INCIDENCE AND NEUROPSYCHOLOGICAL CONSEQUENCES OF MILD TRAUMATIC BRAIN INJURY IN OLDER ADULTS

A thesis presented in partial fulfilment
of the requirements for the degree of Master
of Arts in Psychology at Massey University

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2003

To my grandmother, Dorothy, who inspired my endeavours in the field of Neuropsychology

ABSTRACT

This study examined the epidemiology and neuropsychological effects of Mild Traumatic Brain Injury (MTBI) in older adults (with a mean age of 83). The study was conducted in two parts. Part one involved the administration of a questionnaire to 264 residents from nursing homes and retirement villages. Results indicated that 41.9% of nursing home and 26.5% of retirement village residents reported they had sustained a fall during the past year. Of these falls, 2.3% met criteria for a TBI. Of the retirement village participants, 4.1% indicated they had sustained a head injury during the past five years which met the criteria for a MTBI, equating to an annual incidence rate of 816 per 100,000. Analysis of incidence rate by age revealed TBIs increased with age; older adults aged 84 and under were less likely to have sustained a TBI (2.2%) than those aged 85 and over (4%). Of those who had sustained a TBI, 92.5% were of mild severity, and, of these between 10.8% and 16% had not sought any medical attention. Participants admitted to hospital for orthopaedic injuries were less likely to be diagnosed with a MTBI (18.1%) than those with non-orthopaedic injuries (40%).

Part two involved the administration of measures of attention, memory and executive functioning to 21 MTBI participants. Compared with age matched controls, the MTBI group performed significantly lower on measures of attention. Analysis of the MTBI group according to severity of non-brain injury/s indicated significant differences on measures of memory (visual) and information processing speed. Post hoc analysis within the MTBI group according to fall frequency revealed significant differences on measures of information processing speed, attention and memory (verbal and visual). Further analysis revealed only fall frequency, age, gender and an interaction effect between fall frequency and age predicted neuropsychological performance. The reported findings suggest that the variables of fall frequency and age be taken into consideration when evaluating outcome post MTBI in older old adults.

ACKNOWLEDGEMENTS

I began this project with the hope of increasing our understanding of people with Mild Traumatic Brain Injury. In completing this thesis, I have become aware that such a project could never have been accomplished without the contributions of numerous individuals, whom I would like to acknowledge.

Very special thanks to all the participants who gave so freely of their time. Whether intrigued by the prospect of research or acknowledging the plight of a researcher, they all shared a common vision, an unquestionable desire to assist in the course of research. I thank them sincerely; their level of commitment was both uplifting and inspiring.

I would also like to acknowledge with special appreciation Shirley Burgess from Metlifecare Browns Bay, Shona Colebrook from Metlifecare Crestwood and Jenny Piza from the Masonic Roskill Village, all of whom understood and valued the importance of research in the enterprise of clinical neuropsychology.

And to my Supervisor, Janet Leathem, who originated and enthusiastically encouraged this project throughout its progress; without her expertise, this project could not have been completed.

Thanks also to Dr Ephra Garrett, Lecturer in Psychology, Sione Tu'itahi, Pacific Island Development and Learning Coordinator, Heather Rogan, ESOL Learning Co-ordinator and Virginia Tamanui for your willingness to advise on issues of a cultural nature.

Further, I acknowledge Barry McDonald for your invaluable statistical advice, and Ross Flett, whose statistical direction brought it all together. Finally, I would like to thank my close friends and family, without whose tremendous patience and support there would be no thesis at all.

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CHAPTER 1

OVERVIEW

The proportion of the New Zealand population aged 65 and over is expected to more than double in the next 55 years, from 11.7 percent in 1996 to 25.5 percent in 2051, such increase being greatest after 2011 as the baby boom generation enters older age (Statistics New Zealand, 1998). Such precipitous growth rate is not unique to New Zealand but rather a manifestation of demographic transition within the Western world. As the proportion of older adults in the population increases, it is reasonable to assume that health care problems peculiar to older adults and subsequent demands on the health care system will simultaneously increase. Accordingly, gaining greater insight into health issues at the upper spectrum of life becomes increasingly pertinent.

Falls are a major source of morbidity and mortality amongst older adults. Annually, approximately one third of adults aged 65 and over will fall in any one year (Kannus, Parkkari, Koskinen, Niemi, Palvanen, Jarvinen & Vuori, 1999; Tinetti, 1987; Tinetti, Williams & Mayewski, 1986) with incidence and severity increasing with age (Luukinen, Viramo, Koski, Laippala & Kivela, 1999; Sjoegren & Bjoernstig, 1989; Tinetti, Doucette & Claus, 1995; Tinetti, Doucette, Claus & Marottoli, 1995). The Ministry of Health reports that hospitalisation numbers for falls have increased significantly; in 1988 4,593 adults aged 65 years and over were hospitalized for falls, increasing to 6,663 in 1998 (New Zealand Health Information Service Morbidity Data, 1998/1999).

Falls result in a myriad of complications. With the exception of death, the most serious consequence is traumatic brain injury (TBI) (Kannus, Palvanen, Niemi, Parkkari, Natri, Vuori & Jarvinen, 1999a). Approximately 70% of brain injuries sustained by older adults are due to falling (Kannus, et al., 1999; Nagurney, Borczuk & Thomas, 1998; Rapoport & Feinstein, 2000; Sjoegren & Bjoernstig, 1989). During the last four years various Government statistical agencies report approximately 600 New Zealanders annually over the age of 65 suffered a TBI with cause of injury most frequently attributable to a fall (New Zealand Health Information Service Morbidity Data, 1998/1999; New Zealand Health Information Service Morbidity Data, 1998/1999a; Accident Compensation Corporation, 2000/2001). These statistics may be seriously underestimated. Most are merely reflective of injuries leading to

hospitalisation and do not represent cases seen in emergency departments or doctors' rooms. It is estimated that approximately 40% of clients seen for persisting problems post injury have been assessed only by a General Practitioner (Wrightson & Gronwall, 1999). Secondly, statistics do not reflect those injuries not receiving medical attention. It is estimated that 20-40% of individuals sustaining TBIs do not seek medical attention (Jennett, 1996). It may be that a considerable number of older adults who fall and do not come to medical attention, nonetheless experience a head injury, which meets the criteria for TBI.

Incidences of TBI unrecognised due to limitations as stated above would almost invariably be classified mild. Approximately 80-90% of TBIs are considered mild (Culotta, Sementilli, Gerold & Watts, 1996). Following mild traumatic brain injury (MTBI), individuals frequently experience a triad of neuropsychological dysfunctions; cognitive (e.g., concentration and short term memory loss), physical (e.g., headache, fatigue and dizziness) and behavioural/emotional (e.g., impulsivity and irritability) (Lezak, 1995) that can cause many aspects of daily functioning, previously performed automatically, to become effortful. Older adults tend to be at increased risk for negative outcome following MTBI than younger adults (Fields, Cisewski & Coffey, 2000). Evidence suggests that neurobehavioural complaints tend to persist longer in older adults with some symptoms even increasing (Fields et al., 2000). Examples abound of older adults who have never been able to fully recover from the effects of even a mild TBI (Fields, 1997). Due to the lack of a unified definition of MTBI, diagnosis proves challenging across all age categories. Detection is further exacerbated within older adults because impairment may be due to the sequelae of the TBI, pre-injury variables (e.g., pre-injury medical or psychiatric conditions), medication side-effects, the normal course of aging, a neurodegenerative illness (e.g., Alzheimer's Disease) or some interaction of these variables. Additionally, many older adults who fall sustain soft tissue injuries and fractures (e.g., fibula and neck of femur). Accordingly, the MTBI sustained by an older adult who concurrently presents with a fracture in a confused state may remain undiagnosed; the abnormal mental state being attributed to any of the above variables or remaining undetected. Confusing TBI with any of the above would be extremely unfortunate as non-detection of a TBI may deprive a patient access to treatment and rehabilitation programmes, leaving them unaware of some of the expected sequelae that may impact on aspects of everyday activities.

Due to reasons indicated above there is good reason to believe that many cases of MTBI remain unreported. The purpose of the current research is to provide greater insight into the occurrence of MTBI amongst older adults aged 65 and over.

Furthermore, whilst it is known that falling is responsible for a large number of TBIs in older adults, it remains unknown as to how often falling leads to brain injury. The current research also aims to answer this question.

Chapter Two begins with an overview of the incidence and aetiology of TBI. Also discussed are the various classification systems associated with TBI. Chapter Three focuses on MTBI; neuropsychological, neurophysiological, behavioural and psychiatric sequelae are reviewed. Chapter Four focuses on research exclusive to older adults; neuropsychological and functional recovery research are reviewed. Also discussed are the neurophysiological changes unique to older adults. Finally, the chapter closes with a discussion on the comorbid conditions that may obscure detection of a MTBI in older adults. Chapter Five presents the formulation and hypotheses with the methodology for the study being outlined in Chapter Six. Chapters Seven and Eight outline the Results and Discussion sections respectively.

CHAPTER 2

EPIDEMIOLOGY, CLASSIFICATION AND NEUROPHYSIOLOGY OF TRAUMATIC BRAIN INJURY

Epidemiology refers to the study of the distribution of mental/physical disorders in a population (Kaplan & Sadock, 1998). The current chapter provides an overview of epidemiological data pertaining to Traumatic Brain Injury (TBI) with an emphasis on Mild Traumatic Brain Injury (MTBI) in adults aged 65 and over. After outlining the difficulties in presenting a single definition of TBI, incidence figures, largely based on United States data, are reviewed, with New Zealand statistics sourced (Accident Compensation Corporation, 2000/2001; New Zealand Health Information Service Morbidity Data, 1998/1999) where possible. Characteristics unique to older adults in the aetiology of TBI are also explored, namely; cause of injury, mortality rates, gender, ethnicity, socioeconomic status and severity of injury. Discussion then focuses on the various classification systems unique to TBI including severity of injury and distribution. As the cognitive and behavioural consequences of TBI are directly related to areas of the brain damaged in the course of trauma, an appreciation of the physical and physiological mechanisms of cerebral trauma is necessary to gain an understanding of the consequent neuropsychological sequelae. Accordingly, discussion of classification systems also encompasses primary and secondary, open versus closed and focal versus diffuse injury. Whilst these latter three classification systems are presented in a dichotomous manner, it is important to realise that these systems are heavily entwined.

DEFINITION OF TRAUMATIC BRAIN INJURY

There are many definitions of TBI, with no universal consensus as to what constitutes TBI, particularly MTBI. Most definitions have adopted rather rigorous criteria, requiring an alteration in the level of consciousness (e.g., DSM-III; American Psychiatric Association, 1994). However, it is well known that cerebral injuries can occur without major changes or alterations in the level of consciousness. Accordingly, other definitions of TBI adhere to less stringent criteria, proposing that any alteration of

mental state is sufficient for a diagnosis of MTBI (Ruff & Jurica, 1999). The American Congress of Rehabilitation Medicine Committee (ACRM; Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine, 1993) indicates that not only loss of consciousness but any alteration of mental state is sufficient for a diagnosis of MTBI. Most definitions of MTBI require some indication of physical impact to the head resulting in injury, and, that the injury disturbed neurological function causing confusion, amnesia or alteration of consciousness (or other indication of neurological significance such as severe headache or vomiting without other explanation) (Wrightson & Gronwall, 1999).

Further confusion arises within the term itself; TBI appears in the literature alongside that of head injury and brain injury. TBI implies that changes in cognition, behaviour and mood are directly related to neurological damage sustained as a result of the traumatic event (Bernstein, 1999). Conversely, the term head injury refers to injury to the head and face, independent of damage sustained by the brain. Brain injury is typically used to describe a variety of neurological changes such as stroke or aneurysm as well as traumatic brain injury. Due to the above confusion, most studies define TBI according to severity.

INCIDENCE

Incidence can best be described as the occurrence of new cases during a specified time period relative to the total number of people at risk (Kaplan & Saddock, 1998). A multitude of research, largely limited to the late 1970s / early 1980s, has endeavoured to establish an accurate estimate of the incidence of TBI (e.g., Annegers, Grabow, Kurland & Laws, 1980; Jagger, Levine, Jane & Rimel, 1984; Kraus & Nourjah, 1989; Whitman, Coonley-Hoganson & Desai, 1984). Table 2.1 sets out the incidence rates from studies including older adults. Rates of brain injury range from 180 to 654 per 100,000 of the population.

Table 2.1

Traumatic Brain Injury Incidence Figures from Studies including Older Adults

Study	Participants	Incidence Rate	Severity of TBI
Annegers et al. (1980)	Hospital data only Age adjusted to 1970 US population	193	All severities
Klauber, Barrett-Connor, Marshall & Bowers (1981)	Hospital data only All adults aged 10 years and over	294	All severities
Jagger et al. (1984)	Hospital data only All ages	175-208	All severities
Kraus & Sorenson (1984)	All ages	180	All severities
Frankowski (1986)	Hospital data only All ages	200	All severities
Whitman et al. (1984)	Hospital data only All ages	367	All severities
Sosin, Sniezek & Thurman (1996)	Hospital and Emergency Department data All ages	519 618	Mild Mild/Moderate
Wrightson & Gronwall (1998)	Hospital and Emergency Department data All ages	654	Mild

Due to various methodological problems, comparisons between the above studies can only be made cautiously. Firstly, there is a lack of consistency as to what constitutes a brain injury. Although most studies aim to capture only injuries resulting in neurological injury, some (e.g., Annegers et al., 1980; Whitman et al., 1984) include non-neurological injuries such as fractures to the skull or face. Secondly, whilst some studies are restricted to hospital populations (e.g., Klauber et al., 1981), others represent people treated in emergency departments (e.g., Wrightson & Gronwall, 1998). Thirdly, studies reporting only hospital figures vary considerably, with some including readmissions resulting in double counting (Goldstein & Levin, 1990). Fourthly, there is variation in hospital documentation policies, with many potential brain injuries diagnosed according to cause (i.e., fall or motor vehicle accidents [MVAs]) rather than by nature of injury (Goldstein & Levin, 1990). Fifthly, various criteria are employed to diagnose severity of brain injury; whilst some studies require loss of consciousness,

post-traumatic amnesia, Glasgow Coma Scale (GCS) and neurological signs of brain injury (e.g., Annegers et al., 1980), others only require one or two of these criteria (e.g., Kraus, Black, Hessol, Ley, Rokaw, Sullivan, Bowers, Knowlton & Marshall, 1984; Whitman et al., 1984). Finally, failure to adjust the rates for age in some studies (e.g., Kraus et al., 1984) further accounts for some of the differences reported.

Whilst the above methodological problems make direct comparison difficult, there is also reason to suggest these incidence rates are invariably deflated. As patients are typically classified according to their most severe injury, those receiving other bodily injuries alongside a TBI may have a MTBI obscured. Furthermore, whilst some studies include both patients admitted to hospital and those seen in emergency departments there is no practical way of including those patients treated by general practitioners or the approximate 40% of individuals sustaining a MTBI who do not seek medical attention (Wrightson & Gronwall, 1998).

Despite the above variance, the average incidence rate has been calculated at 237 per 100,000 population (Kraus & Sorenson, 1994). Incidence rates are clearly age related with the highest at risk group being males aged 15-24 years of age (Kraus & Nourjah, 1989), with an incidence rate of approximately 400 per 100,000 (Frankowski, 1986). Injury rates quickly decline after age 24, continuing their descent during the middle-age years before increasing after the age of 65 (Annegers et al., 1980; Kraus et al., 1984) to an estimated incidence rate of 200 per 100,000 (Frankowski, 1986). The risk of TBI continues to increase rapidly throughout the more advanced age range (Kraus et al., 1984).

No formal epidemiological study has been conducted on the incidence and prevalence of TBI in New Zealand adults aged 65 and over. However, New Zealand research conducted by Wrightson & Gronwall (1998) on cases seen in emergency departments indicate that the figures compare reasonably well with overseas research.

Some statistics have been gathered by the Injury Prevention Research Unit at the University of Otago, the Ministry of Health and the Accident and Rehabilitation Compensation Corporation. The Injury Prevention Research Unit (IPRS; New Zealand Health Information Service Morbidity Data, 1998/1999a), report 2,585 brain injuries (International Classification of Diseases [ICD, New Zealand Health Information Service Morbidity Data, 1998/1999] Injury Codes 800-804, 850-854) for the 1998/99 period, with 221 (8.5%) of these sustained by adults aged 65 and over. Statistics available from The Ministry of Health (MOH; New Zealand Health Information Service Morbidity

Data, 1998/1999) report 8137 (ICD injury codes 800-804, 850-854) TBIs for the total population during the period July 1998 to June 1999. Of these, 605 (7.4%) were sustained by individuals aged 65 and over, providing an estimated annual incidence rate of 136 per 100,000. These figures are invariably higher than those available from the IPRU as readmissions (people admitted to hospital more than once for the same injury) and all hospitalisations are included. Conversely, IPRU data only reflect hospitalisation of 24 hours or longer (such criteria controlling for different hospitalisation admission criteria). As many individuals with MTBI are discharged from hospital within 24 hours, statistics available from the IPRU may not adequately reflect incidence rates.

Additionally, the data sets above should be interpreted with caution as they are only representative of discharges from publicly funded hospitals and treatment in private hospitals under publicly funded contracts. Many people who sustain MTBIs are not hospitalised but instead are assessed in emergency departments, doctors' rooms or do not come to medical attention at all. Indeed, research by Wrightson & Gronwall (1998) reported that 94% of individuals with suspected mild injuries seen in emergency departments were not admitted to hospital.

The New Zealand Accident Compensation and Rehabilitation Corporation (ACC; Accident Compensation Corporation, 2000/2001) collects data on all injuries from hospitals, emergency departments and doctors' rooms. For the period 2000/2001, ACC reported 14,255 incidences of concussion/brain injury of which 627 (4.3%) were sustained by adults aged 65 and older. The ACC figures are approximately half the rate of TBI (4.3%) as that reported by either the IPRU (8.5%) or the MOH (7.4%), despite the fact that their figures cover a wider catchment area. Whilst the discrepancy in numbers between those reported by the ACC and IPRU/MOH could be attributed to differences in recording procedures, the disparity cannot be ignored. ACC statistics include data from emergency departments and doctors' rooms. Such cases are typically of mild severity. It could well be that detection of MTBI is obscured by other injuries. Hence, the true incidence of TBI may not be included in the above descriptive statistics.

Statistics provided by Accident Compensation Corporation (Accident Compensation Corporation, 2000/2001) are not broken down by cause of injury. The Ministry of Health (New Zealand Health Information Service Morbidity Data, 1998/1999) ICD injury statistics for the period July 1998 to June 1999 are available for injuries as a whole. Such statistics (E codes 880-888) reflect that for the total population, 26,967 injuries were classified as accidental falls of which 12,797 (47%)

were sustained by those aged 65 and over (reflecting the highest figures for this category). Whilst it cannot be assumed that all accidental falls are synonymous with TBI, the discrepancy in numbers (221 and 605 cases of TBI as reported by the IPRU and MOH respectively, versus 12,797 falls) poses the possibility that many older adults who fall may also concurrently sustain a MTBI which remains undetected. Unfortunately, an estimate of TBI cannot be extrapolated from these statistics as the percentage of falls resulting in TBI remains unknown.

AETIOLOGY

Cause of Injury

For the total population, the most frequent external cause of TBI is injuries due to MVAs (Dacey & Dikmen, 1989; Kraus and Nourjah, 1989), with falls representing the second leading external cause of injury (Luerssen, Klauber & Marshall, 1988). However, differences in specific causes of TBI are apparent across different age groups. For young adults (age 15-24) MVAs remain the predominant cause of TBI (Bigler, 1990; Naugle, 1990). For children and adolescents, accidents around the home account for the majority of injuries, with child abuse becoming increasingly apparent. Among older adults (aged 65 and over) however, the leading cause of injury is falling (Pentland, Jones, Roy & Miller, 1986; Roy, Pentland & Miller, 1986), with MVAs being the secondary causative factor (Parker, 1990; Rakier, Guilburd, Soustiel, Zaaroor & Feinsod, 1995) and the predominant cause of severe and fatal injuries (Pentland et al., 1986).

New Zealand data appear in line with above reporting. The IPRU reports that for older adults for the 1998/99 period, 77% of TBI incidences were attributable to a fall, with MVAs, the second leading cause of injury, accounting for only 16%. Similarly, for the 2000/2001 period, 70% of injuries were due to a fall, with 19% being attributable to an MVA. Comparable statistics are available from the Ministry of Health (New Zealand Health Information Service Morbidity Data, 1998/1999). For the period 1995-1999 the leading cause of TBI was a fall (71%), followed by an MVA (17%) and thirdly being struck by an object (4%).

Mortality

Fatality data range from approximately 3 to 8 per 100,000 hospitalised cases (Fife, Faich, Hollinshead & Boynton, 1986). The rate of fatality for severe TBIs is

approximately twice as high for older adults than younger adults (Fife, 1987). For example, Miller and Pentland (1989) report moderate and severe TBI mortality rates of 20% and 70% respectively for patients aged 65 and over, compared with 1% and 39% in those less than 65 years of age. Conversely, for injuries of mild severity, when severity of brain and non-brain injuries is controlled, mortality rates for older adults are comparable to younger adults (Fields & Coffey, 1994).

Gender

All incidence research suggests that TBIs are much more frequent amongst males than females with an approximate ratio of 2:3 (Annegers et al., 1980, Jagger et al., 1984, Kraus & Sorenson, 1994, Kraus & Nourjah, 1989; Whitman et al., 1984). This discrepancy is particularly evident in the younger adult group (ages 15-24); with young adult men being three times more likely than young adult females to sustain a TBI. The differences in rates may well be attributable to the higher proportion of injuries resulting from MVAs which tend to almost invariably involve males, whereas females are more likely to sustain their injuries from falling (which is less frequent). Conversely, the gender differences apparent in young adults are not present in older adults, with males and females being equally at risk (Fields & Coffey, 1994; Jennett, 1996; Naugle, 1990).

Ethnicity

Research pertaining to the role of ethnicity on TBI is limited. Studies demonstrating a positive relationship between ethnicity and TBI have serious limitations in that some ethnic groups are also overly represented in lower socio-economic groups (which are also risk factors for TBI). Research by Kraus et al. (1984) failed to find a relationship between TBI and ethnicity/race. The role of ethnicity differences in TBI rates have yet to be determined.

Socioeconomic Status

Studies pertaining to the impact of low socio-economic status on the incidence of TBI report equivocal findings. Whilst some research indicate a positive association between rates of TBI and low income (e.g., Kraus, 1984; Whitman et al., 1984) other studies have failed to find such a relationship (e.g., Klauber, 1981).

Severity of Injury

Preliminary research suggests that older adults tend to sustain slightly, but not dramatically so, more severe injuries (Fields et al., 2000). As severity of TBI is correlated with eventual outcome, it could well be that age differences in outcome are due to severity of injury rather than age.

Furthermore, older adults have more severe non-brain injuries (Fields & Coffey, 1994). Fields et al. (2000) suggest that severity of brain injury and severity of other injuries should be taken into consideration when assessing the relationship between age and outcome following TBI.

CLASSIFICATIONS OF TBI

Severity

Brain injury occurs along a continuum of severity. Most attempts to measure brain injury severity depend on neurological or neuropsychological clinical observation post injury. Severity of injury is the most important factor in predicting both post-injury sequelae as well as eventual outcome. TBIs are typically categorised as severe, moderate or mild on the basis of certain clinical criteria: loss of consciousness, length of post-traumatic amnesia and initial Glasgow Coma Score (GCS; Teasdale & Jennett, 1974).

Loss of Consciousness (LOC) / Alteration in Consciousness

Most classifications of brain injury have revolved around some index of initial alteration in the level of consciousness or concussion. Length of coma has been found to correlate strongly with amount of damage to central brain structures (brainstem corpus callosum and cerebellum) suggesting that LOC is related to damage to these subcortical regions (King, 1997). Using length of unconsciousness proves difficult however. Firstly, there is no reliable method of ascertaining whether a patient was or was not unconscious and the length of time they were unconscious (King, 1997). Those sustaining a MTBI, if they do lose consciousness, often regain consciousness by the time they are admitted to hospital (Wrightson & Gronwall, 1999). Furthermore, TBIs can occur without loss or alteration of consciousness (King, 1997) and sometimes these alterations are temporarily delayed. Hence caution should be exercised when using loss or alteration in consciousness in the definition of TBI.

Glasgow Coma Scale

The Glasgow Coma Scale (Teasdale & Jennett, 1974) was the first empirically substantiated and clinically validated rating scale developed to objectively measure degrees of neurological dysfunction; describing states from mild confusion to deep coma (Lezak, 1995). The GCS is a 15-point measure assessing three domains of wakefulness (visual, verbal and motor function). The lowest score attainable indicates absence of eye opening, failure to utter recognisable words and an inability to obey commands. Conversely, the maximum score of 15 implies spontaneous eye opening, demonstration of normal orientation to time, place and person and the following of simple motor commands. The GCS is quick and easy to administer and is considered the standard measure for categorising initial severity of injury (Lezak, 1995). The GCS correlates highly with length of coma and amount of damage to central brain structures during the first week post injury. As with LOC, this suggests that disruptions to consciousness are a manifestation of subcortical activating mechanisms (Richardson, 2000).

A key limitation of the GSC is that the score is variable, depending on the interval between injury and assessment. Ideally, assessment should occur at the time of injury (Teasdale & Jennett, 1974) and cannot be evaluated retrospectively. Particularly in the case of MTBI, the GCS must be administered as soon as possible, in that the majority of symptoms are evidenced within the first few hours post injury (Ruff, Levin, Mattis, High & Marshall, 1989). However, this is often not the case and individuals can subsequently improve with detection consequently overlooked. The converse is also true; individuals can decline, rendering an initial GCS invalid. Limitations are also evident within particular populations, including older adults. Hearing impairments (inability to adequately follow instructions) or the effects of medication or alcohol (impaired consciousness attributed to the effects of such variables) can impact on the score.

