Thomas Kay, Marie Cavallo, and Ora Ezrachi.

how they would rate it presently (T2). If the symptom resolved it was scored 0. Questions were phrased as follows:

> When you saw Dr. X in (relevant month and year), did you suffer from (symptom)?

If yes:

> Has that changed, that is, is it better than, worse than or the same at present as when you saw Dr. X?

If there was complete recovery from the symptom, it was scored 0 on the severity scale.

The *Significant Other Interview Problem Checklist* (Kay, Cavallo, & Ezrachi, 1995) is essentially the same questionnaire as the Interview for the Person with the Head Injury Problem Check List, and is administered in the same manner; only in this case it is administered to an informant (i.e., someone who was familiar with the PHI before the injury, and who is still familiar with them). This significant other (SO) was asked if a symptom was experienced or shown by the PHI and if yes, to indicate to what extent the symptom presents a problem for the PHI. Questions were phrased as follows:

> When (PHI's name) saw Dr. X in (relevant month and year), did she suffer from (symptom)?

If yes:

> Has that changed, that is, is it better than, worse than or the same at present as when she saw Dr. X?

Three composite scores, Affective/Behaviour, Cognitive, and Physical Dependency, were derived from the Problem Checklist scores. The composite was derived by adding the item scores and dividing the sum by the number of items rated. Severity scores were used for comparative purposes, as a severity score assumes the presence of the symptom.

The Activities of Daily Living (ADL) questionnaire (Kay, Cavallo & Ezrachi, 1995) asks the SO to rate the PHI's ability to perform common daily activities. Nineteen items are rated on a 5-point scale from 0 ("unable to do at all, even without assistance") to 4 ("does independently, without prompting"). The SO was asked to indicate performance both at T1 and T2. Two composite scores were derived at by adding T1 and T2 scores respectively and dividing each sum by the number of items answered at each assessment session.

Procedure

Ethical approval for the study was granted by the Research Ethics Committee of the University Of Cape Town, Department Of Psychology.

As noted above, names and contact information for potential participants were gathered from two local neuropsychologists. Neuropsychological test data for the first assessment was drawn from the medico-legal folders before commencement of the second assessment. The potential participants were first contacted by telephone, and appointments were made for them to come to Groote Schuur Hospital for the interview and testing session. Each session lasted approximately 3 hours. The significant other was sometimes interviewed during the same session or, alternatively, an appointment was made for the researcher to assess the participant at a location suitable to them.

I collected data for 37 of the 40 participants. A PhD-level research assistant who is fluent in Afrikaans and well trained in neuropsychological testing collected data for the other three participants.

At the beginning of the interview and testing session, the demographic questionnaire was administered to both the PHI and the SO. Neuropsychological testing followed, and then the HI-FI was administered. Before testing started with the PHI, the significant-other interview was discussed with the SO, who then completed the questionnaire. If the SO needed assistance in completing the questionnaire it was done at the end of the PHI's testing and interview.

Data analysis

This study is in part a repeated-measures design (neuropsychological test data were collected from the same participants at two different times) and in part a longitudinal design using retrospective data. As noted above, data were collected using a battery of standard neuropsychological tests and the Head Injury Family Interview.

Neuropsychological test score norms for different ethnic, socio-economic and language groups are, for the most part, not available in South Africa. For this reason raw scores were used for comparison as opposed to standard scores, except in the case of the WAIS Digit Symbol-Coding and Block Design subtests (South African norms are available in these cases). A standardised composite score for neuropsychological test performance at T1 and T2 was derived by averaging across the *z*-scores on each individual test. This composite score is blunt because it is an average score across all tests, and so does account for, or give information about, changes in multiple directions. Nonetheless, the composite dependent

variable is useful in the context of this study because (a) the current sample size does not allow for the analysis of multiple neuropsychological dependent variables, each one based on the performance on a single test, and (b) the point of interest is overall neuropsychological performance, rather than, for instance, a profile of strengths and weaknesses across various tests.

Data analyses were all conducted using STATISTICA 7.0 (StatSoft, 2007) and the Statistical Package for the Social Sciences (Field, 2005; SPSS Inc., 1997). The threshold for significance was set at p=0.05 for all statistical decisions.

In order to evaluate Hypothesis 1, I first examined the variation within the sample in terms of injury severity, level of education, and age at the time of accident, and then assessed, by means of bivariate correlational statistics, the relationship of those variables to T1 neuropsychological test performance. Then, in the light of those findings, I examined the distribution of neuropsychological test scores at T1, with an eye toward gross examination of whether it appeared that malingering or suboptimal effort was present in any participant at that time. To provide more fine-grained analysis of that question, several steps were subsequently taken. First, differences between T1 and T2 in all neuropsychological test outcome variables were assessed by using the Student's *t*-Test. Due to the small sample size and high number of tests administered, the Bonferroni correction was applied. The Bonferroni method allows for many comparison statements to be made while assuring that an overall confidence coefficient is maintained. Hedge's *g*, which is congruent with Cohen's *d* but adjusted for small sample bias, was used to calculate effect size using the Effect Size Calculator (1996).

To further investigate relevance of the changes from T1 to T2 in neuropsychological test scores, the *Reliable Change Index* (*RCI*; Millis et al., 2001) was employed. The RCI is typically used to detect if statistically significant differences in scores on neuropsychological tests administered at two different times are clinically meaningful. The calculation is based on standard error of difference scores:

$SEd = \sqrt{2}(Se)^2$, where $Se = s(\sqrt{1} - r_{xx})$,

where s is the standard deviation from the first testing occasion and r_{xx} is the test-retest reliability measure. The *SEd* gives information regarding the magnitude of score-change that is unlikely to have occurred by chance (Millis et al., 2001, p. 349).

Here, the RCI was calculated with the Reliable Change Criterion Calculator, using ±1.64 standard deviation to establish a 90% change score confidence limit (Evans, 1998).

The second step in gauging the presence or not of malingering or suboptimal effort at T1 was to conduct a sub-group analysis of 14 participants (seven in a Poor Effort group and seven in a Good Effort group). The Poor Effort group consisted of all participants who fell below the 15.5 cut-off score on the Forced Choice test (Hugo et al., 2001). The Good Effort group consisted of those participants who performed the best (scores of 19 +) on the same test, and who had completed all of the neuropsychological tests at both T1 and T2. Between-group differences on neuropsychological test scores at T1, as well as magnitude of T2-T1 discrepancies, were evaluated using Student's *t*-test (Bonferroni corrected). Finally with regard to Hypothesis 1, a multiple case-study approach was adopted. Six case studies were

produced – three selected on the basis of the best effort scores at T1, and three selected on the basis of the worst effort scores at T1.

In order to evaluate Hypothesis 2, differences between T1 and T2 on all of the relevant outcome variables were assessed by using the Student's *t*-Test (Bonferroni corrected). Hedge's *g* was again used to calculate effect size.

In order to evaluate Hypothesis 3, *Canonical Correlation Analysis* (*CCA*) was used to assess the relations between the outcome variables. CCA allows one to examine patterns of interrelationships between sets of independent and dependent variables, unlike linear regression analysis, which allows consideration of only one independent variable at a time. Thus, CCA introduces a critical advantage over simple regression analysis in that the examination of a wide variety of possible relationships is allowed and the basic relationship is extended to a whole set of dependent variables (Levine, 1977).

CCA subsumes factor analysis as a data reduction technique. Using CCA, one can therefore explain not one, but several dependent variables by a set of independent variables; that is, how the constructs at T1 as a whole are related to the constructs at T2. CCA will not improve a theory; however, it permits crucial analysis of aspects of a theory that seem intractable (Levine, 1977).

The rationale is identifying statistically independent patterns of linkage between the two sets of variables. There may be an infinite number of linear combinations between the sets. Independent patterns are attained by removing the most highly correlated pair, thus constraining "the next set of combinations to be uncorrelated with the first pair" (Levine,

1977, p. 15), allowing for location of subsequent pairs of combinations. Each following pair will have a smaller canonical correlation than the previous pairs, but it will be the highest possible at its generation. Thus, all pairs following the first "are constrained to be uncorrelated with all the preceding combinations" (Levine, 1977, p. 16).

When using CCA, it is important to take cognisance of multi-collinearity, that is, intercorrelated predictors. As Levine states:

> This implies that the confidence intervals around the coefficients will be broad, that one variable may hide or suppress the importance of another variable correlated with the first.... The suppression issue is probably the most crucial in the ability to interpret (Levine, 1977, p. 18).

A solution to this problem is to:

> interpret the content of the variates via the *correlations of the original variables with the canonical variate*.... The use of this approach to substantive interpretation recognises that the composite is a manifestation of some abstract notion and information about the nature of this abstract phenomenon cannot be achieved directly – but can be acquired indirectly by asking what is related to it (Levine, 1977, pp. 18-19).

The risk of interpreting an effect that may not be replicable in future studies or may not be noteworthy should be avoided by only interpreting functions that explain a reasonable

amount of variance between the variable sets. Functions that explain less than 10% of variance are sufficiently weak not to warrant interpretation (Sherry & Henson, 2005).

In order to evaluate Hypothesis 4, *Multiple Regression Analysis* (*MRA*) was used to assess which demographic variables best predict each individual outcome variable. More specifically, I examined the changes in dependent variables (NTS, ADL, behaviour, cognition and PD) associated with changes in independent variables (age at the time of accident, months since injury, years of education, employment status at T1, GCS and PTA).

Results

Each hypothesis will be examined in turn.

Hypothesis 1

T1 neuropsychological performance, and its relationship with demographic/injury variables

Hypothesis 1 suggests that if there are no significant differences in the sample as pertains to injury severity, level of education or other demographic variables that impact neuropsychological test performance, there will not be significant variation in the test scores across participants. If significant differences are present in those demographic variables then neuropsychological test scores may vary significantly across participants. These differences may be accounted for by the demographic variables or they may be accounted for by underachievement in some participants in contrast to genuine effort by others.

As shown in Table 1, there was wide variation across participants in terms of severity of injury, years of education, and age at the time of injury. Only the latter variable's distribution showed a statistically significant deviation from normality, however (Kolmogorov-Smirnov statistic (K-S) = .150, $df = 40$, $p = .024$). Thus, if at T1 there were significant variations in performance across participants, these variations might be attributed to the wide range of ages at the time of injury.

Regarding the relationship between independent variables and test scores at T1, Table 6 shows that, although age at injury and injury severity are not significantly associated with T1 neuropsychological test performance, level of education is highly correlated with test performance at that time. This finding is congruent with a large body of neuropsychological

literature, and is not a surprising finding even in the TBI context (Draper et al., 2007; Hoofien et al., 2002; Tate et al., 2005; Wood & Rutterford, 2006a).

Table 6.

Correlations between T1 Neuropsychological Test Scores and Demographic/Injury Variables

Test	Age		Years of education		Injury severity[a]	
WAIS						
Digit Span	-.002	(40)	.335*	(40)	.139[b]	(38)
Block Design	-.009	(35)	.341*	(35)	.067	(34)
Digit Symbol	-.082	(38)	.353*	(38)	.359*	(36)
COWAT	-.028	(35)	.527*	(35)	.144	(33)
Animals	.139	(39)	.203	(39)	.231	(37)
AVLT						
Trial 5	.039	(37)	.338*	(37)	.109	(37)
Trials 1-5	-.095	(38)	.506**	(38)	.025	(38)
Delayed Recall	-.019	(38)	.419**	(38)	.236	(36)
Purdue Pegboard						
Left hand	-.235	(35)	-.151	(35)	-.078	(33)
Right hand	.082	(37)	.132	(37)	.277	(35)
Both hands	.071	(37)	.135	(37)	.235	(35)
ROCF Copy	.031	(28)	.270	(28)	.211	(27)
TMT						
Part A	.074	(39)	.353*	(29)	.293	(37)
Part B	.108	(39)	.088	(29)	.016	(37)
Forced Choice Recognition	.120	(33)	.369	(33)	.363*	(32)

Note. Numbers in parentheses indicate that sample size upon which the correlation is based. Unless otherwise noted, the correlation coefficients presented are based on the Pearson's *r* statistic.

[a]Judgment of injury severity was based on GCS score upon admission to hospital. [b]The correlation coefficients presented in this column are based on the Spearman's *rho* statistic.

*$p < .05$; **$p < .01$

Because of the variation in the demographic and injury-related factors (particularly the age at the time of injury variable) mentioned above, and because of the strong associations between level of education and performance on most of the T1 neuropsychological tests, significant variation in test scores at T1 was expected. A series of tests of normality of distribution confirmed this expectation. As shown in Table 7, the only variables on which the distribution of scores did *not* significantly deviate from normality were WAIS Block Design and Digit Symbol, COWAT, Animals, AVLT Trial 5 and Trials 1-5, and TMT Part B.

Table 7.

Tests of Normality of Distribution of T1 Neuropsychological Test Variables

Test	K-S	df	*p*
WAIS			
Digit Span	.234	40	< .001**
Block Design	.140	35	.080
Digit Symbol	.108	38	.200[b]
COWAT	.138	35	.092
Animals	.127	39	.114
AVLT			
Trial 5	.136	37	.082
Trials 1-5	.132	38	.093
Delayed Recall	.149	38	.032*
Purdue Pegboard			
Right hand	.210	35	< .001**
Left hand	.221	37	< .001**
Both hands	.260	37	< .001**
RCF – Copy	.339	28	< .001**
TMT			
Part A	.169	39	.007*
Part B	.097	39	.200[b]
Forced Choice Test	.187	33	.005*

[a]Lilliefors Significance Correction. [b]This is a lower bound of the true significance.

*$p < .05$; **$p < .01$

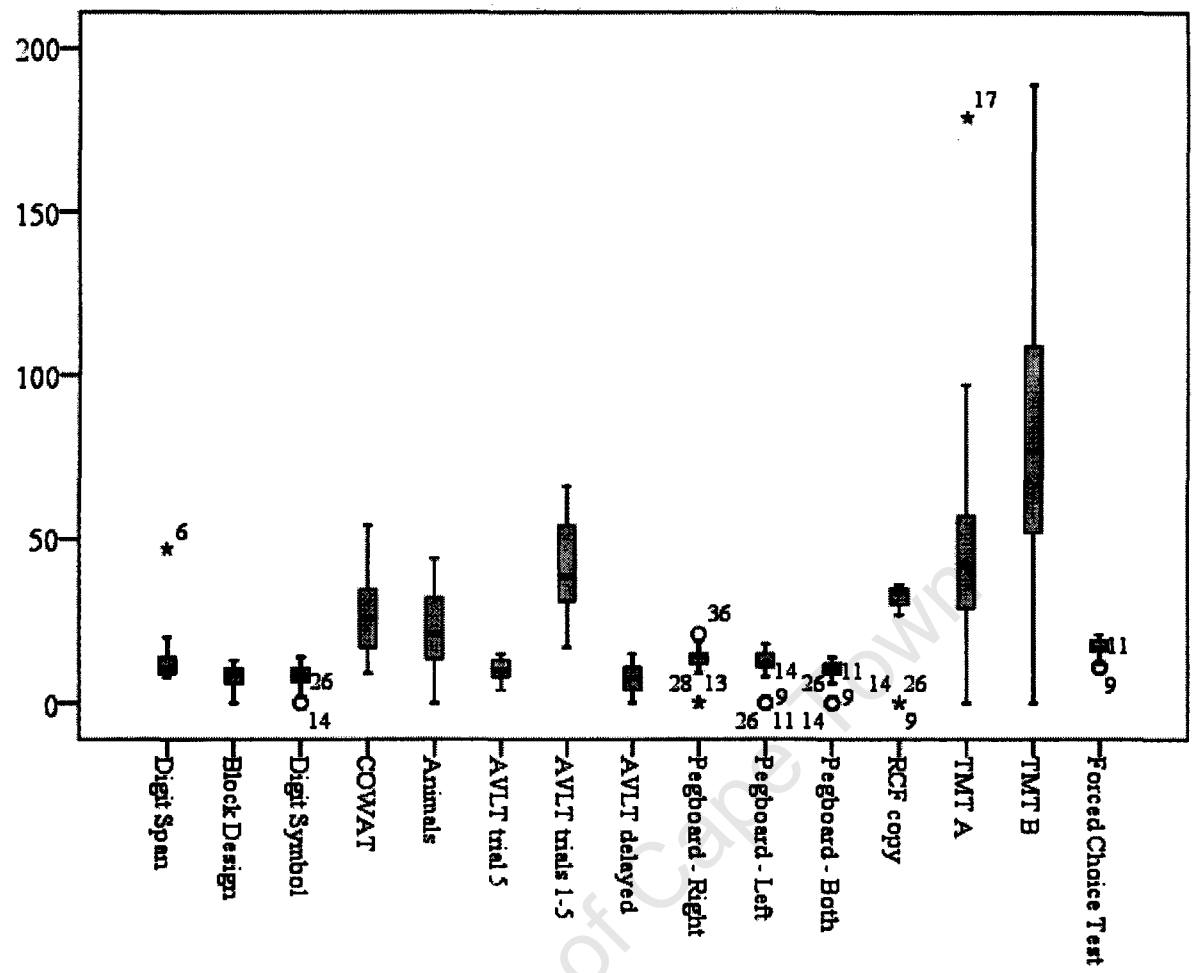

Figure 1. Distribution of Test Scores at T1. Numbers shown in the figure are outliers and specifically refer to the number given to the participant that is an outlier.

The box-and-whisker plots shown in Figure 1 indicate that, on several of the neuropsychological tests, there were cases that might persuasively be regarded as outliers. As these plots show, however, these cases are not consistent across tests; in other words, there is no one participant who is performing exceptionally poorly or exceptionally well, relative to all of the other participants, on all of the T1 neuropsychological tests. Perhaps the only note of interest here, then, is that Participant 9's performance was relatively poor on 4 of the 15 tests (Purdue Pegboard – left hand; Purdue Pegboard – both hands; RCF Copy; and Forced Choice test). This participant was, however, the individual who had sustained the most severe injuries in this sample, and so her relatively poor performance might be regarded as

consistent with the extent of her injuries. Overall, then, the pattern of data presented here suggest that either (a) everyone is malingering, or (b) no-one is malingering. Which of these two suggestions is closest to the reality of the situation was explored, initially, by examining the relationships between neuropsychological test scores at T1 and those at T2.

Relationship between neuropsychological test performance at T1 and T2

As is shown in Table 8, statistically significant changes occurred between T1 and T2 on the following tests: COWAT (improvement) and Purdue Pegboard (right, left, and both hands, decline). Additionally, a small decline occurred in the sum of words remembered across AVLT trials 1-5. Taking the Bonferroni correction into consideration, however, the only differences that remained statistically significant were Purdue Pegboard-left and both hands hand and Purdue Pegboard-both hands. From a clinical perspective, taking the absolute magnitude of the mean differences into consideration, these improvements are small. Furthermore, as shown in Table 8, the Hedge's *g* estimated effect sizes for all neuropsychological test variables ranged from small to medium.

Reliable Change Index (RCI) analyses were conducted for those neuropsychological test variables that were statistically significantly different from T1 to T2. As noted above, difference scores that fell outside a 90% confidence interval (defined by multiplying standard error of difference (*SEd*) scores by ±1.64 standard deviations) were considered as representing statistically reliable changes from T1 to T2. As shown in Table 9, the only tests on which any of the participants showed reliable improvement were the COWAT (1 participant) and the Purdue Pegboard-right hand (6 participants). In fact, more participants showed reliable *deterioration* in performance, particularly on the Purdue Pegboard test.

These analyses, then, do not persuasively argue for malingering or suboptimal effort at T1 testing in contrast to genuine effort at T2 testing.

Table 8.

Neuropsychological Test Performance: Raw Scores

Test	T1			T2			df	*t*	*p*	Hedge's *g*
	n	Mean	S.D.	*n*	Mean	S.D				
WAIS										
DS – F	40	7.73	2.62	40	8.23	1.86	39	-1.12	.26	.27
DS – B	40	5.73	1.75	40	5.5	1.79	39	.83	.40	.21
DS - Total	40	13.46	3.69	40	13.72	3.13	39	-.55	.58	.25
BD	34	21.85	9.77	36	22.87	11.21	33	-.63	.52	.22
DS - Cd	37	38.05	17.77	38	38	17.52	36	-.02	.98	.13
COWAT	35	27.57	13.18	39	31.46	14.46	34	-3.12	.003**	.08
Animals	38	23.5	10.34	39	24.59	11.25	37	-1.39	.17	.10
AVLT										
Trial 5	38	10.16	3.21	40	9.73	3.67	36	1.93	.06	.0
Trial 1-5	38	41.32	13.26	40	39.05	14.34	37	2.41	.02*	.28
Delayed	38	7.58	4.62	40	7.05	4.41	37	1.83	.07	.10
Purdue Pegboard										
Right hand	34	13.91	2.47	31	12.45	2.21	29	2.42	.006*	.12
Left hand	34	12.79	3.36	31	11.61	2.95	29	3.59	.001**	.16
Both hands	33	10.55	2.61	30	9.53	2.23	28	4.41	<.001**	.12
ROCF										
Copy	25	33.02	2.65	34	31.18	5.68	24	1.37	.18	.61
Recall	25	16.46	7.99	33	16.29	8.72	23	-1.24	.22	.37
TMT										
Part A	38	47.5	28.99	38	49.47	24.09	37	-.64	.52	.41
Part B	32	92.44	39.99	32	103.75	43.25	31	-1.46	.15	.39
FCT										
Recall	33	4.67	1.84	37	4.29	1.78	32	.87	.38	.02
Recognition	33	17.06	2.54	37	16.43	2.48	32	.87	.38	.07

Note. The lowest *n* is relevant to the *t* score. DS-F = Digit Span Forward; DS-B = Digit Span Backward; DS-Total = Digit Span Total; BD = Block Design; DS-Cd = Digit Symbol-Coding; COWAT = Controlled Oral Word Association Test; Animals = Semantic (Category) Fluency; AVLT =Auditory Verbal Learning Test; ROCF = Rey-Osterrieth Complex Figure test; TMT = Trail Making Test; FCT = Forced Choice Test.

*$p < 0.05$, **Significant after Bonferroni correction $p < .002$.

Table 9.

Reliable Change Index Intervals for Neuropsychological Tests from T1 to T2

Test	*n*	Prediction interval (±)	Percent Improved	Percent Deteriorated
COWAT	35	14.66	2.5	0
AVLT 1-5	38	16.84	0	5.3
Purdue Pegboard				
Right hand	31	2.21	19.4	45.2
Left hand	33	3.01	0	12.1
Both hands	33	2.34	0	6.1

Note. Sample size column (*n*) represents the number of participants who completed the relevant test at both testing occasions. COWAT = Controlled Oral Word Association Test; AVLT = Auditory Verbal Learning Test.

Comparing a Good Effort group versus a Poor Effort group

To further assess whether malingering or suboptimal effort was present at T1, two sub-groups of participants were created. One group, called the Poor Effort group ($n = 7$), consisted of those participants who had scored below 15.5 on the Forced Choice test. The second group, called the Good Effort group ($n = 7$), consisted of participants who had scored 19 or more on the same test and who had completed all or most of the neuropsychological tests at both T1 and T2. If malingering or suboptimal effort was present in the Poor Effort participants at T1, then one would expect that (a) the Good Effort group would show statistically significantly better overall neuropsychological test performance than the Poor Effort group, and (b) the magnitude of the T2 – T1 differences would be statistically significantly larger in the Poor Effort group than in the Good Effort group.

Table 10 presents demographic and clinical characteristics of the participants in these sub-groups. With regard to these characteristics, independent samples *t*-tests indicated there were no statistically significant between-group differences in terms of age at the time of the accident, years of education, and time between T1 and T2 testing. Similarly, Likelihood Ratio

tests indicated that there were no statistically significant between-group differences in terms of sex, home language, and PTA. There was, however, a statistically significant between-group difference in terms of GCS range (Likelihood Ratio = 7.95, $df = 2$, $p = 0.19$). Better performance at T1 in the Good Effort group may therefore be a result of less severe injury. However, any differences in between-group improvement from T1 to T2 cannot be ascribed to between-group differences in injury severity, given that expected cognitive recovery is complete, and condition stabilized, before T1, regardless of injury severity.

The performance of participants in the two sub-groups on the T1 neuropsychological tests was compared using either Bonferroni-corrected Student *t*-Tests or Mann-Whitney *U* tests (depending on whether assumptions of sphericity were met or not). The results of those comparisons are shown in Table 11. After the Bonferroni correction, there were statistically significant between-group differences on only the WAIS Digit Symbol-Coding subtest and, as expected, on the Forced Choice Test. It should be noted, however, that there were trends toward significant between-group differences on several other tests; whether these trends should be considered indicative of subliminal suboptimal performance or attempts at malingering, or whether they were simply due to the differences in injury severity status between groups, is a question addressed by the subsequent analysis.

The subsequent analysis of neuropsychological test performance of the Good Effort versus the Poor Effort groups involved comparing the average magnitude of T2 – T1 differences, for each of the administered tests, using either Bonferroni-corrected Student *t*-Tests or Mann-Whitney *U* tests (depending on whether assumptions of sphericity were met or not). Table 12 shows the results of this analysis. After the Bonferroni correction was applied, statistically significant differences in the magnitude of T2 – T1 differences were only evident on the

Table 11.

Neuropsychological Test Performance at T1: Poor Effort Group versus Good Effort Group

	Poor Effort Group			Good Effort Group						
Test	*n*	Mean	*SD*	*n*	Mean	*SD*	Test Statistic[a]	*df*	*p*	Hedge's *g*
WAIS										
DS-Total	7	10.57	3.05	7	18.14	12.88	1.51	12	.156	-0.75
BD	7	9.00	2.83	5	10.30	3.60	.703	10	.498	-0.38
DS-Cd	7	7.00	2.29	6	11.67	1.33	4.38	11	.001**	-2.27
COWAT	5	15.20	3.27	7	33.14	12.95	1.00	n/a	.007*	-1.62
Animals	7	16.29	7.63	7	30.14	9.6	2.99	12	.011*	-1.49
AVLT										
Trial 5	7	7.57	3.15	7	12.71	2.50	3.38	12	.005*	-1.68
Trial 1-5	7	31.29	11.84	7	52.00	10.02	3.53	12	.004*	-1.76
Delayed Recall	7	5.86	4.49	7	11.29	3.20	2.61	12	.023*	-1.30
Purdue Pegboard										
Right hand	6	16.17	3.13	5	12.20	6.91	-1.27	9	.236	0.70
Left hand	7	9.43	7.18	6	13.83	2.93	13.50	n/a	.280	-0.72
Both hands	7	7.29	5.53	6	11.50	1.76	11.50	n/a	.169	-0.92
RCF-Copy	3	21.67	18.77	6	33.67	2.58	4.00	n/a	.195	-1.04
TMT										
Part A	7	46.14	12.01	7	28.29	8.26	-3.24	12	.007*	1.61
Part B	7	90.86	75.26	7	61.00	15.14	18.00	n/a	.405	0.51
FCT-Recognition	7	13.14	1.86	7	19.86	0.69	0.00	n/a	.001**	-4.46

Note. Scaled scores are reported for the WAIS Block Design and Digit Symbol-Coding subtests. Raw scores are reported for the rest of the tests. DS-Total = Digit Span Total; BD = Block Design; DS-Cd = Digit Symbol-Coding; COWAT = Controlled Oral Word Association Test; Animals = Semantic (Category) Fluency; AVLT = Auditory Verbal Learning Test; RCF = Rey-Osterrieth Complex Figure test; TMT = Trail Making Test; FCT = Forced Choice Test.

[a]Independent samples *t*-tests were used for all between-group comparisons except in the cases of the following dependent variables: COWAT, Purdue Pegboard-Left hand; Purdue Pegboard-Both hands; RCF-Copy; TMT-Part B; and FCT-Recognition. In these cases, the Mann-Whitney *U*-test was used for between-group comparisons.

*$p < 0.05$; **Significant after Bonferroni correction $p < .003$.

Table 12.

Neuropsychological Test Performance Changes from T1 to T2: Poor Effort Group versus Good Effort Group

	T2 – T1 Difference									
	Poor Effort Group			Good Effort Group						
Test	*n*	Mean	*SD*	*n*	Mean	*SD*	Test Statistic[a]	*df*	*p*	Hedge's *g*
WAIS										
DS-Total	7	.14	2.41	7	-.71	3.50	-.53	12	.603	.26
BD	7	-.07	1.21	5	1.30	.67	2.28	10	.045*	-1.23
DS-Cd	7	.00	.77	6	-.42	1.80	-.56	11	.587	.29
COWAT	5	-.20	2.95	7	2.86	5.11	1.19	10	.261	-.65
Animals	7	.71	2.50	7	.14	8.53	-.13	12	.901	.08
AVLT										
Trial 5	7	.71	2.50	7	-1.14	1.07	-1.81	n/a	.150	.89
Trial 1-5	7	-.71	8.54	7	-2.43	4.43	-.47	n/a	.949	.24
Delayed Recall	7	-1.00	2.45	7	-1.57	2.76	-.41	12	.689	.20
Purdue Pegboard										
Right hand	4	-4.75	6.95	5	-.20	8.53	.86	7	.418	-.51
Left hand	4	-.750	2.22	6	-.83	1.72	-.07	8	.948	.04
Both hands	4	-.50	1.00	6	-1.00	.89	-.83	8	.432	.48
RCF-Copy	3	1.33	1.15	6	-1.17	.98	-3.41	7	.011*	2.15
TMT										
Part A	7	-4.14	18.05	7	-1.71	3.99	.38	n/a	1.00	-.17
Part B	7	-10.43	68.50	7	13.57	12.55	.91	n/a	.276	.45
FCT-Recognition	7	1.71	1.70	7	-2.71	2.63	-3.8	12	.003**	1.86

Note. Scaled scores are reported for the WAIS Digit Span, Block Design and Digit Symbol-Coding subtests. Raw scores are reported for the rest of the tests. DS-Total = Digit Span Total; BD = Block Design; DS-Cd = Digit Symbol-Coding; COWAT = Controlled Oral Word Association Test; Animals = Semantic (Category) Fluency; AVLT = Auditory Verbal Learning Test; RCF = Rey-Osterrieth Complex Figure test; TMT = Trail Making Test; FCT = Forced Choice Test.

[a]Independent samples *t*-tests were used for all between-group comparisons except in the cases of the following dependent variables: AVLT Trial 5; AVLT Trial 1-5; TMT-Part A; TMT-Part B. In these cases, the Mann-Whitney *U*-test was used for between-group comparisons.

*$p < 0.05$; **Significant after Bonferroni correction $p < .003$.

Multiple case-study approach to the malingering question

The first three cases presented below were chosen because the individuals described in them performed below the "questionable effort" cut-off score of 15.5 on the Forced Choice test, scoring 11, 13 and 12, respectively. The second set of three cases were chosen because, in contrast, the individuals described in them performed in the range that is usually associated with optimal effort (i.e., above 15.5), with respective scores of 19, 19 and 18. The information presented in all of the case studies was garnered from the relevant T1 medico-legal files and the corresponding T2 questionnaires, interviews, and neuropsychological test administration.

Case 1 – Name: **MS**

Date of birth: 3 June 1960

Date of injury: 10 November 2002 (aged 42)

Date of first examination (T1): 14 September 2005 (aged 45)

Date of second examination (T2): 9 May 2007 (aged 46)

MS is an Afrikaans-speaking woman who left school at the age of 15 after completing Standard 5 (Grade 7). Before the accident, she worked in a factory; at the time of the accident she worked as a tea-lady and a cleaner. She was unemployed at T1 assessment.

The medical record indicates that MS was in an MVA as a pedestrian, and that she sustained a frontal head injury, a humerus fracture and a knee ligament injury. Her GCS, as recorded on arrival at the hospital, was 7/15. Her PTA was estimated at 11 days. Her head injury was graded as severe. Possible secondary complications included a large haematoma on the

anterior right side of her head. A CT scan of the brain indicated a traumatic sub-arachnoid haemorrhage in the area of the left Sylvian fissure.

With regard to her *physical health status*, at the T1 neuropsychological assessment MS reported that she had continuing problems. These included the following: needing to look down when she walked so that she did not become dizzy; head, arm and leg pain; loss of use of her left arm; excessive fatigue; problems seeing clearly; and anosmia. At the T2 assessment she expressed the same complaints, indicating that these symptoms had not improved (and in some cases had worsened) with time.

With regard to *behavioural problems*, at T1 MS's mother reported that MS did not frequently lose her temper, but that she could frequently be impatient. At both T1 and T2 the mother reported that MS had lost interest in the things that she had previously enjoyed; for example, where she previously enjoyed reading magazines and newspapers and watching television, after the MVA she flipped through magazines and newspapers without reading them, flipped from channel to channel on the television, and sometimes simply stood and stared at nothing in particular. Both MS and her mother, however, indicated that she was less irritable at T2 than she had been at T1.

With regard to her *cognitive status*, at the T1 assessment both MS and her mother complained that the patient was slower than before the accident. Her mother, quoted in the medico-legal report, stated that, "She was like one who did not take notice". MS, in general, left it to her mother to understand what was being asked of her or to explain what was going on. The T1 medico-legal report also indicated the presence of quite severe recent memory impairment. For example, she was unable to go shopping without a list, was not capable of passing on

long messages, and was not able to recall, from day-to-day, details of previous doctor's appointments.

This cognitive status remained much the same at the T2 assessment. In addition to noting that she was "slow" and tired quickly, both MS and her mother indicated that she (a) had difficulty with word finding, (b) was forgetful, (c) could not think clearly and efficiently, and (d) had difficulty with planning and organisation. Although MS did not think that her cognitive status had improved since the T1 assessment, her mother felt that there had been some improvement.

With regard to *mood and affective functioning*, at T1 both MS and her mother reported that MS had changed emotionally and socially after the accident. They noted that, where she was once a sociable, happy person who often joked, she had become withdrawn and did not communicate with friends anymore. They further noted that she was frequently tired and wanted to sleep rather than interact with others. Little changed in her affect and social interaction from T1 to T2.

With regard to *activities of daily living*, both T1 and T2 reports indicated that MS was very dependent on her mother. At T1, reports suggested that due to loss of use of her left hand, she needed her mother to help with washing and dressing. Additionally, she had to be accompanied to buy clothes and could not cook food without supervision. At T2, MS indicated that she generally did not need supervision anymore; however, her mother reported that she still needed help washing and dressing, and needed as much supervision as at T1.

The *neuropsychological test data* for MS are presented in Table 13. Due to the injury to her left hand, MS could complete neither the Purdue Pegboard-left hand and -both hands trials. The RCF was not administered at T1, and was therefore not administered at T2 either. Additionally, MS could not complete Part B of the TMT at either T1 or T2.

Table 13.

Case 1 – MS: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	9	9
Block Design	12	12
Digit Symbol - Coding	35	32
COWAT	13	12
Animals	32	29
AVLT		
Trial 5	8	5
Trials 1-5	33	26
Delayed Recall	8	2
Purdue Pegboard - Right hand	15	14
TMT - Part A	63	44
Forced Choice - Recall	11	12

Note. Raw scores are presented.

As Table 13 illustrates, there was not much change in MS's test performance from T1 to T2 except on two tests: (a) the AVLT, on which she performed more poorly at T2 than at T1 in terms of number of words recalled on Trial 5, the number of words recalled across the five learning trials, and the number of words recalled after a 30-min delay; and (b) Part A of the TMT, which she completed in a shorter time (i.e., performed better on) at T2. With regard to the latter, during T1 testing MS showed both slow processing speed and made a sequencing

error. She was quicker and made no errors at T2 testing, suggesting possible improvements in processing speed, visual attention, and sequencing ability.

With regard to the question of malingering, at T1 MS performed below the cut-off score on the Forced Choice test, suggesting possible suboptimal effort during testing. The medico-legal report by Dr. Hemp states, however, that MS's "performance on these specific screening tasks reflected her performance on testing generally." In addition, the dual facts that her T2 score on this test was only one point better than her T1 score and that there was stability in her performance from T1 to T2 across the vast majority of tests suggest that any improvements on an individual test (such as the TMT-A) are likely due to true cognitive recovery or to other non-effort factors, and argues against malingering in the context of litigation in contrast to genuine effort in the research context.

In *summary*, MS's overall neuropsychological test performance is markedly similar at T1 and T2. Dr Hemp, in her 2005 medico-legal report, commented about the T1 testing that there were times when MS could have done better as she gave up relatively easily during certain tasks (e.g., when generating words on a language task). Such adynamic performance is frequently found in TBI and is frequently attributed to lack of motivation or drive (Walsh, 1985). Given this pattern of performance on neuropsychological tests at T1 and T2, it appears unlikely that MS gave insufficient effort during testing at T1. The data from this case, then, support the group-based statistical analyses which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

Case 2 – Name: **AS**

Date of birth: 28 October 1960

Date of injury: 21 November 1997 (aged 26)

Date of first assessment (T1): 28 June 2001 (aged 29)

Date of second assessment (T2): 17 May 2006 (aged 34)

AS is an English-speaking man who completed high school and received his school leaving certificate (Matric) with exemption. Dr Hemp, in her 2001 medico-legal report, noted that after completing high school, the patient studied for 2 years at the University of the Western Cape but did not complete his degree because he lost his funding. During and following this period of tertiary education, AS was employed as a sales person in a clothing store, after which he worked and trained as a student nurse at Groote Schuur Hospital. His training was terminated after he failed several subjects three times (the maximum number of times failure is allowed). His sister, who was interviewed as part of T1 assessment, ascribed these failures to stressors related to his marriage breaking up. He was not employed when he was assessed at T1 and, at T2, worked as an informal assistant (unsalaried employment) doing odd jobs in the community.

The medical record indicates that AS was admitted to hospital after an MVA in which he was the driver. He was unconscious at the scene of the accident. He had bilateral peri-orbital swelling and contusion (worse on the left than the right). There was blood in his right ear canal, and he had abrasions on his right lateral forehead, the bridge of his nose, his right shoulder and on the right side of his chest. His knees were swollen and tender. A CT scan report indicated that he had an extradural fracture in the left frontal area, deep contusions in both cerebral peduncles (more on the right than the left), and air in the frontal region. He had

an extensive skull fracture in the fronto-temporal region and soft tissue swelling around the frontal region. Extensive cerebral oedema was present. GCS, as recorded on arrival at the hospital, was 7/15. His PTA score, as assessed at the T1 neuropsychological assessment, was more than 4 weeks, indicating a severe head injury.