Post-Traumatic Amnesia (PTA)

Post-traumatic Amnesia (PTA) is another indicator of severity of brain injury and eventual outcome. PTA refers to the length of time between the injury and regaining normal continuous memory functioning; where the individual is assumed to be alert and functioning, although there may be ongoing difficulty retaining new information and processing new memories (anterograde amnesia) and / or difficulty accessing

information for events pre-injury (retrograde amnesia) (Parker, 1990). PTA is considered complete when the individual is oriented and continuous memories are restored.

PTA has limitations when used to classify TBIs and should not be used in isolation as an indicator of severity. Patients are asked to retrospectively recollect events post injury. This is a subjective (e.g., confusing) procedure, often requiring verification from a relative/friend which makes it time consuming. It is also confounded by overestimation due to the inclusion of periods of sleep or impaired consciousness resulting from the side-effects of medication or drugs/alcohol. Underestimation can also occur when isolated memories are reported that do not occur within a continuous period (Lezak, 1995). This is reported to occur in 30% of mild head injuries (Gronwall & Wrightson, 1974). Significant brain trauma has also been found to occur without a clearly defined period of PTA (Kelly, Nichols, Filley, Lilehei, Rubinstein & Kleinschmidt-DeMasters, 1991).

PTA, GSC and LOC are typically combined to form a more comprehensive taxonomy of mild, moderate and severe brain injury. Table 2.2 outlines criteria for severity of TBI according to these three systems.

Table 2.2
Classification System for Measuring Severity of Traumatic Brain Injury

Severity	**Unconsciousness**	**GCS**	**PTA**
Mild Injury	1 - 30 minutes	13-15	< 1 hour
Moderate Injury	> 30 minutes < six hours	9-12	1-24 hours
Severe Injury	≥ Six hours	3-8	≥ 24 hours

Source. Lezak, 1995; Snyder & Nussbaum, 1998.

Levels of PTA have since been increased to include very mild PTA (less than 5 minutes), very severe (1-4 weeks) and extremely severe (longer than 4 weeks) (Snyder & Nussbaum, 1998). PTA lasting longer than 1 week (very severe) has been associated with poor outcome and persistent mental/cognitive dysfunction.

Distribution

Mild TBI represents the greatest proportion of brain injury. Research based on both hospitalisation and emergency department statistics indicate that for the population, approximately 80% are deemed mild, 10% moderate and 10% severe

(Annegers, et al., 1980; Jagger et al., 1984; Klauber et al., 1981; Whitman et al., 1984). It is likely that the majority of those treated by medical practitioners and those not receiving medical attention are also of mild severity. Percentages of MTBI for those aged 65 and over are the same as for those under 65 (Galbraith, 1987).

Attempts have been made to introduce varying levels of MTBI (Varney & Roberts, 1999). The American Academy of Neurology (AAN; Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine, 1993) has recommended three grades of MTBI as outlined below:

Grade 1:
- Transient confusion, no LOC, concussion symptoms or mental status abnormalities on examination resolve in less than 15 mins

Grade 2:
- Transient confusion, no LOC
- Concussion symptoms or mental status abnormalities on examination lasting more than 15 mins

Grade 3:
- LOC
  a) Brief (seconds)
  b) Prolonged (minutes)

To date there is a lack of research supporting AAN recommendations.

Neurophysiology: Primary/Secondary

A further classification of TBI exists within its neurophysiological effects; primary and secondary injury. Primary injury occurs immediately at the time of trauma due to forces applied to the cranial contents and complications developing as a result of the initial cerebral trauma. This sets in motion secondary effects occurring subsequent to the initial injury. As these secondary reactions are the only treatable forms of injury, trauma care is largely directed towards preventing or minimising secondary damage and consequently the severity of some sequelae.

The following is an overview of generic neurophysiological research with a separate review of the neurophysiological effects of MTBI outlined in Chapter Three and the literature pertaining to the neurophysiological changes unique to older adults being presented in Chapter Four.

As the current research pertains to injury subsequent to falling, which is predominantly associated with closed injuries[1], neurophysiological discussion will focus on this aspect of TBI

Primary Injury

Damage to the brain is attributable to both linear and rotational forces. Primary injuries typically occur due to impact or acceleration forces involving neural or vascular aspects of the brain and comprises both macroscopic (lacerations and contusions) and microscopic lesions (cell and axonal damage) (Gennarelli, 1993).

Contusion

Contusions (bruises) are focal damage to the surface of the brain and white matter due to impact. Injury is characterised by cell and axonal damage, hemorrhages (bleeding) and edema (swelling) (Parker, 1990).

Several patterns of contusions are apparent. Primarily, the force of impact results in a contusion at the site of impact (coup injury). This creates a pressure gradient causing a spontaneous rebounding of the brain to the diametrically opposite side (contrecoup injury) typically resulting in a larger contusion than at the site of impact (Kolb & Whishaw, 1996; Lezak, 1995). Between 50% - 80% of focal injuries resulting in direct impact to the head, are due to contrecoup injuries (Lezak, 1995).

Furthermore, movement of the brain within the skull causes the brain to rub against, and collide with, the rough surface of the skull (McAllistair, 1994; Parker, 1990). This produces lacerations and contusional lesions to areas of the brain interfacing stationery edges, ridges and bony protuberances (McAllister, 1994); particularly anterior and inferior surfaces of the frontal and temporal lobes (Bigler, 1990; Cassidy, 1994; Lezak, 1995; McAllister, 1994; McIntosh, Smith, Meaney, Kotapka, Gennarelli & Graham, 1996; Richardson, 1990). Finally, rotational restriction of the brain within the skull produces contusions along the medial surfaces of the cerebral hemispheres and the upper surface of the corpus callosum (Richardson, 2000).

[1] An overview of closed injuries is outlined on page 19

Diffuse Axonal Injury

Diffuse Axonal Injury (DAI) refers to axonal and cell damage spread out over the central nervous system (CNS) with temporary or permanent loss of function, but without gross pathology (Gennarelli, 1987). DAI is the primary process responsible for TBI and is common following all severities of TBI. Even simple concussion is associated with axonal injury (Parker, 1990). DAI is considered to be the basic pathology of MTBI with the final outcome depending on the presence and nature of secondary injury.

Neurological damage occurs as a result of both linear and/or rotational forces. Linear forces generate a translational acceleration/deceleration of the brain typically resulting in focal and minor damage (Richardson, 2000). Conversely, rotational forces occur when the skull rotates relative to the brain (McAlister, 1994; Parker, 1990; Richardson, 2000). Rotational forces between cellular structures of different densities cause strain on delicate nerve fibres and blood vessels resulting in damage ranging from microscopic lesions resulting in brief physiologic disruption of function to widespread stretching and disconnection of axons (McAllistair, 1994; Parker, 1990). Damage occurs in both cortical and subcortical regions, being most obvious at the junction of gray and white matter fibres. The rotational force appears to play a role in the loss of consciousness (due to alterations on the brain stem and subsequent interference of the ascending reticular activating pathways) invariably producing post-traumatic concussion symptoms (e.g., dizziness, amnesia, headaches and confusion). With increasing severity there is damage to the corpus callosum and brainstem (Parker, 1990) with corresponding disturbances of consciousness and vestibular and motor dysfunction.

Neurochemical changes can also result in DAI. Neuronal injury leads to the release of a variety of excitatory neurotransmitters including glutamate, aspartate and acetylcholine (Katayama, Cheung & Gorman, 1988, cited in Fogel & Duffy, 1994). These excitatory amino acids lead to the formation of free radicals with resultant toxic cell damage, leading to postsynaptic dendritic swelling, nuclear shrinkage and cell death (Faden, Demediuk, Panter & Vink, 1989). Excitatory amino acids have little impact on consciousness but are thought responsible for long-term behavioural effects. Fluctuations in the intracellular concentrations of calcium and magnesium have also been implicated in the DAI process, with corresponding necrosis and energy failure.

Severe DAI can be present but may not manifest in CT, EEG or neurological examination.

Secondary Injury

Secondary injuries can be either focal (e.g., hematoma/hemorrhage) or diffuse (e.g., increased intracranial pressure, hydrocephalus, ischemia and edema). These indirect complications can be as destructive, if not more so, than direct damage. There are a variety of secondary effects; the most important tend to be hemorrhage, edema, ischemia and damage to white matter, especially the corpus callosum.

Hemorrhage/Hematomas

Contusions and strains due to impact may lead to lacerations of arteries and veins and subsequent leakage of blood (hemorrhage). The blood becomes trapped within the skull creating a hematoma (mass blood lesion) which produces mechanical distortion increasing pressure on surrounding cerebral structures. As the cranium cannot expand, air and liquid filled spaces surrounding the brain are compressed. Resultant swelling then pushes against softer brain mass, damaging brain tissue (Lezak, 1995). Hematomas tend to intensify underlying cerebral damage and are associated with greater cognitive impairment (Cullum & Bigler, 1986). Subdural hematomas, in particular, are more likely to occur when an injury is sustained as a result of a fall than from any other cause (Richardson, 2000) and are associated with greater morbidity and higher mortality.

Ischemia

Ischemia refers to local anaemia due to mechanical obstruction of blood supply, increasing the chance of neuronal death.

Cerebral Edema

Cerebral edema (brain swelling due to collection of fluid in and around damaged tissue) is a normal physiological response to tissue damage and consequently the most common secondary result of brain injury (Richardson, 2000). The swelling tends to exaggerate whatever damage has already occurred (Lezak, 1995).

Increased Intracranial Pressure

Hematomas, edema and hydrocephalus (one or a combination) may increase intracranial pressure. Normally, compensatory strategies cater for such expansion by decreasing pressure in other areas. However, when these compensatory manoeuvres break down, intracranial pressure increases, diminishing cerebral blood flow leading to ischemia (obstruction of blood flow) and brain shift (a physical shift of brain tissue

from one intracranial compartment to another) leading to herniation syndromes (Cassidy, 1994).

Hydrocephalus

Hydrocephalus refers to an excessive amount of cerebrospinal fluid in the ventricular system, which may lead to ventricular enlargement. This occurs when blockage by blood interferes with the normal absorption of cerebrospinal fluid (King, 1997).

Infection

Intracranial infections (e.g., abscess or meningitis) are usually the result of severe head injury attributable to skull fracture or compound depressed fractures. Brain abscesses can result in intracranial pressure and herniation syndromes, whilst meningitis can lead to both intracranial pressure and hydrocephalus (King, 1997).

Ventricular Enlargement

Ventricular enlargement occurs as a result of atrophy (shrinking) within the cerebral cortex. Such atrophy is typical within frontal and temporal lobes resulting in corresponding deficits in complex reasoning/problem solving, memory and social emotional functioning (Bigler, 1990).

Open/Closed

TBIs are classified as either open or closed. An open injury involves the penetration of the cranium and durae. These injuries tend to more focal, damaging discrete regions of tissue usually producing distinct symptoms which can show fast and spontaneous recovery (Kolb & Whishaw, 1996). The vast majority of TBIs are closed, nonpenetrating injuries in which the skull remains intact (Snyder & Nussbaum, 1998). The fundamental mechanism of injury is rapid acceleration and deceleration of the brain resulting in focal or diffuse injury (McAllistair, 1992).

Focal/Diffuse

Closed injuries can be either focal or diffuse. Focal damage is associated with damage to small or well-differentiated areas. The resultant localised lesions are large enough to be detected macroscopically (e.g., contusions, hemorrhage leading to epidural, subdural or intracerebral hematomas) (Gennarelli, 1993; Richardson, 2000). Diffuse damage is associated with generalised neurological dysfunction and usually not associated with macroscopically visible lesions. They are caused by rapid

acceleration/deceleration or twisting movements of the brain within the cranial vault. Such injury produces diffuse axonal shearing as well as lacerations or contusions when the moving brain comes in to contact with the more stationary protuberances of the base of the skull (typically in the orbital, frontal, or temporal areas) (Bigler & Clement, 1997; Gennarelli, 1993; Richardson, 1990).

MULTIPLE TRAUMATIC BRAIN INJURIES

Despite the cumulative pathological and clinical effects of multiple MTBIs being well documented (Gronwall & Wrightson, 1974; Richardson, 2000), the majority of TBI research fails to take this variable into consideration. The effects of multiple TBIs are typically ascribed to boxers and footballers (Richardson, 2000). Studies which have taken multiple TBIs into consideration typically report a worse neuropsychological outcome (e.g., Bernstein, Lawson, & Segalowitz, 1996) than studies excluding this variable (e.g., Levin, Mattis, Ruff, Eisenberg, Marshall, Tabaddor, High & Frankowski, 1987).

In terms of the neurophysiological aspects of multiple TBIs, whilst damage to axons and cell bodies due to a single mild injury is well documented, evidence for the cumulating effects of multiple injuries is indirect. The literature indicates that individuals sustaining concussions on multiple occasions demonstrate an increase in cognitive impairment, providing good evidence of a cumulation effect (Kolb & Whishaw, 1996).

Previous brain injury also serves as a high risk factor for subsequent brain injury (Annegers et al., 1980). Incidence rates are reported to vary with age; doubling after brain injury in those aged under 14, tripling after injury in those aged 15-24, and for those aged 25 and over, producing an incidence rate five times higher than that expected (Annegers et al., 1980).

SUMMARY

The epidemiological literature on TBI must be interpreted with caution due to there being considerable variability across studies in terms of TBI definitions and diagnostic criteria making cross-study comparison difficult. Despite these limitations the estimated incidence rate of TBI for older adults is estimated at 200 per 100,000, the majority of which are mild with the most frequent diagnosis being concussion. This estimate however is considered to be much lower than the true incidence figure because

unreported MTBIs are not included. Older adults sustain the second highest incidence rate of TBI, increasing after the age of 65. These injuries are more likely to be sustained through falls, occurring equally in both males and females. Older adults appear to sustain both more severe TBIs and total body injuries than younger adults.

Severity of injury can be measured by either its initial presentation or consequential outcome. The GCS quantifies severity of unconsciousness assessing motor, verbal and eye opening behaviour and is considered the predominate MTBI definition. Loss or impairment of consciousness and PTA are other criteria for defining MTBI. Due to limitations within all systems, results based on only one definition should be interpreted with caution.

Physical injury sustained by the brain is the fundamental component in determining the corresponding sequelae of injury and as such is a necessary prerequisite in the discussion of the consequences of MTBI. Primary complications can occur at the site of injury (coup injury) creating pressure forcing the brain to the other side of the skull producing additional damage (contrecoup injury). This movement can create a twisting and shearing of nerve fibres leading to diffuse damage, particularly in the frontal and temporal lobes. Multiple secondary injuries can also occur, the main route of damage being haemorrhage and ischemia. The majority of injuries are closed, resulting in focal and/or diffuse damage. An array of research supports the cumulative effects of TBI.

CHAPTER 3:

MILD TRAUMATIC BRAIN INJURY

The following chapter presents an overview of the literature pertaining to MTBI with an emphasis on adults aged 65 and over. Following MTBI, individuals exhibit a wide variety of disabling symptoms. The neuropsychological sequelae of MTBI typically appear across a wide variety of cognitive domains. Most particularly, a common complaint is an inability to remember. Impairment is also evident within the areas of attention, learning, initiating, planning and organising and communication. The exact manifestation of symptoms depends on multiple factors; organic damage, reactive emotional stress secondary to the event and pre-morbid personality. The chapter commences with an overview of the neurophysiological effects of MTBI, followed by and outline of neuropsychological sequelae. Also discussed are the subjective post-concussive symptoms and behavioural and Psychiatric sequelae. The Chapter closes with a review of generic MTBI recovery research.

NEUROPHYSIOLOGY OF MILD TRAUMATIC BRAIN INJURY

The neurophysiology of MTBI is largely thought to occur at a microscopic (cellular) level (Raymond & Bennett, 1999). However, due to the lack of neurological deficit on physical examinations and neurodiagnostic procedures, a certain amount of controversy surrounds the existence of neurophysiological damage. However, the contribution of human studies via clinical observation, imaging and neurophysiological studies (Jenkins, Teasdale, Hadley, Macpherson & Rowan, 1986; Levin et al., 1987), occasional autopsy material (Oppenheimer, 1968) and experimental injury in primates (Povlishock & Coburn, 1989) has enabled considerable insight into the cellular and chemical processes of MTBI.

Alteration in consciousness suggests pervasive neuronal impairment (Gennarelli, 1993). Loss of consciousness results from strain on fibres within the reticular formation (Kolb & Whishaw, 1996). These fibres sustain permanent microscopic damage even in the case of concussion or without the head being struck. In the latter case this can be attributable to deceleration/rotational forces as the brain collides with the inside surface

of the skull. Oppenheimer (1968) found damage to axons at autopsy from those who suffered a MTBI but died from other causes. One of these patients had no loss of consciousness and PTA of approximately 20 minutes, suggesting that even mild concussion may be associated with permanent damage in the form of microscopic lesions.

Similarly, findings from animal studies (Povlishock & Coburn, 1989) provide evidence that MTBI is associated with axonal injury and even concussion. Mechanically induced mild concussion produced numerous degenerating axons in the brainstem concluding that cerebral concussion indicated reversible physiological impairment and minor anatomical injury (Gennarelli, 1993).

Damage not only occurs at the axonal level. One study of patients diagnosed with cerebral concussion after a mild head injury found 5% sustained cerebral contusions, 1% intracerebral haemorrhages and 14% some other form of intracranial lesion (Kraus and Nourjah, 1989).

NEUROPSYCHOLOGICAL SEQUELAE OF MILD TRAUMATIC BRAIN INJURY

The neuropsychological sequelae of MTBI follows coherently from the neurophysiology, with secondary reactions and premorbid factors also playing a role in the manifestation of sequelae. Three patterns of neuropsychological impairment are evident following closed head injury. Firstly, diffuse axonal injury (DAI) is considered to be the basic pathology of MTBI, with corresponding reductions in information processing speed and attention/concentration (Alexander, 1995; Bigler, 1990; Gentilini, Nichelli & Schoenhuber, 1989; Ruff et al., 1989). Secondly, lesions involving the most vulnerable parts of the brain (frontal and temporal lobes) result in impairment characteristic of these brain regions. Due to the frequency with which temporal lobes are impaired, difficulties with memory and learning (Alexander, 1995; Bigler, 1990; Gentilini, Nichelli, Schoenhuber, Bortonlotti, Tonelli, Falasca & Merli, 1985; Ruff et al., 1989) are apparent. Frontal lobe dysfunction is associated with executive problems; initiating, planning and following through a course of action (Alexander, 1995; Bigler, 1990; Gentilini et al., 1985; Ruff et al., 1989). The combined diffuse, frontal and temporal injuries can lead to neurolinguistic problems (e.g., dysarthria; difficulty with articulation, naming and word finding) (Schapiro & Sacchetti, 1993). Thirdly, functions mediated by regions of the cortex sustaining coup and/or contrecoup injury are impaired (Lezak, 1995).

For individuals sustaining MTBIs, cognitive complaints are usually the most difficult to cope with; individuals are acutely aware of their deficits resulting in a considerable degree of psychological distress. The following section discusses cognitive functions impaired in the course of trauma.

Information Processing Speed

Information processing refers to the registering and processing of incoming information and the subsequent output of this information (Schapiro & Sacchetti, 1993). Impairment in this area is a common long-term cognitive symptom of MTBI (Levin et al., 1987) and is considered to be largely attributable to DAI (Lezak, 1995; McAllistair, 1994). Individuals with impaired information processing would appear seemingly slow when it comes to carrying out quite basic tasks. They may display the ability to engage in a variety of distinct activities, but are unable to perform them simultaneously.

Attention / Concentration

Attention and concentration impairment are invariably among the most common of cognitive complaints associated with TBI (Gentilini, et al., 1985; Gentilini et al., 1989; Levin et al. 1987; Parker, 1990; Rimel, Giordani, Barth, Boll & Jane, 1981; Schapiro & Sacchetti, 1993). Slowed information processing speed appears to account for many of the attention deficits (Levin et al., 1987). Attention comprises focussed attention (ability to focus on one aspect of information whilst simultaneously ignoring irrelevant and distracting information), divided attention (engaging in two activities simultaneously), and sustained attention (or concentration; length of time attention is able to be maintained on a task). Deficits in these areas manifest as difficulty following conversations, concentrating on reading, engaging in more than one task at a time and completing activities.

Learning and Memory

Memory and learning deficits are common cognitive symptoms following MTBI (Gentilini, et al., 1985; Levin et al. 1987; Parker, 1990; Rimel et al., 1981; Schapiro & Sacchetti, 1993), considered largely attributable to temporal lobe damage. Learning is impaired due to difficulty consolidating new memories and retrieving new information. Deficits are particularly evident when there are time delays between presentation and

retrieval of information (Schapiro & Sacchetti, 1993). Such impairment typically manifests as absentmindedness, interfering significantly with activities of daily living.

Executive Functioning

Deficits are apparent in executive functioning; planning, initiating, maintaining and following through a course of action. Such impairment is largely attributable to frontal and prefrontal damage (Lezak, 1995) although sometimes is misperceived as a psychiatric problem (Schapiro & Sacchetti, 1993). Individuals have difficulty carrying out goal directed behaviour. Deficits in both initiative and planning typically manifest as organisational deficits (Schapiro & Sacchetti, 1993); individuals have difficultly shifting set from one task to another (i.e., difficulty establishing priorities or distinguishing relevant from irrelevant information). Typical complaints are inability to get motivated to engage in an activity, and, once initiated, difficulty carrying the activity through.

Communication

Specific language disorders are rare following MTBI and when they are apparent, manifest typically in the form of aphasic and nonaphasic deficit. Aphasic complaints include difficulty finding words, anomia, following conversations and completing sentences. Nonaphasic complaints include verbal expansiveness (excessive speech and an unawareness of when to cease, allowing others to contribute), tangentiality (difficulty staying focussed on original ideas) and usage of strange phrases (Schapiro & Sacchetti, 1993).

SUBJECTIVE COMPLAINTS AND BEHAVIOURAL AND PSYCHIATRIC SEQUELAE OF MILD TRAUMATIC BRAIN INJURY

In addition to the cognitive sequelae described above, subjective complaints and behavioural and psychiatric sequelae are often observed following MTBI (Alexander, 1995; Bigler, 1990; Bohnen, Jolles, Twijnstra, Mellink & Wijnen, 1995; Gentilini et al., 1985; Ruff et al., 1989). Most research acknowledges that the affective symptomology following MTBI can be exaggerated by pre-existing personality disturbances (Schapiro & Sacchetti, 1993), however much controversy exists as to the role of premorbid factors (e.g., premorbid personality, psychiatric history, neurological history) and organic factors in this manifestation of post-injury behaviour. Whilst research indicates that behavioural and psychiatric symptoms are dependent on premorbid personality

characteristics (McAllistair, 1994), other literature states that such affective symptomology is within the typical profile of frontal, temporal and diffuse injury (McAllister, 1992).

Post-Concussive Syndrome

Post-Concussive symptoms appear across three categories; cognitive complaints (e.g., attention, concentration and memory), affective complaints (e.g., anxiety, mood swings, depression, anger and irritability) and somatic complaints (e.g., headache, dizziness, fatigue, noise intolerance and photosensitivity) (Bohnen et al., 1995). These subjective symptoms are often observed following all levels of severity of TBI and should not be considered synonymous with MTBI (McAllister, 1994). Approximately 50-80% of MTBI patients will report one or more post-concussive symptoms immediately post injury (Levin et al., 1987; Mandel, Sataloff & Schapiro, 1993), typically subsiding within a few days or weeks. A substantial proportion of individuals continue to complain of these symptoms beyond the initial post-traumatic period; such persistence being known as the Post-Concussive Syndrome (PCS). To date, there is no precise definition of PCS. Rather, the presence of several post-concussive symptoms (e.g., concentration deficits, anxiety and headaches) facilitates the diagnosis of this syndrome (Bernstein, 1999).

PCS is assessed through self-report measures due to difficulties surrounding objective measurement. Distinctions have been made between early and late onset PCS (Richardson, 2000). Symptoms occurring immediately following the injury (e.g. headaches, dizziness and blurred vision) are temporary and are considered organic in nature. Conversely, symptoms developing some weeks later (e.g., irritability, anxiety and depression) are considered symptomatic of an adverse emotional reaction to the injury; it being difficult to explain from an organic perspective how symptoms can develop several weeks or months after the injury (Richardson, 2000).

The majority of PCS symptoms subside within three (Leininger, Gramling, Farrel, Kreutzer & Peck, 1990) and six months (Klein, Hous & Jolles, 1996) with most individuals being symptom free within twelve months. However, a small proportion of patients continue to complain of PCS symptoms from one year (Bohnen, Twijnsra & Jolles, 1992; Rimel, 1981) to five years (Masson, Maurette, Salmi, Dartigues, Vecsey, Destaillats & Erny, 1996; Mazaux, Masson, Levin, Alaoui, Maurette & Barat, 1997) post injury. A history of prior head injury, increased age, other bodily injuries,

complications (depressed skull fracture, CT evidence cerebral contusions or haemorrhages) and psychosocial factors have been implicated with poorer outcomes (Schapiro & Sacchetti, 1993).

Behavioural Sequelae

Irritability

Irritability is considered the most common emotional symptom post MTBI (Schapiro & Sacchetti, 1993). Whilst irritability is consistent with PCS it would also be expected as a result of frontal lobe damage. Irritability manifests as overreaction to rather trivial everyday events, difficulty adapting to change and not coping well with changes in routine (Schapiro & Sacchetti, 1993).