Several behavioural and cognitive problems were reported at the first assessment and were still present at the second assessment. With regard to *behavioural problems*, the patient's sister reported several difficulties at the T1 assessment. For instance, his behaviour was childish to the point where he sometimes argued with children, and he was unpredictable, did "stupid" things, and laughed at inappropriate times (for example, when someone was crying). She reported that at T2, however, he had become much calmer over the 3 years since the T1 assessment, but that his behaviour was not much different to what it was when he was first tested. Specifically, she stated that he tended to argue less but seemed to be more irritating to other people due to his persistence in expressing a need to help everyone financially and emotionally, despite him not being capable of doing so. Furthermore, she stated that she felt that he was apathetic and anhedonic. AS's sister noted, during the interview with her at T2, that the outcome of the litigation and settlement of the case did not influence his behaviour.

Behavioural observations by the examiner during T2 testing suggested that in general conversation AS was tangential and did not focus on questions asked of him. Furthermore, he appeared to lack insight into his condition and behaviour.

With regard to his *cognitive status,* at the T1 neuropsychological assessment, AS's sister reported that he had difficulties with (a) concentration (e.g., he was easily distractible and appeared to be becoming more so), (b) forgetfulness (e.g., he watched films that he had seen

before but could not recall seeing them; he generally lost track of what he was doing or where he put objects), (c) thinking clearly, (d) planning and organisation (e.g., he needed constant reminding of the tasks and goals he had set himself), and (e) setting realistic goals. At T2 she reported that these symptoms had not changed from the first assessment to the second assessment. At T1 AS's sister also noted that since the accident he had tried to pass his learner driver's licence test four times but had failed on all occasions. AS reported at the second assessment that his concentration had improved and was normal, that his memory had improved, and that he had no difficulty planning and organising things.

With regard to *mood and affective functioning,* at T1 the patient's sister reported that he angered quickly, was aggressive, restless and had mood swings. At T2 she reported that, despite being calmer than before, he still exhibited the same mood swings and aggression. AS reported that he felt that he had become a calmer and more caring person after the accident.

Regarding *social functioning,* the patient's sister reported at T1 that AS did not have any friends and did not partake in activities that he used to enjoy. She told of how he often talked about getting married in the future, driving and working. However, she thought it unlikely to happen as he needed constant supervision. During the T2 interview he expressed the same desires as at T1, saying that he wanted to work as a nurse again. Both he and his sister reported that he was less dependent on others at T2 and that he needed less supervision; however, even at that stage he could not live and function on his own.

At T2, AS was still not capable of working in the open labour market and worked as an informal assistant (unsalaried employment) doing odd jobs. He had not succeeded in getting his driver's licence and was still single. During conversation with him and his sister it was

clear that he lacked insight into his behavioural and cognitive difficulties. He frequently interrupted and was verbose and tangential.

Table 14.

Case 2 – AS: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	11	9
Block Design	31	27
Digit Symbol - Coding	29	29
COWAT[a]	7	11
Animals	18	23
AVLT		
Trial 5	13	15
Trials 1-5	52	47
Delayed	14	14
RCF Copy	33	35
TMT A	60	25
TMT B	158	61
Forced Choice – Recall	13	15

Note. Raw scores are presented.

[a]Score is presented for the letter 'F' only.

The *neuropsychological test data* for AS are presented in Table 14. The table illustrates that there was some change in AS's performance from T1 to T2. Marked improvement occurred on both the TMT A and TMT B, suggesting possible improvements in visual attention and sequencing ability. Additionally, there were some more minor improvements on the letter and semantic fluency tasks. In contrast, AS's performance, deteriorated on: (a) Digit Span – on both occasions he repeated six digits forwards, but at T2 he could only repeat three digits backwards in comparison to five at T1; (b) Block Design – his analysis and synthesis of the

designs were good at both testing occasions, but his performance was slower at T2; and (c) AVLT Trails 1-5 – he recalled fewer words across the set of learning trials at T2 than at T1, suggesting poorer sustained learning ability at T2. Performance differences on other tests between T1 and T2 were generally small and insignificant.

With regards to the question of malingering, at T1 AS performed below the cut-off score on the Forced Choice test, suggesting possible suboptimal effort during testing. The medico-legal report by Dr Hemp states, however, that throughout testing AS was motivated and appeared to be trying hard, and that malingering was not suspected. His markedly improved performance on TMT A and TMT B at T2 may be ascribed to better concentration at T2. It is unlikely that his improvement on this test at T2 can be ascribed to malingering in light of the stability of his performance across some of the other tests and his decline in performance on others. Finally, the fact that his T2 score on the Forced Choice test was only two points better than his T1 score, and that that score therefore remained below the cut-off level suggesting suboptimal effort, argues against malingering in the context of litigation in contrast to genuine effort in the research context.

In *summary*, AS's performance varied on tests across the board, but there was no pattern of improvement. Given this pattern of performance on neuropsychological tests at T1 and T2, it appears unlikely that AS gave insufficient effort during testing at T1. Instead, his poor performance on tests of sustained attention at T1 may be attributed to his general lack of interest in events around him and his inability to hold attention onto single stimuli for relatively long periods. The data from this case, then, support the group-based statistical analyses which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

Case 3 – Name: **NJ**

Date of birth: 26 December 1981

Date of injury: 14 February 1998 (aged 16)

Date of first assessment (T1): 18 January 2002 (aged 20)

Date of second assessment (T2): 28 September 2006 (aged 24)

NJ is an English-speaking man who left school after completing Standard 2 (Grade 4). Dr Frances Hemp, in her 2002 medico-legal report, noted that, although his early childhood development and health were reportedly normal, he started attending school late. He left school because his mother felt that he was neither suited to nor enjoyed school. He subsequently became the breadwinner in the household as he immediately started working in a garage after leaving school. Before his head injury he also worked at a newspaper house, washing food containers and cleaning fridges, and did building work and sold vegetables, fruit, and scrap. After the head injury (at both T1 and T2) he was informally employed, washing cars or cleaning yards.

The medical record indicates that NJ was admitted to hospital after he was involved in a MVA as a passenger. He had a laceration in the left occipital area and there was blood in his urine as a result of a ruptured bladder. A CT scan showed that he had brain swelling, worse on the left than on the right, a smear subdural of 4mm on the right and a midline shift of 4mm. GCS, as recorded on arrival at the hospital, was 7/15. His PTA score, as assessed at T1, was estimated at 5 weeks, indicating a severe head injury.

NJ presented with cognitive and behavioural complaints at both assessments. Regarding *behavioural problems*, at T1 his mother reported that he "swears and carries on" and was

easily irritated where, before the accident, he was a quiet person. At T2, his mother confirmed that, since the head injury, he continued to have (a) temper outbursts, (b) increased irritability, (c) mood swings and difficulty with bringing his emotions under control, (d) frequent arguments with others, and (e) bouts of physical violence. At T2, NJ confirmed that, since the head injury, he had been having temper outbursts that were becoming worse over time, along with mood swings and difficulty with bringing his emotions under control. According to both him and his mother, these behaviours remained largely the same between T1 and T2, but did become worse when he was using alcohol.

With regard to his *cognitive status,* at the T1 assessment NJ reported that his memory was poor and that he was forgetful. He stated that, for example, he would go to a shop intending to buy certain items but would forget what they were on the way there. His mother confirmed this report. At T2, NJ's mother reported that since the accident he tired more quickly and displayed (a) memory difficulties, (b) word-finding difficulties, which often led to circumlocutory ways of expressing himself, (c) poor concentration, (d) difficulty thinking clearly and efficiently, and (e) difficulty with planning and organisation. She noted that he had deteriorated on most of these aspects from T1 to T2, showing only small improvements in his concentration and memory abilities. NJ confirmed at T2 that he had difficulty with word-finding, concentration, memory, thinking clearly and efficiently, and planning and organisation. He felt that he had deteriorated in all of these aspects, but did note that he was less distractible than before.

With regard to *social functioning*, NJ reported at T1 that he still had many friends and freely talked to anyone. His mother reported at T2 that his social functioning had not markedly changed since T1. Specifically, she reported that he continued to be very dependent on others

and that he still needed constant supervision. During his T2 interview NJ disputed this report, stating that he was never dependent on anyone and that he needed only some supervision. The *neuropsychological test data* for NJ are presented in Table 15. TMT-B was not administered at T1 due to his inability to perform the test as a result of his low level of education. The Purdue Pegboard test was not administered at T1, and was therefore not administered at T2 either.

Table 15.

Case 3 – NJ: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	9	12
Block Design	12	9
Digit Symbol - Coding	21	17
COWAT	17	15
Animals	12	14
AVLT		
Trial 5	5	6
Trials 1-5	17	22
Delayed	4	3
TMT A	42	58
Forced Choice – Recall	12	14

Note. Raw scores are presented.

As Table 15 illustrates, there were minimal overall changes in NJ's neuropsychological test performance from T1 to T2. Across testing sessions, he improved on the WAIS Digit Span subtest. Specifically, his performance on digits forwards remained the same but he improved on digits backwards (a span of 3 at T1 compared to 4 at T2). Although it appeared to the examiner that his success on managing four digits backward at T2 was more a matter of

guesswork than a confident and concrete answer, this increased score on a test of working memory is consistent with his self-report of becoming less distractible in the interval between T1 and T2. His improved performance at T2 on the sum of words learned across AVLT Trials 1-5 is confirmation that he showed better ability to sustain attention at the second neuropsychological assessment session.

NJ's continued poor performance on the AVLT Delayed Recall trial at T2 suggests that, despite improved concentration and learning abilities, he continued to show similar memory impairment as at T1. Furthermore, he showed moderately more impaired processing speed at T2 compared to T1, as indicated by his performance on the Digit Symbol-Coding and TMT A tests. Finally, the difficulties he had with visuo-spatial analysis and synthesis on the Block Design subtest at T2 were even more evident than at T1.

With regards to the question of malingering, NJ performed below the cut-off score, suggesting probable suboptimal effort on the Forced Choice test. His performance was similar at T1 and T2. The facts that (a) his T2 score on this test was only two points better than his T1 score, (b) his test performance declined in some cases, and (c) improvements in performance on some tests are consistent with self- and other-reported improvements in attention and concentration abilities, suggest that it is unlikely NJ was malingering in the context of litigation but giving genuine effort in the research context. This conclusion is consistent with the report given by Dr. Hemp in her 2001 medico-legal report, where she comments that her impression was that, at T1 testing, NJ was doing his best throughout testing.

In *summary*, then, the patterns of neuropsychological test performance at T1 and T2 in this case support the group-based statistical analyses which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

The following three cases performed well on the Forced Choice test during their first neuropsychological assessment (i.e., malingering at T1 is not suspected in these cases).

Case 4 —Name: **WM**

Date of birth: 8 October 1965

Date of injury: 17 December 2001 (aged 36)

Date of first examination (T1): 12 February 2004 (aged 39)

Date of second examination (T2): 21 August 2006 (aged 40)

WM is an English-speaking woman who left school after she failed Standard 9 (Grade 11). She subsequently completed a typing course and worked both as a receptionist and an administration clerk for several years. At the time of the accident, she was working at a helpdesk and doing debt collection for a corporate company. At the time of the T1 assessment, she was employed by the same company she had worked for at the time of the accident, but in a reduced capacity. Her work entailed "following up on vehicle"' and helping out at the help-desk if other staff were absent. By the time of the T2 assessment, WM had been medically boarded and was unemployed. She was, however, working informally (in an unsalaried capacity) as a data capturer for her church. At the T2 interview sessions, her husband reported that he had to assist in this work by double checking its accuracy.

The medical record indicates that WM was in a MVA as a passenger, which resulted in a right leg femur fracture, multiple abrasions on her left hand, and dilation and fixation of her left pupil. With regard to head injuries sustained in the MVA, a CT scan report stated that there appeared to be blood related to the quadrigeminal plate cistern/mid brain on the left, as well as subtle areas of high density at the grey/white interface – possibly petechial haemorrhages – features thought to be suggestive of diffuse axonal injury. The sulcul markings were reduced. Her GCS, as recorded on arrival at the hospital, was 10/15 (in the range of a moderate head injury). Her PTA, as assessed at T1, was estimated at 8-9 weeks, placing her in the category for severe head injury.

At the T1 neuropsychological assessment, both WM and her husband reported that she had some physical and cognitive problems. With regard to her *physical health status*, she mainly complained about pain in her right leg and double vision when she looked to the far right. She appeared to be more concerned with her physical problems, while her husband was primarily concerned with her behavioural problems and mood swings.

With regard to her *behavioural problems*, WM's husband reported at T1 that she was "restless" – for example, she could no longer watch a complete television programme or a film from beginning to end as she could not sit still for long enough. He reported that before the accident she was a very active and energetic person who organised everything, an enthusiastic cook who made exciting lunch boxes for their children, and that she cared about her appearance. He stated that, post-morbidly, this all changed due to lack of effort in these spheres. The accident further resulted in her not being able to do many things for herself anymore (e.g., she could no longer manage the children). These behavioural problems remained unchanged at T2. WM did not report any behavioural difficulties at the second

assessment for either T1 or T2. Her husband reported that, in addition to the symptoms discussed under mood and affective functioning, she was still restless, became bored quickly and that she frequently complained about things.

With regard to her *cognitive status*, at T1 WM reported that she could only concentrate for a short period and that she did not have the patience to read books. She thought, however, that her day-to-day memory was fine. She reported that her temporal perception was disturbed in that it felt to her that things that had happened in the past year had happened 4 years ago.

Her husband reported at T2 that she was (a) still expressing herself in a wordy manner, (b) easily distractible, and (c) forgetful. He also stated that she had difficulty with thinking clearly and efficiently, and had difficulty planning and organising things. He felt that most of the symptoms of cognitive dysfunction that were present at T1 were still present at T2. WM reported at T2 that she remained as easily distractible as at the T1 assessment, but that the word-finding and memory difficulties she had experienced at T1 were completely resolved.

With regard to her *mood and affective functioning*, at T1 WM reported that she was constantly aggravated by insignificant things. For instance, she would become easily irritated with her children for no reason, and she felt as if she was taking her frustration out on the children. She recognised this as undesirable behaviour. Also at T1, WM's husband reported that she appeared frustrated by her limitations. He stated that she appeared frequently close to tears, easily irritated, and non-communicative. He noted that she was pushing their children away; and they appeared to be anxious because they had to gauge carefully if she was in the right mood to be approached.

WM was visited at her home for the T2 assessment and interview session. She said that, since the T1 assessment, her mood had improved and that she did not feel depressed or irritable. She reported that as she was getting better, she was becoming more aware of her shortcomings, and that despite ongoing shortcomings she had regained some self-confidence. Her husband, however, reported during his T2 interview that she was as irritable as before and that her temper outbursts had worsened since the first assessment. (It should be noted that WM agreed with her husband on this latter point.) Her husband further reported that her mood swings and difficulty in bringing her emotions under control once expressed were present at both T1 and T2 and that there had been no real change in them.

With regard to *activities of daily living,* WM had, post-morbidly, lost interest in activities such as cooking, decorating the house and making herself attractive (as mentioned previously). She tended to do only what was required from her, rather than making an effort to do things better, as she did before the accident. Her husband reported at both T1 and T2 that she was not dependent on others and did not need supervision. In contrast, WM reported on both occasions that she was, to some degree, dependent on her husband.

The *neuropsychological test data* for WM are presented in Table 16. As the table illustrates, there were significant gains from T1 to T2 on only two tests: the WAIS Block Design subtest, and the Semantic Fluency test (Animals). One possible reason for the marked improvement on the latter may be that she was showing true cognitive recovery as a result of her concerted effort (as she reported in her interview) to do word puzzles to improve her cognition. This may also account for her improvement on Block Design.

WM's neuropsychological test performance was poorer on three tests: (a) Digit Symbol-Coding, (b) Purdue Pegboard-right hand, and (c) TMT-B. This slowing in processing speed may be due to the diffuse axonal injury that she suffered at the time of the accident.

Table 16.

Case 4 – WM: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	17	18
Block Design	42	48
Digit Symbol - Coding	82	66
COWAT	53	51
Animals	11	23
AVLT	11	11
Trial 5	44	40
Trials 1-5	10	8
Delayed Recall	17	18
Purdue Pegboard		
Right hand	16	12
Left hand	12	12
Both hands	13	11
RCF – Copy	35	33
TMT		
Part A	26	27
Part B	39	65
Forced Choice – Recall	19	20

Note. Raw scores are presented.

With regard to the question of malingering, WM performed very well on the Forced Choice test at both T1 and T2 and thus malingering was not suspected at T1.

In *summary*, the overall picture in this case is that WM's neuropsychological, behavioural and social profile remained the same at T2 as it was at T1. There was some evidence, from both T1 and T2 assessments, that she did not have good insight into her condition and did not comprehend the full extent of her behavioural symptoms. In comparison to the three cases previously presented (MS, AS and NJ), the profile of change from T1 to T2 was quite similar, despite the fact that malingering or suboptimal effort might have been suspected in those three cases but not in this one. Specifically, in all four cases presented thus far, the individuals concerned showed improvement on some neuropsychological tests from T1 to T2, along with decline on some other measures. In no case, however, was there a pattern of exceptionally poor overall T1 performance and substantial overall improvement at T2. The data from this case, then, also support the group-based statistical analysis which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

Case 5 – Name: **WD**

Date of birth: 17 August 1969

Date of injury: 29 April 1997 (aged 27)

Date of first examination (T1): 14 May 2002 (aged 31)

Date of second examination (T2): 30 November 2006 (aged 36)

WD is an English-speaking woman who completed high school and attained her school leaving certificate (Matric) with exemption. She was registered as a part-time graduate student in Fine Art with the University of South Africa (distance/correspondence education) and working as a teller for a large bank when the accident occurred. Consequently, she did

not complete her degree and was unemployed when assessed at T1. She was self-employed (unspecified) at T2. She was married at T1 and divorced at T2.

The medical record indicates that WD was involved in an MVA as a driver, and that the accident resulted in an abrasion over her nose, a laceration on her right leg, a bump on her left leg, and a bumped and bleeding right thumb. The medical record also noted that she was unconscious, cold and shocked when she arrived at the hospital (no time frame was given). Her GCS was 6/15 on admission to hospital. Her PTA, as assessed at T1, was estimated at 10 days. She was therefore classified as having suffered a severe head injury. The medical record and expert witness reports contained no description of focal neurological findings and no CT scan report.

WD reported both physical and cognitive complaints at both T1 and T2. With regard to her *physical health status*, at T1 she reported that she was suffering from persistent headaches. This condition had resolved at T2. At both T1 and T2, WD complained of (a) hand-eye coordination difficulty, (b) problems with depth perception, (c) poor balance, (d) loss of sense of taste, and (e) poor sense of smell. She also stated at both assessment occasions that she generally had difficulties with daily activities such as tying her shoes, walking, and talking. Her mother independently confirmed that these symptoms were present at both T1 and T2.