Dependency

Changing interpersonal relationships (e.g., children taking on a more parental role) can cause loss of independence. Older adults can become doubtful of their ability to carry out everyday activities and indecisive in situations where they may need to depend on themselves.

Personality Changes

Personality changes are not particularly common in patients sustaining a MTBI, being more common following severe TBI. Changes following MTBI are considered more reflective of pre-morbid behavioural disorders than organic damage (Richardson, 2000).

Psychiatric Sequelae

Depression

Depressive symptoms (e.g., lack of interest, fatigue and sleep disturbance) are common following MTBI (McAllister, 1992; Schoenhuber & Gentilini, 1988) and PCS. Hence, whilst depressive symptoms appear as a significant contributor to psychiatric disability post MTBI, it remains unknown whether it exists as part of the PCS or as a discrete major depressive episode. Differentiating between organic and psychiatric aetiology proves challenging. Many who endorse depressive symptoms have premorbid characteristics (e.g., psychiatric history) which may contribute towards the depressive symptomatology. Additionally, neuropsychological changes tend to be exacerbated by

psychological reactions to cognitive sequelae. Particularly with MTBI, individuals are aware of cognitive dysfunctions causing them considerable distress. Compounding this, many individuals do not attribute difficulties to TBI causing them to doubt their own ability with corresponding loss of self-esteem (Schapiro & Sacchetti, 1993). This often manifests as secondary problems; psychological reactions to the symptoms and resultant disability. As their cognitive symptoms persist, the associated distress can lead to depression. Additionally, their depressive symptoms tend to lead to withdrawal and social isolation, further exacerbating the depression.

Post-Traumatic Stress Disorder

Post-Traumatic Stress Disorder (PTSD) is more likely to occur following MTBI than severe TBI, largely due to the absence of post-traumatic amnesia (Snyder & Nussbaum, 1998). Symptoms of PTSD include intrusive recollections, disturbed sleep, nightmares, avoidance and increased startle response. There is difficulty ascertaining whether symptoms following the traumatic event are attributable to PTSD or PCS. Research suggests that PTSD symptoms may have a delayed onset whilst PCS symptoms appear immediately and improve over time. However, both PTSD and PCS may occur simultaneously.

There is the suggestion that PTSD symptoms may mask as symptoms of psychopathology due to overlapping symptomology (e.g., anxiety, depression) (Leathem & Babbage, 2000). For example, the Symptom Checklist-90-R (a measure of psychopathology) reveals that TBI sufferers score high on many scales (e.g., hostility, anxiety and depression). However, such elevations may be a consequence of neuropathology rather than psychopathology. For example, endorsement of items such as "nervousness and shakiness inside" or "blaming self for things" may be a manifestation of irritability rather than hostility. Results from such measures suggest that individuals display psychopathology when in fact they do not (Leathem & Babbage, 2000).

Anxiety

Anxiety symptoms (e.g., headaches, blurred vision and sensitivity to noise) are also common following MTBI (Levin et al., 1987). These symptoms are synonymous with PCS symptomology. An array of research supports a relationship between anxiety and PCS (McAllister, 1994), such symptoms being considered attributable to emotional

factors. However, it is equally plausible that organic damage plays a role in maintaining anxiety. Studies that have employed this variable find controls as likely to endorse anxiety symptoms as MTBI patients (Dikmen, McLean & Temkin, 1986; Schoenhuber & Gentilini, 1988). Hence the relationship between TBI and anxiety remains obscure.

NEUROPSYCHOLOGICAL RECOVERY FOLLOWING MILD TRAUMATIC BRAIN INJURY

Recovery for adults from the cognitive sequelae of MTBI is a controversial area. Whilst there exists an array of literature documenting that cognitive deficits associated with MTBI subside within a few months post-injury (Bornstein, Podraza, Para, Whitacre, Fass, Rice & Nasrallah, 1993; Dikmen et al., 1986; Dikmen, Machamer, Winn & Temkin, 1995; Levin et al., 1987; McLean, Temkin, Dikmen & Wyler, 1983) there also exists support for long term neuropsychological deficits (Arcia & Gualtieri, 1994; Bernstein et al., 1996; Binder, Rohling & Larrabbee, 1997; Bohnen et al., 1992; Gentilini et al., 1985; Klein, et al., 1996; Leininger et al., 1990; Stuss, Stethem, Hugenholtz, Picton, Pivik & Richard, 1989).

Rapid Recovery

Numerous studies are available documenting the typical rapid recovery from the cognitive deficits associated with MTBI (Bornstein et al., 1993; Dikmen et al., 1986; Dikmen et al., 1995; Levin et al., 1987; McLean et al., 1983). Such research suggests that individuals return to pre-injury status within 1-3 months post injury (see Table 3.1).

Table 3.1
Literature Documenting the Rapid Recovery of Neuropsychological Functioning

Study	Participants (and ages)	Time of assessment post injury	Findings
McLean et al. (1983)	20 TBI 52 controls (15-60)	3 days	Different on measures of memory, speed and distractibility
		1 month	No significant differences on any of the measures
Dikmen et al. (1986)	20 MTBI 19 controls (15-60)	1 month	MTBI worse on attention, flexibility and quickness and delayed recall
		1 year	No differences at 1 year
Levin et al. (1987)	57 patients 56 controls	1 week 1 month	TBI different on digit span, PASAT, visuomotor speed No differences at 3 months
		3 months	
Dikmen et al. (1995)	161 TBI 132 trauma controls (M = 29, SD 13)	1 month 1 year	No differences on Halstead Reitan and measures of attention and memory at 1 year
Bornstein et al. (1993)	24 MTBI + HIV 24 controls (M=34, SD=6)	14.8 years	No significant difference on measures of attention, memory, executive functioning

Adapted: Bernstein, 1999

The first three above studies indicate that cognitive declines evident days post injury are negligible one month (McLean et al., 1983), three months (Levin et al., 1987) and one year (Dikmen et al., 1986) post injury. However, whilst these studies excluded participants with a prior history of MTBI, facilitating in-depth analysis of the consequences of a single MTBI, it is questionable whether the findings extend to the MTBI population, most of whom will have previous instances of injury.
A prospective study (Dikmen et al., 1995) also found no difference between groups one year post injury on a comprehensive battery of measures. Finally, Bornstein et al. (1993) compared MHI with HIV patients years post injury and found no difference. This study employed participants with very mild injuries.

Together these studies indicate that MTBI typically results in rapid recovery and is not associated with long-term persistent neuropsychological deficits.

Long Term Neuropsychological Sequelae

The persistence of long term neuropsychological sequelae post MTBI is also well documented by both retrospective and prospective studies (see Table 3.2).

Cognitive deficits have been reported three months (Bohnen et al., 1992; Stuss et al., 1989) and five months (Gentilini et al., 1989) post injury. Findings from Stuss et al. (1989) are particularly interesting considering that most participants within the MTBI group only reported symptoms of mild concussion at time of injury. A metanalysis (Binder et al., 1997) of neuropsychological outcome among patients with no reported cognitive complaint three months post injury found small but significant differences, particularly on measures of attention, suggesting that MTBI might be associated with subtle long term cognitive sequelae.

Support also exists for long-term cognitive deficits persisting up to three years (Arcia & Gualtieri, 1994; Bohnen et al., 1992; Leininger et al, 1990) post MHI. In one of these studies (Arcia & Gualtieri, 1994) severity of injury was not controlled, hence it is unknown whether these findings are applicable to MTBI. Of particular interest is the study by Leininger et al. (1990) which found that irrespective of whether MTBI participants experienced a loss of consciousness or reported simply being dazed or concussed, they performed no differently from each other, lending support to the argument that neurobehavioural deficits can occur without a loss of consciousness.

There is little research comparing MHI with controls years post injury, with studies available being typically retrospective. Bernstein et al. (1996) assessed participants with self-reported MTBI approximately six years post injury, finding the MTBI groups performed worse on difficult sustained attention tasks. Klein et al. (1996) found significant TBI effects several decades post injury on all tests of complex memory and information processing speed tasks. Particularly striking is that TBI patients reported good recovery and no cognitive complaints upon selection for the study, yet they still performed worse than controls. Unfortunately, this study failed to distinguish between mild and moderate TBI. As such it is difficult to ascertain how generalisable the results are to MTBI.

Table 3.2
Literature Documenting the Long Term Recovery of Neuropsychological Functioning

Study	Details of participants (and ages)	Time post injury	Findings
Stuss et al. (1989)	22 MTBI (all ages)	3-90 days	Deficits on tests of divided and focussed attention
Binder et al. (1997)	Metanalysis of 8 studies	3 months	Significant differences on measures of attention
Gentilini et al. (1989)	48 MTBI 48 controls	5 months	MTBI group displayed attention and concentration deficits
Arcia & Gualtieri (1994)	26 TBI (mild/mod) 25 controls (M=30, SD=11)	10 months	TBI significantly worse on measures of sustained attention and response speed
Leininger et al. (1990)	53 MTBI 23 controls (19-60)	6-8 months	MTBI significantly poorer on Category Test, Paced Auditory Serial Additional Test-Revised, Auditory Verbal Learning Test, Complex figure-Copy
Bohnen et al. (1992)	44 patients (15-45)	3 months	MTBI patients significantly slower on Stroop Colour and Word Test
Bernstein et al. (1996)	10 MTBI controls	6 years	MTBI significantly worse on sustained attention tasks
Klein, et al. (1996)	Mild-moderate TBI Group 1: 40-59 (n=45) Group 2: > 60 (n=45)	30 years	TBI worse on all memory and information processing tasks

Adapted. Bernstein, 1999

Research Discrepancies

Certain pre-injury and post-injury variables are proposed to account for the above discrepancies between short-term and long-term neuropsychological recovery. Age, history of previous head injury, premorbid variables, methodological issues have all been found to moderate the relationship between neuropsychological performance and recovery (Fife et al., 1986; Lanzino, Kassell, Germanson, Kongable, Truskowski, Torner & Jane, 1996; Pentland et al., 1986; Rakier et al., 1995).

For example, research employing older participants typically report more adverse neuropsychological consequences than research employing a younger group (e.g., Bornstein et al., 1993). Similarly, studies that have acknowledged the effects of prior

TBI (e.g., Bernstein et al., 1996) report worse outcomes than studies excluding this variable (e.g., Levin et al., 1987). Pre-existing conditions (e.g., long term alcohol use, anti-inflammatory medications, previous neurological disorders [TBI, stroke and dementia]) can all reduce cerebral reserve leading to a much greater degree of dysfunction than might otherwise be expected (Galbraith, 1987). Another factor that could help explain the persistence of neuropsychological complications is the particular measures employed. Many studies employing less taxing attention tests (e.g. Dikmen et al., 1986) tend to report absent or clinically insignificant findings. Conversely, studies employing highly demanding tasks (Bohnen et al., 1992; Leininger et al., 1990) are more likely to detect subtle differences between groups. It could be that neuropsychological impairment amongst MTBI patients may be subtle and only demonstrable by particularly sensitive tests. Finally, emotional reactions to injury, pre-injury personality characteristics, education and occupation have also been associated with neurobehavioural outcome (Dikmen, et al., 1986).

SUMMARY

Research on the neurophysiology of MTBI suggests that head injuries considered trivial may be associated with neurophysiological effects. The types of injury seen, both macroscopically and microscopically, are similar in quality and location to those seen with moderate and severe degrees of brain injury. Neuropsychological impairment is evident across a wide variety of cognitive domains following MTBI. Much of this impairment can be attributed to deficits in information processing speed. Subjective complaints of poor memory and attention, headache, dizziness and irritability are often reported following injury. Such post-concussional symptoms are distinct from, but frequently accompany MTBI. These symptoms typically reside within days or weeks with the persistence of these symptoms being known as the Post-Concussive Syndrome (PCS). Whilst early research suggested that much of the aetiology of PCS was psychological, recent evidence supports its organic role. Behavioural disturbances such as irritability and dependency are also common following MTBI. Changes in personality are not typically associated with MTBI; behavioural disturbances are largely considered resultant of pre-injury personality patterns. Depressive and anxiety symptoms are common following MTBI. The exact aetiology however remains obscure; organic and psychiatric causative factors being implicated. A review of the recovery literature for MTBI offers support for long-term neuropsychological impairment post

MTBI and suggests that the current understanding of rapid recovery post MTBI may need to be altered to include permanent impairment.

CHAPTER 4

RECOVERY FROM MILD TRAUMATIC BRAIN INJURY IN OLDER ADULTS

The following chapter reviews research pertaining to the recovery of Mild Traumatic Brain Injury as it affects older adults. Most studies eliminate the extremes in age or have not explored this variable. Functional outcome research is also reviewed. Discussion then centres on the various factors that tend to exacerbate neurophysiological deficits within older adults. The chapter concludes by examining comorbid conditions; it is argued that detection of MTBI amongst older adults is often obscured due to the presence of comorbid conditions.

NEUROPSYCHOLOGICAL RECOVERY MILD TRAUMATIC BRAIN INJURY

The literature pertaining to the recovery of cognitive sequelae amongst older adults is particularly sparse with only one study available pertaining to MTBI. Accordingly, the following discussion pertains to recovery of neuropsychological function amongst older adults following all severities of TBI (Aharon-Peretz, Kliot, Amyel-Zvi, Tomer, Rakier & Feinsod, 1997; Goldstein, Levin, Presley, Searcy, Colohan, Eisenberg, Jann & Bertolino-Kusnerik, 1994; Goldstein, Levin, Roberts, Goldman, Kalechstein, Winslow & Goldstein, 1996; Luukinen et al., 1999; Mazzucchi, Cattelani, Missale, Gugliotta, Brianti & Parma, 1992) (see Table 4.1). A separate discussion of neuropsychological recovery from MTBI for all adults was presented in Chapter Three.

Table 4.1
Literature Documenting Neuropsychological Recovery in Older Adults

Study	Age of participants	Time post injury	TBI severity
Mazzucchi et al. (1992)	50-75	10 months	All severities
Goldstein et al. (1994)	> 50	7 months	Mild to moderate
Goldstein et al. (1996)	> 50	1 month	Mild to moderate
Aharon-Peretz et al. (1997)	> 60	6 weeks	All severities
Luukinen et al. (1999)	> 70	2 years	Mild

The first of these studies (Mazzucchi et al., 1992) assessed the general intellectual functioning of older adults sustaining a TBI of all severities. Results indicated 50% of participants displayed generalised cognitive deterioration with only 25% displaying minimal or no deterioration. This deterioration was apparent whether of mild or moderate to severe injury. However, pre-morbid cognitive deficits were not controlled, limiting conclusions about the cognitive sequelae of the brain injury (Rapoport & Feinstein, 2000). Finally, cognitive performance was assessed on a gross rather than specific level of cognitive such as memory and language.

Studies which have sought to address some of the above limitations, suffer different methodological problems (i.e., small sample size and employing relatively young participants in "old" age categories). Goldstein et al. (1994) compared the neurobehavioral performance of 22 TBI patients with 16 controls on more specific cognitive domains (expressive language, memory, attention and information processing speed and executive processing). Significant between group differences were found in three of four cognitive domains suggesting that TBI in older adults produces cognitive deficits influencing the same neurobehavioral areas affected in younger adults (expressive language, memory and reasoning) (Fields et al., 2000).

A subsequent study by Goldstein et al. (1996) compared the neuropsychological profiles of 14 TBI patients, 14 probable Alzheimer's' Disease patients and 14 members of the community on measures of verbal memory, letter and category fluency and naming. Consistent with their previous study (i.e., Goldstein et al., 1994) results indicted that the head injury group performed worse than the controls on both language and memory tasks. A limitation of the above studies is that relatively young patients (> 50 years) were classified in the "older age" category, whereas conventionally older age

is defined as 65 years plus. Furthermore, the small sample sizes also limits generalisability.

Aharon-Peretz et al. (1997) designed a study to specifically compare the neurobehavioural consequences of TBI in older adults (aged 60 years and over) sustaining a TBI with both orthopaedic patients and controls six weeks post injury. Findings were consistent with previous research; the TBI group were significantly impaired on measures of attention, memory, language and reasoning. However, no differences were found between the TBI and orthopaedic groups. The researchers concluded that premorbid cognitive decline might have been present prior to the injury, contributing to the aetiology of the injuries. However, it is also possible that the orthopaedic group sustained a TBI that was obscured by the presence of limb fractures. Whilst the study states that orthopaedic patients were hospitalised for limb factures without sustaining a head injury, how brain injury was excluded in the orthopaedic group was not indicated. It remains unknown whether orthopaedic non-brain injuries obscured the detection of MTBI.

The above research assesses short-term neuropsychological outcome. Only one study (Luukinen et al., 1999) has assessed the long-term cognitive performance of older adults post MTBI caused by falling. Whilst MTBI was not found to lead to increased risk for cognitive decline, cognitive performance was only assessed broadly via the shortened version of the Mini-Mental Status Examination.

FUNCTIONAL RECOVERY FOLLOWING MILD TRAUMATIC BRAIN INJURY

A review of the literature reveals the fairly robust finding that older adults generally fare worse in terms of negative outcome (functional disability (as assessed by measures of disability, such as Glasgow Outcome Scale) and higher mortality) following severe TBI (e.g., Annegers et al., 1980; Cifu, Kreutzer, Marwitz, Rosenthal, Englander & High, 1996; Fields, 1991; Fife et al., 1986; Lanzino et al., 1996; Pentland et al., 1986; Ruff et al., 1989; Wilson, Pentland, Currie & Miller, 1987). Studies encompassing all severities of TBI, similarly report differences in mortality or functional disability between younger and older adults (Deb, Lyons & Koutzoukis, 1998; Pentland et al., 1986). However, these studies did not control for severity of brain and non-brain injuries. Fields et al. (2000) report that when all severities of brain injury are included, mortality rate begins to increase at approximately age 55. When severity

of injury is controlled for, this trend is similarly apparent for both mild and severe injuries. However, for brain injuries of mild severity, when both severity of brain and non-brain injuries are controlled, mortality rates are low across all age groups. Hence, although age appears to play a role in mortality risk following TBI, if older adults sustain more severe injuries, mortality could be a manifestation of severity of injury rather than age. Fields et al. (2000) also report that none of the above studies addressed pre-morbid functioning. Older adults are more likely to have premorbid cognitive and medical problems that may well impact on functioning. One study found high incidence rates of cardiovascular disease, diabetes and cerebrovascular disease amongst older adults with TBI (Rakier et al., 1995). Whilst pre-morbid functioning could well impact on functional performance, this variable has not been considered when comparing younger and older adults and limits interpretation of the data (Fields et al., 2000).

NEUROPHYSIOLOGICAL INJURY

The following discussion outlines neurophysiological changes peculiar to older adults (an overview of the generic neurophysiological classification systems were presented in Chapter Two and an outline of the neurophysiological literature pertaining to MTBI was presented in Chapter Three). Whilst the neurophysiological changes associated with TBI in older adults are largely comparable to that of younger adults, there are complicating factors that tend to exacerbate deficits when MTBI is superimposed.

Firstly, older adults have a greater vulnerability to vascular complications (e.g., subdural hematomas and intracranial hemorrhages) (Fogel & Duffy, 1994; Luerssen et al., 1988) due to age related degenerative changes in blood vessels. Secondly, neuronal death and axonal atrophy increases exponentially with age. This decrease in cortical size increases the distance from the brain surface to the venous sinuses making the bridging veins more prone to shearing (Fields et al., 2000; Raskin, Mateer & Tweeten, 1998). Accordingly, even MTBI increases the possibility of subdural and subarachnoid hematoma (Cummings & Benson, 1992; Fields et al., 2000; Raskin & Mateer, 2000) and intracerebral hemorrhage (Broderick, Brott, Tomsick, Miller & Huster, 1991). Fields et al. (2000) report that these age related differences appear more apparent with mild or moderate TBI rather than severe TBI. Thirdly, the aging brain is associated with pathologic changes such as neurofibrillary tangles and plaques which may lead to less effective transmission.

Neurochemical changes naturally occurring as part of the aging process may also result in increased neurobehavioural impairment (King, 1997). Firstly, the aging process is associated with decreased levels of catecholamines. MTBI results in the sudden release of catecholamines creating a decrease in levels and corresponding metabolites. The already lowered levels of catecholamines in the aging brain are considered to exacerbate this course leading to a worse outcome (Boyeson & Feeney, 1990). Finally, decreased metabolic reserves and less effective detoxification of free radicals occur with advancing age (King, 1997). Cerebral trauma results in the release of excitotoxic neurotransmitters. Due to the reduced efficiency, older adults are thought to be more susceptible to the release of these chemicals.

Types of Brain Injury

The types of brain injury sustained by older adults are largely comparable to that of United States adults (e.g., Kraus & Sorenson, 1994). Table 4.2 sets out type of brain injury based on data extrapolated from The New Zealand Health Information Service Morbidity Data (1998/99) using ICD-9-CM criteria.

Table 4.2

Number (and Percent) of Brain Injuries by Fracture Status and Anatomic Location

	n fractures					
Brain Injury (ICD Code)	**Vault (800)**	**Base (801)**	**Face (802)**	**Multiple/ Unspecified (803, 804)**	**No fracture**	**Total n**
Concussion	0	0	3	0	169	172
(850)	0%	0%	2%	0%	98%	46%
Contusion –	1	1	0	0	16	18
laceration (851)	5.5%	5.5%	0%	0%	89%	4.8%
Haemorrhage	3	9	1	0	98	111
(852, 853)	3%	8%	1%	0%	88%	30%
Other intracranial	0	0	1	1	69	71
(854)	0%	%	1.5%	1.5%	97%	19%
Total n	4	10	5	1	352	372
	1%	2.5%	1%	0.5%	95%	100%

Source: The New Zealand Health Information Service Morbidity Data (1998/99). Adapted from Kraus & Sorenson, 1994.

The above data indicates that for older adults, the majority of brain injuries do not result in skull fracture (98%).

COMORBID VARIABLES

Following mild to moderate TBI, patients exhibit a constellation of cognitive, behavioural and physical symptoms. A difficult issue in diagnosing older adults is determining whether the cognitive impairment is a consequence of the injury or due to other aetiologies; a normal manifestation of the aging process, premorbid variables such as neurodegenerative illness (e.g., dementia) or the effects of medication. Preliminary research indicates that many of these comorbidities can be differentiated.

The following section outlines research pertaining to age and dementia. The side-effects of medication is also discussed due to the large amount of older adults who take prescribed medication and the similarity of symptomology with TBI. The issue of orthopaedic injuries is also raised due to the likely focus on medical problems which can obscure the diagnosis of brain injury.

Age

Support for the contention that the effects of TBI can be differentiated from the normal course of aging can be indirectly drawn from research comparing older adults who have sustained a TBI with age matched controls (Aharon-Peretz et al., 1997; Goldstein et al., 1994; Goldstein et al., 1996; Luukinen et al., 1999 & Mazzucchi et al., 1992). These studies were reviewed above ("Neuropsychological Recovery from Mild Traumatic Brain Injury" – see page 37) indicating that the effects of TBI in older adults can be differentiated from the normal course of aging.

Furthermore, there is little to suggest that the neuropsychological profile of TBI varies dramatically as a function of age. The following section outlines research comparing the neuropsychological performance of older and younger adults as a result of TBI. Discussion is limited to studies pertaining to MTBI.

A number of studies suggest that older adults experience a more negative outcome as a result of TBI than younger adults (Fields, Taylor & Starratt, 1993; Fields & Coffey, 1994a; Klein et al., 1996; Raskin et al., 1998) (see table 4.3).

Table 4.3

Evidence for a More Negative Neuropsychological Outcome for Older Adults Following TBI

Study	Participants	TBI Severity	Primary findings
Fields et al. (1993)	Older 50-95 (n=49) Younger 18-45 (n=139)	Mild	Post-traumatic neurobehavioral screening inventory
Fields & Coffey (1994a)	Older (n=96) Younger (n=472)	Mild	Older adults performed worse on 7/8 measures (Digit span backward, trails A & B), Wechsler Memory Scale-Revised Logical Memory-I&II, Visual Reproduction-I & II)
Klein et al. (1996)	Older: > 60 (n=45) Young: 40-59 (n=45)	Mild / Moderate	TBI worse on all memory and information processing tasks
Raskin et al. (1998)	Older: > 40 Younger: < 40	Mild / Moderate	Older adults performed worse on tests of time dependent attention, and long term verbal memory

Fields et al. (1993) compared older (aged > 50) and younger (aged 18-45) adults finding older adults performed worse than younger adults. A major limitation with this study was their inclusion of relatively young (>50 years) adults making generalisation to older adults difficult. A second study by Fields & Coffey (1994a) compared the neuropsychological performance of younger versus older adults who sustained a MTBI one week post injury and found older adults performed significantly worse on seven of the eight measures. Unfortunately, the age of the participants was not specified.

Klein et al. (1996) compared older (>60) with younger (40-59) adults who had sustained a TBI of either mild or moderate severity. Older adults fared worse on measures of memory and executive function. Unfortunately, mild and moderate injury was not discriminated; hence attributing these findings to mild injury becomes difficult.

Raskin et al. (1998) also tested the performance of older adults against the normative sample, finding older adults to perform worse on tests of time dependent attention and long term verbal memory. A major limitation with this study was their inclusion of relatively young (>40 years) adults. Secondly, as the study comprised

injuries of both mild and moderate severity, it is difficult to generalise the findings to MTBI.

Other research suggests that neuropsychological symptoms in older adults are comparable to that of younger adults (Aharon-Peretz et al., 1997; Fields & Coffey, 1994a; Fields, 1997; Goldstein et al., 1994; Wilson, Vizor & Bryant, 1991) (See Table 4.4).