With regard to *behavioural problems,* at T1 WD reported that she was more likely to speak her mind since the accident and that she got very angry, but felt that she could control it. She did not report having this difficulty at T2. Her husband reported at T1 that she was much more aggressive and exploded without provocation and without regard for situation, that she was verbally abusive, threw things and was very unpredictable. Her mother confirmed at T2

that she was irritable, restless, had temper outbursts, got into arguments with others and became bored quickly. As with her cognitive difficulties (discussed below), these symptoms of behavioural problems had improved somewhat over time since T1.

With regard to her *cognitive status,* at T1 WD complained of difficulties with (a) word-finding, (b) memory, (c) organising and planning, (d) being slow, and (e) doing more than one thing at a time. At T1, her husband described her as having (a) a selective memory, (b) difficulty with organising and planning, (c) only succeeding in completing tasks (e.g., cleaning the house) if she stuck to a strict routine, (d) an inability to plan ahead in time. He also stated that she had a tendency to get distracted from important tasks (e.g., she would help her son with his homework only to realise later that she had not prepared anything for supper), that she lacked business insight and that he could not discuss money matters with her. These complaints were also present at T2. WD reported the degree of impairment to be more or less the same at T2 as at T1. Her mother reported that WD also grew fatigued quickly, expressed herself in a wordy manner, and had impaired ability to sustain concentration for extended periods of time. Her mother felt that there was slight improvement in most symptoms of cognitive dysfunction from T1 to T2.

With regard to her *mood and affective functioning,* at T1 WD's husband reported that she was emotionally very stable before the accident and that she was capable of rationally working out problems without upsetting people around her. Since the accident, however, he claimed that she was "extremely morbid". He stated that she had become emotionless and had fairly rapid mood swings. He further stated that she had become manipulative and only believed the truths that she wanted to believe (i.e., she had apparently lost capacity for objectivity). At T2, WD's mother substantiated these claims, noting particularly the continued presence of mood

swings, difficulty in bringing emotions under control, and generalized anxiety. WD did not admit to any of these difficulties at either T1 or T2, suggesting somewhat poor insight into her condition.

With regard to *activities of daily living*, WD reported at T2 that she had always been independent and that she could take care of herself. Her mother reported at T2 that there was some initial dependency, but that she had become less dependent on others since T1. At the same time, however, her mother stressed that the biggest changes that occurred in WD since the accident were that she was less independent, that she had lost her self-confidence, and that she tended to be less sociable than before. At T2, WD was in a child custody battle with her husband. Her desire to have shared custody of her children was a great inspiration to her to improve herself and prove to the world that she was 'normal'.

Table 17.

Case 5 – WM: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	11	11
Block Design	32	35
Digit Symbol - Coding	48	50
COWAT	29	33
Animals	19	21
AVLT		
Trial 5	15	15
Trials 1-5	66	66
Delayed Recall	9	10
Purdue Pegboard		
Right hand	17	17
Left hand	9	9
Both hands	35	34
RCF – Copy	17	14
TMT		
Part A	45	61
Part B	82	92
Forced Choice – Recall	19	18

Note. Raw scores are presented.

The *neuropsychological test data* for WD are presented in Table 17. As the table illustrates, there was not much change in WD's neuropsychological performance from T1 to T2. The only notable aspect here is mild decline in performance on both parts of the TMT, suggesting that her information processing speed may be deteriorating.

With regard to the question of malingering, her Forced Choice test score at T1 was not suggestive of suboptimal effort. Given the pattern of subsequent performance at T2, it

appears likely that she produced genuine effort on both testing occasions. Dr. Hemp, in her 2005 medico-legal report, concurs with this interpretation, commenting that, during T1 testing, WD appeared motivated and applied herself well during testing.

In *summary*, then, the stability in test performance from T1 to T2 in this case is similar to that shown in the previous case studies presented here. Information from the patient's husband at T1 and from her mother at T2 suggests that she showed some behavioural improvement, but that these improvements were not translated into major changes in cognitive functioning at T2. The data from this case, then, support the group-based statistical analysis which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

Case 6 – Name: **ES**

Date of birth: 8 March 1972

Date of injury: 25 May 2001 (aged 29)

Date of first examination (T1): 25 May 2005 (aged 33)

Date of second examination (T2): 9 July 2007 (aged 35)

ES is an Afrikaans-speaking woman who completed 12 years of education but did not pass her school leaving certificate (Matric) examinations. She explained this failure by saying that she had been socialising too much and that she had mixed with the wrong circle of friends during her last year of school. After that failure, she did not attempt the Matric examinations again; instead, she did casual work on a regular basis, working as a cashier, receptionist, stock clerk, and salesperson for various businesses. At the time of the accident, she was working as a stock clerk for a large supermarket chain. When assessed at T1, she was on a

disability grant and working intermittently as a switchboard operator at a shopping mall. She reported at that interview session that she found her work difficult as she could not manage to deal with two calls simultaneously, and did not always get all the relevant information from callers. At T2, she was newly employed on a part-time basis at a small finance firm, doing filing and other low-level office work. She reported that this was a sheltered setting and that her employers did everything possible to facilitate a good working environment for her.

The medical record indicates that ES was involved in an MVA as a pedestrian. The accident resulted in severe head injuries (including a base of skull and Le Fort III fractures), lacerations of her lip and the right frontal area, a laceration to the right thigh, a fractured femur and a dislocated patella. Her GCS, as recorded on arrival at the hospital, was 7/15. Her PTA as estimated at T2 was 40 days. She was therefore classified as having suffered a severe head injury. A CT scan of the brain 3 years after the accident showed evidence of reconstructive surgery bilaterally to the facial bones, a slightly displaced fracture of the right posterior orbital wall, and areas of low density in the right parieto-temporal, right occipital and right posterior parietal regions, suggesting post-traumatic spongiosis.

At the T1 assessment and interview session, ES reported both physical and cognitive problems. With regard to her *physical health status,* at T1 she complained that she could not pick things up with her left arm and that she lacked sensation in that limb. She still had these difficulties at T2. At T1, she also reported that she could not read for extended periods as she became cross-eyed. This difficulty had been, for the most part, resolved at the T2 assessment. At both assessments, ES's balance was poor due to the injury to her right leg. At T1, she reported suffering dizzy spells; this condition was slightly improved at T2. Her sleep pattern was disturbed at T1 but normal at T2. These complaints, and their changes across time, were verified by her parents at both assessments.

With regard to *behavioural problems*, ES's parents reported at T1 that she had started to use alcohol more frequently than before the accident, and she confirmed that she sometimes went out and got drunk. Alcohol use no longer appeared to be a problem at T2.

With regard to her *cognitive status,* at both T1 and T2 ES felt that she was very "sharp" before the accident and that as a result of the accident her "understanding" was not as quick as it had been before. Both she and her parents reported that she could not remember as well as before; for example, she could not remember where she put things and, when listening to a story, she could not recall all of its details at a later stage. She could also not remember everything that she read. She ascribed her difficulty with finding routes to her poor memory (although formal testing showed that she had problems with directionality and with comprehending visuo-spatial relationships). ES reported that her memory remained the same from T1 to T2 and that, at both T1 and T2, she had poor concentration and difficulty thinking clearly and efficiently.

With regard to her *mood and affective functioning,* at T2 ES reported that, as at T1, she was generally feeling depressed, and it worsened annually at the time that the accident occured. She felt that her face and body were ugly due to the scars from the accident. She also felt that she had become an "uglier" person in the sense that she had "ugly" outbursts and used "ugly" language. She reported that her mood was labile, and that she often struggled to bring her emotions under control. She reported that at T2 her temper outbursts were not as bad as at T1, and that she was less inclined to get into arguments with others.

With regard to *activities of daily living,* at T2 ES reported that she did chores around the house and cooked. Neither she nor her parents felt that she needed constant and close

supervision; however, they did admit that she was dependent on others on a daily basis in that she needed reminding of what she had to do due to her poor memory and that she needed guidance as she tended to be unorganised, despite being able to take care of herself.

The *neuropsychological test data* for ES are reported in Table 18. The WAIS Digit Symbol-Coding subtest was not administered at T1 and was therefore not administered at T2 either.

Table 18

Case 6 – ES: Neuropsychological Test Performance

Test	T1	T2
WAIS		
Digit Span	14	17
Block Design	12	16
COWAT	31	34
Animals	19	19
AVLT		
Trial 5	15	12
Trials 1-5	53	56
Delayed	8	10
Purdue Pegboard		
Right hand	18	17
Left hand	9	10
Both hands	10	10
RCF – Copy	28	24
TMT		
Part A	20	15
Part B	49	122
Forced Choice – Recall	18	17

Note. Raw scores are presented.

The small T1 to T2 improvements ES showed on some of the tests (e.g., WAIS Digit Span and Block Design, COWAT, AVLT Trials 1-5 and Delayed Recall) are slight and most likely of no clinical significance (they could, for instance, be attributed to practice or other carryover effects). With regard to the one test on which she performed markedly worse at T2 compared to T1 (TMT-Part B), her poorer performance, in light of her improved performance on TMT-Part A, could also be attributed to her varying attention span.

With regard to the question of malingering, ES's Forced Choice test score at T1 was not suggestive of suboptimal effort. Given her pattern of subsequent neuropsychological test performance at T2, it appears likely that she produced genuine effort on both testing occasions. Dr. Hemp, in her 2001 medico-legal report, concurs with this interpretation, commenting that, during T1, there was no suggestion that ES was doing less than her best, that her variable concentration and attention span seemed genuine and that she gave a motivated performance.

In *summary*, then, the stability in ES's test performance from T1 to T2 is consistent with self- and other-reported stability in behavioural and cognitive status over the same period. The similarity of performance over time reflects that of the other case studies discussed here, suggesting that any improvements on individual test are likely due to true cognitive recovery or to other non-effort factors (and that any declines are likely due to slow progression of, for example, attentional dysfunction, or to other non-effort factors). The data from this and all of the other cases presented in this section therefore support the group-based statistical analysis which indicated that patients with moderate to severe head injury who are assessed in the context of litigation are not inclined to malinger.

Hypothesis 2

Cognitive, behavioural and ADL symptom presentation across T1 and T2

As noted in the literature review, the general tenor of previous studies is that symptom presentation stabilises at approximately 2 years post-injury. Therefore, my second hypothesis is that self- and other-reported cognitive and behavioural status, as well as self- and other-reported level of physical dependency and other-reported degree of independence in activities of daily living (ADL), will show no statistically or clinically significant difference between T1 and T2 assessments, given that both assessments occurred more than 2 years post-injury.

Before moving on to the inferential data analytic evaluation of this hypothesis, it is useful to examine the responses of the head-injured participants and their significant others on individual HI-FI items related to behavioural status, cognitive status, and level of physical dependency. Table 19 shows what percentage of participants (and separately, what percentage of significant others) stated that particular symptoms were present at T1 and at T2.

As can be seen in the column referring to PHI self-report, with regard to behavioural status more participants at T2 than at T1 endorsed items relating to the presence of bad temper, difficulty in controlling emotions, tendencies toward being argumentative, and feelings of loneliness. Many fewer participants reported personality change (i.e., a difference in distinctive traits of mind and behaviour as a whole) at T2 compared to T1. With regard to cognitive status, there is not much self-reported change from T1 to T2. With regard to items that the HI-FI categorizes as belonging to the physical dependency factor, more participants complained of headaches and visual difficulties at T2 than at T1. Furthermore, although fewer participants reported that they needed supervision at T2 than at T1, the same

percentage of participants (62.5%) reported that they were dependent on others on a daily basis at T1 as at T2.

With regard to reports by significant others, across all domains these did not indicate much change from T1 to T2. There were marginally more significant other reports of word-finding difficulty and planning at T2 compared to T1. In contrast, at T2 fewer significant others reported the presence of restlessness, physically violent behaviour, easy boredom, and loneliness than at T1.

Table 19.

PHI and SO Reports of Individual Behavioural, Cognitive, and Physical Dependency Problems at T2

Domain	PHI		SO	
	T1	T2	T1	T2
Behavioural				
Headaches	60	67.5	75	75
Irritability	55	55	80	80
Restlessness	27.5	27.5	70	67.5
Temper	47.5	52.5	40	40
Mood swings	57.5	57.5	70	70
Control of emotions	35	37.5	65	62.5
Argumentative	35	37.5	45	45
Physically violent behaviour	25	25	35	32.5
Getting bored easily	52.5	52.5	65	62.5
Complaining	32.5	32.5	60	60.5
Anxiety	42.5	42.5	65	65
Depression	55	55	60	60
Loneliness	57.5	62.5	55	52.5
Personality change	65	40	60	60
Cognitive				
Fatigue	72.5	72.5	75	75
Word-finding difficulty	70	70	65	67.5
Expressing self in wordy manner	40	42.5	60	60
Distractible	65	65	65	65
Concentration	60	60	67.5	67.5
Memory	87.5	87.5	80	80
Planning	55	55	67.5	72.5
Setting realistic goals	22.5	25	55	55
Following through on tasks	50	50	65	65
Physical Dependency				
Visual difficulties	40	47.5	52	55
Poor balance	65	62.5	60	60
Slowness	82.5	82.5	82.5	82.5
Dysarthria	30	32.5	37.5	37.5
Apathy	45	45	57.5	57.5
Lack of initiative	30	27.5	60	60
Dependency on others	62.5	62.5	65	65
Needing supervision	45	40	52.5	52.5

Note. Numbers presented are percentages of the total sample ($N = 40$).

In order to evaluate the hypothesis under consideration here, Student *t*-Tests comparing all of the HI-FI outcome measures (viz., separate PHI- and SO-reported composite scores for

symptom presence and symptom severity in the domains of behaviour, cognition, and physical dependency at T1 and T2, as well as for an SO-reported composite score for ADL capability at T1 and T2) were conducted.

Composite scores for the outcome variables mentioned above are presented in Table 20. Initial analyses suggested that statistically significant changes in PHI-reported symptom presence from T1 to T2 occurred in the domains of behaviour and cognition, and that statistically significant changes in SO-reported symptom presence from T1 to T2 occurred in the domains of behaviour and ADL capability. When Bonferroni corrections were taken into consideration, however, only two T1 to T2 changes remained statistically significant: the presence of PHI-reported behavioural problems and the presence of SO-reported ADL impairments. The effect size associated with the former was in the range conventionally described as large, whereas the effect size associated with the latter was in the medium range (Cohen, 1988). More specifically, and as the table shows, PHIs self-reported a significant decline in the presence of behavioural problems, an account that is consistent with SOs reporting a significant improvement in the PHI's ADL capabilities. Interestingly, however, SO reports did not indicate a significant decline in the presence of behavioural problems in the PHI from T1 to T2.

Table 20.

Self- and Other-Reported Symptom Presence at T1 and T2

	T1[a]	T2	*df*	*t*	*p*	Hedge's *g*
PHI						
Symptom Presence						
Behaviour	0.58 (0.18)	0.46 (0.24)	39	7.53	<.001**	.56
Cognition	0.66 (0.30)	0.67 (0.30)	39	-0.81	.42	.0
PD	2.66 (1.59)	2.46 (1.64)	39	0.79	.43	.12
Symptom Severity						
Behaviour	2.04 (1.41)	1.76 (1.35)	39	1.53	.13	.20
Cognition	2.84 (1.81)	2.48 (1.66)	39	2.09	.04*	.20
PD	0.50 (0.25)	0.50 (0.24)	39	.0	1	.0
SO						
Symptom Presence						
Behaviour	0.67 (0.26)	0.64 (0.25)	39	2.33	.02*	.12
Cognition	0.74 (0.36)	0.75 (0.33)	39	-0.72	.47	.0
PD	0.58 (0.29)	0.59 (0.29)	39	-0.57	.57	.03
Symptom Severity						
Behaviour	2.85 (1.84)	2.70 (1.87)	39	0.58	.57	.08
Cognition	3.50 (2.14)	3.38 (2.18)	39	0.39	.69	.05
PD	0.58 (0.29)	0.59 (0.29)	39	-0.57	.57	.03
ADL	2.78 (1.20)	3.11 (0.91)	39	-2.62	.01**	.31

Note. Data are presented for all 40 participants in the current sample, with the exception of 39 participants for ADL. PHI = Person with the Head Injury; PD = Physical Dependency; SO = Significant Other; ADL = Activities of Daily Living.

[a]In this column and in the column headed T2, means are presented with standard deviations in parentheses.

*$p < .05$; **Significant after Bonferroni correction at $p < .01$.

To further explore changes in ADL capability between T1 and T2, item-by-item analyses of SO ADL reports were conducted. Table 21 presents these analyses, and shows that, after application of the Bonferroni correction, shopping for food is the only ADL capability that statistically significantly improved (and with a large effect size) from T1 to T2. Before the Bonferroni correction was applied, there was a tendency toward general improvement with

regard to self-care capabilities, as well as with regard to independent feeding, preparing meals, brushing teeth, washing hair, going to the toilet, and helping with household chores.

Table 21.

The Report of Significant Others on ADL Capabilities of Patients at T1 and T2

Activity	T1		T2		*t*	*p*	Hedge's *g*
	n	Mean (*SD*)	*n*	Mean (*SD*)			
Shopping for food	38	1.71 (1.37)	38	3.13 (1.18)	-6.49	<.001**	1.10
Preparing meals	38	2.76 (1.51)	38	3.36 (1.02)	-2.90	.006*	0.46
Feeding self	39	3.41 (1.29)	39	3.92 (0.26)	-0.55	.01*	0.54
Cleaning up after meals	39	2.94 (1.43)	39	3.35 (1.01)	-2.16	.03*	0.33
Choosing own clothes	39	2.97 (1.42)	39	3.30 (0.97)	-1.83	.73	0.27
Dressing self	39	3.30 (1.30)	39	3.56 (1.02)	-1.57	.12	0.22
Washing own clothes	38	2.97 (1.49)	38	3.00 (1.45)	-.14	.88	0.02
Showering/bathing	39	3.23 (1.32)	39	3.61 (0.90)	-2.11	.04	0.33
Brushing teeth	39	3.48 (1.04)	39	3.76 (0.62)	-2.43	.01*	0.32
Washing hair	39	3.28 (1.23)	39	3.64 (0.77)	-2.33	.02*	0.35
Going to the toilet	39	3.58 (1.06)	39	3.92 (0.35)	-2.17	.03*	0.43
Keeping track of finances	39	2.10 (1.44)	39	2.33 (1.38)	-1.32	.19	0.16
Paying own bills	39	2.10 (1.51)	39	2.51 (1.51)	-2.01	.05	0.27
Managing own finances	39	1.92 (2.05)	39	2.05 (1.43)	-1.30	.20	0.07
Making necessary purchases for self	38	2.57 (1.51)	38	2.86 (1.31)	-1.56	.12	0.20
Cleaning own room	38	2.78 (1.39)	38	3.15 (1.12)	-1.56	.05	0.29
Helping with household chores	39	2.92 (1.24)	39	3.35 (0.90)	-2.48	.01*	0.39
Doing yard work and repairs	35	2.68 (1.56)	35	3.08 (1.37)	-1.83	.07	0.27
Could be trusted to take care of self	39	2.92 (1.24)	39	3.35 (0.90)	-2.48	.01*	0.39
Could be trusted to live in own dwelling	39	2.68 (1.56)	39	3.08 (1.37)	-1.83	.07	0.27

*$p < .05$; **Significant after Bonferroni correction at $p < .005$.