Table 4.4
Evidence that Neuropsychological Deficits Following TBI in Older Adults are Comparable to that of Younger Adults

Study	Participants	TBI Severity	Primary findings
Wilson et al. (1991)	13-65	Severe	No difference on cognitive tests
Goldstein et al. (1994)	> 50	Mild / moderate	Like younger adults, older adults were impaired on tests of expressive language, memory and reasoning
Aharon-Peretz et al. (1997)	>60	Mild / moderate	Like younger adults, older adults performed more poorly on neuropsychological tests (word fluency, visual and verbal memory and reasoning) than controls
Fields & Coffey (1994a)	Young Older	Mild	MTBI older adults worse on only 1/8 measures
Fields (1997)	Older Younger	Mild	Neuropsychological performance not significantly different on most tests of memory and attention

One of the earliest studies addressing the impact of age on cognitive performance found no evidence to suggest that age was a predictor of severity of cognitive impairment (Wilson et al., 1991). However, only participants sustaining a severe injury were included and hence results cannot be extrapolated to MTBI. Furthermore, only participants aged 13-65 were included and hence is not considered representative of older adults, being aged 65 and over.

Goldstein et al. (1994) assessed the neurobehavioural performance of mild to moderate TBI in older adults in the initial stages post-injury. Significant impairment

was evident in three of the four cognitive domains suggesting that the acute neuropsychological effects of MTBI in older adults produces cognitive deficits influencing the same neuropsychological areas affected in younger adults (Fields et al., 2000). A limitation of this study was its inclusion of relatively young (aged > 50) participants. However, a subsequent study (Aharon-Peretz et al., 1997) assessing the neurobehavioural consequences of TBI in older adults (aged > 60) confirmed these findings; like younger adults, older adults were significantly impaired on measures of word fluency, visual and verbal memory and reasoning.

The major limitation of the above studies is their lack of a direct comparison with younger adults. One study that directly compared younger and older adults (Fields & Coffey, 1994a) initially reported significant differences between the two groups. However, when the effects of age were controlled by converting raw scores to age based percentile scores, older adults only differed on one measure (digit span backwards). These findings were verified in a second study (Fields, 1997) comparing younger and older adults following MTBI; neuropsychological performance was not significantly different on most tests of memory and attention.

Dementia

Following MTBI, cognitive changes within the domains of attention and memory are apparent. These same cognitive dysfunctions are manifestations of dementia. Hence, an older adult experiencing cognitive dysfunction as a result of a head injury may have cognitive changes incorrectly attributed to dementia rather than the TBI. A critical diagnostic issue is whether the neurobehavioural sequelae are due to the head injury or a dementia predating the injury. Preliminary research suggests there are differences between the neuropsychological profiles of older adults who have sustained a head injury and older adults with dementia. The author is aware of only two studies addressing the neurocognitive differences between TBI and dementia.

Goldstein et al. (1996) compared the neuropsychological profiles of 14 older adults who sustained mild and moderate TBIs 31 days post-injury with 14 patients diagnosed with probable (early) Alzheimer's Disease (AD). Tests assessing verbal memory (via the shortened version of the California Verbal Learning Test (CVLT) for demented populations) and expressive language (visual naming subtest of the Multilingual Aphasia Examination) were administered, as deficits in these areas are well

documented in AD patients. Results indicated that AD patients exhibited impaired recall memory and semantic processing relative to TBI patients.

Young, Fields & Lovell (1995) compared 33 older adults with a TBI and 35 with dementia (participants were aged 65 and over). All participants were administered attentional measures (Digit Span Forward and Backward, Trails A), executive functioning (Trails B) and memory (delayed recall). Results indicated those in the dementia group performed more poorly on executive functioning and memory.

Medication

Older adults consume between 4 and 10 or more medications on a daily basis (Flaherty, Perry, Lynchard & Morley, 2000; Yang, Tomlinson & Naglie, 2001). Medications (antihypertensives, sedatives, anxiolytics) for the treatment of various disorders/conditions (e.g., anxiety, depression, bacterial infections and colds) have been associated with symptoms such as dizziness, drowsiness (Sasser, Hammond & Lincourt, 2001) cognitive dysfunction; poor concentration, attention and memory impairment (Green, 2000) and reduced information processing speed (Sasser et al., 2001) largely mirroring MTBI symptomology.

Older adults are more likely to be prescribed medications such as hypnotic or sedative analgesics. Older adults presenting with reversible cognitive symptoms due to a MTBI may have their symptoms attributed to medication side effects. Additionally, behavioural symptoms of MTBI such as restlessness, sleep disturbances and disinhibition may be treated with pharmacological agents having further sedative and anticholinergic effects.

Orthopaedic Injuries

Another area in which the detection of head injuries may be obscured is that of orthopaedic injuries. Approximately 4-6% of falls result in fracture (Tinetti, 1987) with another 5-10% resulting in soft tissue injuries requiring hospitalisation (Sasser et al., 2001). A significant number of patients admitted to hospital for orthopaedic injuries yet not diagnosed with a TBI, present later for long-term neurological complications (Wrightson & Gronwall, 1999). Hence older adults appearing confused after a fall may receive treatment for the physical consequences of the fall whilst a potential TBI remains undetected. Similarly, the cause of the fall (e.g., cardiac dysfunction) may be treated and the TBI may be missed.

SUMMARY

Available research indicates MTBI deficits in older adults remain evident up to seven months post injury. Only one study has assessed the long term cognitive sequelae post MTBI which failed to demonstrate any significant long term effects. Whether the pattern evident from generic MTBI outcome research (as highlighted in Chapter 3) (i.e., long term cognitive impairment) is generalisable to older adults remains uncertain. However, due to limitations within the five studies focussing on older adults (i.e., small sample size and incorporating relatively young participants), it is expected that the pattern evident within the generic adult MTBI literature would be similarly apparent for older adults. Additional research is required as to the long-term implications of MTBI in older adults.

Functional outcome research indicates that whilst age has been associated with increased functional disability and higher mortality following TBI, confounding variables such as premorbid cognitive and medical problems, severity of brain and non-brain injuries may explain the relationship between age and negative outcome.

The existence of pre-existing or co-morbid medical or neurological diseases may exacerbate neuropsychological complications following MTBI in older adults.

There are numerous comorbid conditions that can obscure the diagnosis of MTBI in older adults. Whilst the aging process has been associated with cognitive impairment, research indicates that the effects of age can be differentiated from TBI. From the available research there is little to suggest that the neurobehavioural profile of TBI varies dramatically as a function of age. Dementia is another condition of which cognitive symptoms can often be attributed. However, the neuropsychological performance of older adults with TBI appears to be qualitatively different from that of dementia. Medication side effects are also associated with cognitive impairment, particularly memory dysfunction. It is important that the cognitive impairment associated with MTBI be considered before attributing cognitive dysfunction to any of these conditions. Finally, orthopaedic injuries can also obscure detection of a MTBI due to a focus on the overt physical, rather than neuropsychological, aspects of the injury.

The medical professional may well consider an older adult who presents as confused following a fall as less of a concern than younger adults who are confused as the above pre-morbid and comorbid conditions may make confusion in older adults more likely.

CHAPTER 5:

THE PRESENT STUDY: FORMULATION/HYPOTHESES

Mild Traumatic Brain Injury when sustained by older adults results in a myriad of cognitive and behavioural complications. Current epidemiological research indicates an approximate MTBI incidence rate of 200 per 100,000 (Frankowski, 1986) for this age category. Such estimations are typically indicative of injuries requiring hospitalisation and usually do not include either emergency department or doctor's rooms' statistics, or the 20-40% of individuals sustaining MTBIs who do not seek medical attention (Jennett, 1996). Furthermore, comorbid conditions may mask MTBI symptomology, making detection of brain trauma particularly challenging. Together, such findings suggest current epidemiological data on MTBI sustained by older adults may be extremely conservative.

The current study aims to provide a more comprehensive estimate of the incidence of MTBI attributable to falls amongst a sample of older adults. As incidence rate data say little about the frequency of falls that result in TBI, a further aim is to identify the proportion of falls resulting in TBI. The study also aims to add to existing research by addressing the discrepancy between official MTBI incidence rates and estimated unofficial data based on neuropsychological referrals for long term cognitive problems due to head injuries. Accordingly, cases of MTBI which do not receive medical attention will be looked at. A comparison between individuals who meet criteria for a MTBI and are hospitalised for orthopaedic versus non orthopaedic injury will also be conducted to ascertain if overt physical injuries may serve to inhibit MTBI detection.

The current study also aims to add to the existing MTBI recovery research focussing on older adults. Accordingly for this second part of the study, only cases of MTBI will be selected; cases of moderate and severe TBI will be excluded. Whilst there exists a multitude of research documenting both the effects of MTBI both in the short term (Bornstein et al., 1993; Dikmen et al., 1986; Dikmen et al., 1995; Levin et al., 1987; McLean et al., 1983; Ruff et al., 1989) and long term (Arcia & Gualtieri, 1994; Bernstein et al., 1996; Binder et al., 1997; Bohnen et al., 1992; Bohnen et al., 1995; Gentilini et al., 1985; Klein, et al., 1996; Leininger et al., 1990; Raskin et al., 1998;

Rimel et al., 1983; Stuss et al., 1989), the literature pertaining specifically to older adults is sparse. Four studies have assessed the effects of short term cognitive functioning (Aharon-Peretz et al., 1997; Goldstein et al., 1994; Goldstein et al., 1996) and only one study broadly assessed the long-term implications of MTBI (Luukinen et al., 1999). The current study aims to contribute to current geriatric TBI literature by comparing the performance of a group of older adults with MTBI with a control group on neuropsychological measures up to five years post injury. It is hypothesized that the MTBI group will obtain lower scores than the control group. Further, comparisons will be made within the MTBI group on neuropsychological measures, where it is expected that individuals sustaining multiple TBIs will experience more difficulty than individuals sustaining a single fall, and individuals with severe non-brain injuries will experience more difficulty than those sustaining mild non-brain injuries.

PART ONE: EPIDEMIOLOGY/AETIOLOGY

Hypothesis One: Fall Incidence Rates

Nursing home residents will report more falls on an annual basis than retirement village residents.

This hypothesis is based on research indicating that one third of adults aged 65 and over will fall in any one year (Kannus, et al., 1999; Tinetti, 1987) and that 30-40% of nursing home residents fall each year (Tinetti et al., 1986).

Hypothesis Two: Proportion of Falls resulting in TBI

That a certain proportion of falls will result in TBI.

While it is known that approximately 70% of TBIs sustained by older adults are attributable to falling (Kannus, et al., 1999; Nagurney et al., 1998; Rapoport & Feinstein, 2000; Sjoegren & Bjoernstig, 1989) exactly how many falls result in TBI remains unknown.

Hypothesis Three: MTBI Incidence Rate

The annual incidence rate for fall induced MTBI sustained by older adults will be greater than 519 per 100,000 of the population.

This hypothesis is based on the Sosin et al. (1996) household survey of a national sample conducted through the U.S. Census Bureau where an incidence rate for MTBI of 519 per 100,000 was reported. As one of the inclusion criteria for that study was loss of consciousness, it was expected that the current study, which does not require LOC (as MTBI may occur without LOC), will produce a higher rate.

Hypothesis Four: Increasing Incidence Rates

Incidence rates for TBIs attributable to falls will increase with age.

This hypothesis is based on research which indicates that fall incidence rates increase with age (Luukinen et al., 1999; Sjoegren & Bjoernstig, 1989; Tinetti et al., 1995).

Hypothesis Five: Severity of TBI

Of injuries meeting criteria for a TBI, 80-90% will be classified mild.

This hypothesis is based on research conducted by Culotta et al. (1996) who suggest that 80-90% of TBIs are considered mild.

Hypothesis Six: Seeking of Medical Attention

Of those participants whose injuries meet the criteria for a fall induced MTBI, 20-40% will not have sought medical attention.

This hypothesis is based on research suggesting that approximately 20%-40% of individuals sustaining a MTBI do not seek medical attention (Jennett, 1996).

Hypothesis Seven: Diagnosis of Orthopaedic versus Non-Orthopaedic Injuries

Participants meeting criteria for a MTBI and admitted to hospital for orthopaedic injuries will be less likely to be diagnosed with a TBI than those admitted to hospital with non-orthopaedic injuries.

This hypothesis is based on research which indicates that a significant number of patients are admitted to hospital for orthopaedic injuries yet are not diagnosed with TBI despite the fact that they provide a significant number of neuropsychological referrals for long term cognitive problems (Wrightson & Gronwall, 1999).

Hypothesis Eight: Post-Concussive Symptoms

Participants meeting the criteria for a MTBI will report more post-concussive symptoms than those without MTBI.

This hypothesis is based on research reporting that post-concussive symptomology is present in approximately 50-80% of MTBI patients immediately post injury (Levin et al., 1987; Mandel et al., 1993) and that for a substantial proportion of individuals, such symptoms continue beyond the post-traumatic period (Dikmen et al., 1986; McLean et al., 1983).

PART TWO: NEUROPSYCHOLOGICAL MEASURES

Hypothesis Nine: MTBI versus Controls

Participants in the MTBI group will obtain lower scores on neuropsychological measures than participants from the control group.

This hypothesis is based on research which indicates that older adults who have sustained a MTBI are likely to obtain lower scores on neuropsychological measures than older adults who have not sustained such an injury (Aharon-Peretz et al., 1997; Goldstein, et al., 1994; Goldstein et al., 1996; Mazzucchi et al., 1992).

Hypothesis Ten: MTBI Group – Multiple TBIs

Participants who have sustained multiple TBIs will obtain lower scores on neuropsychological measures than participants who have sustained only a single TBI.

This hypothesis is based on research indicating the effects of multiple TBIs are cumulative (Gronwall & Wrightson, 1974; Richardson, 2000).

Hypothesis Eleven: MTBI Group – Severity of Non-Brain Injury

Participants who have fallen and sustained severe non-brain injuries will obtain lower scores on neuropsychological measures than participants who have fallen and sustained mild or no non-brain injuries.

This hypothesis is based on outcome research suggesting that severity of non-brain injury acts as a modulating variable for outcome post TBI (Fields & Coffey, 1994).

Hypothesis Twelve: Normative Data

Results of the control group will not differ significantly from the normative group.

It is expected that the non-brain damaged control group is representative of the general population and will therefore score similarly to the normative groups for the respective neuropsychological measures.

Hypothesis Thirteen: Patient Competency Rating Scale

Compared to family members' ratings, participants in the MTBI group will rate themselves more competent on the Patient Competency Rating Scale (PCRS) compared to the ratings of family members (i.e., PCRS Relative's Form). Conversely, within group differences are not expected for the control group.

This hypothesis is based on findings from Prigatano and Fordyce (1986) who report that most TBI sufferers in rehabilitation typically rate themselves as more competent when compared to family members' ratings.

CHAPTER 6

METHOD

RESEARCH SETTING

Residents from three Nursing Homes / Retirement Villages (Metlifecare Browns Bay, Crestwood Retirement Village and Rest Home and Roskill Masonic Village Complex) were invited to participate.

ETHICAL ISSUES

The study was designed in accordance with Massey University's (2002) Code of Ethical Conduct for Research, Teaching and Evaluation Involving Human Participants and the New Zealand Psychological Society's (2002) Code of Ethics. This project was reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, Massey University Human Ethics Committee and the Board of Trustees at Metlifecare Browns Bay, Crestwood Retirement Village and Rest Home and Roskill Masonic Village Complex.

Informed Consent

The aims and methodology of the project were fully explained to potential participants by the principal investigator upon initial visitation and was supported by an information sheet. Separate information sheets were prepared for both parts of the study for all participants (Appendix I – see pages 119, 121 & 123), staff members at nursing homes (Appendix I – see page 125) and friend/relatives (Appendix I – see page 131). The information sheets also highlighted the fact that participation was voluntary, that participants could decline to participate at any stage and how to contact the researcher and other personnel involved in the study. For Part Two a consent form (Appendix I – see page 127) was required to be signed before commencement. Another consent form (Appendix I – see page 129) was required to be signed by the participant before contacting their friend/relative (for forwarding of Patient Competency Rating Scale). All participants were invited to receive a summary of the results.

Confidentiality

Code numbers were assigned to data (questionnaires and measures) completed by participants. Data was only accessed by the researcher or her supervisor. Completion of the questionnaire and administration of the neuropsychological measures was conducted in a private room.

Other Issues

Prior to administration of measures, it was explained to participants that they could experience some difficulty on tests. It was anticipated that this would offset any concern about their performance.

In keeping with good professional practice, the researcher was mindful of the effects of motivation, fatigue, medication-side effects and depression.

Given the prevalence of health problems in older adults, sensitivity to such issues was exercised. Participants were asked if they could hear the researcher comfortably and if they required glasses.

PART ONE: ADMINISTRATION OF QUESTIONNAIRE

Participants

The combined nursing homes / retirement villages provided a total population of 451 older adults. From this, 320 residents were deemed eligible to complete the questionnaire (being aged 65 and over and without a diagnosis of dementia). Of these 320 residents, 10 declined to participate, 17 were either too ill or had been hospitalised and 29 were absent on the days the researcher visited. A total of 264 participants participated in Part One of the study.

Inclusion / Exclusion Criteria

Residents aged 65 and over were eligible to participate. In conjunction with nursing personnel, all residents were screened for a diagnosis of dementia prior to conducting the research. The Roskill Masonic Village Complex (nursing home) provides for a higher percentage of clients requiring increased nursing support, and accordingly a lower percentage of residents were eligible for inclusion in the study compared to either Metlifecare Browns Bay or Crestwood.

Table 6.1 presents the demographic characteristics of participants who participated in Part One of the study.

Table 6.1
Demographic Analysis of Participants Participating in Part One of the Study

		Nursing Homes		Retirement Villages		Total	
		N	%	N	%	N	%
Gender							
Male		23	20	40	27	63	24
Female		94	80	107	73	201	76
Age							
65-69		-	-	6	4	6	2
70-74		2	2	13	9	15	6
75-79		8	7	31	21	39	15
80-84		30	26	49	33	79	30
85+		77	66	48	33	125	47
Ethnicity	Pakeha	83	71	102	69	185	70
	Maori	2	2	-	-	2	1
	European	30	25	39	27	69	26
	Other	2	2	6	4	8	3
Education							
No High School		44	38	36	25	80	30
High School (1-3 yrs)		36	31	49	33	85	32
High School (6th Form)		14	12	25	17	39	15
High School (7th Form)		15	13	23	16	38	14
University (Undergraduate)		3	3	7	5	10	4
University (Postgraduate.)		-	-	1	1	1	1
Other		5	4	6	4	11	4

There were no significant differences between nursing homes and retirement villages in terms of gender ($t [258] = 1.43$, $p = 0.15$), ethnicity ($t [262] = -0.66$, $p = 0.508$) or education ($t [262] = -1.73$, $p = 0.084$).

Whilst Maori represent 14.3% of the New Zealand population (Census, 2001) they only represented 2% of the study sample. Geographical location can explain some of this discrepancy; Mt Roskill (Roskill Masonic Village Complex) has a Maori population of 3.9%, Browns Bay (Metlifecare Browns Bay) 4.5% and Green Bay (Crestwood Retirement Village) 8.9% (Census, 2001) (the two Maori participants were from Mt Roskill and Green Bay). However, geographical location cannot account for the entire discrepancy, suggesting that Maori elderly are more likely to be looked after by their whanau than retire to a retirement village or nursing home.

Measure

A questionnaire (Appendix II – see page 133) was designed specifically for this study. The questionnaire comprised four components: (1) basic demographic information; (2) exclusion criteria and confounding variables; (3) history of falling and

consequences, and; (4) common subjective complaints frequently experienced following a MTBI. An outline of the process involved in administrating the questionnaire is appended (see Appendix III – page 141).

Basic Demographic Information

Information was gathered on gender, age, ethnicity and education to enable comparison on neuropsychological measures with the normative sample and to assist in matching with controls. The variable of age was also used to examine the hypothesis concerning increased incidence of falls with age.

Exclusion Criteria and Confounding Variables

Information on neurological disorders (dementia and stroke) was obtained to assist with exclusion criteria. Such individuals were excluded as such diagnoses could influence results. Information on medication / alcohol / drug usage, psychiatric disorders and prior head injury was gathered to ensure participants were equal on such premorbid variables.

Fall History

Details surrounding the fall(s) were gathered to ensure ICD criteria (see page 60 for definition) was met. The number of falls sustained was required to examine the hypothesis concerning multiple TBIs attributable to falls. Information pertaining to physical injuries sustained during the fall was required to examine the hypothesis concerning severity of non-brain injuries. Details were also collected regarding problems sustained as a result of the fall (e.g., loss of consciousness, altered mental state) to identify fall(s) meeting ACRM criteria for MTBI.

Frequent subjective complaints

A list of subjective complaints frequently experienced following a MTBI was included to ascertain whether such complaints served to differentiate between participants who had and had not fallen.

Procedure

Formal contact was made with Nurse Managers from approximately twenty rest homes / retirement villages seeking approval to conduct the research within these establishments. Appointments were then made with Nurse Managers from three different nursing homes / retirement villages expressing an interest in participating. These meetings involved various personnel. The aims of the research, how the respective establishments would be involved and requirements of staff and residents were discussed. Following this meeting, formal approval was required from various Committees / Boards within the nursing homes / retirement villages seeking formal approval to conduct the research. Following approval, a mutually agreed upon commencement date was established.

An initial meeting with the Nurse Manager facilitated basic orientation; building maps, name lists, community activities (i.e., avoiding research on days residents were on trips). Residents meeting inclusion criteria were approached in their rooms or units on an individual basis. Up to three attempts were made to contact residents initially not present when the researcher called. Those interested in participating after the nature and purpose of the study was explained were given an information sheet. Residents were then given the option to complete the questionnaire at that point or arrange a future convenient time. Initial methodology involved participants completing their own questionnaire. However, after the distribution of ten questionnaires, it became apparent that various challenges (e.g., difficulty reading / interpreting the questionnaire, tremors, fatigue and difficulty recalling events) rendered completion of the questionnaire by some residents difficult.

From this point completion of the questionnaire adopted a more qualitative procedure. Participants were invited to "tell their story" surrounding the fall. The set format of the questionnaire was not adhered to; rather the researcher listened to what participants said and recorded details on the questionnaire. When participants had completed their recount of the event(s), specific questions were asked to glean required details that had not been supplied.

Completion of the questionnaire took approximately 10 – 25 minutes, after which time participants were thanked for their assistance.

PART TWO: ADMINISTRATION OF NEUROPSYCHOLOGICAL MEASURES

Participants

From the sample completing the questionnaire two groups of participants meeting particular criteria were drawn. Participants were included in the MTBI group based on their retrospective account of having sustained a fall meeting ICD-9 injury codes (E codes - E880A-E889A) and on meeting ACRM criteria for a MTBI. Such criteria were applied until 21 participants were obtained. Participants for the control group had no fall history and were matched on age. It was not possible to match on other variables due to the small number of participants who met the combined criteria.

Inclusion Criteria

Definition of Fall

A fall was defined as an injury occurring as a consequence of a fall in accordance with International Classification of Diseases, ninth revision (ICD-9) criteria, needed to meet external cause of injury codes (E codes - E880A-E888A) for injuries attributable to falls (See Table 6.2). Only falls sustained during the last five years were included. Original methodology limited fall history to three years post injury (in accordance with long term MTBI research (Arcia & Gualtieri, 1994; Bohnen et al., 1992; Leininger et al., 1990; Raskin et al., 1998) indicating cognitive deficits persist up to three years post injury). However, recall difficulties surrounding this cut-off period resulted in a less conservative time period being adopted.

Table 6.2
International Classification of Diseases Accidental Falls Coding Criteria

	Accidental Falls
E880	Fall on or from stairs or steps
E881	Fall on or from ladders or scaffolding
E882	Fall from or out of building or other structure
E883	Fall into hole or other opening in surface
E884	Other fall from one level to another
E885	Fall on same level from slipping, tripping or stumbling
E886	Fall on same level from collision, pushing or shoving by other person
E887	Fracture, cause unspecified
E888	Other and unspecified fall

Source: New Zealand Health Information Service Morbidity Data, 1998/1999.

Definition of Mild Traumatic Brain Injury

Incidents of head injury reported by participants were reviewed to determine their eligibility for a MTBI. A MTBI was defined according to the definition developed by the Mild Traumatic Brain Injury Committee of the Head Injury Interdisciplinary Special Interest Group of the American Congress of Rehabilitation Medicine (ACRM) (1993), namely, any person who has had a traumatically induced physiological disruption of brain function as manifested by at least one of the following:

1. Any period of loss of consciousness;
2. Any loss of memory for events immediately before or after the accident;
3. Any alteration in mental state at the time of the accident (e.g., feeling dazed, disoriented, or confused);
4. Focal neurological deficits(s) that may or may not be transient but where the severity of the injury does not exceed the following:
    a. Loss of consciousness of approximately 30 minutes of less;
    b. After 30 minutes, an initial Glasgow Coma Scale (GCS) of 13-15; and
    c. Posttraumatic amnesia (PTA) not greater than 24 hours.

Moderate TBIs were defined as those injuries resulting in a loss of consciousness greater than 30 minutes. Injuries resulting in a loss of consciousness greater than 1 hour were classified as severe.

Exclusion Criteria

Participants reporting a fall induced moderate or severe TBI were excluded due to the study's focus on MTBI[2]. Participants with a prior diagnosis of a stroke were also excluded as this could have impacted on results; neuropsychological performance possibly being compromised by such neurological condition, rendering it difficult to isolate the impact of TBI. Table 6.3 presents demographic characteristics for participants who participated in Part Two of the study.

There were no significant differences between groups in terms of age ($t [39] = 0.03$, $p = 0.98$), ethnicity ($t [40] = 0.84$, $p = 0.41$) or education ($t [40] = -0.49$, $p = 0.96$).

[2] Cases of moderate TBI were included in hypotheses pertaining to TBI as opposed to those focusing on MTBI (i.e., Hypotheses 1, 2, 3 & 5 of Part One and Hypothesis 10 of Part Two)

However, there was a significant difference between groups in terms of gender (t [29] = -2.13, p = 0.04); there being five (24%) males in the control group, compared to one (5%) in the MTBI Group.

Table 6.3
Demographic Analysis of Participants Participating in Part Two of the Study

			MTBI (N = 21)		Controls (N = 21)	
			N	%	N	%
Gender						
Male			1	5	5	24
Female			20	95	16	76
Age	65-74		2	67	1	33
	75-84		9	47	10	53
	85-94		10	50	10	50
Ethnicity	Pakeha		16	76	16	76
	European		5	24	4	19
	Other		-	-	1	5
Education						
No High School Education			10	48	9	43
High School (1-3 years completed)			4	19	5	24
High School (Sixth Form)			2	10	3	14
High School (Seventh Form)			4	19	3	14
University (Undergraduate)			-	-	1	5
Other			1	5	-	-
Medication Usage		Yes	19	91	18	86
		No	2	20	2	10
		Not Supplied	-	-	1	5
Alcohol	Daily		-	-	1	5
	Weekly		2	10	2	10
	Once a month		1	5	2	10
	Less than once a month		3	14	7	33
	Never		15	71	9	43
Diagnosed	Anxiety	- Yes	2	10	-	-
		- No	19	91	21	100
	Depression	- Yes	5	24	1	5
		- No	16	76	20	95

In terms of pre-morbid factors, there were no differences between groups in respect of alcohol usage, (t[40] = 1.42, p = 0.16) or a diagnosis of anxiety (t [40] = -1.45, p = 0.16) or depression (t [40] = -1.79, p = 0.08). A comparison of other psychiatric conditions (e.g., Schizophrenia, Post-Traumatic Stress Disorder or Obsessive Compulsive Disorder) was not conducted as none of the participants endorsed these items. Finally,

there were no differences between groups in regard to medication usage (t [38] = 0.58, p = 0.56). Original methodology sought to obtain
medication intake from participants' blister packs (aluminium foiled package containing weekly medication) in order to compare pre-morbid medication usage between the MTBI and control groups. However, as patient authorisation was required by nursing personnel (staff held the packs) to release this information, time constraints rendered this aspect of analysis to be abandoned. Whilst retirement village participants were responsible for their own blister packs, some participants expressed distress in disclosing such information, had mislaid their package or were uncertain whether they had one. Accordingly, a medication comparison was also not pursued for this group of participants.

Measures

The following neuropsychological measures (see Appendix IV, page 143) considered sensitive to functional areas impaired following MTBI were administered. Administration instructions are outlined in Appendix V (see page 163).

Information Processing Speed

Digit Symbol (DS)

Digit Symbol is a performance subtest of the Wechsler Adult Intelligence Scale (WAIS-III) (Wechsler, 1997) measuring motor persistence, sustained attention, response speed and visuomotor coordination. The test comprises a series of numbers paired with a corresponding hieroglyphic symbol. Participants are presented with rows of blank boxes and numbers and are required to match the symbols to the numbers as quickly as possible. Normative data is available up to age 89 with test reliability high (range = .82 to .88) (Lezak, 1995). This test has been selected due to its sensitivity to minimal brain damage; being consistently more sensitive to brain damage than other WAIS subtests (Lezak, 1995).

Attention

California Older Adult Stroop Test (COAST)

The COAST is an adaptation of Stroop-type tests, being tailored specifically for an older population. Difficulties with traditional Stroop-type tests (e.g., discriminating colours, identifying with size of stimuli, etc.) warranted adoption of a version more

sensitive to the effects of age. The COAST (Pachana, Marcopulos, Yoash-Gantz & Thompson, 1997) is a test of selective attention. The test comprises three pages, each with 50 items presented in five columns of 10 items. The test is timed with 45 seconds for each trial. There are three trials; reading names of colours printed in black ink, naming colours of patches written as XXXX and naming the colour of ink which different colour names are printed in. This third trial, the interference trial, requires the selective processing of only one visual feature (colour of ink) while continuously blocking the processing of the word (reading the word). Normative data is available up to the age of 80 (Ivnik, Malec, Smith, Tangalos & Petersen, 1996). The Stroop test is considered sensitive to the effects of brain damage (Spreen & Strauss, 1993).

Memory

Visual Reproduction I, II & Recognition (VR)

Visual Reproduction (Wechsler, 1997a) is a subtest from the Wechsler Memory Scale III (WMS-III). VR allows the consideration and comparison of immediate and delayed recall and is one of the most commonly used measures of visual or nonverbal memory. The test involves the presentation of five designs to the participant for 10 seconds and then the immediate recall after 25-35 minutes. The VR subtest demonstrates good validity and reliability with normative data being available up to age 89. This test has been selected due to its sensitivity to the effects of head trauma; distinguishing a group of patients with MTBI from controls (Lezak, 1995).

Rey Auditory Verbal Learning Test (RAVLT)

The RAVLT (Rey, 1964; Spreen & Strauss, 1993) measures immediate memory span, new learning, free recall, recognition and susceptibility to interference (Rey, 1964). The test consists of 15 nouns (list A) read aloud for five trials with each trial being followed by a free recall test. Upon completion of trial 5 an interference list of 15 words (list B) is presented followed by a free recall test of that list. Following this, recall of the first list is tested without further presentation of those words. After a 20 minute delay period recall is again tested for list A. Finally recognition is tested by requiring participants to identify list A words from a list of 50 words. Normative data are available for adults up to age 84 (Ivnik, Malec, Tangalos, Kokmen & Kurland, 1990). The RAVLT demonstrates modest test-retest reliability with correlations of approximately 0.55 and is sensitive to verbal memory deficits. The RAVLT is sensitive to verbal memory deficits in a variety of patient groups (Lezak, 1995).

Executive Functioning

Trail Making Test (TMT) – Part A & B

The TMT, from the Army Individual Test Battery (1944), is a test of motor speed, visual attention and mental flexibility taking approximately five minutes to administer. Part A requires the participant to follow a sequence mentally by drawing lines connecting randomly arranged encircled numbers as quickly as possible. Part B requires alternately connecting consecutively numbered and lettered circles as quickly as possible. Slow performance on both parts (especially Part B) indicates the possibility of brain damage. Apart from brain damage, visual scanning and tracking difficulties provide information as to how the participant follows a sequence mentally, deals with more than one stimulus at a time (Spreen & Strauss, 1993) and demonstrates flexibility to shift course during an ongoing activity (Spreen & Strauss, 1993). This test was selected as performances by patients with MTBI are slower than those of controls, with such slowness increasing with severity of damage (Leininger et al., 1990).

Wisconsin Card Sorting Test (WCST-64)

The WCST-64 (Greve, 2001) assesses abstraction ability and the ability to shift and maintain the set. The test involves a pack of 64 cards on which are printed four designs similar to the stimulus cards, varying in colour, geometric form and number. The participant is instructed to match each of the cards in the decks to one of the four stimulus cards according to a principle that the participant deduces from the pattern of the examiner's responses to the participant's placement of the cards. Practical constraints resulted in the abbreviated version being employed over the standard WCST. Numerous data supports the comparability of the two versions (Greve, 2001); the standard version being a well established measure of executive function.

Functional Behaviour

The Patient Competency Rating Scale (PCRS)

The PCRS (Prigatano & Fordyce, 1986) is a 30-item self-report questionnaire that evaluates self-awareness (the ability to appraise one's current strengths and weaknesses) following TBI. The PCRS is a 30-item self-report instrument which asks participants to use a 5-point likert scale to rate the degree of difficulty in a variety of tasks and functions. The participant's responses are compared to those of a significant other (relative or friend) who rates them on the identical items. Impaired self-awareness may be inferred from discrepancies between the two ratings, such that the participant

overestimates their abilities compared to the informant. Awareness of deficit may also be examined separately for the various domains sampled by PCRS items. These include activities of daily living, interpersonal, behavioural and emotional function and cognitive abilities (Heilbronner, Millsaps, Azrin & Mittenberg, 1993, cited in Leathem, 1998). The PCRS demonstrates good reliability figures for both patients (r = .97) and relatives (r = .92) (Prigatano, Altman & O'Brien, 1990, cited in Leathem, 1998). Factor analysis revealed six relatively discrete factors supporting content validity (Heilbronner, et al., 1993, cited in Leathem, 1998). The PCRS is being selected due to its provision of insight into behavioural limitations resulting from TBI that the neuropsychological tests employed in this study are unable to provide.

Procedure

Participants for Part Two of the study were drawn from those who had participated in Part One. Residents from retirement villages meeting inclusion criteria for Part Two of the study were contacted individually via the telephone and were given an overview of this phase of the study and what would be required of them. If they were interested in participating, an appointment was then made and an information sheet was posted prior to the appointment. Participants were given time to read the information sheet and have any questions answered. Voluntary participation was emphasised. The same procedure applied to rest home residents, with the exception that they were approached in person rather than via the telephone. Accordingly an information sheet was left with them rather than being posted.

Prior to administering the neuropsychological measures, participants were asked to complete a consent form. Administration occurred on an individual basis taking approximately 45 – 90 minutes with breaks included as required. A copy of the research data sheet is appended (see Appendix VI, page 171). Completion of the PCRS took place at the conclusion of testing. Participants were invited to nominate a relative or friend, who knew them well, to also complete the PCRS. A permission slip was provided to contact this person. The relative/friend (informant) nominated to complete the PCRS had an information sheet, PCRS and stamp addressed envelope posted to them. Provision was made at the bottom of the PCRS for the informant to receive a summary of the results.

At the conclusion of testing, participants were thanked for their involvement.

CHAPTER 7

RESULTS

PART ONE: EPIDEMIOLOGY / AETIOLOGY

Hypothesis One: Fall Incidence Rates

Nursing home residents will report more falls on an annual basis than retirement village residents.

Figure 7.1 outlines the proportion of nursing home and retirement village participants sustaining a fall during the last year.

Nursing home participants were more likely to report a fall(s) than participants from retirement villages (t [253] = -2.83, p = 0.01).

Forty-nine (41.9%) of the 117 residents across the three nursing homes (Metlifecare Browns Bay, Metlifecare Crestwood and the Masonic Roskill Village) reported they had sustained a fall during the past year. Residents from the Masonic Nursing Home were more likely to have reported a fall during the past year (46.5%) than either Browns Bay (37.5%) or Crestwood (39.5%).

Thirty-nine (26.5%) of the 147 residents across the three retirement villages reported they had sustained a fall during the past year. Residents from Crestwood were less likely to have reported a fall during the past year (20%) than either Browns Bay (27.6%) or Masonic (25.9%). However, these differences were not significant.

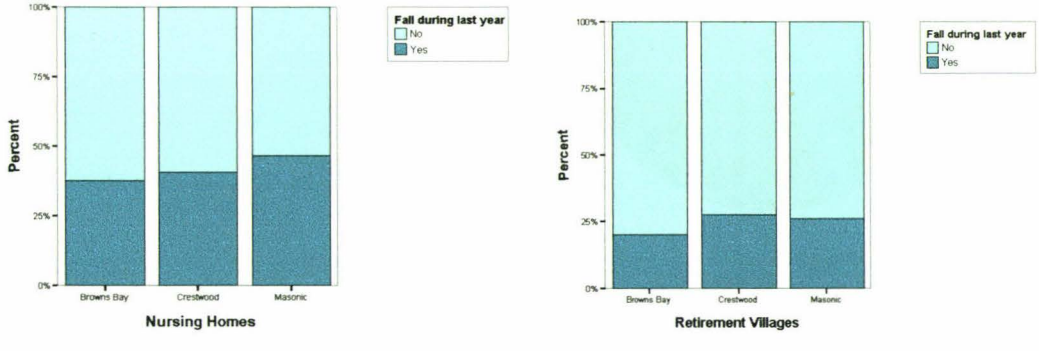

Figure 7.1. Proportion of nursing home and retirement village participants sustaining a fall during the last year

Combining nursing homes and retirement villages produced a total of 264 participants. Over the five year period that the study covered, 146 participants reported a fall(s); 44 (30.1%) reported one fall, 35 (23.9%) reported two falls, 24 (16.4%)

reported three falls and 43 (29.5%) reported having sustained more than three falls (a value of four was ascribed to cases of more than three falls), producing a total of 358 falls. Figure 7.2 indicates falls sustained by participants according to frequency.

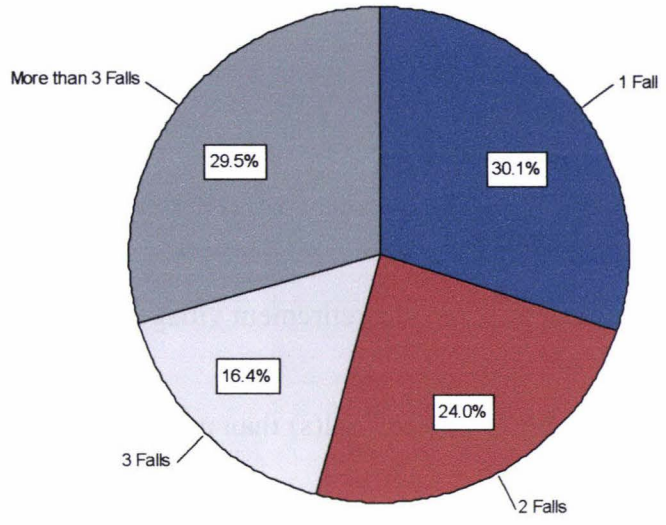

Figure 7.2. Fall(s) sustained by participants according to frequency

Figures 7.3 and 7.4 outline causes of falling and injuries attributable to falling.

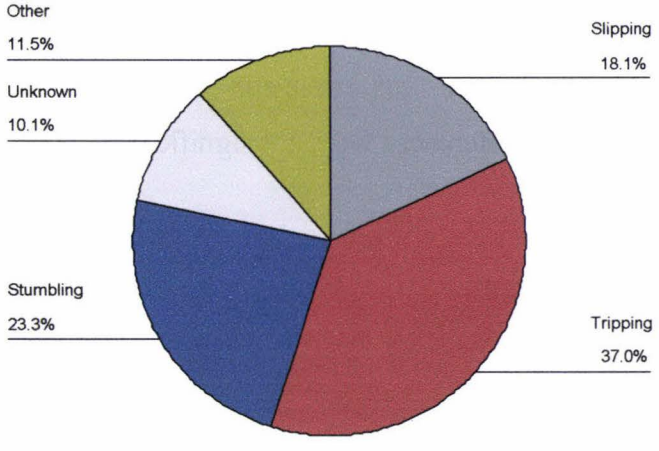

Figure 7.3. Fall(s) sustained by participants according to cause of injury

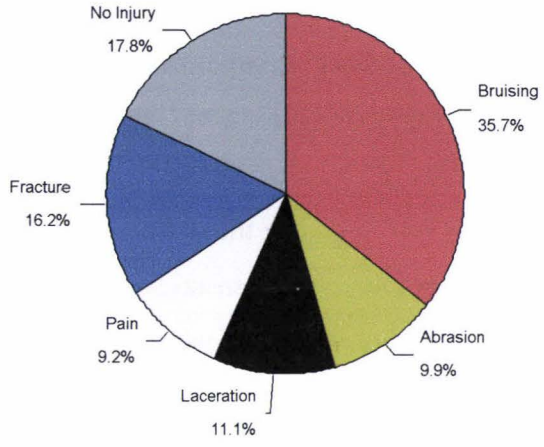

Figure 7.4. Type of injury sustained following a fall(s)

Hypothesis Two: Proportion of Falls resulting in TBI

That a certain proportion of falls will result in TBI.

Of the 358 falls, 41 (11.5%) met criteria for a TBI (one person sustained two such falls, i.e., 40 participants met the criteria for a TBI). Prorated down from five years, this equates to an annual incidence rate of 2.3% (i.e., 2.3% of falls result in TBI per year). Analysis according to origin of sample revealed nursing home participants collectively sustained 199 falls, 22 (11.1%) of these meeting criteria for a TBI. Retirement village participants collectively sustained 159 falls, 18 (11.3%) of these meeting criteria for a TBI.

Hypothesis Three: MTBI Incidence Rate

The annual incidence rate for fall induced MTBI sustained by older adults will be greater than 519 per 100,000 of the population.

Calculation of incidence rates were based on retirement village data as this was considered more representative of the community at large. Eighteen (12.2%) of the 147 retirement village participants had sustained a head injury during the past five years which met the criteria for a MTBI. Pro-rated for one year only, this equates to an annual incidence rate of 2,449 per 100,000. Ten (6.8%) of the 147 retirement village participants had sustained a head injury which did not meet MTBI criteria. This figure is likely to be particularly conservative due to the large amount of participants who were uncertain whether they had hit their heads. Analysis of injuries resulting in loss of consciousness (adopting the same methodology as Sosin et al., 1996) revealed that six

(4.1%) of the 147 participants sustained a MTBI during the five years, reducing the annual incidence rate to 816 per 100,000.

Nursing home data indicated that 19 (16.2%) of the 117 participants had sustained a head injury during the past five years which met the criteria for a MTBI, equating to an annual incidence rate of 3,247 per 100,000. Analysis restricted to cases of LOC revealed six of the 117 participants sustained a MTBI, reducing the incidence rate to 1,025 per 100,000. Fourteen (11.9%) of the 117 participants had sustained a head injury which did not meet MTBI criteria. Again, due to the uncertainty of participants as to whether they had hit their heads, this figure is considered particularly conservative.

For the group as a whole (retirement village and nursing home data combined), the calculated annual incidence rate was 2,803 per 100,000, which was reduced to 909 per 100,000 when adopting stricter criteria.

Hypothesis Four: Increasing Incidence Rates

Incidence rates for TBIs attributable to falls will increase with age.

From the 264 participants, 40 (15.2%) (including the three cases of moderate TBI) indicated they had sustained a fall during the last five year period which met criteria for a TBI. This equates to an annual incidence rate of 3.0%. Table 7.1 presents incidence rates for the entire sample across three age categories. Participants aged 85+ reported a higher incidence rate (4%) than those in the 75-84 year age category (2.6%). This incidence rate was not higher than that of the 65-74 year age category (3.2%). However, combining the two lowest aged categories (65-74 and 75-84) indicates that 15 of the 139 participants (10.8%) sustained falls meeting TBI criteria which resulted in an annual incidence rate of 2.2%, less than that of from the 85+ category.

Table 7.1
TBI Incidence Rates by Age Category

	Frequency	Fall Induced TBI	Percent	Incidence Rate
65-74	21	3	16.0%	3.2%
75-84	118	12	12.8%	2.6%
85+	125	25	20.0%	4.0%
Total	**264**	**40**		

Hypothesis Five: Severity of TBI

Of injuries meeting criteria for a TBI, 80-90% will be classified mild.

Of the 40 injuries meeting criteria for TBI, the majority (92.5%) were mild in severity, with three (7.5%) being of moderate severity (all cases of moderate TBI represented nursing home residents). No reported incidents of TBI met criteria for the severe category. Table 7.2 classifies the 37 MTBIs according to the three grades as outlined in the Method Section. Adoption of stricter MTBI criteria (loss of consciousness) revealed that 12 of 15 (80%) TBIs were of mild severity.

Table 7.2
Levels of MTBI

		Total		Nursing Home		Retirement Village	
		N	%	N	%	N	%
Grade 1		2	5.4%	1	2.7%	1	2.7%
Grade 2		23	62.2%	11	29.7%	12	32.4%
Grade 3	A	3	8.1%	1	2.7%	2	5.4%
	B	9	24.3%	5	13.5%	4	10.8%

Hypothesis Six: Seeking of Medical Attention

Of those participants whose injuries meet the criteria for a fall induced MTBI, 20-40% will not have sought medical attention.

Of the 37 participants whose injuries met the criteria for MTBI over the 5 year period, only three (8.1%) had not sought medical attention. All three participants resided in retirement villages.

Hypothesis Seven: Diagnosis of Orthopaedic versus Non-Orthopaedic Injuries

Participants meeting criteria for a MTBI and admitted to hospital for orthopaedic injuries will be less likely to be diagnosed with a TBI than those admitted to hospital with non-orthopaedic injuries.

Of the 37 participants who met criteria for a MTBI, 11 (29.7%) had either been seen at an emergency department or hospitalised for orthopaedic injuries at the time of the MTBI and 10 (27%) for non-orthopaedic injuries. The remaining 16 participants (43.3%) with MTBI were seen in doctors' rooms or did not come to medical attention. Whilst two (18.1%) of the 11 sustaining orthopaedic injuries and four (40%) of the 10

with non-orthopaedic injuries were diagnosed with a TBI, these differences were not significant (t [19] = -1.08, p = 0.29).

Of these six participants receiving diagnoses, two (33%) were diagnosed with a brain injury (one (12.5%) received a laceration (ICD Code 851) which resulted in a CT scan) and the other four (66%) were diagnosed as having sustained a TBI/concussion (ICD Code 850). Figure 7.5 outlines the type of injury sustained and whether or not a TBI was diagnosed.

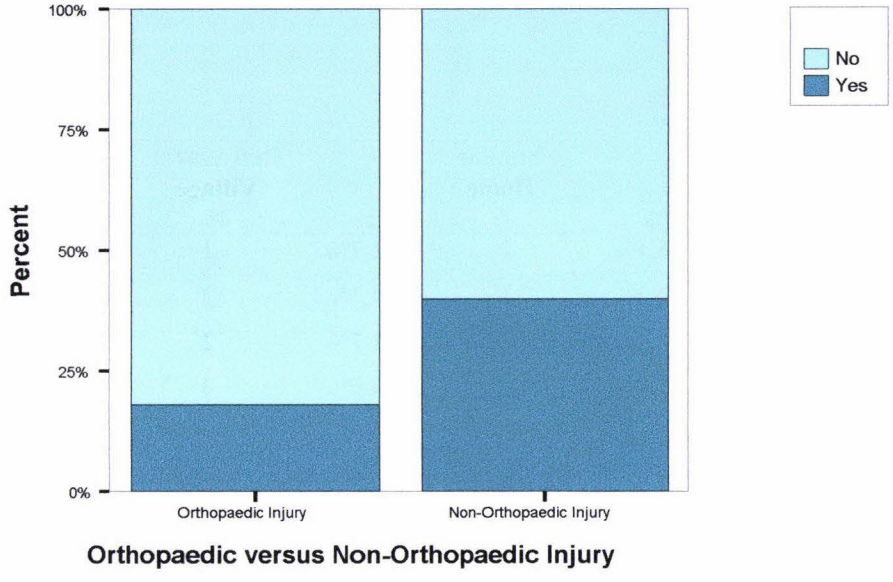

Figure 7.5. Diagnosis of hospitalised orthopaedic and non-orthopaedic injuries

Hypothesis Eight: Post-Concussive Symptoms

Participants meeting the criteria for a MTBI will report more post-concussive symptoms than those without MTBI.

Fifteen participants from the MTBI group and sixteen controls (i.e., participants who had not reported TBI) responded to this portion of the questionnaire (located at the end of the form). In some instances, responses to this portion were not gathered as the researcher considered the participants were too tired to continue. Whilst the MTBI group reported more difficulty than the control group on 21 of the 27 symptom items, only one item (anxiety) reached significance (t [29] = -3.04, p = 0.01). An analysis of post concussive symptoms between the MTBI group and controls is outlined in Appendix VII (see page 179).

PART TWO: NEUROPSYCHOLOGICAL MEASURES

The various indices on the neuropsychological measures met the assumptions required to perform t-tests. T-tests were conducted to compare neuropsychological functioning (Visual Reproduction subtests, AVLT, COAST, WCST-64, Trail Making Test and the Patient Competency Rating Scale) between the following groups:

MTBI versus controls

- Neuropsychological Measures

MTBI Group

- Participants sustaining multiple TBIs and those sustaining only a single TBI
- Participants sustaining severe non-brain injuries and those sustaining mild non-brain injuries

Normative Data / Present Study

- Patient Competency Rating Scale

The following post hoc analyses were also conducted:

- Diagnosis of Orthopaedic / Non-Orthopaedic Injury of Participants Reporting Post-Concussive Symptoms
- MTBI Group – Fall Frequency
- MTBI Group – predictive ability of Fall Frequency / Severity of Non-
- Brain Injury / Time since Injury
- Patient Competency Rating Scale and Fall Frequency
- Revised Trail Making Test

Hypothesis Nine: MTBI versus Controls

Participants in the MTBI group will obtain lower scores on neuropsychological measures than participants from the control group.

Table 7.3 shows means and standard deviations for the groups on each neuropsychological test.

Memory

There were no significant differences between groups on both Visual Reproduction and RAVLT.

Attention and Information Processing

The MTBI group obtained significantly lower scores on the COAST colour-word task than the control group (t [38] = -2.32, p = 0.03). The control group was also faster on Trails A and the Digit Symbol sub-test, but these differences were not significant.

Executive Functioning

Although the control group performed at a higher level in their ability to shift and maintain the set on the WCST than the MTBI group, the differences were not significant. It should be noted however that Trails B scores of the MTBI group may have been overestimated as only those who could perform the task were included; 13 of the 21 MTBI (61.9%) compared to 19 of the 21 (90.4%) control group.