In summary, the analyses here confirm that there is no difference in PHI-reported cognitive status and level of physical dependency, and no difference in SO-reported cognitive and

behavioural status, and level of physical dependency, from T1 to T2. The analyses do indicate, however, there is some improvement from T1 to T2 in (a) PHI-reported behaviour and (b) SO-reported ADL capability, specifically with regard to shopping, self-care and hygiene. Whether these changes are clinically significant is a matter for conjecture; this matter will be addressed in the Discussion.

Hypothesis 3

Evaluating multidimensional psychosocial outcome using canonical correlation analysis

The third hypothesis states that each measured predictor/outcome variable will account for only a portion of overall long-term multidimensional psychosocial functioning following head injury. To test this hypothesis, two separate canonical correlation analyses (CCAs) were conducted to evaluate the multivariate shared relationship between particular sets of variables. Essentially, what canonical correlation accomplishes here is to help us understand how many dimensions are necessary to understand the association between the two sets of variables, and which of those dimensions are of clinical significance. The first CCA measured the association between a set of T1 variables (neuropsychological test composite score, self-reported cognitive and behavioural status, self-reported level of physical dependency, and other-reported degree of independence in ADL; these can be considered as independent variables in the CCA) with the same set of variables as measured at T2 (these can be considered the dependent variables in the CCA). The second CCA also measured the association between a set of T1 variables (this time, neuropsychological test composite score, other-reported cognitive and behavioural status, other-reported level of physical dependency, and other-reported degree of independence in ADL; again, these are considered as independent variables) with the same set of variables as measured at T2 (again, these are considered the dependent variables).

In neither of the models did the analysed data violate multivariate normality assumptions. With regard to interpretation of the obtained results, due to this study's relatively small sample size, canonical correlations less than 0.30 were not interpreted (Sherry & Henson, 2005). Furthermore, because the statistics of interest here were fundamentally unidirectional (i.e., I was concerned with the ability of the set of independent (T1) variables to account for variance in the set of dependent (T2) variables), what is presented below largely focuses on examining (a) how many dimensions describe the relationship between the T1 and T2 variables, (b) to what degree the set of predictor (T1) variables influences each of those dimensions, and (c) the amount of the dependent (T2) variable variance that might be accounted for or shared with the independent (T1) variables.

CCA: Measures related to report by person with the head injury (PHI)

Table 22 shows the values of the canonical correlations and tests of dimensionality for the five explanatory dimensions that were extracted for these data.

Table 22

First CCA: Canonical correlation values and tests of dimensionality

Dimension[a]	Canonical Correlation	Squared Correlation	Wilks's Λ	*F*	*df 1*	*df 2*	*p*
1	.89	.80	.005	14.07	25	112.95	< .001
2	.85	.73	.026	13.81	16	95.34	< .001
3	.83	.68	.094	14.26	9	78.03	< .001
4	.72	.51	.295	13.88	4	66.00	< .001
5	.62	.39	.606	22.10	1	34.00	< .001

[a]The rank of the given canonical correlation (from largest to smallest). As always in CCA, there are as many canonical dimensions as there are variables in the smaller of the two variable sets (and there were five variables in each of the sets in this analysis).

The leftmost column of the table shows the derived dimensions for this CCA. Canonical dimensions (sometimes called roots, canonical variates or canonical functions; these terms are often used interchangeably) are latent variables that are analogous to factors obtained in factor analysis.[8]

In the model shown above, there are five canonical dimensions, all of which are statistically significant. The null hypothesis being tested here is that all of the correlations associated with the dimensions in the given set are equal to zero in the population. The test starts with the full set of dimensions (i.e., the question is whether all five dimensions are statistically significant); subsets generated by omitting the greatest dimension in the previous set are then

[8] In fact, the way these dimensions are derived is similar to the process followed in unrotated factor analysis. That is to say, the dimension consists of a correlational relationship between two linear composites, one for the set of dependent variables and the other for the set of independent variables (these are called *canonical variates*). The first dimension is derived so as to have the highest intercorrelation between the two sets of variables, and each subsequent pair is then derived so that it exhibits the maximum relationship between the two sets of variables not accounted for by preceding sets of variates. This is why in CCA each subsequent pair of canonical variates is always less strongly related than the previous (i.e., the canonical correlation associated with each dimension diminishes with each step).

tested in turn. In this CCA, the second dimensionality test is dimensions 2-5, and so on until dimension 5 is tested alone.

The *canonical correlations* shown in Table 22 are simply linear combinations of the two sets of canonical variates: the T1 measurements (independent variables) and T2 measurements (dependent variables). The canonical correlations are therefore simply bivariate (Pearson) correlations of the pairs of canonical variates, and can be interpreted as such: they measure the strength of the overall relationship between the canonical variates for the independent and dependent variables. The *squared canonical correlation* for each dimension, then, provides an estimate of the amount of shared variance between the optimally weighted canonical variates for the independent and dependent variables (Hair, Anderson, Tatham, & Black, 1998). Therefore, the first dimension here accounts for approximately 80% of the shared variance in the relationship between the first two linear composites of T1 and T2 variables.

The squared canonical correlation does *not*, however, represent the portion of variance the linear composites of the sets of independent and dependent variables have extracted from their respective sets of variables. Therefore, before one can conclude that canonical analysis has uncovered relationships of practical (and, in this case, clinical) significance (i.e., before one can safely argue that there is justification in interpreting each of the canonical dimensions), one must carry out further analyses, involving measures other canonical correlations, in order to help determine the amount of the variance in the set of dependent variables that is accounted for by or shared with the set of independent variables (Hair et al., 1998).

One such analysis is the Stewart-Love index of redundancy (Stewart & Love, 1968). This index[9] provides a useful summary measure of the ability of independent variables (always considered as a set) to explain variation in the dependent variables (always considered one at a time). The index measure is thus analogous to the R^2 in any standard multiple regression analysis, and may be similarly interpreted. What the index of redundancy helps us do, then, is to determine which of the identified canonical dimensions might justifiably be interpreted as being of practical and clinical significance.

Appendix D presents tables showing calculations of the Stewart-Love redundancy indices for each of the five identified canonical dimensions. As can be seen, both the first and second dimensions have redundancy index values of at or above .15, and thus merit interpretation (Hemphill, 2003). The last three dimensions (with redundancy indexes of .12, .11 and .06 respectively) do not warrant interpretation.

Now that the statistical significance of the canonical relationship has been established for the various dimensions, and the magnitude of those dimensions and their redundancy indices have been examined for acceptability, the next stage in CCA is interpretation of the canonical variates. Here, we use two of the three methods for interpretation outlined by Hair et al. (1998): canonical weights (standardized coefficients) and canonical loadings (structure correlations).

Table 23 presents the standardized canonical coefficients for the two interpretable dimensions across the sets of both independent and dependent variables. These canonical coefficients

[9] Basically, the value of the index statistic is calculated by (1) calculating the squared multiple correlation coefficient (R^2) between the set of independent variables and each individual dependent variable, and then (2) averaging those squared coefficients to arrive at a summary R^2. For further details of the calculation, see Hair et al. (1998).

define the linear relationship between each of the original variables in a given set (independent or dependent variable) and each of the canonical dimensions, and show the ratio of importance of each of the original variables in calculating the canonical score for each of the canonical dimensions. These standardized canonical coefficients are interpreted in the same manner as one would interpret standardized regression coefficients (Canonical Correlational Analysis. UCLA: Academic Technology Services, Statistical Consulting Group, n.d.).

Table 23

First CCA: Canonical weights for the five canonical dimensions

	Dimension	
Variable	1	2
T1 (Independent)		
PHI-reported behaviour	-.46	.13
PHI-reported cognition	1.11	-.10
PHI-reported PD	-.23	-.42
SO-reported ADL	.31	-.62
NT score	-.35	-.62
T2 (Dependent)		
PHI-reported behaviour	-.31	.07
PHI-reported cognition	1.05	-.21
PHI-reported PD	-.11	-.43
SO-reported ADL	.25	-.51
NT score	-.28	-.78

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

Within the set of (T1) independent variables, then, the first canonical dimension is most strongly influenced by self-reported cognitive status, and the second by other-reported ADL capability and neuropsychological test performance. Within the set of (T2) dependent variables, the most strongly influential original variables for the two canonical dimensions were identical to those for the set of independent variables.

Another interpretative step is required, however, because these canonical weights can be unstable (particularly in cases of multicollinearity) due to the fact that they are calculated with the sole aim of optimizing the canonical correlation (Hair et al., 1998). This second

interpretive step involves calculation of the canonical loadings for the independent and dependent canonical variates for all of the interpretable canonical dimensions.

Canonical loadings, or canonical structure correlations, give a measure of the simple linear correlation between one of the original observed variables in set of independent or dependent variables and the set's canonical variate. This coefficient, then, is interpreted in the same way as a factor loading in conventional factor analysis: It reflects the variance that the original observed variable shares with the canonical variate (i.e., the relative contribution of each original observed variable to each canonical dimension; the larger the coefficient, the more important a contribution it makes to deriving that dimension).

Table 24 presents the canonical loadings for the independent and dependent variates for the two interpretable canonical dimensions. As can be seen, within the set of (T1) independent variables, then, the first canonical dimension is most strongly influenced by self-reported cognitive status, neuropsychological test performance and self-reported physical dependency. Note also that all of these coefficients are positive except for neuropsychological test performance, which suggests that that the latter is a suppressor variable. Within the set of (T1) independent variables, the second canonical dimension is most strongly influenced by other-reported ADL capability and neuropsychological test performance. Within the set of (T2) dependent variables, the most strongly influential original variables for the two canonical dimensions were identical to those for the set of independent variables.

Table 24

First CCA: Canonical structure for the five canonical dimensions

	Dimension	
Variable	1	2
T1 (Independent)[a]		
PHI-reported behaviour	.01	-.25
PHI-reported cognition	.77	-.19
PHI-reported PD	.31	-.32
SO-reported ADL	.16	-.70
NT score	-.49	-.72
T2 (Dependent)[b]		
PHI-reported behaviour	.14	-.06
PHI-reported cognition	.89	-.09
PHI-reported PD	.40	-.16
SO-reported ADL	.06	-.64
NT score	-.48	-.76

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]Data presented are correlations between the independent variables and their canonical variates. [b]Data presented are correlations between the dependent variables and their canonical variates.

CCA: Measures related to report by the significant other (SO)

Table 25 shows the values of the canonical correlations and tests of dimensionality for the five explanatory dimensions that were extracted for these data. As before, the leftmost column of the table shows the derived dimensions for this CCA.

Table 25

Second CCA: Canonical correlation values and tests of dimensionality

Dimension[a]	Canonical Correlation	Squared Correlation	Wilks's Λ	*F*	*df 1*	*df 2*	*p*
1	.86	.74	.018	8.86	25	112.95	< .001
2	.83	.68	.069	8.32	16	95.34	< .001
3	.73	.53	.218	7.53	9	78.03	< .001
4	.66	.44	.467	7.65	4	66.00	< .001
5	.41	.16	.835	6.70	1	34.00	0.14

[a]The rank of the given canonical correlation (from largest to smallest). Again, there are as many canonical dimensions as there are variables in the smaller of the two variable sets (and, again, there were five variables in each of the sets in this analysis).

As in the previous model, in this model there are five canonical dimensions, all of which are statistically significant. The canonical correlations and squared canonical correlations are interpreted in the same way as for the previous model. The first dimension here accounts for approximately 74% of the shared variance in the relationship between the first two linear composites of T1 and T2 variables.

Appendix E presents tables showing calculations of the Stewart-Love redundancy indices for each of the five identified canonical dimensions in this model. As can be seen, only the first dimension has a redundancy index (.26) of more than .15 and therefore merits interpretation (Hemphill, 2003). The last four dimensions (with redundancy indexes of .07, .12, .05 and .04 respectively) do not warrant interpretation.

Table 26 presents the standardized canonical coefficients for the single interpretable dimension across the sets of both independent and dependent variables. Again, these data are interpreted in an identical manner to those in the previous CCA (see Table 23).

Table 26

Second CCA: Canonical weights for the five canonical dimensions

Variable	Dimension 1
T1 (Independent)	
SO-reported behaviour	-.07
SO-reported cognition	-.03
SO-reported PD	.16
SO-reported ADL	-.24
NT score	-.86
T2 (Dependent)	
SO-reported behaviour	-.07
SO-reported cognition	-.23
SO-reported PD	.41
SO-reported ADL	-.11
NT score	-.82

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

Table 27 presents the canonical loadings for the independent and dependent variates for the sole interpretable canonical dimension. Again, these data are interpreted in an identical manner to those in the previous CCA (see Table 24). As can be seen, within the set of (T1) independent variables, the first canonical dimension is most strongly influenced by neuropsychological test performance, other-reported cognitive status and other-reported physical dependency (all the correlations are negative except for other-reported physical dependency, indicating that this latter variable is a suppressor variable). Within the set of (T2) dependent variables, the most strongly influential original variables for the first canonical dimension was identical to that for the set of independent variables.

Table 27

Second CCA: Canonical structure for the five canonical dimensions

Variable	Dimension 1
T1 (Independent)	
SO-reported behaviour	.001
SO-reported cognition	.22
SO-reported PD	.41
SO-reported ADL	-.51
NT score	-.96
T2 (Dependent)	
SO-reported behaviour	.19
SO-reported cognition	.39
SO-reported PD	.65
SO-reported ADL	-.47
NT score	-.96

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]Data presented are correlations between the independent variables and their canonical variates. [b]Data presented are correlations between the dependent variables and their canonical variates.

CCA: Summary

The third hypothesis states that each measured predictor/outcome variable will account for only a portion of overall long-term multidimensional psychosocial functioning following head injury. Both CCAs reported here suggested a fairly strong overall relationship between the set of independent variables and the set of dependent variables. However, the technical literature on CCA (e.g., Sherry & Henson, 2005) suggests that if the variance extracted is small, the value of the function is questionable, meaning that the practical significance of the model may be low as it does not explain a large proportion of the dependent variable's

variance. Similarly, the redundancy index can be used to determine which of the identified canonical dimensions might justifiably be interpreted as being of clinical and practical significance. The results for the first CCA (i.e., the one including self-report measures) indicate that only the first two dimensions have a redundancy index higher than .15, giving it practical significance warranting interpretation (Hemphill, 2003). In the first dimension self-reported cognitive status appear to contribute to variance in the independent variable, and in the second dimension other-reported ADL capability and neuropsychological test performance appear to contribute to variance in the independent variable. The results for the second CCA (i.e., the one including other-report measures) showed that only the first dimension falls above .15 meriting interpretation suggesting that the first canonical dimension is most strongly influenced by neuropsychological test performance followed by other-reported cognitive status.

Hypothesis 4

This hypothesis, which is based on previous findings in the TBI long-term outcome literature, suggests that measures of injury severity (viz., GCS and PTA) will not be predictive of outcome at T2, but that demographic and clinical variables (in this case, age at the time of the accident, months since injury, level of education, and employment status at T1) will be predictive of outcome at T2. Multiple regression analyses were used to test this hypothesis.

More specifically, eight separate linear multiple regressions were conducted, with the above-mentioned independent variables simultaneously forced into the model and used as regressors to predict, at T2, (a) neuropsychological test performance, (b) PHI self-reported behavioural status, (c) PHI self-reported cognitive status, (d) PHI self-reported level of physical dependency, (e) SO-reported behavioural status, (f) SO-reported cognitive status, (g) SO-

reported level of physical dependency, and (h) SO-reported ADL capability. In each of (a) – (h), the dependent variable was the relevant composite score, derived as discussed in the Methods section and identical to that used in the analyses used to evaluate Hypotheses 2 and 3. With regard to dummy coding of the categorical variables, employment status at T1 was simply coded as one comparison of Employed versus Unemployed; GCS was coded as two comparisons to the group that appeared most frequently in the data (i.e., the comparisons were Severe versus Mild and Severe versus Moderate); and PTA was coded in an identical way to GCS.[10]

In each of the models reported below, 38 of the 40 cases were used in the analyses because GCS data were missing for two of the participants. With regard to ensuring that the assumptions underlying regression analyses were met (e.g., assumptions of independent errors and assumptions of no multicollinearity), following recommendations in Field (2005) I checked Durbin-Watson, VIF, and tolerance statistics, as well as casewise diagnostics, for each model. In each case, those assumptions were met. For instance, within each of the eight models values of the Durbin-Watson statistic were all close to 2.0, none of the VIF statistics were greater than 10 (and the average VIF for each model was close to between 1.0 and 2.0), and no tolerance statistic fell below 0.2. Furthermore, no individual case was found to be irregularly influencing any of the models.

[10] The groups described earlier as "none", "very mild", and "mild" PTA were collapsed into one category ("mild"). Similarly, the groups described earlier as "severe", "very severe", and "extremely severe" PTA were collapsed into one category ("severe").

Predicting neuropsychological test performance at T2

Table 30 shows the results of the multiple regression analysis for this outcome variable. As can be seen, the only predictor to make a significant contribution to the model was Years of Education, ß = .635, $t(31) = 5.11$, $p < .001$. The part correlation between Years of Education and T2 neuropsychological test performance (i.e., the relationship between the predictor and the outcome variable, controlling for the effects of all the other predictors) was .58. Furthermore, the data suggest that this model accounted for 60% of the variance in neuropsychological test performance at T2. The ANOVA testing whether the model is significantly better at predicting T2 neuropsychological test performance than would be an approach using the mean as best guess (i.e., by how much we might improve our prediction by fitting the model; Field, 2005, p. 189) confirmed that the model is a good fit for the data, $F(8, 31) = 5.79$, $p < .001$. This positive correlation between neuropsychological test score and years of education suggests that participants with better education performed better on neuropsychological testing.

Table 30.

Summary of Regression Analysis for Variables Predicting Neuropsychological Test Performance at T2 (N = 38)

Variable	*B*	*SE B*	*ß*
Age at the time of the accident	.004	.005	.096
Months since injury	.005	.002	.254
Years of education	.081	.016	.635**
Employment status at T1			
Employed vs. unemployed	.138	.106	.158
GCS			
Severe vs. moderate	-.131	.210	-.079
Severe vs. mild	.225	.157	.205
PTA			
Severe vs. moderate	-.194	.250	-.097
Severe vs. mild	-.242	.201	-.166

Note. $R^2 = .60$ ($p < .001$).

*$p < .05$; **$p < .01$.

Predicting self-reported behavioural status at T2

Table 31 shows the results of the multiple regression analysis for this outcome variable. As can be seen, two predictors, both of them related to injury severity, made a significant contribution to the model: GCS (Severe versus Mild comparison), where ß = .610, $t(31) = 3.81$, $p < .001$, and PTA (Severe versus Mild comparison), where ß = -.33, $t(31) = -2.15$, $p = .04$. The part correlation between GCS (Severe versus Mild comparison) and T2 self-reported behavioural status was .48. The part correlation between PTA (Severe versus Mild comparison) and T2 self-reported behavioural status was -.27. The curious fact that these two associations were in opposite directions will be further commented upon in the Discussion. Furthermore, the data suggest that this model accounted for 50% of the variance in PHI-reported behavioural status at T2. The ANOVA testing whether the model is significantly

better at predicting T2 self-reported behavioural status than would be an approach using the mean as best guess confirmed that the model is a good fit for the data, $F(8, 31) = 3.88$, $p = .003$.