Table 7.3
Comparison on Neuropsychological Measures between MTBI Group and Controls

	Possible MTBI			Control				
Measure	**n**	**M**	**SD**	**n**	**M**	**SD**	*t*	*p*
Visual Reproduction								
I	21	6.67	3.32	21	6.38	2.38	0.32[a]	0.75
II	21	8.29	3.52	21	7.43	1.81	0.99	0.33
Recognition	19	10.58	2.8	19	9.21	1.93	1.75	0.89
AVLT								
Trial 1	21	3.57	1.66	21	3.57	1.81	0.00	1.00
2	21	4.95	2.09	21	5.33	1.91	-0.62	0.54
3	21	5.95	2.60	21	5.62	2.38	0.43	0.67
4	21	6.38	3.47	21	6.10	2.91	0.29	0.77
5	21	7.14	3.25	21	6.62	3.54	0.50	0.62
Total	21	28.48	11.94	21	27.20	10.68	0.35	0.73
Interference	21	3.14	1.77	21	2.76	1.73	0.71	0.48
6	21	4.33	3.88	21	3.48	3.20	0.78	0.44
7	20	9.65	3.87	21	4.62	3.31	-0.09	0.93
Recognition	20	9.20	3.86	21	8.33	3.83	1.10	0.28
COAST								
Colour	21	42.24	11.79	20	42.70	10.59	-0.14	0.89
Colour Word	20	6.80	3.62	20	9.30	3.51	-2.22	0.03*
WCST-64								
TC	19	32.84	11.06	18	37.78	10.85	-1.37	0.18
TE	19	31.16	11.06	18	28.17	8.82	0.91	0.37
PR	19	21.79	15.61	18	21.44	10.69	0.08	0.94
PE	19	18.16	11.30	18	18.67	8.47	-0.15	0.88
NPE	19	13.00	10.55	18	11.39	7.40	0.54	0.60
CLR	19	22.26	13.72	18	26.39	12.00	-0.97	0.34
CC	19	1.32	1.06	18	2.83	5.62	-1.16	0.26
T1C	19	15.74	15.82	18	20.78	19.28	-0.87	0.39
FMS	18	0.61	0.92	17	4.53	15.37	-1.08	0.30
Digit Symbol Coding	19	8.05	3.46	18	8.44	2.90	-0.38	0.71
Trail Making Test								
Part A	20	92.35	77.34	20	63.55	28.53	1.56	0.13
Part B	13	188.31	88.74	19	206.74	141.44	-0.42	0.68

* $p < 0.05$
[a] Equal variances not assumed

Hypothesis Ten: MTBI Group – Multiple TBIs

Participants who have sustained multiple TBIs will obtain lower scores on neuropsychological measures than participants who have sustained only a single TBI.

As only one individual met criteria for multiple TBIs, this hypothesis was not conducted.

Hypothesis Eleven: Neuropsychological Measures – Severity of Non-Brain Injury

Participants who have fallen and sustained severe non-brain injuries will obtain lower scores on neuropsychological measures than participants who have fallen and sustained mild or no non-brain injuries.

Severe non-brain injuries were defined as those injuries requiring fractures, dislocations and soft tissue injuries needing suturing. Mild non-brain injuries included bruises, superficial lacerations and wounds not requiring suturing. One participant who sustained mild non-brain injuries was excluded due to sustaining a severe non-brain injury (fracture) as a result of a previous fall. Of those sustaining severe non-brain injuries, one had fallen in the last three weeks, three during the last six months and three more than a year ago. Within the single fall group, one had fallen in the last three weeks, two during the last twelve months and two more than a year ago. Table 7.4 shows means and standard deviations for the groups on the neuropsychological measures.

Memory

Participants sustaining mild non-brain injuries functioned at a higher level in their ability to recall and recognize visual stimuli than participants in the severe group, with these differences being significant for VRII and VR-Recognition. Although participants who had sustained severe non-brain injuries recalled fewer words overall on the RAVLT, these differences were not significant.

Attention and Information Processing

Although the mild non-brain injury group were less likely to react to the colour/word discrepancy and took less time to complete Trails A, their performance was not significantly different to those sustaining severe non-brain injuries. The mild non-brain injury group also processed information significantly faster on the Digit Symbol sub-test.

Executive Functioning

Whilst the severe non-brain injury group took longer than the mild non-brain injury group to complete Trails B, this measure did not differ between groups. Although the mild non-brain injury group more accurately shifted and maintained the set on the WCST, these differences were also non-significant.

Table 7.4
Comparison of MTBI Group on Neuropsychological Measures According to Severity of Non-Brain Injury(s)

	Severe Non-Brain Injury			Mild Non Brain Injury				
Measure	**n**	**M**	**SD**	**n**	**M**	**SD**	*t*	*p*
Visual Reproduction								
VRI-I	8	5.50	2.88	12	7.50	3.61	-1.31	0.21
VRI-II	8	6.13	1.64	12	9.75	3.89	-2.87	0.01*
Recognition	7	8.57	1.13	12	11.75	2.86	-2.78	0.01*
AVLT								
Trial 1	8	3.38	1.06	12	3.67	2.06	-0.37	0.72
2	8	5.00	2.27	12	4.92	2.15	0.08	0.94
3	8	6.38	2.88	12	5.67	2.61	0.57	0.57
4	8	5.88	3.36	12	6.92	3.70	-0.64	0.53
5	8	6.13	2.10	12	7.92	3.85	-1.34	0.20[a]
Total	8	26.75	10.43	12	29.92	13.58	-0.56	0.58
Interference	8	2.38	1.85	12	3.75	1.60	-1.77	0.09
6	8	3.50	2.78	12	4.92	4.64	-0.85	0.41[a]
7	8	3.38	2.77	12	5.33	4.27	-1.14	0.27
Recognition	8	9.38	3.54	11	9.91	4.42	-0.28	0.78
COAST								
Colour	8	40.75	11.61	12	44.08	12.33	-0.61	0.55
Colour Word	8	6.13	4.22	11	7.09	3.39	-0.55	0.59
WCST-64								
TC	7	30.14	5.18	11	36.09	12.61	-1.18	0.26
TE	7	33.86	5.18	11	27.91	12.61	1.18	0.26
PR	7	26.57	15.00	11	15.27	9.74	1.95	0.07
PE	7	22.00	10.69	11	13.18	6.79	2.15	0.05
NPE	7	11.86	7.60	11	14.73	12.22	-0.55	0.59
CLR	7	19.14	6.67	11	26.27	15.43	-1.15	0.27
CC	7	1.14	0.69	11	1.55	1.21	-0.79	0.44
TIC	7	15.29	15.24	11	17.45	16.83	-0.28	0.79
FMS	6	0.50	0.84	11	0.73	1.01	-0.47	0.65
Digit Symbol Coding	7	5.71	2.43	11	9.36	3.26	-2.53	0.02*
Trail Making								
Part A	8	130.25	111.82	11	65.64	25.89	1.87	0.08
Part B	4	227.25	106.16	8	157.25	73.99	1.35	0.21

* $p < 0.05$
[a] Equal variances not assumed

Hypothesis Twelve: Normative Data

Results of the control group will not differ significantly from the normative group.

This hypothesis was rejected as the control group tended to score lower than the normative group on neuropsychological measures. Due to small sample sizes, comparisons were unable to be conducted on the WCST-64 for age groups less than 70 and age groups less than 80 on Trails and the AVLT. Tables 7.5, 7.6 and 7.7 display

normative data. As shown in Table 7.5, significant differences were seen on two Visual Reproduction subtests and Digit Symbol Coding.

Table 7.5
Comparison of Means between the Present Study and Normative Data on Visual Reproduction, WCST-64, COAST & Digit Symbol Coding

			MTBI Group				Control Group		
Measure	**Norms**	**n**	**M**	***t***	***p***	**n**	**M**	***t***	***p***
Visual Reproduction (a)									
VRI-I	10	21	6.67	-4.60	0.00*	21	6.38	-6.98	0.00*
VRI-II	10	21	8.29	-2.23	0.04*	21	7.43	-6.53	0.00*
Recognition	10	19	10.58	0.90	0.38	19	9.21	-1.78	0.09
WCST-64 (b)									
Age Group									
70-79 CC	2.6	4	1.25	-2.15	0.12	3	1.67	-1.40	0.30
TE	22.8	4	34.50	1.25	0.30	3	33.33	3.31	0.08
PR	14.8	4	16.75	0.32	0.77	3	24.00	1.05	0.40
PE	12.7	4	14.75	0.42	0.70	3	21.33	1.39	0.30
NPE	10.7	4	19.75	1.04	0.38	3	12.00	0.26	0.82
80-89 CC	2.2	14	1.43	-2.84	0.01*	14	3.21	0.60	0.56
TE	25.7	14	29.64	1.67	0.12	14	26.64	0.38	0.71
PR	20.4	14	23.57	0.70	0.50	14	20.86	0.16	0.87
PE	16.2	14	19.36	0.97	0.35	14	18.00	0.80	0.44
NPE	9.0	14	10.29	0.66	0.52	14	11.07	1.01	0.33
COAST (c)									
Colour/Word	10	20	6.80	-3.95	0.00*	20	9.30	-0.89	0.38
Digit Symbol Coding (d)	10	19	8.05	-2.53	0.02*	18	8.44	-2.28	0.04*

* $p < 0.05$
(a) From Wechsler (1997a)
(b) From Axelrod, Jiron, & Henry (1993)
Note: Age category 60-69 was not computed as there was only one participant in this category
Note: Stroop norms were used due to similarity between COAST and Stroop
(c) From Axelrod et al. (1993)
(d) From Wechsler (1997)

Table 7.6
Comparison of Means between the Present Study and Normative Data on the Trail Making Test (a)

	Norms		MTBI Group		Control Group	
Age Group	A	B	M(A)	M(B)	M(A)	M(B)
65-69	38.04	94.56	87.00 *(n=1)* #	-	56.00 *(n=1)* #	140.00 *(n=1)* #
70-74	45.04	123.69	35.00 *(n=1)* #	90.00 *(n=1)* #	67.00 *(n=1)* #	335.00 *(n=1)* #
75-79	46.78	127.13	109.67 *(n=2)* #	222.00 *(n=2)* #	45.00 *(n=3)* #	170.67 *(n=3)* #
80+	60.21	195.93	93.07 *(n=15)* p=.168 t =1.45	191.40 *(n=10)* p=.88 t= -.162	67.53 *(n=15)* p=.37 t=.90	210.07 *(n=14)* p=.75 t=.33

* $p < 0.05$
\# T-test not computed due to small numbers in group
\## T-test not computed due to unavailability of normative data for this particular age category
(a) From Siegert & Cavana (1997)

Table 7.7
Comparison of Means between the Present Study and Normative Data on the AVLT(a)

Age / *n*	Trial 1	2	3	4	5	List B	Trial 6	Trial 7	Rec
65-69									
Norm	5.70	8.60	9.70	10.60	11.20	4.70	9.10	8.30	13.30
MTBI Group *1*[#]									
x	9.00	9.00	7.00	12.00	12.00	6.00	9.00	10.00	11.00
Controls *1*[#]									
x	7.00	9.00	10.00	12.00	13.00	5.00	10.00	10.00	12.00
70-74									
Norm	5.50	7.80	9.10	10.20	10.50	4.10	8.30	7.40	12.70
MTBI Group *1*[#]									
x	5.00	7.00	10.00	10.00	13.00	4.00	13.00	13.00	14.00
Controls *1*[#]									
x	5.00	7.00	10.00	10.00	13.00	4.00	13.00	13.00	14.00
75-79									
Norm	5.00	7.00	8.20	9.20	10.10	4.20	7.80	6.90	12.50
MTBI Group									
x	3.67	7.00	8.67	8.33	8.33	4.00	4.67	6.33	12.50
Controls *3*[#]									
x	3.67	5.00	7.67	5.33	9.00	3.33	4.00	5.67	10.33
80-84									
Norm	4.40	6.50	7.70	8.60	9.00	3.50	6.70	5.50	12.30
MTBI Group *6*									
x	3.00	3.83	4.83	5.33	5.50	3.00	2.83	2.50	9.00
t	-2.43	-6.64	-3.29	-4.07	4.58	-0.87	-5.50	-2.38	-1.93
p	0.06	0.00*	0.02*	0.01*	0.01*	0.43	0.00*	0.06	0.11
Controls *6*									
x	3.50	5.00	6.00	6.67	6.17	3.67	3.67	4.50	8.00
t	-1.18	-2.91	-2.49	-1.78	-1.90	0.25	-2.03	-0.78	-2.94
p	0.29	0.03*	0.06	0.14	0.12	0.81	0.10	0.47	0.03*
85+									
Norm	4.00	6.00	7.40	7.90	9.10	3.10	6.20	5.40	12.30
MTBI Group *10*									
x	3.20	4.40	5.30	5.50	6.70	2.60	3.80	3.80	8.90
t	-3.21	-2.67	-2.87	-1.99	-2.19	-0.86	-1.80	-1.68	-2.63
p	0.01*	0.02*	0.02*	0.08	0.04*	0.41	0.11	0.13	0.03*
Controls									
x	3.20	5.20	4.40	5.50	5.40	2.10	2.90	3.60	7.30
t	-1.31	-1.10	-4.18	-2.88	-3.61	-2.08	-3.67	-1.78	-3.54
p	0.22	0.30	0.00	0.02	0.01	0.07	0.01	0.11	0.01

* $p < 0.05$
[#] T-test not computed due to small numbers in group
(a) From Ivnik, Malec, Tangalos, Kokmen & Kurland

Hypothesis Thirteen: Patient Competency Rating Scale

Compared to family members' ratings, participants in the MTBI group will rate themselves more competent on the Patient Competency Rating Scale (PCRS) compared to the ratings of family members (i.e., PCRS Relative's Form). Conversely, within group differences are not expected for the control group.

In addition to cognitive status, self reported functional ability was assessed. Due to low level response on the relative's form of the PCRS, within group comparisons were not conducted. Rather, between group (i.e., MTBI and control) comparisons were made. Table 7.8 shows results from the comparison on the PCRS between the MTBI and control groups. The MTBI group scored lower than the control group on 25 of the 30 items from the PCRS (although only three of these (laundry, scheduling daily activities, understanding new instructions) reached a significant level).

Table 7.8

Comparison on PCRS Between MTBI Group and Controls

Item	MTBI Group (n = 21) M	SD	Control Group (n = 21) M	SD	*t*	*p*
Activities of Daily Living						
1	4.10	1.09	4.57	1.08	-1.42	0.16
2	4.57	0.68	4.62	0.87	-0.20	0.84
3	4.62	0.67	4.71	0.72	-0.45	0.66
4	4.29	1.10	4.81	0.93	-1.67	0.10
5	4.05	1.40	4.81	0.93	-2.08	0.05[a]*
6	4.19	1.17	4.57	1.03	-1.12	0.27
14	2.67	1.93	2.52	1.81	0.25	0.81
26	4.57	0.68	4.86	0.36	-1.71	0.10[a]
Interpersonal						
8	4.00	0.89	4.33	0.80	-1.28	0.21
15	3.95	1.02	4.48	0.75	-1.89	0.07
17	4.38	0.92	4.29	0.78	0.36	0.72
20	4.71	0.56	4.71	0.56	0.00	1.00
21	3.95	1.12	4.33	0.73	-1.31	0.20
22	3.57	1.40	4.19	0.87	-1.72	0.10[a]
23	4.05	0.97	4.52	0.60	-1.91	0.06
Cognitive						
7	4.71	0.46	4.81	0.40	-0.71	0.48
9	3.81	1.08	4.14	0.48	-1.30	0.21[a]
10	3.71	1.15	4.19	0.87	-1.51	0.14
11	3.57	1.17	3.71	1.06	-0.42	0.68
12	4.43	0.98	4.48	0.81	-0.17	0.87
13	4.14	0.96	4.38	0.81	-0.87	0.39
24	4.19	0.93	4.86	0.36	-3.07	0.01[a]*
25	3.86	1.01	4.43	0.68	-2.15	0.04*
Emotional						
16	4.14	1.06	4.33	0.73	-0.68	0.50[a]
18	3.67	1.11	4.14	0.79	-1.60	0.12[a]
19	4.24	1.00	4.71	0.56	-1.91	0.07[a]
27	4.29	0.90	4.29	0.78	0.00	1.00
28	4.19	0.68	4.00	0.89	0.78	0.44
29	4.38	0.81	4.62	0.59	-1.09	0.28[a]
30	4.38	1.12	4.67	0.58	-1.041	0.30

* $p < 0.05$

[a] Equal variances not assumed

POST HOC RESULTS

Diagnosis of Orthopaedic / Non-Orthopaedic Injury of Participants Reporting Post-Concussive Symptoms

Figure 7.6 is a revised version of Figure 7.5 which compared the number of MTBI participants diagnosed with a TBI according to whether they had sustained orthopaedic versus non-orthopaedic injuries. Another analysis was conducted which only included participants who reported post-concussive symptoms. It was considered that individuals who had sustained a fall which met criteria for a MTBI, and, who concurrently reported concussive symptoms would be more likely to have their MTBI detected. Of the five participants who met criteria for a MTBI and reported concussive symptoms, one (20%) had been diagnosed as having sustained a TBI. Conversely, three of the eight participants (37.5%) admitted for non-orthopaedic injuries were diagnosed.

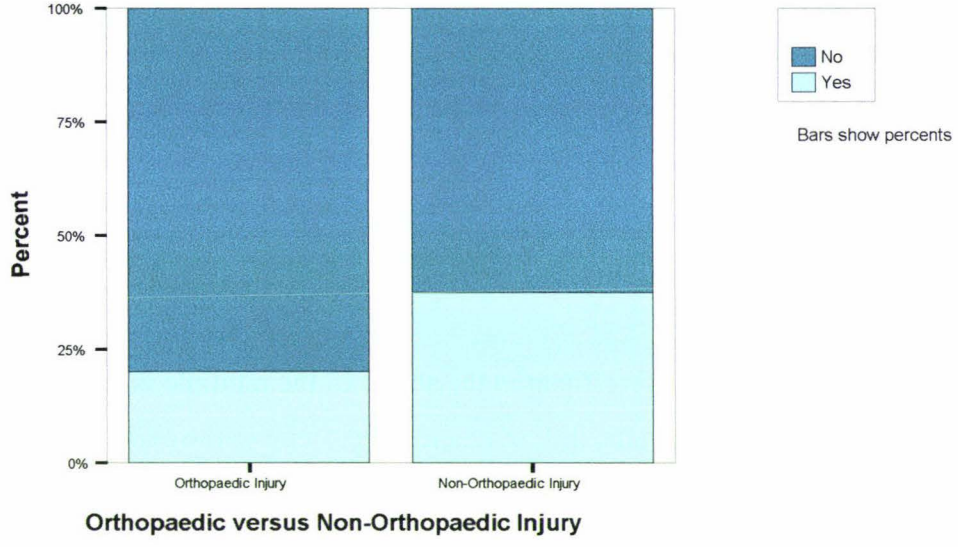

Figure 7.6. Diagnosis of hospitalised orthopaedic and non-orthopaedic injuries reporting post-concussive symptoms

MTBI Group - Fall Frequency

Whilst participants within the MTBI group had given a detailed account of a fall which met criteria for a MTBI, many expressed uncertainty surrounding symptoms sustained in subsequent and prior falls. Many of these falls involved substantial knocks to the head. Accordingly, whilst these falls did not meet criteria for a MTBI, they may have resulted in neuropsychological impairment. Accordingly, a comparison between participants who had sustained multiple falls and those who had sustained only a single fall was conducted. Multiple falls were categorised as those cases in which more than

three falls had been sustained. Of those sustaining multiple falls, one had fallen in the last three weeks, three during the last six months and three more than a year ago. Within the single fall group, one had fallen in the last three weeks, two during the last twelve months and two more than a year ago. Table 7.9 presents data for these analyses.

Memory

Analysis indicated significant differences between groups; the multiple fallers' group recalled and recognised fewer designs from all three Visual Reproduction subtests and recalled less words on the RAVLT. Whilst the multiple group recalled fewer words on Trial 1 and recognised fewer words on Recognition of the RAVLT, these differences were not significant.

Attention and Information Processing

Multiple and single fallers differed significantly on the COAST colour-word task with the single group less likely to react to the colour/word discrepancy. Whilst the multiple group took twice as long to complete Trails A, this difference was not significant. The single group also processed information significantly faster on the Digit Symbol sub-test.

Executive Functioning

Again, analysis of Trails B overestimated the ability of the multiple group because only individuals who could perform the task were included; three of the eight multiple (37.5%) participants compared to three of the five (60.0%) single group could complete the measure. When the multiple group did complete this measure however, they took longer than the single group to complete the task. Although the single group were more likely to infer conceptual relationships on the WCST, these differences were non-significant.

Table 7.9

Comparison of MTBI Group on Neuropsychological Measures According to Fall Frequency

	Multiple Falls			Single Fall				
Measure	**n**	**M**	**SD**	**n**	**M**	**SD**	***t***	***p***
Visual Reproduction								
VRI-I	8	4.13	1.13	5	10.20	2.86	-5.48	0.00*
VRI-II	8	6.00	0.93	5	12.60	3.72	-4.91	0.00*
Recognition	7	9.43	1.10	4	13.75	3.30	-2.75	0.02*
AVLT								
Trial 1	8	3.00	0.76	5	4.60	2.88	-1.53	0.16
2	8	3.63	1.69	5	6.40	1.67	-2.90	0.02*
3	8	4.13	2.42	5	7.20	1.64	-2.49	0.03*
4	8	4.63	1.69	5	9.20	3.70	-3.08	0.01*
5	8	4.63	1.41	5	9.60	4.28	-3.10	0.01*
Total	8	20.00	6.76	5	37.00	12.08	-2.88	0.03[a]*
Interference	8	2.13	0.99	5	4.20	1.79	-2.72	0.02*
6	8	2.25	2.38	5	7.60	4.51	-2.83	0.02*
7	8	1.63	1.92	5	7.00	4.74	-2.91	0.01*
Recognition	8	8.13	4.58	5	10.80	3.42	-1.12	0.29
COAST								
Colour	8	43.00	10.45	5	43.00	9.59	0.00	1.00
Colour Word	8	5.25	3.15	4	8.75	1.26	-3.48	0.01*
WCST-64								
TC	7	33.71	9.11	5	36.60	15.76	-0.40	0.70
TE	7	30.29	9.11	5	27.40	15.76	0.40	0.70
PR	7	25.43	17.79	5	20.20	22.73	0.45	0.66
PE	7	20.86	12.47	5	17.00	16.69	0.46	0.66
NPE	7	9.43	9.57	5	10.40	8.44	-0.18	0.86
CLR	7	23.86	11.28	5	24.80	21.70	-0.10	0.92
CC	7	1.71	1.11	5	1.20	1.30	0.74	0.48
TIC	7	17.57	16.64	5	6.60	6.07	1.39	0.19
FMS	7	0.29	0.49	5	1.00	1.41	-1.26	0.24
Digit Symbol Coding	7	6.57	3.16	5	10.40	1.67	-2.46	0.03*
Trail Making								
Part A	7	121.71	124.73	5	61.00	23.48	1.06	0.31
Part B	3	220.00	101.53	3	167.33	100.55	0.64	0.56

* $p < 0.05$
[a] Equal variances not assumed

MTBI Group – Predictive ability of Fall Frequency / Severity of Non-Brain Injury / Time since Injury on Neuropsychological Performance

Whilst significant differences on a number of neuropsychological measures had been found between those sustaining multiple versus single falls, and, those sustaining severe versus mild non-brain injuries, there was considerable overlap between these two groups (five of the eight participants who had sustained multiple falls had also sustained

a severe non-brain injury). As such, it was unknown whether fall frequency or severity of non-brain injury explained these differences. Additionally, both of these variables could be explained by time since injury, as it was not possible to hold this variable constant.

Accordingly, a multiple regression was constructed with fall frequency and severity of non-brain injury as independent variables. In order to assess for the effects of time since injury, the independent variable of whether a fall had been sustained in the last year was included. The results of the stepwise regression for participants meeting criteria for MTBI with the neuropsychological measures serving as the dependent variable are presented in Table 7.10.

The first dependent variable selected was RAVLT total score (Trials 1-5). Fall frequency explained 19% of the variance in RAVLT total score and was highly significant ($F[1,19] = 5.55$, $p<0.05$). This variable was retained in the model. Neither of the other two variables added to the predictive power of the model. The independent variables of age and gender were then added. These three independent variables together explained 49% of the variance in RAVLT total score, being highly significant ($F[3,17] = 7.30$, $p<0.05$).

Finally, an interaction effect was added to the model for the number of falls and age. This resulted in a further increment in R^2 (0.72, $p<0.001$). Together, these four independent variables (fall frequency, age, gender and the interaction effect) explained 72% of the variance on the RAVLT total score, which was highly significant ($F[4,16] = 14.05$, $p<0.001$).

This model with age, gender, number of falls and an interaction between age and number of falls as independent variables formed the base model for the analysis of the remainder of the neuropsychological measures. The resulting models were significant for all trials of the RAVLT with the exception of the interference list and trial 6. A significant model also resulted for Visual Reproduction II (both measures being representative of the cognitive domain of memory). Models for all other measures were not significant. Assessment of data for violation of multiple regression assumptions is outlined in Appendix VIII (see page 181).