Table 31.

Summary of Regression Analysis for Variables Predicting Self-Reported Behavioural Status at T2 (N = 38)

Variable	*B*	*SE B*	*ß*
Age at the time of the accident	-.007	.017	-.059
Months since injury	-.017	.008	-.302
Years of education	-.076	.054	-.194
Employment status at T1			
Employed vs. unemployed	.348	.361	.129
GCS			
Severe vs. moderate	1.143	.718	.225
Severe vs. mild	2.044	.537	.610**
PTA			
Severe vs. moderate	-.748	.853	-.122
Severe vs. mild	-1.474	.686	-.330*

Note. $R^2 = .50$ ($p < .05$).

*$p < .05$; **$p < .01$.

Predicting other-reported behavioural status at T2

Table 32 shows the results of the multiple regression analysis for this outcome variable. As can be seen, the only predictor to make a significant contribution to the model was Years of Education, ß = -.427, $t(31) = -2.59$, $p = .014$. The part correlation between Years of Education and T2 other-reported behavioural status was -.39. This negative correlation suggests that, according to significant-other reports, participants with fewer years of education presented with more behavioural problems at T2 than did those with more years of education.

Overall, however, the data suggest that this model accounted for only 30% of the variance in SO-reported behavioural status at T2. The ANOVA testing whether the model is significantly better at predicting T2 other-reported behavioural status than would be an approach using the mean as best guess confirmed that the model is not a good fit for the data, $F(8, 31) = 1.62, p = .16$.

Table 32.

Summary of Regression Analysis for Variables Predicting Other-Reported Behavioural Status at T2 (N = 38)

Variable	*B*	*SE B*	*β*
Age at the time of the accident	-.009	.028	-.054
Months since injury	-.003	.014	-.040
Years of education	-.230	.089	-.427*
Employment status at T1			
Employed vs. unemployed	.125	.591	.034
GCS			
Severe vs. moderate	-.042	1.173	-.006
Severe vs. mild	1.095	.878	.237
PTA			
Severe vs. moderate	1.686	1.395	.199
Severe vs. mild	-.276	1.122	-.045

Note. $R^2 = .30$.

*$p < .05$.

Predicting self-reported cognitive status at T2

Table 33 shows the results of the multiple regression analysis for this outcome variable. As can be seen, none of the predictors made a significant contribution to the model. The data go on to suggest that this model accounted for only 19% of the variance in PHI-reported

cognitive status at T2. The ANOVA testing whether the model is significantly better at predicting T2 self-reported behavioural status than would be an approach using the mean as best guess confirmed that the model is not a good fit for the data, $F(8, 31) = 0.91, p = .519$.

Table 33.

Summary of Regression Analysis for Variables Predicting Self-Reported Cognitive Status at T2 (N = 38)

Variable	*B*	*SE B*	*β*
Age at the time of the accident	.013	.029	.081
Months since injury	.000	.014	-.011
Years of education	-.079	.093	-.151
Employment status at T1			
Employed vs. unemployed	-.781	.615	-.217
GCS			
Severe vs. moderate	2.199	1.223	.323
Severe vs. mild	.269	.915	.060
PTA			
Severe vs. moderate	-.477	1.454	-.058
Severe vs. mild	-1.043	1.169	-.174

Note. $R^2 = .19$.

Predicting other-reported cognitive status at T2

Table 34 shows the results of the multiple regression analysis for this outcome variable. As can be seen, the only predictor to make a significant contribution to the model was Years of Education, ß = -.595, $t(31) = -4.03$, $p < .001$. The part correlation between Years of Education and T2 other-reported behavioural status was -.54. This negative correlation suggests that, according to significant-other reports, participants with fewer years of education presented with poorer cognitive status at T2 than did those with more years of education.

Furthermore, the data suggest that this model accounted for 43% of the variance in SO-reported cognitive status at T2. The ANOVA testing whether the model is significantly better at predicting T2 self-reported behavioural status than would be an approach using the mean as best guess confirmed that the model is a good fit for the data, $F(8, 31) = 2.96$, $p = .014$.

Table 34.

Summary of Regression Analysis for Variables Predicting Other-Reported Cognitive Status at T2 (N = 38)

Variable	*B*	*SE B*	*β*
Age at the time of the accident	.006	.029	.032
Months since injury	.003	.014	.038
Years of education	-.373	.093	-.595**
Employment status at T1			
Employed vs. unemployed	-.483	.616	-.112
GCS			
Severe vs. moderate	-.538	1.225	-.066
Severe vs. mild	.833	.916	.155
PTA			
Severe vs. moderate	.463	1.456	.047
Severe vs. mild	.794	1.171	.111

Note. $R^2 = .43$ ($p < .05$)

*$p < .05$; **$p < .01$.

Predicting self-reported levels of physical dependency at T2

Table 35 shows the results of the multiple regression analysis for this outcome variable As can be seen, two predictors made a significant contribution to the model: Months Since Injury, where ß = -.386, $t(31) = -2.22$, $p = .034$, and T1 Employment Status (the comparison of Employed versus Unemployed), where ß = -.398, $t(31) = -2.58$, $p = .015$. The part correlation between Months Since Injury and T2 self-reported levels of physical dependency was -.32. The part correlation between T1 Employment Status and T2 self-reported levels of physical dependency was -.38. This set of negative correlations suggest that, according to self-reports, (a) the less time elapsed since the injury the more physically dependent the PHI tended to be at T2, and (b) those who were employed at T1 tended to be less physically dependent at T2.

The data suggest, however, that this model accounted for only 34% of the variance in PHI-reported levels of physical dependency at T2. The ANOVA testing whether the model is significantly better at predicting T2 self-reported behavioural status than would be an approach using the mean as best guess confirmed that the model is not a good fit for the data, $F(8, 31) = 2.02, p = .077$.

Table 35.

Summary of Regression Analysis for Variables Predicting Self-Reported Levels of Physical Dependency at T2 (N = 38)

Variable	*B*	*SE B*	*ß*
Age at the time of the accident	.017	.017	.163
Months since injury	-.019	.009	-.386*
Years of education	.024	.055	.069
Employment status at T1			
Employed vs. unemployed	-.948	.367	-.398*
GCS			
Severe vs. moderate	.104	.730	.023
Severe vs. mild	.005	.546	.002
PTA			
Severe vs. moderate	-.274	.868	-.050
Severe vs. mild	.435	.698	.110

Note. $R^2 = .34$.

*$p < .05$.

Predicting other-reported levels of physical dependency at T2

Table 36 shows the results of the multiple regression analysis for this outcome variable. As can be seen, the only predictor to make a significant contribution to the model was Years of Education, ß = -.407, $t(31) = -2.53, p = .017$. The part correlation between Years of Education and T2 other-reported levels of physical dependency was -.37. This negative correlation

suggests that, according to significant-other reports, participants with more years of education tended to be less physically dependent at T2 than did those with fewer years of education.

The data further suggest, however, that this model accounted for only approximately 33% of the variance in SO-reported levels of physical dependency at T2. The ANOVA testing whether the model is significantly better at predicting T2 other-reported levels of physical dependency than would be an approach using the mean as best guess confirmed that the model is not a good fit for the data, $F(8, 31) = 1.89$, $p = .097$.

Table 36.

Summary of Regression Analysis for Variables Predicting Other-Reported Levels of Physical Dependency at T2 (N = 38)

Variable	*B*	*SE B*	*β*
Age at the time of the accident	-.001	.024	-.009
Months since injury	-.013	.012	-.189
Years of education	-.193	.076	-.407*
Employment status at T1			
Employed vs. unemployed	-.633	.508	-.194
GCS			
Severe vs. moderate	-.058	1.010	-.009
Severe vs. mild	.315	.755	.078
PTA			
Severe vs. moderate	-.451	1.200	-.060
Severe vs. mild	.842	.965	.155

Note. $R^2 = .33$.

*$p < .05$.

Predicting other-reported ADL capabilities at T2

Table 37 shows the results of the multiple regression analysis for this outcome variable. As can be seen, the only predictor to make a significant contribution to the model was Months Since Injury, ß = .412, $t(31) = 2.37$, $p = .024$. The part correlation between Months Since Injury and T2 other-reported ADL capabilities was .35. This correlation suggests that, according to significant-other reports, the longer the time since injury, the more ADL-capable the PHI is at T2.

The data further suggest, however, that this model accounted for only 34% of the variance in SO-reported ADL capabilities at T2. The ANOVA testing whether the model is significantly better at predicting T2 ADL than would be an approach using the mean as best guess confirmed that the model is not a good fit for the data, $F(8, 31) = 2.00$, $p = .080$.

Table 37.

Summary of Regression Analysis for Variables Predicting Other-Reported ADL Capabilities at T2 (N = 38)

Variable	*B*	*SE B*	*ß*
Age at the time of the accident	.011	.013	.135
Months since injury	.016	.007	.412*
Years of education	.062	.042	.234
Employment status at T1			
Employed vs. unemployed	.186	.281	.102
GCS			
Severe vs. moderate	.297	.559	.086
Severe vs. mild	.492	.418	.217
PTA			
Severe vs. moderate	-.128	.664	-.031
Severe vs. mild	-.193	.534	-.064

Note. $R^2 = .34$.

*$p < .05$.

In summary, the hypothesis suggesting that measures of injury severity (viz., GCS and PTA) will not be predictive of outcome at T2, but that demographic and clinical variables (in this case, age at the time of the accident, months since injury, level of education, and employment status at T1) will be predictive of outcome at T2 was only partially confirmed. For instance, years of education is predictive of neuropsychological test performance, other reported behavioural status, cognitive status, and levels of physical dependency at T2, and self-reported cognitive status at T2. In contrast, however, age at the time of accident was not predictive of T2 outcome in any of the models. Furthermore, and also contrary to prediction, injury severity was statistically significantly associated with poorer PHI-reported behavioural status at T2.

Discussion

The primary purpose of the present study was to extend the fairly small body of knowledge on long-term neuropsychological and functional outcome in TBI individuals who have been part of a litigation process. Furthermore, the study was designed to contribute to the literature on long-term outcome in TBI individuals who have not received cognitive rehabilitation, as well as to establish a South African literature on long-term outcome in TBI. In this part of the dissertation, the status of each hypothesis, with regard to the observed data, will be discussed in separate sub-sections. Within each of these sub-sections, the relationship between the current data and the extant literature will also be explored.

Hypothesis 1

This hypothesis, which deals with the likelihood of malingering at the neuropsychological assessment conducted within the litigation context (i.e., the T1 assessment), firstly required examination of the distributions of injury-related (viz., severity[11] and age at injury) and demographic (viz., level of education) variables. Although these variables showed a wide range, they were fairly normally distributed, with the exception of age at the time of injury, and only level of education was statistically significantly associated with neuropsychological test performance at T1. An examination of the distribution of neuropsychological test scores across participants at T1, then, revealed that they showed no discernible pattern other than that which may be attributed to level-of-education differences making it unlikely that lack of effort was present during testing while the participant was in the process of litigation.

[11] The groups described earlier as "none", "very mild", and "mild" PTA were collapsed into one category ("mild"). Similarly, the groups described earlier as "severe", "very severe", and "extremely severe" PTA were collapsed into one category ("severe").

Neuropsychological test findings are frequently used to assess a person's ability to function after TBI. Understanding long-term cognitive changes, if any, as measured with neuropsychological instruments is important in and outside the context of litigation. In keeping with previous findings (e.g., McKinley et al., 1983; Millis et al., 2001; Wood & Rutterford, 2006a), the current data showed that neuropsychological test performance was not indicative of significant cognitive change over a long period of time, and the changes that did occur appear to be of little clinical significance. Comparison of test means at T1 and T2 showed very small changes, with RCI analysis indicating that there was no real (i.e., clinically significant) change over time on even those tests that were statistically significant. In comparison to this study and in a non-litigating sample, Millis et al. (2001) found statistically significant improvements on attention, working memory, logical memory, and visuo-spatial functioning; however, from a clinical perspective, the changes were small when considering the mean and median differences. Effect sizes were small to medium and no real change was present using the RCI. The greatest improvements tended to be in problem-solving and complex attention. It must be kept in mind that these patients (in Millis et al.) received acute care and in-patient rehabilitation in the model system that they were enrolled in.

One aspect of neuropsychological test performance that is of note here is that of participants on the Purdue Pegboard. After the Bonferroni correction was applied, the results indicated a small decline in Purdue Pegboard (both hands and left hand) functioning from T1 to T2. This task taps motor ability and is also demanding of cognitive speed and attentional control. If this test was process pure with regard to cognitive speed it would be suggestive of increased cognitive slowing over time, however, and since it is not, this result should be interpreted with caution as physical function was not assessed and the slowing may be as a result of

motor impairment or physical injury rather than (diffuse) brain injury. Despite this concern, this finding supports previous findings of slowed mental and motor speed long after TBI (Hoofien et al., 2001; Millis et al., 2001). This slowed psychomotor processing is characteristic of diffuse axonal damage that occurs in most TBI, and that might persist long after other cognitive functions have reached plateau. For instance, Tabaddor, Mattis, and Zazula (1984) tested TBI patients over a 1-year period and found that Purdue Pegboard results were lower than average at baseline and remained so at follow-up, albeit slightly improved. They mused that patients may continue to improve over time post-TBI. The notion of continual improvement is not supported by the present study. Millis et al. (2001) point out that neuropsychological recovery is not uniform; for instance, for some individuals recovery may continue for some years after the injury, while for others considerable impairment may remain even at 5 years post-injury. Studies such as these illustrate that despite the general view that the neuropsychological functioning of TBI patients plateaus at approximately 2 years post-injury, it is not necessarily possible to draw conclusions about very long-term outcome at such an early stage after injury.

Further investigation neuropsychological performance changes and sub-optimal effort from T1 to T2 within sub-groups in the present study (a Poor Effort group who consisted of all participants who fell below the cut-off score on the Forced Choice test level suggesting suboptimal effort, and a Good Effort group consisting of those participants who performed the best on the same test) suggested that, even in cases where malingering at T1 might have been suspected, improvements from T1 to T2 were no greater in magnitude (and of no greater clinical import) than in cases where no malingering was suspected.

With regard to the statistically significant differences at T1 between the Good Effort group and the Poor Effort group (i.e., on the WAIS Digit Symbol-Coding subset and Forced Choice test), these might be explained by a statistically significant difference in the number of severely head injured participants in the groups. In the Poor Effort group, all the participants had a GCS score of less than 12 (i.e., they were all, with the exception of one participant who fell in the moderate range, categorized as having experienced a severe head injury). In contrast, only 3 of the 7 participants in the Good Effort group had GCS scores of less than 9; the rest of the participants had GCS scores in the 13-15 range (i.e., they were all categorized as having experienced a mild head injury).

The literature frequently reports cognitive slowing in severe head injury. Furthermore, patients who have sustained severe head injury, in comparison to those who have sustained a mild head injury, present more frequently with impairments of memory (Mazaux et al., 1997; Millis et al., 2001). Such processing speed and memory deficits might account for the slower performance by participants in the Poor Effort group on the WAIS Digit Symbol subtest, as well as for their relatively poor performance on the Forced Choice test. Taking this into consideration, in terms of differences between the Poor Effort group and the Good Effort group, the findings are consistent with what one would see in terms of mild versus severe head injury. By implication none of the participants were malingering or showed less than optimal effort at either T1 or T2 and the poor performance in the Poor Effort group on the Forced Choice test of effort at both T1 and T2 may be ascribed to neurological factors (viz., injury severity) rather than to non-neurological factors (viz., malingering or less than optimal effort).

In order to view the malingering question from a different perspective, I adopted a multiple case-study approach (Shallice, 1988; Walsh, 1985) and presented individual case-based analyses of the three participants who performed worst on the Forced Choice test of effort and the three participants who performed best on the same test. The pattern of test performance across cases was similar, and there was no obvious pattern of improvement from T1 to T2 (as one would have expected if there had been malingering at the initial assessment) in the first set of three cases. Additionally, there was not one specific behavioural impairment that differentiated the participants who had poor effort scores from the participants with good effort scores.

After investigation from multiple perspectives, then, the current data suggest that it is highly unlikely that non- or pseudo-neurological factors, such as lack of effort or adopting a 'sick role', were present during assessment in the medico-legal context in this sample of TBI litigants. Taken together, the data suggest that cerebral dysfunction, rather than demographic variability or erratic effort, is the principle cause underlying variation in performance in the current sample. These findings on neuropsychological testing are important as the possibility that claimants may fake low scores when assessed for forensic purposes has been suggested in the literature and by clinicians. The present findings support those presented by Wood and Rutterford (2006a) and McKinlay et al. (1983) in showing that claimants with severe head injury are not inclined to fake low scores during neuropsychological assessment in the context of litigation.

Hypothesis 2

This hypothesis, which dealt with the question of stabilisation in ADL, cognition, behaviour and physical dependency, proffered that these measures will not be significantly different

from T1 (2 years plus post-injury) to T2 (3 years plus post-injury). Addressing this hypothesis firstly required examination of HI-FI outcome measures (viz., separate PHI- and SO-reported composite scores for symptom presence and symptom severity in the domains of behaviour, cognition, and PD at T1 and T2, as well as for the SO-reported composite scores for ADL at T1) over T1 and T2. As a whole, this prediction was not confirmed as there were significant improvements in both PHI-reported behavioural status as well as SO-reported ADL capability. These were the only two domains in which significant change was reported.

Symptom presence and severity

Although the participants reported changes in the presence of behavioural symptoms from T1 to T2, the severity of the symptoms that were present at T2 did not change significantly from that at T1.As reported in the Results section above and as shown in Table 18, the most frequently reported symptoms, at both T1 and T2, spanned the spectrum from behavioural to cognitive to affective problems: memory difficulties, slowness, fatigue, word-finding difficulty, distractibility, irritability, and planning difficulties. This finding is consistent with data reported by Olver et al. (1996), who showed that 5 years post-TBI fatigue was most commonly reported in their participants followed by memory difficulties, irritability, slowed thinking, and planning difficulties.

The data from this study are also further consistent with those reported by Olver et al. (1996) in terms of suggesting that there is a general increase in neurological complaints by TBI individuals over long-term follow-up. For instance, there is persistence of visual difficulties (47.5% at T2 in this study, and 42% at 5-year follow-up in Olver et al.), and an increase in the reports of headaches (from 60% at T1 to 67.5% at T2 in this study, and from 31% at 2 years post-TBI to 42% at 5 years post-TBI in Olver et al.).

Regarding symptom presence related to behaviour, cognition and physical dependency, only the behaviour composite score as reported by the PHI was statistically significant, indicating a decrease in symptoms. This change is not consistent with collateral reports. This improvement in behaviour, as reported by the PHI, may indicate real improvement in behaviour from T1 to T2, or may be as a result of lack of insight by the PHI into their behaviour. Since this finding was not supported by the SO the latter suggestion appear to be the more likely one.

The incidence of 'personality change' (i.e., a difference in distinctive traits of mind and behaviour as a whole) was reported more frequently by the significant other than by the person with the head injury. This significant result appears to be largely due to fewer injured individuals reporting personality change at T2 compared to T1, compared to significant others who indicated that there was no difference in the degree of personality change between T1 and T2. Supporting previous research, this pattern of data suggests that reports on behaviour as given by the person with the injury may not be reliable (Draper et al., 2007). Unreliable reporting by the PHI may be as a result of several factors - acclimatisation to the personality change, that is, the initial concern experienced about the personality change has dissipated and therefore is not considered a symptom anymore; it may also be due to lack of insight into their own personality change; or it may be as a result of a combination of these factors (Draper et al., 2007).

Activities of Daily Living

As noted above, I predicted that there would not be a significant change in psychosocial measures from T1 to T2. That prediction was not confirmed. The data suggested there were statistically significant improvements in ADL capabilities (as measured by collateral reports)

from T1 to T2. More specifically, shopping for food appeared to be the area of ADL on which most robust improvement was reported, although there was a tendency toward general improvement in primary self-care, particularly with regard to nutrition and personal hygiene.

These data imply that head-injured individuals are more capable of taking care of themselves in those domains at T2 than at T1. Although ADL is a complex measurement that is not uniformly applied in the literature, making it difficult to draw comparisons between studies, the current results support Olver's (1995) findings that a significant number of patients reported improvement, from year 1 to year 5 post-TBI, in the ability to independently accomplish activities of daily living. This finding is interesting when taking into consideration that there was no comprehensive improvement in neuropsychological functioning. Improvement in ADL in the absence of neuropsychological improvement may be ascribed to increased self-awareness, developing a daily routine, or acquiring better coping skills with time.

The current data do not, however, imply that ADLs can be performed without supervision at T2: Recall that significant others reported that 100% of PHI who needed supervision with regard to ADL at T1 continued to require such supervision at T2. The current data are therefore, in this regard, consistent with those reported by Hammond et al. (2004) and Whitnall et al. (2006), who found that there was little global change in independence from year 1 to year 5 post-injury, and that rate of disability at year 1 and years 5-to-7 post-injury were very similar.

Financial management skills

Mazaux et al. (1997) reported that patients were most disabled, inter alia, in financial management and administrative tasks. The authors made no specific comments about the relationship of their findings to the context of litigation, however. In the context of litigation, an understanding of financial management skills in the head-injured individual is particularly important for two reasons. First, the court has to decide whether that person is fit to manage his/her own finances and, second, there frequently are later requests for lifting curator bonuses (i.e., if a patient was found unfit to manage her money and a curator bonus was appointed, that patient may, at a later date, request to have the bonus lifted, effectively regaining control of financial management).

The current data suggest that, as measured by collateral reports, there is little change from T1 to T2 in the ability of head-injured litigants to manage their own finances. That is, significant others reported that there are continuing and numerous symptoms of difficulty with managing finances. Although some functional gains did seem to occur after settlement, these improvements were small and of questionable clinical significance. Although one must interpret the data with caution due to the small sample size, the improvements that did occur may partly be explained by the fact that, by T2, the participants may have developed increasing self-awareness and/or better strategies and coping skills when confronted with the practical consequences of their head injuries (Olver et al., 1995).

Hypothesis 3

The purpose of CCA is to explain the relationships between two sets of variables, and not to model the individual variables. These analyses suggested a fairly strong overall relationship, for both PHI-report and SO-report, between outcome measures at T1 and T2.

Evaluating multidimensional psychosocial outcome using canonical correlation analysis

With regard to the self-report model, outcome at T2 was strongly related to neuropsychological testing at T1, self-reported physical dependency at T1, and self-reported cognition at T1 on the first canonical dimension, with the latter being the strongest predictor. This piece of data is consistent with earlier reports that cognitive and physical function at 1 year post-TBI is predictive of level of functioning over the long term (Hammond, Grattan, et al., 2004), and that the most frequent and homogenous symptoms reported by TBI patients are those related to self-reported cognitive abilities (Gordon et al., 2000). On the second canonical dimension neuropsychological test score and other-reported ADL were the strongest predictors, with the former being stronger. Improvements noted in ADL were mainly related to personal care and hygiene and no improvement was noted in, for example, financial management abilities. This begs further investigation into which aspects of ADL may be predictive of outcome in this population. As expected, behaviour was not strongly related to outcome at T2. The poor correlation for behaviour may be due to the lack of insight that head-injured persons tend to have over their behavioural and emotional changes, which are not generally related to their cognitive level (McKinlay et al., 1983).

As expected, the same constructs that are predictive in the head-injured person's analysis are also predictive for the significant other evaluation, but they are hierarchically different. Other-reported physical dependency was the strongest predictor followed by other-reported

cognition. This pattern of data is again consistent with earlier reports that cognitive function at 1 year post-TBI is predictive of level of functioning over the long term (Hammond, Grattan et al., 2004) and suggests that SO-reported physical dependency, in conjunction with SO-reported cognition, are the most informative predictors in the context of collateral information.

In comparing the two CCA models discussed above, two points are perhaps most relevant. First, in both models physical dependency and cognition are strong predictors (Gordon et al, 2000; Hammond, Grattan, et al., 2004). Second, the results of neuropsychological testing appear to be a more significant predictor of self-reported outcome measures than of significant other-reported outcome measures. Indeed, with regard to the latter (when the whole model is considered), neuropsychological testing is the weakest of all the predictors entered into the model. This latter finding, in particular, highlights the importance of collateral information (such as reports from a spouse or partner about physical dependency, activities of daily living, and changes in cognitive, affective, and behavioural patterns) when assessing a patient, instead of relying *only* on the results of neuropsychological assessments.

In a related vein, both models reported here suggested a fairly strong overall relationship between the set of independent variables and the set of dependent variables. This finding supports the fact that it is not possible to predict outcome on only one sphere of a patient's functioning; all spheres have to be simultaneously considered. Therefore, when the clinician discusses possible long-term outcomes with patients and family members, he or she should keep in mind that no single variable, and no set of variables, provides a 100% accurate prediction of outcome. Long-term predictions of outcome for individual patients should not be made on generalisations, neither should generalisation dictate what is to be expected from

individuals who are being treated (Hammond, Grattan et al, 2004). As mentioned previously, due to the low practical significance of the other factors within the model, speculation on their relevance is not advisable. In a study with a larger sample size, such speculation and further interpretation might be warranted.

To summarise, each outcome variable I considered was generally a good predictor of itself across time, and measured the same aspects from T1 to T2. Furthermore, these outcome measures are highly correlated with themselves, indicating that there is little difference between the outcome variables from T1 to T2. Finally, a factor that may be of interest to future researchers in the field is that the outcome variables have different levels of predictive value in the self-report model, compared to the significant other-report model.

Hypothesis 4

Demographic predictors

Multiple regression analyses were used to assess if age at injury, months since injury, years of education, employment status at T1, GCS and PTA would predict outcome at T2 on objective measures of neuropsychological function, other-reported ADL, self- and other-reported behaviour, cognition and physical dependency. Different demographic predictors are relevant for the head injured person and the significant other. In the former case, physical dependency was predicted by length of time since the accident and employment. Years of education were predictive of neuropsychological outcome. On the SO-report, higher education predicted behaviour, cognition and physical dependency. Consistent with the literature, age at the time of injury was not a predictor (Asikainen et al., 1996; Hoofien et al., 2002; Levin et al., 1990; Thomsen, 1984; Wood & Rutterford, 2006a; Wood & Rutterford 2006b).

Predicting neuropsychological test performance at T2

Consistent with previous research, years of education were predictive of performance on neuropsychological tests. The reasons for this finding may be many – for example, better educated people are more test-wise and tend to have better cognitive reserve (Kesler et al., 2003). The current result, however, supports Asikainen et al.'s (1998) suggestion that variables such as level of premorbid education increase in predictive weight for outcome with time, while other demographic predictors (e.g., GCS and PTA) become less relevant. Furthermore, education has been found to be consistently and significantly associated with long-term outcome in TBI (Dawson & Chipman, 1995; Draper, Ponsford, & Schönberger, 2007; Hoofien, Vakil, Gilboa, Donovick, & Barak, 2002; Tate, Broe, Cameron, Hodgkinson, & Soo, 2005; Wood & Rutterford, 2006b).

Predicting self-reported behavioural status at T2

Consistent with some previous studies, GCS and PTA were predictive of change in self-reported behavioural status from T1 to T2 (Hammond, Grattan, et al., 2004; Hoofien et al. 2002). Curiously, however, the correlation for these two variables is in different directions: GCS is positively correlated with self-reported behavioural status at T2 (implying that the less severely injured participants reported more behavioural problems), whereas PTA is negatively correlated with self-reported behavioural status at T2 (implying that the more severely injured participants reported more behavioural problems). This inconsistency may be as a result of PTA acting as a suppressor variable, or because GCS was recorded on admission to hospital and secondary insult (e.g., oedema or infection) resulting in more severe brain injury is not reflected. When looking at the data individually GCS and PTA are well aligned (if a case is classified as severe by one measure it is statistically significantly

likely to be classified as severe by the other). However, there are a few cases that don't match (e.g., 4 people are classified as severe by PTA but as mild by GCS). The possibility exists that these few cases are driving the GCS correlation in the wrong direction.

GCS nor PTA are perfect measures of head injury severity and PTA has been found to be more predictive of functional status than GCS (Sherer, et al., 2002; Sherer, et al., 2008). Sometimes, as in this instance, these measures don't match up. In general, though PTA appears to be the better measure (Sherer et. al., 2002). In this instance it also supports the expectation that the more severe the head injury as measured by PTA, the more likely it is the person will report a high number of behavioural problems at T2.

Predicting self-reported levels of physical dependency at T2

Regression analyses indicated a negative relationship between self-reported physical dependency and employment status at T2, suggesting that those who were employed at T1 were likely to be less physically dependent at T2 than those who were not employed at the initial assessment (Oddy et al., 1985; Sander et al., 1996). Additionally, this trend in the data suggests that the less physically dependent a person is at T1, the more likely it is that he/she will be employed at T2.

As stated before, this finding should be interpreted with caution as the severity of orthopaedic injuries was not assessed. It is thus unknown in the current context whether all participants were physically capable of working at T1. This does not necessarily mean that starting work earlier leads to less physical dependence. It may be that those with less severe orthopaedic injuries were capable of working at T1 and that recovery from less severe injuries is more likely, leading to less physical dependence.

Predicting other-reported outcome at T2

A higher number of years of education predicted three outcomes: better cognition, fewer behavioural symptoms, and less physical dependency on others. With regard to cognition, the observed relationship is consistent with previous research suggesting that there is more cognitive reserve (and thus more protection from potentially devastating cognitive effects of TBI) in those with better education (Dawson & Chipman, 1995; Draper et al., 2007; Hoofien et al., 2002; Tate et al., 2005; Wood & Rutterford, 2006a); furthermore, better education not only influences the sphere of cognition, but also behaviour and physical independence. This finding suggests that patients with a higher education tend to recover better globally than those who have less education. Furhtermore, one of the commonly reported problems after TBI is defects in learning, with the most frequent memory impairment being recall of new information (Thomsen, 1984; Thickpenny-Davis & Barker-Collo, 2007). Having a larger existing skill set pre-accident may allow for better existing coping strategies.

Predicting ADL as reported by the significant other

The relationship between months since injury and ADL predicted improvement in activities of daily living over time. This supports my earlier finding (as discussed earlier under the heading 'Activities of daily living') that there is an improvement in ADL over time and that patients become more self-sufficient in this sphere as time progresses.

Long term employment outcome in TBI

Findings on employment in this population is briefly discussed as future capacity for employment is a key question in financial compensation in litigation.

The ability to work and earn a living is important to most people. Capacity for employment is frequently affected by a head injury, mostly in the sense that those who have suffered such an injury either cannot return to the same level of employment as before the injury, or cannot return to employment at all. A head injury influences not only the autonomy of the person who suffered it, but also that of family members; it influences the ability of the individual to function on a daily basis in society. During litigation, the ability to return to employment, and the level of that employment, are important factors in determining whether the injured individual will be compensated, and, if so, how large the financial settlement will be. Understanding return to work and how it influences long-term outcome in TBI is therefore important.

Unlike Olver (1995), who found a decrease in employment from 50% at 2 years post-TBI to 40% at 5 years post-TBI, in the present sample there was an increase in employment from 62.5% at T1 to 75% at T2. This increase in employment in the present sample may be explained by the fact that litigants may not want to work while their case is in progress (thus reporting no employment at T1), as it might negatively affect the size of their compensation payment from the RAF. Also of note here is the fact that, at both T1 and T2, litigants in the current study were employed at a lower economic level than before the injury.

When removing participants who are employed in informal assistance, that is, not receiving a salary, the number of persons employed (55%) remained the same at T1 and T2. However, the percentage of individuals gainfully employed differed. At T1 12% and at T2 26% were employed in unpaid jobs. Although Dawson and Chipman (1995) in their epidemiological follow-up reported only a 25% employment rate, in that study one-third of those who were employed worked in sheltered or unpaid jobs. Hoofien et al. (2001) reported an employment

rate of 60% post-injury, also with approximately one-third of working participants non-competitively employed. Those data closely resemble the present study's findings at T2. It should be noted that, in the present study, the ability to be employed in some capacity did not necessarily result in financial gain, which supports Cattelani et al's. (2002) finding that successful competitive re-employment does not necessarily result from a satisfying outcome in re-acquiring functional independence.

Summary and Conclusions

As hypothesised, neuropsychological testing was not indicative of significant cognitive change from T1 to T2. Individual analysis of case studies further excluded the likelihood that malingering was present during litigation. The data suggests that claimants with severe head injury are not inclined to fake low scores during neuropsychological assessment in the context of litigation.

It was predicted that there will not be a significant change in PHI- and SO-reported behaviour, cognition and physical dependency and SO-reported ADL. This hypothesis was not wholly supported. Some improvement was evident in ADL, however the gains were small and the clinical significance of these improvements is questionable as they may not impact significantly on the head injured person's life. PHI-reports, but not SO-reports, suggested a decrease in behavioural symptoms from T1 to T2. It should be noted that self-report regarding behaviour from the person with the head injury may not be reliable due to lack of insight, which may also explain the discrepancy found here between the PHI- and SO-reports.

As predicted, there was a significant relationship between outcome measures as measured at T1 and T2. The main contributors for the PHI-report regarding outcome were cognition,

physical dependency and neuropsychological test score. On the SO-model physical dependency and cognition were the most significant predictors. This suggests that physical dependency and cognition as reported by the significant other, as opposed to cognition, physical dependency and neuropsychological test score in the PHI-model, predicts outcome at T2. Clinicians should note that when predicting future outcome different weighting should be given to different spheres of function as reported by the person with the head injury and a significant other, and that a holistic focus on global dysfunction is necessary. Generalizations should not dictate how individual patients are treated.

Regarding demographic predictors, the hypothesis that GCS and PTA will not be predictive of outcome was not supported as a whole. Injury severity measures appear to be predictive of self-reported behaviour. It is not surprising that GCS and PTA was not predictive of other outcome measures as these severity measures may not be strong predictors given that the literature indicates that severity factors tend to be increasingly weak predictors as time progresses (Wood & Rutterford, 2006a). As pertains to the other demographic predictors, again, different predictors were relevant as reported by the head injured person and as reported by the significant other. In the former case, physical dependency was predicted by length of time since the accident; and employment and years of education were predictive of neuropsychological outcome. On the SO-report years of education predicted behaviour, cognition and physical dependency.

Overall, then, the current data suggest that TBI individuals continue to suffer from significant difficulties in all spheres of their lives even after case settlement. Furthermore, the data strongly suggest that there is essentially little change between pre- and post-settlement

assessment results and that litigants who have suffered a severe head injury are not inclined to give sub-optimal effort in the context of litigation.

Limitations and Directions for Future Research

The interpretations made on the basis of the current data are provided with caution, given the following methodological limitations of this study:

1. As stated numerous times earlier in the paper, this study features a small sample size. Future studies, be they longitudinal or cross-sectional, should focus on recruiting more participants (and possibly doing so across multiple regions in South Africa).
2. It is quite possible that certain information about demographic and health factors at T1 is less reliable than other information gathered about the participants' status at T1. More specifically, Interview for the Person with the Head Injury Problem Checklist and the Significant Other Interview Problem Checklist (Kay, Cavallo, & Ezrachi, 1995), as well as SO-reports on ADL at T1 are all retrospective and rely on the veracity of the memory of both the participant and the significant other. In contrast, objective information sourced from the medico-legal folders at T1, and from T1 neuropsychological testing, are much more reliable. Clearly, future studies in this area might do well to adopt a longitudinal prospective design, which in this case could be more powerful in that they avoid the issues highlighted above and could possibly yield more accurate information regarding, for instance, changes in symptom presence and severity across time. Additionally, such a design would encompass the employment of identical test batteries at T1 and T2, and might also lead to less attrition in the sample across time (i.e., more T1 participants might be willing to be followed up at T2).
3. The current sample was limited to persons who are conversational in English, irrespective of their first language. This inclusion criterion led to the exclusion of a large section of

the South African population. Clearly, a national sample, possibly featuring multi-site collaborative work aimed at more representative sampling, is a target for future research endeavours.

4. The relatively low levels of educational attainment and educational quality of some participants and significant others led to numerous difficulties with the administration of the research questionnaires. For instance, the Activities of Daily Living questionnaire is relatively complicated and so understanding it proved challenging for those significant others with lower levels and quality of education. For this reason, I decided not to administer it to the TBI individual, given that that person's ability to comprehend what the questionnaire required from him/her was put in serious doubt.
5. With regard to the actual neuropsychological testing session at T2, TBI patients who go through a process of litigation have extensive experience with neuropsychological testing. Thus, the risk of practice effects does exist; this risk is not of great concern, however, because at least 2 years had passed since the T1 assessment and RCI was used in analysis.
6. With regard to non-neurological factors impacting on neuropsychological testing at T2, for practical and financial reasons I limited the test session to one 3-hour meeting. Had testing been extended to two or more sessions, it is quite likely that fewer individuals would have participated due to difficulties in setting aside time and/or travelling to the test session. Had testing been limited to one session, but extended over 4 or more hours, the head-injured participants, who often have difficulty with concentration and have slowed cognitive functioning, might have been less willing to participate and certainly would have been susceptible to fatigue hampering test performance. Clearly, these time constraints allowed for a limited number of tests to be administered; future research will need to take these factors into strong account when attempting to design a research test battery.

7. Because head-injury individuals were requested to participate in the study, there was the consequent risk of a self-selection or volunteer bias. I attempted to overcome this risk by assuring participants that they were free to stop the interview at any time if they felt that they could not continue. It was further made clear to participants that the research was independent and confidential and that there was no possibility of the study affecting their compensation status.
8. The sample was restricted to largely one neuropsychologist's practice, which may not be representative of other claimants.
9. Many measures were based on retrospective ratings in which the patients had to recall their status at both T1 and T2. This method of rating may be contributing to the high correspondence of these ratings across T1 and T2.

Future TBI research might compare litigants who have had rehabilitation with those who have not had rehabilitation. Although it is unlikely that there will be a change in neuropsychological status over time, rehabilitation may lead to greater functional improvement and better integration into society. Furthermore, assessment of long-term financial independence and financial management, and how these are related to function, is needed. Research in South Africa on social interaction with families and friends and the interrelationships between functional abilities and interaction in the social environment will also be beneficial.