Table 7.10
MTBI Group – Predictive ability of Fall Frequency / Severity of Non-Brain Injury / Time since Injury on Neuropsychological Performance

Measure	Standardised Coefficients (Beta)	*p*	Model Summary[a] Adjusted R^2	*p*
Visual Reproduction				
VRI-I			0.23	0.12
Fall Frequency	1.43	0.85		
Age	0.08	0.66		
Gender	0.09	0.67		
Interaction (Fall frequency & age)	1.48	0.79		
VRI-II			0.52	0.00**
Fall Frequency	-6.47	0.01*		
Age	-0.93	0.02*		
Gender	0.27	0.11		
Interaction (Fall frequency & age)	6.02	0.02*		
Recognition			0.02	0.40
Fall Frequency	-2.55	0.48		
Age	-0.12	0.83		
Gender	0.24	0.34		
Interaction (Fall frequency & age)	2.21	0.55		
AVLT				
Trial 1			0.68	0.00**
Fall Frequency	-7.60	0.00**		
Age	-1.44	0.00**		
Gender	0.52	0.00**		
Interaction (Fall frequency & age)	7.52	0.00**		
Trial 2			0.38	0.02*
Fall Frequency	-3.77	0.04*		
Age	-0.85	0.04*		
Gender	0.40	0.18		
Interaction (Fall frequency & age)	3.47	0.22		
Trial 3			0.69	0.00**
Fall Frequency	-8.64	0.00**		
Age	-1.57	0.00**		
Gender	0.29	0.03*		
Interaction (Fall frequency & age)	8.51	0.00**		
Trial 4			0.39	0.02*
Fall Frequency	-5.86	0.04*		
Age	-1.07	0.01*		
Gender	0.27	0.15		
Interaction (Fall frequency & age)	5.60	0.06		
Trial 5			0.75	0.00**
Fall Frequency	-8.72	0.00**		
Age	-1.58	0.00**		
Gender	0.35	0.00**		
Interaction (Fall frequency & age)	8.57	0.00**		
Total			0.72	0.00**
Fall Frequency	-7.40	0.00**		
Age	-1.43	0.00**		
Gender	0.40	0.00**		
Interaction (Fall frequency & age)	7.19	0.00**		

Measure	Standardised Coefficients (Beta)	*p*	Model Summary[a] Adjusted R^2	*p*
Interference			0.29	0.65
Fall Frequency	0.44	0.32		
Age	-0.70	0.82		
Gender	-0.12	0.54		
Interaction (Fall frequency & age)	0.58	-0.86		
Trial 6			0.25	0.07
Fall Frequency	-4.93	0.11		
Age	-0.93	0.05		
Gender	0.18	0.37		
Interaction (Fall frequency & age)	4.68	0.14		
Trial 7			0.80	0.00**
Fall Frequency	-9.73	0.00**		
Age	-1.71	0.00**		
Gender	0.23	0.03**		
Interaction (Fall frequency & age)	9.61	0.00**		
Recognition			-0.11	0.72
Fall Frequency	-3.09	0.39		
Age	-0.70	0.20		
Gender	0.19	0.43		
Interaction (Fall frequency & age)	2.99	0.42		
COAST				
Colour Task			-0.24	0.99
Fall Frequency	0.47	0.90		
Age	0.01	0.98		
Gender	0.08	0.76		
Interaction (Fall frequency & age)	-0.51	0.90		
Colour Word Task			0.07	0.29
Fall Frequency	-5.74	0.11		
Age	-0.86	0.10		
Gender	-0.02	0.92		
Interaction (Fall frequency & age)	5.60	0.12		
WCST-64				
TC			-0.09	0.64
Fall Frequency	-5.30	0.18		
Age	-0.32	0.56		
Gender	-0.10	0.69		
Interaction (Fall frequency & age)	5.53	0.19		
TE			-0.09	0.64
Fall Frequency	5.30	0.18		
Age	0.32	0.56		
Gender	0.10	0.69		
Interaction (Fall frequency & age)	5.53	0.19		
PR			-0.24	0.91
Fall Frequency	0.51	0.39		
Age	1.74	0.67		
Gender	0.01	0.97		
Interaction (Fall frequency & age)	-1.90	0.66		
PE			-0.23	0.89
Fall Frequency	0.53	0.37		
Age	1.91	0.64		
Gender	0.02	0.93		
Interaction (Fall frequency & age)	-2.09	0.63		

Measure	Standardised Coefficients (Beta)	*P*	Model Summary[a] Adjusted R^2	*p*
NPE			0.08	0.32
Fall Frequency	3.51	0.32		
Age	-0.23	0.65		
Gender	0.08	0.73		
Interaction (Fall frequency & age)	-3.57	0.35		
CLR			-0.10	0.66
Fall Frequency	-4.46	0.27		
Age	-0.28	0.64		
Gender	-0.03	0.90		
Interaction (Fall frequency & age)	4.75	0.27		
CC			0.07	0.33
Fall Frequency	-4.69	0.52		
Age	-0.35	0.22		
Gender	0.01	0.98		
Interaction (Fall frequency & age)	5.21	0.21		
T1C			0.46	0.18
Fall Frequency	0.53	0.19		
Age	8.90	0.01*		
Gender	0.36	0.84		
Interaction (Fall frequency & age)	8.86	0.01*		
FMS			0.13	0.87
Fall Frequency	-1.97	0.66		
Age	-0.02	0.98		
Gender	-0.09	0.74		
Interaction (Fall frequency & age)	1.79	0.71		
Digit Symbol Coding			-0.14	0.77
Fall Frequency	-1.71	0.66		
Age	-0.07	0.90		
Gender	0.03	0.92		
Interaction (Fall frequency & age)	1.43	0.72		
Trail Making				
Part A			0.07	0.30
Fall Frequency	6.64	0.07		
Age	0.87	0.10		
Gender	0.03	0.88		
Interaction (Fall frequency & age)	-6.56	0.08		
Part B			-0.32	0.88
Fall Frequency	-1.73	-0.35		
Age	-0.06	-0.08		
Gender	-0.28	-0.86		
Interaction (Fall frequency & age)	1.83	0.36		

[a] Predictors: Interaction (fall frequency and age), gender, age, fall frequency

* $p < 0.05$

** $p < 0.01$

Comparison of MTBI Group according to Fall Frequency on the PCRS

Table 7.11 is a revised version of Table 7.8 which compared the MTBI and Control Groups on the Patient Competency Rating Scale. As analysis had revealed the variable of fall frequency served to discriminate within the MTBI group, another analysis was conducted which compared participants' ratings on the PCRS according to fall frequency. The multiple falls group scored lower than the single fall group on 28 of the 30 items from the PCRS, with 11 of these items reaching a significant level.

Table 7.11
Comparison of MTBI Group according to Fall Frequency on the PCRS

	Multiple Falls (n = 8)		Single Fall (n = 5)			
Item	**M**	**SD**	**M**	**SD**	*t*	*p*
Activities of Daily Living						
1	3.75	1.18	4.40	0.89	-1.06	0.31
2	4.13	0.84	5.00	0.00	-2.97	0.02[a]*
3	4.25	0.77	4.60	0.89	-0.79	0.45
4	3.63	1.42	4.80	0.45	-1.78	0.10
5	3.13	1.55	4.40	1.34	-1.51	0.16
6	4.13	1.36	4.80	0.45	-1.06	0.31
14	2.13	1.81	3.40	2.19	-1.14	0.28
26	4.00	0.76	5.00	0.00	-2.91	0.01*
Interpersonal						
8	3.75	0.71	4.60	0.55	-2.28	0.04*
15	3.63	1.06	4.00	1.00	-0.63	0.54
17	4.00	1.20	4.40	0.55	-0.705	0.50
20	4.50	0.76	4.80	0.45	-0.80	0.44
21	3.25	0.89	4.60	0.89	-2.66	0.02*
22	2.75	1.39	4.40	0.89	-2.35	0.04*
23	3.25	1.04	4.40	0.55	-2.27	0.04*
Cognitive						
7	4.50	0.54	5.00	0.00	-2.65	0.03[a]*
9	3.00	0.76	4.20	1.30	-2.12	0.05
10	2.88	0.64	4.60	0.55	-4.97	0.00**
11	3.25	1.28	4.00	1.23	-1.04	0.32
12	3.75	1.28	4.80	0.45	-1.74	0.11
13	3.63	1.06	4.60	0.89	-1.70	0.12
24	3.88	0.84	4.80	0.45	-2.26	0.04*
25	3.13	0.84	4.60	0.89	-3.02	0.01*
Emotional						
16	3.38	1.19	4.20	0.85	-1.35	0.21
18	2.88	1.13	4.40	0.55	-2.80	0.01*
19	4.00	1.20	4.60	0.89	-0.96	0.36
27	4.13	0.99	4.80	0.45	-1.67	0.12[a]
28	4.25	0.71	3.80	0.84	1.04	0.32
29	4.13	0.84	4.40	0.89	-0.56	0.59
30	4.63	0.74	4.00	1.73	0.91	0.39

* $p < 0.05$
** $p < 0.01$
[a] Equal variances not assumed

Revised Trail Making Test

Table 7.12 is a revised version of Table 7.3 (limited to the Trail Making Test - B) which compared the MTBI and control groups on neuropsychological measures. Whilst the MTBI group completed Trails B quicker than the control group, they were also less likely to complete this measure. Another analysis was conducted which assigned the longest time taken to complete Trails B to those participants who either did not complete this measure or did not have it administered due to difficulty responding to the Trails B sample. Results are shown in Table 7.12. Adopting this methodology indicated that although the MTBI would take longer than the Control Group to complete Trails B, such difference would be no more than could be expected by chance.

Table 7.12
Comparison of MTBI and Control Groups on the Trail Making Test – Part B

	Possible MTBI			Control				
Measure	**n**	**M**	**SD**	**n**	**M**	**SD**	***t***	***p***
Trail Making Test Part B	21	354.67	227.92	21	246.57	183.94	1.69	0.10[a]

* $p < 0.05$
[a] Equal variances not assumed

Normative Data

Table 7.13 is a revised version of Table 7.5 (limited to Visual Reproduction I & II & Digit Symbol Coding). It was hypothesised that the control group's data unexpected deviation from the normative sample on these measures could be attributable to the inclusion of nursing home residents in the sample (conversely the normative group did not reflect this population). As indicated in Table 7.13, analysis of retirement village participants only, revealed no significant differences between the two groups on Digit Symbol Coding. For Visual Reproduction I & II, the control group did perform significantly lower than the normative sample.

Whilst the control group also differed significantly from the normative sample on various subtests of the AVLT, analysis of nursing home and retirement village participants on these subtests could not be established due to small numbers.

Table 7.13
Comparison of Means between Retirement Village and Nursing Home Participants on Visual Reproduction I & II and Digit Symbol Coding

		MTBI Group				Control Group			
Measure	**Norms**	**n**	**M**	***t***	***p***	**n**	**M**	***t***	***p***
Visual Reproduction (a)									
Retirement Village									
VRI-I	10	10	8.20	-1.59	0.15	10	6.4	-4.20	0.00*
VRI-II	10	10	9.70	-0.23	0.82	10	7.20	-4.33	0.00*
Nursing Home									
VRI-I	10	11	5.27	-6.39	0.00*	11	6.36	-5.59	0.00*
VRI-II	10	11	7.00	-4.01	0.00*	11	7.64	-4.81	0.00*
Digit Symbol Coding (b)									
Retirement Village	10	10	9.30	-0.79	0.45	9	9.00	-0.81	0.44
Nursing Home	10	9	6.67	-2.83	0.02*	9	7.89	-3.46	0.01*

* $p < 0.05$
(a) From Wechsler (1997a)
(b) From Wechsler (1997)

CHAPTER 9

DISCUSSION

PART ONE: EPIDEMIOLOGY / AETIOLOGY

Fall Incidence Rates

Falls sustained by nursing home participants during the last year (41.9%) was marginally higher than that reported by Tinetti et al. (1986) (30-40%). This slight variance is attributable to the higher rate of falls reported from residents of The Masonic (46.5%) due to this establishment's provision for a higher percentage of residents requiring increased nursing support.

Retirement village participants reporting falling during the last year (26.5%) was comparable to the approximate one third reported by Kannus et al. (1999) and Tinetti (1987).

The number of falls sustained by participants during the past five years was variable; participants were as likely to report sustaining one fall as they were multiple falls. The most common cause of falling was tripping with bruising being the most common injury resultant of falling.

Findings indicated that approximately 2.3% of falls result in TBI each year. This figure may be underestimated as a value of four was ascribed when participants indicated they had sustained more than three falls. This conservative figure was employed due the large number of participants who could not recall exactly how many falls they had sustained.

MTBI Incidence Rate

The annual incidence rate for the current study (2,449 per 100,000) was much greater than that reported by Sosin et al. (1996) (519 per 100,000). Such a deviance was expected due to methodological differences. Sosin et al. (1996) required stricter inclusion criteria (i.e., loss of consciousness) whilst the current study included cases of disturbed neurological function other than loss of consciousness (as MTBI can occur irrespective of this variable). The current study's figures also appear higher than New

Zealand research by Wrightson & Gronwall (1998) which reported an incidence rate of 654 per 100,000.

In attempting to reconcile data from this study with that of Sosin et al. (1996); analysis limited to cases involving a loss of consciousness reduced the incidence rate (816 per 100,000). Whilst this incidence rate still remains higher than that reported by Sosin et al. (1996) or that of Wrightson & Gronwall (1998) (654 per 100,000), both studies are reflective of all ages whilst the current study is restricted to age 65 and over. Epidemiological research reveals a bimodal peak incidence of TBI for individuals aged 15-24 and 65+ (Frankowski, Jagger, Kraus, 1984; Kraus, 1987). A higher incidence rate would be expected from a study focussing exclusively on one of these areas.

In terms of incidence rates increasing with age, results indicated that whilst the incidence rate for the 85+ category (4%) was higher than that of the 75-84 year age category (2.6%), this was not higher than the 65-74 years of age category (3.2%). Conversely, a multitude of research indicates incidence rates for TBI increase with age. Such discrepancy is likely a function of the low number of participants in this lower age category. Indeed combining the two lowest categories (65-74 and 75-84) produced a lower incidence rate (2.2%) than that of the 85+ age category.

Severity of TBI

The proportion of TBIs classified as mild was slightly higher (92.5%) than the expected range reported in previous research (Culotta et al., 1996). This is largely attributable to the cited study requiring loss of consciousness as criteria for MTBI. In comparison, the current study adopted a definition of MTBI which only required a disturbance of neurological function. Such methodology resulted in a number of fall induced injuries meeting criteria for a MTBI in the current study that would not have done so in the cited research. Indeed, adoption of such stricter criteria produced a lower proportion of mild injuries (78.6%), which was more in line with previous research.

Seeking of Medical Attention

The percentage of participants who had not sought medical attention (10.8%) was considerably lower than the 20-40% reported by Jennett (1996) or the 25% reported by Sosin et al. (1996). Analysis revealed those not seeking medical attention were from retirement villages. In attempting to explain this variation from existing research, both the above studies represented household data whereas the current study represented

nursing homes and retirement villages. Protocol across the three nursing homes dictated that all fall incidents resulting in an altered state required medical intervention. Whilst this was not the case for retirement village participants, it could be that the proximity and the availability of medical amenities within the attached nursing home meant retirement village residents were more likely to seek treatment in the event of a fall related injury.

Diagnosis of Orthopaedic versus non-Orthopaedic Injuries

Results are in accordance with research by Gronwall & Wrightson (1999) which suggests that a significant number of individuals treated for orthopaedic injuries sustain concurrent TBIs that are not diagnosed. Findings from the current research indicated that although participants with orthopaedic injuries met clinical criteria for MTBI, they appeared less likely to receive a diagnosis of MTBI (18.1%) than those with non-orthopaedic injuries (40%). Analysis including only participants who reported post-concussive symptoms revealed orthopaedic patients were still less likely to be diagnosed (20%) than non-orthopaedic patients (37.5%). In interpreting this finding, it could be that the presence of overt orthopaedic injuries obscured detection of more subtle forms of injury such as MTBI, and/or, their symptomology was blurred by the effects of analgesia or anaesthesia or was misattributed to other comorbid cognitive or medical problems.

Analysis according to the type of brain injury sustained revealed that injuries were in line with that reported by Kraus (1984) and the Ministry of Health (New Zealand Health Information Service Morbidity Data 1998/1999); most injuries resulted in concussions (66%).

Post-Concussive Symptoms

Whilst the MTBI group reported more difficulty than the control group on the majority of items, such differences were not significant. Such lack of significance could be due to data collection methodology. As the symptom list was at the end of the questionnaire, and as many participants were becoming fatigued, the symptoms were read aloud. A simple yes/no dichotomy was adopted rather than the original five point rating scale. In effect this may have potentially reduced the variability between groups and could explain the lack of significant findings.

PART TWO: NEUROPSYCHOLOGICAL MEASURES

Results indicate that MTBI in older adults produces cognitive deficits in the domain of attention. The first study assessing the cognitive status of older adults (Mazzucchi et al, 1992) reported that approximately 50% of participants exhibited generalised deterioration. A comparison of the neurobehavioural performance of participants with controls found them impaired on measures of language, memory and reasoning (Goldstein et al., 1994). A subsequent study by this same group confirmed language and memory deficits (Goldstein et al., 1996). Another study found deficits in fluency, memory and reasoning (Aharon-Peretz et al., 1997). The current study did not support the existing literature. Methodological differences between the two studies make it difficult to draw conclusions. Whilst two of the studies (Goldstein et al., 1994; Goldstein et al., 1996) included moderate TBI, the third (Aharon-Peretz et al., 1997) encompassed all severities of TBI. Accordingly, it is unclear just how these previous findings apply to MTBI alone. Secondly, the above studies were conducted within a six week to seven month period post injury whilst the current study assessed injury up to five years post injury. The only study which assessed the long-term (two years post injury) cognitive performance of older adults post injury due to falling (Luukinen et al., 1999) also reported that MTBI did not lead to increased risk for cognitive decline. However, comparison with this study is also limited as cognitive functioning was assessed broadly via the shortened version of the Mini-Mental Status Examination, whilst the current study focuses on specific cognitive domains.

Reported significant differences between groups within the domain of attention are in direct contrast to both the Goldstein et al. (1994) and Aharon-Peretz et al. (1997) studies which did not find significant differences. However, these findings are in line with generic MTBI research which suggests reductions in attentional capacity at three months (Binder et al., 1997; Bohnen et al., 1992), five months (Gentilini et al., 1989), two years (Raskin et al., 1998), and up to six years (Bernstein et al., 1996) post injury.

Whilst significant differences were not found for any of the measures within the domain of executive functioning, clinical observation of Trails B revealed that the MTBI participants were less likely to complete this test. Had the MTBI completed Trails B, they may have been slower than the control group. Whilst, the WCST-64 did not serve to discriminate between groups, a number of participants across the study expressed difficulty in clearly identifying the colour yellow. It could be that

concentrating on the clarity of the yellow stimuli distracted from the overall aim of the measure.

Subsequent analysis within the MTBI group according to severity of non-brain injuries revealed significant differences within memory and information processing speed domains, with the severe non-brain injury group scoring lower on neuropsychological measures than the mild non-brain injury group. While these trends were also seen on measures of attention and executive functioning, the differences were not significant. These results support the preliminary research by Fields & Coffey (1994) which highlighted the role of non-brain injuries in MTBI outcome.

Post hoc analysis within the MTBI group according to fall frequency revealed significant differences within the domains of memory (verbal and visual) and attention, with participants who sustained multiple falls scoring lower on neuropsychological measures than participants who sustained a single fall. Whilst significant differences were not found within the domain of executive functioning, participants sustaining multiple falls took longer to complete Trails B and performed at a lower level overall on the Wisconsin than those sustaining a single fall. Significant differences were also found for digit span, a measure of information processing speed. These findings are particularly interesting considering that whilst many of these falls resulted in the head being hit, did not meet criteria for a MTBI[4]. This finding lends indirect support to the existing literature on the cumulative effects of head injury (Gronwall & Wrightson, 1974; Richardson, 2000).

Whilst analysis to this point indicated both severity of non-brain injury and fall frequency served to differentiate participants within the MTBI group, subsequent analysis revealed that only fall frequency predicted neuropsychological performance[5]. There was no evidence to suggest that severity of non-brain injuries was a predictor of neuropsychological performance. This suggests that the positive findings in respect to severity of non-brain injuries were attributable to the considerable overlap of participants who had sustained both multiple falls and severe non-brain injuries. Similarly, there was no evidence to suggest that time since injury was a predictor of

[4] With the exception of one individual, all participants only sustained a single MTBI – all other falls did not meet criteria for a MTBI as outlined in the results section

category. However incidences of other falls failed to meet this criterion.

[5] For memory domain only (Visual Reproduction II and various subtests of the RAVLT)

performance on any of the neuropsychological measures.

Further analysis revealed age and gender also served to predict neuropsychological performance[5]; the older the participant and/or if they were of female gender, the lower their score on the neuropsychological measures[5]. Whilst the significance of age as a predictor tends to support the limited research that older adults experience a more negative outcome as a result of TBI than younger adults (Fields et al., 1993; Fields & Coffey, 1994a; Klein et al., 1996; Raskin et al., 1998), such statement needs to be interpreted with caution. These studies typically compared younger (< 50) with older (> 50) adults, limiting generalisation to the current study (which had a mean age of 92). Furthermore, research has indicated that when the effects of age are controlled by converting raw scores to age based percentile scores, neuropsychological performance between older and younger adults is not significantly different (Fields, 1997). As the majority of the significant findings within the current study were within a measure which utilised raw scores (RAVLT), the predictive role of age could have been insignificant if this variable were controlled. Finally, whilst gender served as a significant predictor, current research indicates that gender differences are not present in older adults (Fields & Coffey, 1994; Jennett, 1996; Naugle, 1990). Considering that the female lifespan tends to surpass that of males (i.e., that female participants are more likely to be old older adults), the inclusion of gender in this model is quite likely a function of age.

A final analysis revealed an interaction effect between fall frequency and age; the older the participant and the more falls they sustained, the lower their scores on the neuropsychological measures[5]. This would suggest that the impact of multiple falls is far more consequential in old older adults. Of particular concern for this select group of older adults, is that the effect of multiple falls, irrespective of whether they meet criteria for a MTBI, are associated with cognitive dysfunction.

Normative Data

As expected, the MTBI group scored significantly lower than the normative sample on Visual Reproduction I & II, COAST, Digit Symbol Coding and various subtests within the AVLT. However, such differences were also evident for the control group (with the exception of the COAST). Whilst is was hypothesised that this unexpected deviation could be attributable to the current study's inclusion of nursing home residents, analysis of these measures according to origin of sample (nursing home

/ retirement village) produced mixed results. Whilst inclusion of nursing home residents could explain the control group's deviation from the normative group on Digit Symbol Coding, this was not the case for Visual Reproduction I & II; retirement village participants were as likely as nursing home participants to perform significantly lower than the normative sample.

Whilst neither nursing home nor retirement village groups differed from the normative sample on the WCST-64, Trails or various subtests of the AVLT, such findings need to be interpreted with caution. Comparison of the current sample with the normative group was difficult as these measures had not been standardised. This resulted in data being analysed according to varying age categories which subsequently produced low numbers in each category. Lack of significant differences between groups on the above measures could be attributable to low numbers in each age category.

Patient Competency Rating Scale

Analysis of the PCRS indicated that although the MTBI group scored lower overall than controls, significant results were no more than what might have been found by chance. Post hoc analysis of the MTBI group according to fall frequency revealed significant differences on approximately one third of items (these differences were largely apparent within the cognitive and interpersonal categories). Similarly, inspection of the post-concussive symptom checklist from the questionnaire indicated that whilst all participants who had sustained multiple falls reported the continuance of symptoms post injury, only one participant who had sustained a single fall reported problems. Whilst it could be that this particular subset of the MTBI group (i.e., those sustaining multiple falls) had some insight into their level of functioning, it could also be that this particular group are more prone to a negative recall.

Suggestions for Future Research

More research is required on geriatric TBI. Within the realms of this research, a focus on MTBI and the long term implications of MTBI are paramount. A study is needed which compares younger and older adults on premorbid functioning to establish whether TBI produces similar cognitive dysfunction across the age spectrum. Also required is a comparison on neuropsychological performance of "older" and "old older" adults to assess the differential impact of TBI at this upper end of the age continuum.

Universal consensus of an appropriate definition of MTBI needs to be adopted. Such a definition needs to acknowledge MTBI irrespective of loss of consciousness.

MTBI research should incorporate cases of MTBI that are not treated in hospitals or emergency departments. These cases constitute a significant proportion of MTBIs and should be acknowledged accordingly.

Direct findings from the current study also offer suggestions for future research. Whilst Trails B tended to discriminate between the MTBI group and controls, this indice could not be explored as data was not available for all participants. This measure could be explored as a potential discriminator in future research. Future studies involving either the COAST or WCST-64 with older adults will need to consider upgrading the current colour range to reflect the visual limitations of an older population.

Additionally, while the above study revealed no evidence that time since injury was a predictor of performance on the neuropsychological measures, this variable was only assessed broadly via occurrence of the injury within a twelve month period. Future research should incorporate a more conservative time frame of approximately six months.

Finally, whilst this study highlighted the cumulative effects of falling, it remains unknown whether the falls were subsequent or prior to the MTBI. Future research should address this relationship to ascertain if fall induced MTBIs lead to subsequent falls.

Limitations

An important methodological limitation within the current study is its concentration on MTBI attributable to falls only. Falls are estimated to constitute approximately 70% of MTBI cases, with the remaining 30% being attributable to other causes (e.g., pedestrian accidents and motor vehicle collisions). Whilst this initially suggests incidence rates reported in the current study are conservative, considering that with advancing age TBIs are more likely to occur as a result of falls and less likely to occur as a result of motor vehicle collisions (Naugle, 1990), the reported incidence rate may not be particularly conservative.

Due to the retrospective nature of the study, it is difficult to be certain that falls are representative of the five year period. Whilst every attempt was made to ensure all

falls were inclusive of this particular time period, many participants expressed uncertainty on this variable.