Finally, despite the limitations of this study, I hope that it will still provide useful information for neuropsychologists doing medico-legal work and for the Road Accident Fund itself. In addition, I hope that it will set the table for larger, less methodologically limited studies that

may have real impact on public health policy with regard to traumatically brain-injured individuals.

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Appendixes

Appendix A

Subscale 1 – Cognitive
Fatigue
Word finding difficulty
Expressing self in wordy manner
Distractible
Concentration
Memory
Planning
Setting realistic goals
Following through on tasks

Subscale 2 – Functional/Activities of daily living
Shopping for food
Preparing meals
Feeding self
Cleaning up after meals
Choosing own clothes
Dressing self
Washing own clothes
Showering/bathing
Brushing teeth
Washing hair
Going to the toilet
Keeping track of finances
Paying own bills
Managing own finances
Making necessary purchases for self
Cleaning own room
Helping with household chores
Doing yard work and repairs
Could be trusted to take care of self
Could be trusted to live in own dwelling

Subscale 3 – Affective/Behavioural

Headaches
Irritability
Restlessness
Temper
Mood swings
Control of emotions
Argumentative
Physically violent behaviour
Getting bored easily
Complaining
Anxiety
Depression
Loneliness
Personality change

Subscale 4 – Physical Dependency

Visual difficulties
Poor balance
Slowness
Dysarthria
Apathy
Lack of initiative
Dependency on others
Needing supervision

Appendix B

Informed consent to participate in research

UNIVERSITY OF CAPE TOWN

Department of Psychology

University of Cape Town Rondebosch 7701 South Africa
Telephone: (021) 650-3111
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Informed Consent to Participate in Research and Authorization for Collection, Use, and Disclosure of Protected Health Information

This form provides you with information about the study and seeks your authorization for the collection, use and disclosure of your health information necessary for the study. The Principal Investigator (the person in charge of this research) or a representative of the Principal Investigator will also describe this study to you and answer all of your questions. Your participation is entirely voluntary. Before you decide whether or not to take part, read the information below and ask questions about anything you do not understand. By participating in this study you will not be penalized or lose any benefits to which you would otherwise be entitled.

1. **Name of Participant**

_____

2. **Title of Research Study**

   Functional, Behavioural and Neuropsychological Predictors of Outcome in Traumatic Brain Injury.

3. **Principal Investigator and Telephone Number(s)**

   Hatta Gouse, M.A. (Ph.D. Candidate)
   Department Psychology
   University of Cape Town
   021 – 465 1228

4. **What is the purpose of this research study?**

   This study will assess the neuropsychological, functional and behavioural status of individuals who have suffered a traumatic brain injury (TBI) in a motor vehicle accident (MVA) after they have received financial compensation. The question is whether there is a degree of recovery in patients after compensation. Further, what predisposing, precipitating and perpetuating factors might lead to different illness behaviour between improved and non-improved groups.

5. What will be done if you take part in this research study?

This study requires you to do a series of neuropsychological tests. These tasks will measure aspects of language, memory, attention and motor skills. In addition you and a family member will be asked some questions and complete some questionnaires about your daily functioning and behaviour, mood, symptoms of emotional or psychological problems, history of such problems, and medical history. The interview will consist of one session which should not last longer than three hours. If at any time during the experiment you find any of these procedures uncomfortable, you are free to discontinue your participation.

6. What are the possible discomforts and risks?

We will be asking you for information about sensitive issues, such as your mood and substance use. If you are not comfortable answering these questions you can choose not to answer or discontinue participation in the study.

7. What are the possible benefits of this study?
This research will aim to lead to better understanding of TBI and the development of a model which will better serve to accurate prognosis in the clinical and medico-legal arena.

8. Can you withdraw from this research study and if you withdraw, can information about you still be used and/or collected?

You may withdraw your consent and stop participation in this study at any time.
Information already collected may be used.

9. Once personal information is collected, how will it be kept confidential in order to protect your privacy and what health information about you may be collected, used and shared with others?

Information collected will be stored in locked filing cabinets or in computers with security passwords, Only certain people - the researchers for this study and certain University of Cape Town officials - have the legal right to review these research records. Your research records will not be released without your permission unless required by law or a court order.
Information will be gathered from you, a family member, past and current health records, and from procedures such as physical examinations x-rays, and blood tests. More specifically the following information may be collected, used, and shared with others:

- Laboratory, X-Ray, CT, MRI, and other test results.
- Records of physical and psychological exams.
- Information related to diagnosis and treatment of a mental health condition, as reported by subjects and physicians.
- Questionnaire information.

If you agree to be in this research study, it is possible that some of the information collected might be copied into a "limited data set" to be used for other research purposes. If so, the limited data set may only include information that does not directly identify you.

10. Signatures

As a representative of this study, I have explained to the participant the purpose, the procedures, the possible benefits, and the risks of this research study; the alternatives to being in the study; and how the participant's health information will be collected, used, and shared with others:

_____ _____
Signature of Person Obtaining Consent and Authorization Date

You have been informed about this study's purpose, procedures, and risks; how your protected health information will be collected, used and shared with others. You have received a copy of this form. You have been given the opportunity to ask questions before you sign, and you have been told that you can ask other questions at any time.

You voluntarily agree to participate in this study. You hereby authorize the collection, use and sharing of your protected health information. By signing this form, you are not waiving any of your legal rights.

_____ _____
Signature of Person Consenting and Authorizing Date

_____ _____
Signature of Person Consenting and Authorizing Date

Please indicate below if you would like to be notified of future research projects conducted by our research group:

_____ (initial) Yes, I would like to be added to your research participation pool and be notified of research projects in which I might participate in the future.
Method of contact:

Phone number: _____

E-mail address: _____

Mailing address: _____

_____

Appendix C

Demographic questionnaire

Demographic Questionnaire

Patient #:_____ **Date:**_____

1. Birth date:_____ **2. Age:**_____ **3. Age at time of accident:**_____

4. Date of accident:_____ **5. Date 1st tested:**_____

6. Months since injury:_____

7. Handedness: 1. L 2. R **8. Sex:** 1. M 2. F

9. Date of settlement:_____ **10. Months since settlement:**_____

11. Compensation

11.1 Are you receiving financial compensation? 1. Y 2. N

11.2 How long have you been receiving compensation for? _____

11.3 How is the money being paid to you? 1. Lump sum 2. Instalments

11.4. Is the money being paid to 1. you 2. Curator.

12. What is your home language?
1. English
2. Afrikaans
3. isiNdebele
4. isiXhosa
5. isiZulu
6. Sepedi
7. Sesotho
8. Setswana
9. siSwati
10. Tshivenda
11. Xitsonga
12. Other (specify)_____

13. Education

1. No education:_____

2. Primary school education:_____

3. Secondary school education:_____

4. Tertiary education:_____

5. College degree:_____

6. Undergraduate degree:_____

7. Postgraduate degree:_____

8. Years of education:_____

14.1. Do you have children? 1. Y 2. N **14.2. Number of children?** _____

15. Marital Status:

	Pre-injury	T1	T2
1. Single			
2. Partnered			
3. Married			
4. Divorced			
5. Widowed			

16. Employment status:

Employment status	Pre-injury	T1	T2
1. Working	Y N	Y N	Y N

17. Type of employment:

Type of employment	Pre-injury	T1	T2
1. Professional			
2. Office work			
3. Factory work			
4. Homemaker			
5. Student			
6. Retired			
7. Service industry			
8. Informal assistance			
9. Manual labour			
10. Self employed			
11. Unemployed			

17.1. Did you enjoy the work that you did before the accident? 1. Y 2. Somewhat 3. N

17.2. If you could go back to work, will you choose to do the same work again? 1. Y 2.N

17. 3. Do you get paid for the work that you are currently doing? 1. T 2. N. 3. na

18. Psychiatric History

	Pre-injury	T1	T2
1. Depression			
2. Anxiety			
3. PTSD			
4. Other			
5. None			

If other, please elaborate_____

19. Drug history: Cigarettes, Marijuana, Mandrax, Cocaine, E, Heroin, Tik, Nicotine, Over-the-counter drugs, Chronic conditions.

	Before MVA	Pre-compensation	Post-compensation	Drug Type
1. Severe problem				
2. Moderate problem				
3. No problem				
4. No drugs				

20. Alcohol history:

	Before MVA	Pre-compensation	Post-compensation	Drink of choice
1. Severe problem				
2. Moderate problem				
3. No problem				
4. No alcohol				

21. Aetiology

1. MVA: driver		
2. MVA: passenger		
3. Seatbelt		
3. MVA: pedestrian		
4. Motorcycle	With helmet	Without helmet
5. Cyclist		

22. Duration of coma (from accident to first eye opening/speech)

1. No LOC	
2. < 20 mins	
3. 20-60 mins	
4. 1-2 hours	
5. 2 hours – 1 day	
6. 2-3 days	
7. 4-7 days	
8. > 7 days	

23. GSC admission score

	On site	Hospital
1. 3-8		
2. 9-12		
3. 13-15		
4. Sedation/morphine		
5. Dominoes		
6. Intubation and ventilation		
7. Later 1 in GCS due to 2^{ary} BI		

24. PTA (excluding coma period) (Lezac)

1. None	
2. <5 mins (very mild)	
3. 5-60 mins (mild)	
4. 1-24 hours (moderate)	
5. 24 hours – 7 days (severe)	
6. 1-4 weeks (very severe)	
7. > 4 weeks (extremely severe)	
8. Medication clouding consciousness	
9. Secondary complications	
10. Retrograde amnesia	Y N Time:

25. CT/MRI abnormalities

1. None	
2. Left hemisphere only	
3. Right hemisphere only	
4. Bilateral	
5. Diffuse Axonal Injury	
6. Generalised atrophy	
7. White matter changes	
8. Other	

26. Brain surgery

1. Yes	2. No
3. Other surgery Y N	

27. Medical history

0. None	
1. HIV	
2. HP	
3. DM	
4. Other	

28. Type of Injury

28.1. Type of injury	
28.1.1. Diffuse axonal injury	
28.1.2. Concussion	
28.1.3. Base of skull fracture	
28.1.4. Brain swelling	L R Diffuse
28.1.5. Laceration	L LF LP Back R RF RP Back
28.1.6. Contusion	
28.1.7. Sinus	

28. Type pf injury cont.

28.2.1. Haemorrhagic lesions	
1. Subdural haematoma	
2. Epidural haematoma	
3. Subarachnoid haematoma	
4. Intracerebral haemorrhage	
5. Intraventricular haemorrhage	
6. Haematoma	
28.3. Neurosurgical Interventions	
28.3.1. Craniotomy to	
1. Evacuate haematoma/contused brain/burr holes	
2. Elevate fracture fragments	
3. Manage intractable raised intracranial pressure	
28.3.2. Insertion of devices to monitor intracranial pressure	
1. Richmont bolt	
28.4. Electroencephalography:	Y N Location:
28.5. Seizures	<24 hr <1 week <1 month <1 yr >1 yr

29. Location of Focal injury (cc = contra-coup injury)

Location of focal injuries					
29.1. Frontal lobe			**29.3. Parietal lobes**		
1. Unilateral left			1. Unilateral left		
2. Unilateral right			2. Unilateral right		
3. Bilateral			3. Bilateral		
4. Orbito basal			4. Anterior		
5. Dorso lateral			5. Superior		
6. Mesial frontal			6. Inferior		
			7. Posterior		
29.2. Temporal lobes			**29.4. Occipital lobe**		
1. Unilateral left			1. Unilateral left		
2. Unilateral right			2. Unilateral right		
3. Unilateral			3. Bilateral		
4. Anterior pole					
5. Dorsal			**29.5.Cerebellum**		
6. Ant med temp					
7. Post med temp					

30. Other injuries:

	Yes	Left	Right
1. Facial bone fractures			
2. Head laceration			
3. Neck			
4. Upper spine			
5. Lower spine			
6. Shoulder			
7. Arms			
8. Chest			
9. Pelvis			
10. Hip			
11. Legs			
12. Ankles			
13. Abdominal injuries			
14. None			
15. Other: Specify			

31. Other complications:

1. Hypoxia	26.1.1. Length:
2. Hemiparesis	26.2.1. L 26.2.2. R
3. Polytrauma	
4. Hallucinations	
5. Post-traumatic dementia	
6. Persistent neurogenic pain	
7. Nerve root damage	
8. Dysgeusia	
9. Intoxicated at time of accident	
10. None	
11. Other: Specify	

32. Medication:

Have you taken any medication today? Y N
If yes, what? _____

_____

Pre-accident	Pre-compensation	Post-compensation

Appendix D

First CCA: Calculation of Redundacy Indices for the Identified Canonical Dimensions

Table D1

First CCA: Redundancy index for the first canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
PHI-reported behaviour	.136	.018			
PHI-reported cognition	.895	.801			
PHI-reported PD	.401	.161			
SO-reported ADL	.057	.003			
NT score	-.483	.233			
Dependent variate		1.216	0.243	.80	0.194
T1 (Independent)					
PHI-reported behaviour	.010	0.0001			
PHI-reported cognition	.766	0.587			
PHI-reported PD	.307	0.094			
SO-reported ADL	.164	0.027			
NT score	-.489	0.239			
Independent variate		0.947	0.189	.80	0.151

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table D2

First CCA: Redundancy index for the second canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
PHI-reported behaviour	-0.056	0.003			
PHI-reported cognition	-0.086	0.007			
PHI-reported PD	-0.164	0.027			
SO-reported ADL	-0.638	0.407			
NT score	-0.756	0.572			
Dependent variate		1.016	0.203	0.73	0.148
T1 (Independent)					
PHI-reported behaviour	-0.245	0.060			
PHI-reported cognition	-0.194	0.038			
PHI-reported PD	-0.318	0.101			
SO-reported ADL	-0.703	0.494			
NT score	-0.72	0.518			
Independent variate		1.211	0.242	0.73	0.177

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table D3

First CCA: Redundancy index for the third canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
PHI-reported behaviour	-0.084	0.007			
PHI-reported cognition	0.021	0.0004			
PHI-reported PD	0.832	0.692			
SO-reported ADL	-0.207	0.043			
NT score	-0.34	0.116			
Dependent variate		0.858	0.172	0.68	0.117
T1 (Independent)					
PHI-reported behaviour	-0.063	0.004			
PHI-reported cognition	0.129	0.017			
PHI-reported PD	0.781	0.610			
SO-reported ADL	-0.29	0.084			
NT score	-0.232	0.054			
Independent variate		0.768	0.154	0.68	0.105

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table D4

First CCA: Redundancy index for the fourth canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
PHI-reported behaviour	-0.588	0.346			
PHI-reported cognition	-0.423	0.179			
PHI-reported PD	-0.337	0.114			
SO-reported ADL	0.667	0.445			
NT score	-0.189	0.036			
Dependent variate		1.119	0.224	0.51	0.114
T1 (Independent)					
PHI-reported behaviour	-0.742	0.551			
PHI-reported cognition	-0.597	0.356			
PHI-reported PD	-0.436	0.190			
SO-reported ADL	0.474	0.225			
NT score	-0.233	0.054			
Independent variate		1.376	0.275	0.51	0.140

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table D5

First CCA: Redundancy index for the fifth canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
PHI-reported behaviour	-0.791	0.626			
PHI-reported cognition	-0.112	0.013			
PHI-reported PD	-0.074	0.005			
SO-reported ADL	-0.318	0.101			
NT score	0.208	0.043			
Dependent variate		0.788	0.158	0.39	0.061
T1 (Independent)					
PHI-reported behaviour	-0.621	0.386			
PHI-reported cognition	-0.049	0.002			
PHI-reported PD	-0.064	0.004			
SO-reported ADL	-0.412	0.170			
NT score	0.335	0.112			
Independent variate		0.674	0.135	0.39	0.053

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Appendix E

Second CCA: Calculation of Redundacy Indices for the Identified Canonical Dimensions

Table E1

Second CCA: Redundancy index for the first canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
SO-reported behaviour	0.187	0.035			
SO-reported cognition	0.388	0.151			
SO-reported PD	0.651	0.424			
SO-reported ADL	-0.469	0.220			
NT score	-0.961	0.924			
Dependent variate		1.753	0.351	0.74	0.259
T1 (Independent)					
SO-reported behaviour	0.001	0.000			
SO-reported cognition	0.216	0.047			
SO-reported PD	0.410	0.168			
SO-reported ADL	-0.509	0.259			
NT score	-0.957	0.916			
Independent variate		1.390	0.278	0.74	0.206

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table E2

Second CCA: Redundancy index for the second canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
SO-reported behaviour	0.310	0.096			
SO-reported cognition	-0.059	0.003			
SO-reported PD	0.028	0.001			
SO-reported ADL	-0.646	0.417			
NT score	0.089	0.008			
Dependent variate		0.526	0.105	0.68	0.071
T1 (Independent)					
SO-reported behaviour	0.355	0.126			
SO-reported cognition	-0.097	0.009			
SO-reported PD	0.085	0.007			
SO-reported ADL	-0.631	0.398			
NT score	0.169	0.029			
Independent variate		0.569	0.114	0.68	0.077

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table E3

Second CCA: Redundancy index for the third canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
SO-reported behaviour	0.621	0.386			
SO-reported cognition	0.777	0.604			
SO-reported PD	0.213	0.045			
SO-reported ADL	-0.246	0.061			
NT score	-0.128	0.016			
Dependent variate		1.112	0.222	0.53	0.118
T1 (Independent)					
SO-reported behaviour	0.614	0.377			
SO-reported cognition	0.809	0.654			
SO-reported PD	0.184	0.034			
SO-reported ADL	-0.178	0.032			
NT score	0.007	0.000			
Independent variate		1.097	0.219	0.53	0.116

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table E4

Second CCA: Redundancy index for the fourth canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
SO-reported behaviour	-0.510	0.260			
SO-reported cognition	-0.125	0.016			
SO-reported PD	-0.167	0.028			
SO-reported ADL	-0.457	0.209			
NT score	0.051	0.003			
Dependent variate		0.515	0.103	0.44	0.045
T1 (Independent)					
SO-reported behaviour	-0.608	0.370			
SO-reported cognition	-0.184	0.034			
SO-reported PD	-0.327	0.107			
SO-reported ADL	-0.429	0.184			
NT score	0.116	0.013			
Independent variate		0.708	0.142	0.44	0.062

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).

Table E5

Second CCA: Redundancy index for the fifth canonical dimension

Variate/Variables	Canonical Loading	Canonical Loading Squared	Average Loading Squared	Canonical R^2	Redundancy Index[a]
T2 (Dependent variables)					
SO-reported behaviour	-0.472	0.223			
SO-reported cognition	-0.476	0.227			
SO-reported PD	-0.708	0.501			
SO-reported ADL	0.305	0.093			
NT score	-0.224	0.050			
Dependent variate		1.094	0.219	0.16	0.035
T1 (Independent)					
SO-reported behaviour	-0.356	0.127			
SO-reported cognition	-0.506	0.256			
SO-reported PD	-0.827	0.684			
SO-reported ADL	0.355	0.126			
NT score	-0.204	0.042			
Independent variate		1.234	0.247	0.16	0.039

Note. PD = level of physical dependency; ADL = activities of daily living capability; NT score = composite score on neuropsychological tests.

[a]The redundancy index is calculated as (the average loading squared) times (the canonical R^2).