A further methodological limitation is recall bias; those participants who recalled a fall meeting criteria for a MTBI may have exaggerated symptoms (i.e., loss of consciousness, post-traumatic amnesia or alteration in mental state). Such phenomenon is a common limitation of the self report methodology and may have resulted in an overestimation of the incidence rate for MTBI and could also explain the lack of significant findings when comparing the neuropsychological performance of the MTBI group with controls.

Whilst participants were matched on age, attempts to match demographic variables including gender, ethnicity and level of education were not successful. Additionally, participants were representative of nursing homes and retirement villages. Accordingly, generalising to the general population may be limited.

Finally, due to administration problems, the Patient Competency Rating Scale (PCRS) was not administered in the likert scale fashion intended. Rather a yes/no dichotomy was adopted. This effectively reduced any real differences between groups and could explain the lack of significant differences between the MTBI and control groups.

Summary and Conclusions

In summary, the results from this study suggest that outcome post MTBI is associated with long term cognitive sequelae and is influenced by the effects of fall frequency and age. Individuals who have sustained a MTBI with a history of multiple falls who appear at the upper spectrum of the over 65 years of age category constitute a subset of MTBI suffers who are at increased risk of cognitive dysfunction post injury. Classification of a MTBI in adults aged over 65 should take fall history into consideration, and, it may be that cases of MTBI accompanied by multiple falls be more correctly classified as of moderate severity. Replication is encouraged with a larger sample to assess the interaction between fall frequency and age with the effect of time since injury.

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APPENDICES

APPENDIX I. INFORMATION SHEETS AND CONSENT FORMS

Minor methodological differences in approaching Nursing Homes and Retirement Village participants for participants in Part two (e.g., telephone contact) resulted in separate information sheets being prepared for these two groups. All forms are presented at 80% of their actual size.

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INFORMATION SHEET FOR PARTICIPANTS
(Part One)

Incidence of falls and subsequent injury

You are being asked to participate in a research study about falls and the outcome of falling. We are interested in talking to people regardless of whether or not you have fallen. The study is in two parts. In the first part you will be asked to complete a 15-minute questionnaire about any falls you have had as well as associated problems. It is assumed that filling in the questionnaire means you agree to participate.

Participation in the study is voluntary and you can decline to participate or withdraw at any time. You also can refuse to answer particular questions.

Later on you may be approached to participate in the second part of the study. This part will involve both people who have and have not sustained a fall being given some tests measuring things like memory and attention. Again, participation is voluntary; you are under no obligation to participate in this part of the study.

Please be assured that all responses are confidential. All questionnaires will be kept in a locked drawer and will only be accessed by the researcher and her supervisor. When the study is written up, there will be no way of identifying participants. Upon completion of this study information will be kept for a period of ten years (as per Regional Ethics' requirements) before being destroyed.

This study is being conducted by Petina Newton and her Supervisor, Dr Janet Leathem, from the Psychology Department at Massey University. The research will go towards the completion of Petina's Master's Degree and it is hoped will contribute towards understanding the consequences of falls amongst older adults.

In the unlikely event of a physical injury as a result of your participation in this study, you will be covered by the accident compensation legislation with its limitations. If you have any questions about ACC please feel free to ask the researcher for more information before you agree to take part in this trial.

If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact a Health and Disability Advocate, phone: (0800 555 050 Northland to Franklin / 0800 42 36 38 (4 ADNET) mid and lower North Island).

This project has been reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, Metlifecare Browns Bay and the Massey University Human Ethics Committee (WGTN Protocol 02/110). If you have any concerns about the conduct of this research, please contact Dr Pushpa Wood, Chair, Massey University Regional Human Ethics Committee: Wellington, telephone 04 801 2794 ext 6723, email P.Wood@massey.ac.nz. If you have any questions regarding the study, please ask Petina when she is visiting or alternatively you can contact her through the Psychology Clinic at Massey University (443 9700 x 6864). Dr Janet Leathem is also available on this number.

Thank you for your cooperation today.

Petina M Newton
M.A. Student

Janet Leathem (PhD)
Professor of Neuropsychology

Version 3: 18 July 2002

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INFORMATION SHEET FOR PARTICIPANTS
Nursing Home
(Part Two)

Incidence and outcome of falls

As discussed today, I am leaving you with this information sheet and will contact you again within the next few days to arrange a suitable time for an appointment.

When you recently completed the questionnaire about falls you may remember that some people were going to be asked to participate in the second part of the study. I am now ready to commence the second part which involves the administration of some tests measuring things like memory and attention. These areas are being tested because sometimes people experience difficulty with these things after a fall. We are asking fallers and non-fallers to participate because we are interested in comparing the results of these two groups.

One of the tests concerns your ability to do everyday tasks such as remembering to do things and daily activities. It would be useful for the same questionnaire to be completed by someone who knows you well, a relative or a friend. This is because sometimes, people find it difficult to rate themselves in these areas and a relative or friend can give another perspective. The form takes approximately 15 minutes to complete. If there is someone who could be approached to complete this questionnaire, please fill out the attached permission form and I will collect this from you when we meet.

The testing will be done on an individual basis and will take approximately 45 minutes. Please remember, participation is voluntary and you have the right to discontinue with a particular question or test. You also have the right to withdraw from the study at any time. Please be assured that all responses are confidential. There is no way that the person you nominate to complete the questionnaire will know how you responded. All questionnaires and results from tests will be kept in a locked drawer and will only be accessed by the researcher and her supervisor. When the study is written up, there will be no way of identifying participants. Upon completion of this study information will be kept for a period of ten years (as per Regional Ethics' requirements) before being destroyed.

In the unlikely event of a physical injury as a result of your participation in this study, you will be covered by the accident compensation legislation with its limitations. If you have any questions about ACC please feel free to ask the researcher for more information before you agree to take part in this trial.

If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact a Health and Disability Advocate, phone: (0800 555 050 Northland to Franklin / 0800 42 36 38 (4 ADNET) mid and lower North Island).

This project has been reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, (the Board of Trustees at Nursing Home/Retirement Village) and the Massey University Human Ethics Committee, WGTN Protocol 02/110. If you have any concerns about the conduct of this research, please contact Dr Pushpa Wood, Chair, Massey University Regional Human Ethics Committee: Wellington, telephone 04 801 2794 ext 6723, email P.Wood@massey.ac.nz. If you have any questions regarding the study, please ask Petina when she is visiting or alternatively you can contact her through the Psychology Clinic at Massey University (443 9700 x [extension yet to be determined]). Dr Janet Leathem, Petina's Supervisor, from the Psychology Department at Massey University is also available on the above number.

Thank you again for assisting us with this research study.

Petina M Newton
M.A. Student

Janet Leathem (PhD)
Professor of Neuropsychology

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INFORMATION SHEET FOR PARTICIPANTS
Retirement Village
(Part Two)

Incidence and outcome of falls

As discussed in our recent telephone conversation, I am sending you this information sheet and will contact you again within the next few days to arrange a suitable time for an appointment.

When you recently completed the questionnaire about falls you may remember that some people were going to be asked to participate in the second part of the study. I am now ready to commence the second part which involves the administration of some tests measuring activities like memory and attention. These areas are being tested because sometimes people experience difficulty with these things after a fall. We are asking fallers and non-fallers to participate because we are interested in comparing the results of these two groups.

One of the tests concerns your ability to do everyday tasks such as remembering to do things and daily activities. It would be useful for the same questionnaire to be completed by someone who knows you well, a relative or a friend. This is because sometimes, people find it difficult to rate themselves in these areas and a relative or friend can give another perspective. The form takes approximately 15 minutes to complete. If you would be comfortable nominating a person who could be approached to complete this questionnaire, please fill out the attached permission form and I will collect this from you when we meet.

The testing will be done on an individual basis and will take approximately 45 minutes. Please remember, participation is voluntary and you have the right to discontinue with a particular question or test. You also have the right to withdraw from the study at any time. Please be assured that all responses are confidential. All questionnaires and results from tests will be kept in a locked drawer and will only be accessed by the researcher and her supervisor. When the study is written up, there will be no way of identifying participants. Upon completion of this study information will be kept for a period of ten years (as per Regional Ethics' requirements) before being destroyed.

In the unlikely event of a physical injury as a result of your participation in this study, you will be covered by the accident compensation legislation with its limitations. If you have any questions about ACC please feel free to ask the researcher for more information before you agree to take part in this trial.

If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact a Health and Disability Advocate, phone: (0800 555 050 Northland to Franklin / 0800 42 36 38 (4 ADNET) mid and lower North Island).

This project has been reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, (the Board of Trustees at Nursing Home/Retirement Village) and the Massey University Human Ethics Committee, WGTN Protocol 02/110. If you have any concerns about the conduct of this research, please contact Dr Pushpa Wood, Chair, Massey University Regional Human Ethics Committee: Wellington, telephone 04 801 2794 ext 6723, email P.Wood@massey.ac.nz. If you have any questions regarding the study, please ask Petina when she is visiting or alternatively you can contact her through the Psychology Clinic at Massey University (443 9700 x [extension yet to be determined]). Dr Janet Leathem, Petina's Supervisor, from the Psychology Department at Massey University is also available on the above number.

Thank you again for assisting us with this research study.

Petina M Newton
M.A. Student

Janet Leathem (PhD)
Professor of Neuropsychology

Version 3: 18 July 2002

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INFORMATION SHEET FOR STAFF

Incidence and outcome of falls

My name is Petina Newton, a graduate student at Massey University. I am conducting research as part of my Masters Thesis, which involves residents of Metlifecare Browns Bay. The research pertains to the incidence of falls, associated problems and outcomes of falling and it is hoped will contribute towards understanding the consequences of falls amongst older adults.

The study is divided into two parts. During the first part, all residents of Metlifecare Browns Bay will be invited to complete a 15-minute questionnaire, which asks about any previous falls and associated problems as a result of the fall. Upon completion of the questionnaire, two groups (some who have and others who have not sustained a fall/s) will be invited to participate in the second part of the study. This will involve the administration of a series of tests concentrating in areas such as memory and attention.

One of the tests concerns the participant's ability to do everyday tasks such as remembering to do things and daily activities. Participants will also be asked to nominate a relative or friend who will also be invited to complete the same questionnaire (Patient Competency Rating Scale [PCRS]) regarding the participant's ability to perform these tasks and functions. Having the relative/friend complete the questionnaire is considered useful as sometimes people find it difficult to rate themselves in these areas and a relative or friend can give another perspective.

Participation in the study is voluntary and participants can decline to participate or withdraw at any stage. They can also refuse to answer particular questions.

All questionnaires and results from tests will be kept in a locked drawer and will only be accessed by the researcher and her supervisor. When the study is written up, there will be no way of identifying participants. Upon completion of this study information will be kept for a period of ten years (as per Regional Ethics' requirements) before being destroyed.

This project has been reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, Metlifecare Browns Bay and the Massey University Human Ethics Committee (WGTN Protocol 02/110). If you have any concerns about the conduct of this research, please contact Dr Pushpa Wood, Chair, Massey University Regional Human Ethics Committee: Wellington, telephone 04 801 2794 ext 6723, email P.Wood@massey.ac.nz. If you have any questions regarding the study, please ask Petina when she is visiting or alternatively you can contact her through the Psychology Clinic at Massey University (443 9700 x 6864). Dr Janet Leathem, Petina's Supervisor, from the Psychology Department at Massey University is also available on this number.

Petina M Newton
M.A. Student

Janet Leathem (PhD)
Professor of Neuropsychology

Version 3: 18 July 2002

CONSENT FORM
(Part Two)

Incidence and outcome of falls

I have read the information sheet for Part one of the study and have also had the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study at any time and to decline to answer any particular questions. I agree to provide information to the researchers on the understanding that it is private and confidential. When the study is written up, there will be no way I can be identified.

I agree to participate in Part Two of this study according to the conditions outlined in the information sheet.

Name: .....

Signature: .....

Date: .....

I would like to receive a summary of the results of the study. Yes / No

CONSENT FORM TO CONTACT INFORMANT
(Part Two)

Incidence and outcome of falls

I ..... have checked with my friend/relative and they have agreed to be part of this study.

Person's name: _____

Relationship to person: _____

Person's address: _____
(if known): _____

Signed: _____

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INFORMATION SHEET FOR INFORMANTS
(Part Two)

Incidence and outcome of falls

My name is Petina Newton, a graduate student at Massey University. I am conducting research as part of my Masters Thesis, which pertains to the incidence of falls, associated problems and outcomes of falling. It is hoped this will contribute towards understanding the consequences of falls amongst older adults. (Name) was involved in the second aspect of the study, which looked at the outcome of falling.

(Name) completed a group of tests measuring aspects of functioning such as memory and attention. One of the tests asked about the participant's ability to do everyday tasks such as remembering to do things and daily activities. It would be useful for the same questionnaire to be completed by someone who knows the participant well, such as a relative or a friend. This is being done because sometimes people find it difficult to rate themselves in these areas and a relative or friend can give another perspective. (Name) has nominated you to complete this questionnaire, which takes approximately 15 minutes to complete. A return addressed envelope is also enclosed.

Participation in the study is voluntary and you can decline to participate or withdraw at any time. You also can refuse to answer particular questions. It is assumed that filling in the questionnaire means you agree to take part. Please be assured that all responses are confidential. There is no way that the person you are filling in the questionnaire about will know how you responded. All questionnaires and results from tests will be kept in a locked drawer and will only be accessed by the researcher and her supervisor. When the study is written up, there will be no way of identifying participants. Upon completion of this study information will be kept for a period of ten years (as per Regional Ethics' requirements) before being destroyed.

In the unlikely event of a physical injury as a result of your participation in this study, you will be covered by the accident compensation legislation with its limitations. If you have any questions about ACC please feel free to ask the researcher for more information before you agree to take part in this trial.

If you have any queries or concerns regarding your rights as a participant in this study, you may wish to contact a Health and Disability Advocate, phone: (0800 555 050 Northland to Franklin / 0800 42 36 38 (4 ADNET) mid and lower North Island).

This project has been reviewed and approved by the Auckland Ethics Committee on behalf of Wellington Ethics Committee, (the Board of Trustees at Nursing Home/Retirement Village) and the Massey University Human Ethics Committee, WGTN Protocol 02/110. If you have any concerns about the conduct of this research, please contact Dr Pushpa Wood, Chair, Massey University Regional Human Ethics Committee: Wellington, telephone 04 801 2794 ext 6723, email P.Wood@massey.ac.nz. If you have any questions regarding the study, please ask Petina when she is visiting or alternatively you can contact her through the Psychology Clinic at Massey University (443 9700 x [extension yet to be determined]). Dr Janet Leathem, Petina's Supervisor, from the Psychology Department at Massey University is also available on the above number.

Thank you again for assisting us with this research study.

Petina M Newton
M.A. Student

Janet Leathem (PhD)
Professor of Neuropsychology

Version 2: 17 June 2002

APPENDIX II. QUESTIONNAIRE

Fall Questionnaire

Private and Confidential

This questionnaire is for everyone over the age of 65 regardless of whether you have sustained a fall, or fall related injury. You are asked to think carefully about any fall you may have previously had, and answer as accurately as possible. All your responses will be confidential.

Participation in the study is voluntary and you can decline to participate or withdraw at any time. You also can refuse to answer particular questions. If there is something of which you are uncertain, please do not hesitate to ask.

Code Number: _____

Gender:

- ☐ Male
- ☐ Female

(please tick one)

Age: _____

Ethnicity:

- ☐ Pakeha
- ☐ Maori
- ☐ Pacific Islander
- ☐ Asian
- ☐ Other (please explain): _____

(please tick one)

Education: *(please select highest level achieved)*

- ☐ No High School Education
- ☐ High School (1-3 years completed)
- ☐ High School (Sixth Form)
- ☐ High School (Seventh Form)
- ☐ University (Undergraduate)
- ☐ University (Postgraduate)
- ☐ Other (please specify): _____

(please tick one)

---------✂----------

(This strip will be cut off once corresponding code allocated)

Name: .....

1. Have you ever been diagnosed with any of the following:
(select more than one if appropriate)

- ☐ Head injury requiring hospitalisation
- ☐ Dementia
- ☐ Stroke / Learning disorder
- ☐ Drug or alcohol abuse problem
- ☐ Other (please specify): _____
- ☐ Anxiety
- ☐ Depression
- ☐ Schizophrenia
- ☐ Post-traumatic Stress Disorder
- ☐ Obsessive Compulsive Disorder

2. Do you currently use any non-prescription / over the counter medication? Yes / No *(please circle one)*

If so, what medication do you use? _____

And, how often would you use them?

_____

3. How often do you drink alcohol?

- ☐ Daily
- ☐ Weekly
- ☐ Once a month
- ☐ Less than once a month
- ☐ Never

4. During the last three years have you ever had a fall that you would consider serious? Yes / No *(please circle one)*

If so, why did you consider this fall serious?

_____

_____

If so, how long ago did you have this fall?

- ☐ In the last three weeks
- ☐ 3 - 6 weeks ago
- ☐ Less than 3 months ago
- ☐ 3 - 6 months ago
- ☐ 6 - 12 months ago
- ☐ More than 12 months ago

5. How many serious falls have you had in the past three years? 0 1 2 3 or more *(please circle one)*

The following section is now going to ask specific questions about falls. If you have not had a serious fall, skip the pages with grey boxes and jump ahead to page 5

Following is a series of questions relating specifically to conditions surrounding your fall. Could you please complete the questions outlined in the shaded area on the next 2 pages. If you have experienced more than one fall in the past 3 years, extra boxes are provided at the back to detail these falls:

A. How did the fall occur?

_____

_____

B. Did you experience any problems due to the fall? Yes / No *(please circle one)*

If so, what problems did you experience?

_____

_____

Do you still experience any of these problems? Yes / No *(please circle one)*

If yes, which ones?
(in the space below, please record those problems from above which you still experience today)

_____

_____

C. Did your fall result in any of the following *(select more than one if appropriate)*:

- ☐ No injury
- ☐ Abrasion
- ☐ Bruising
- ☐ Laceration
- ☐ Sprain or strain injuries
- ☐ Pain or swelling
- ☐ Fracture (please explain where on body): _____
- ☐ Other (please explain): _____

D. How did you sustain the fall?

- ☐ Slipping
- ☐ Tripping
- ☐ Stumbling
- ☐ Other (please specify): _____

E. Activity engaged in when fall occurred:

- ☐ Getting into or out of bed
- ☐ Getting up from sitting
- ☐ Sitting down
- ☐ Reaching, bending, performing daily activity
- ☐ Stand still (just went down)
- ☐ Walking
- ☐ Unknown
- ☐ Other *(Please explain)*: _____

F. Did you fall from:

- ☐ Same level
- ☐ Stairs or steps
- ☐ One level to another
- ☐ Other (please explain): _____

G. Did you hurt your head when you fell? Yes / No *(please circle one)*
Please give details

_____

_____

H. Did you experience a loss of consciousness? Yes / No *(please circle one)*
If you were unconscious, how long were you unconscious for?

- ☐ Five minutes or less
- ☐ 20 minutes or less
- ☐ More than 20 minutes

I. Did you experience any loss of memory for events immediately before or after the fall? Yes / No *(please circle one)*
If you lost memory for events immediately before the fall, how long did you experience this loss of memory for?

- ☐ Less than 24 hours
- ☐ More than 24 hours

If you lost memory for events immediately after the fall, how long did you experience this loss of memory for?

- ☐ Less than 24 hours
- ☐ More than 24 hours

J. Did you have any alteration in mental state (e.g., feeling dazed or confused) at the time of your fall? Yes / No *(please circle one)*
Please explain:

_____

_____

K. What attention did you receive due to the fall?

- ☐ None
- ☐ Family member
- ☐ First aid officer
- ☐ Chemist or Pharmacist
- ☐ Physiotherapist
- ☐ Nurse
- ☐ GP or family doctor
- ☐ Emergency department without hospitalisation
- ☐ Admitted to hospital
- ☐ Other (please explain):

_____

The following are problems that people can sometimes have after sustaining an injury. Using the rating scale below, if you consider you have ever experienced any of the following problems, please circle the response that best describes how you experience the problem:

1 Not a problem	2	3	4	5 A very serious problem

Difficulty Concentrating	1 2 3 4 5
Easily distracted	1 2 3 4 5
Nausea	1 2 3 4 5
Sleep-wake disturbances	1 2 3 4 5
Lethargy	1 2 3 4 5
Loss of temper	1 2 3 4 5
Not feeling "with it"	1 2 3 4 5
Difficulty eating	1 2 3 4 5
Attention difficulties	1 2 3 4 5
Takes longer to do things	1 2 3 4 5
Dizziness	1 2 3 4 5
Impulsive	1 2 3 4 5
Depression	1 2 3 4 5
Quickness to anger	1 2 3 4 5
Uncoordinated	1 2 3 4 5
Loss of voice	1 2 3 4 5
Forgetfulness	1 2 3 4 5
Headaches	1 2 3 4 5
Sensitivity to light	1 2 3 4 5
Irritability	1 2 3 4 5
Difficulty finding words in a conversation	1 2 3 4 5
Excessively moody	1 2 3 4 5
Fatigue	1 2 3 4 5
Bothered by noise	1 2 3 4 5

Anxiety	1 2 3 4 5
Difficulty following a conversation	1 2 3 4 5
Difficulty dealing with stressful situations	1 2 3 4 5

Thank you for completing this questionnaire

APPENDIX III
ADMINISTRATION INSTRUCTIONS FOR QUESTIONNAIRE

Note: Instructions are in standard type whilst italics delineates text to be read to participants

---

INFORMATION SHEET

This information sheet tells you about the research. Please read the sheet carefully and make sure you are happy with what it says. You can keep this sheet.

Allow time to read information sheet.

As it says on the information sheet, this part of the research involves completing a 15-20 minute questionnaire about any falls you may have had. We are trying to find out how many people aged 65 and over fall and we also want to look at some of the outcomes of falling. Do you have any questions you'd like to ask me about the research?

Answer any questions.

The questionnaire is in three parts. The first part asks some general information whilst the second part asks questions specifically relating to fall(s). If you haven't had a fall, then I won't be asking you for any information for this part. However, I would still really appreciate you responding to the third part which lists some problems that people sometimes have and asks you to consider if these problems are a concern to you. Do you have any questions about the questionnaire?

Answer any questions.

Would you be interested in participating in this stage of the research?

Thank participant.

If I could just ask you some demographic questions ...
Can I ask what your age is please? (whilst participants aged less than 65 were not included in study, their details were still collected in order that they felt they could make a worthwhile contribution)
And your ethnicity?
What was your highest level of education?

I'm now going to ask you about some conditions you may have previously had.
Have you ever had a head injury and required hospitalisation (if yes, check severity)
Have you ever had a stroke or a heart attack? (If yes, which one)
Have you ever had a drug or an alcohol problem?
Have you ever been diagnosed with anxiety or depression? (If yes, which one)
What about schizophrenia, post-traumatic stress disorder or obsessive compulsive disorder?

Now, I'd like to ask you about medication. Do you currently take any medication?
And what about alcohol, do you drink any alcohol?

Now we're at the part of the questionnaire that asks about falls. Have you had a fall in the past five years? (If no, thank participant for their time. If yes, ask participant to elaborate on details surrounding the fall, whilst probing where necessary to gather required information.)

Thank you for all that information. We're almost at the end of the questionnaire. This final part involves some common problems that people sometimes experience. If I call out some of these problems, can I get you to call out "yes" if the problem is one you experience and "no" if it's not.

This final part was not conducted for all participants. At this stage some participants appeared to be quite tired and accordingly the information was not gathered.

Thank you very much for participating in this study. The study is very important and your participation is greatly appreciated.

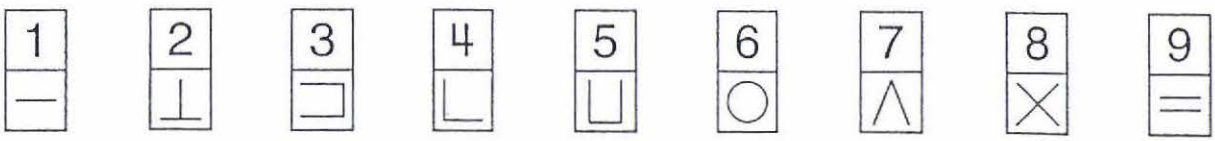
If you wish, a summary of results from the research can be made available for you. This would be sent out in about six months. Would you like to receive a summary?

If the participant indicated they would like a copy, a notation was made to forward same upon completion.

APPENDIX IV

NEUROPSYCHOLOGICAL MEASURES

DIGIT SYMBOL



Sample Items

2	1	3	7	2	4	8	2	1	3	2	1	4	2	3	5	2	3	1	4

5	6	3	1	4	1	5	4	2	7	6	3	5	7	2	8	5	4	6	3

7	2	8	1	9	5	8	4	7	3	6	2	5	1	9	2	8	3	7	4

6	5	9	4	8	3	7	2	6	1	5	4	6	3	7	9	2	8	1	7

9	4	6	8	5	9	7	1	8	5	2	9	4	8	6	3	7	9	8	6

2	7	3	6	5	1	9	8	4	5	7	3	1	4	8	7	9	1	4	5

7	1	8	2	9	3	6	7	2	8	5	2	3	1	4	8	4	2	7	6

California Older Adult Stroop Test

RED GREEN YELLOW RED YELLOW

YELLOW RED GREEN YELLOW GREEN

GREEN GREEN YELLOW RED RED

YELLOW GREEN RED GREEN RED

GREEN YELLOW GREEN RED YELLOW

RED RED YELLOW GREEN RED

GREEN YELLOW RED GREEN YELLOW

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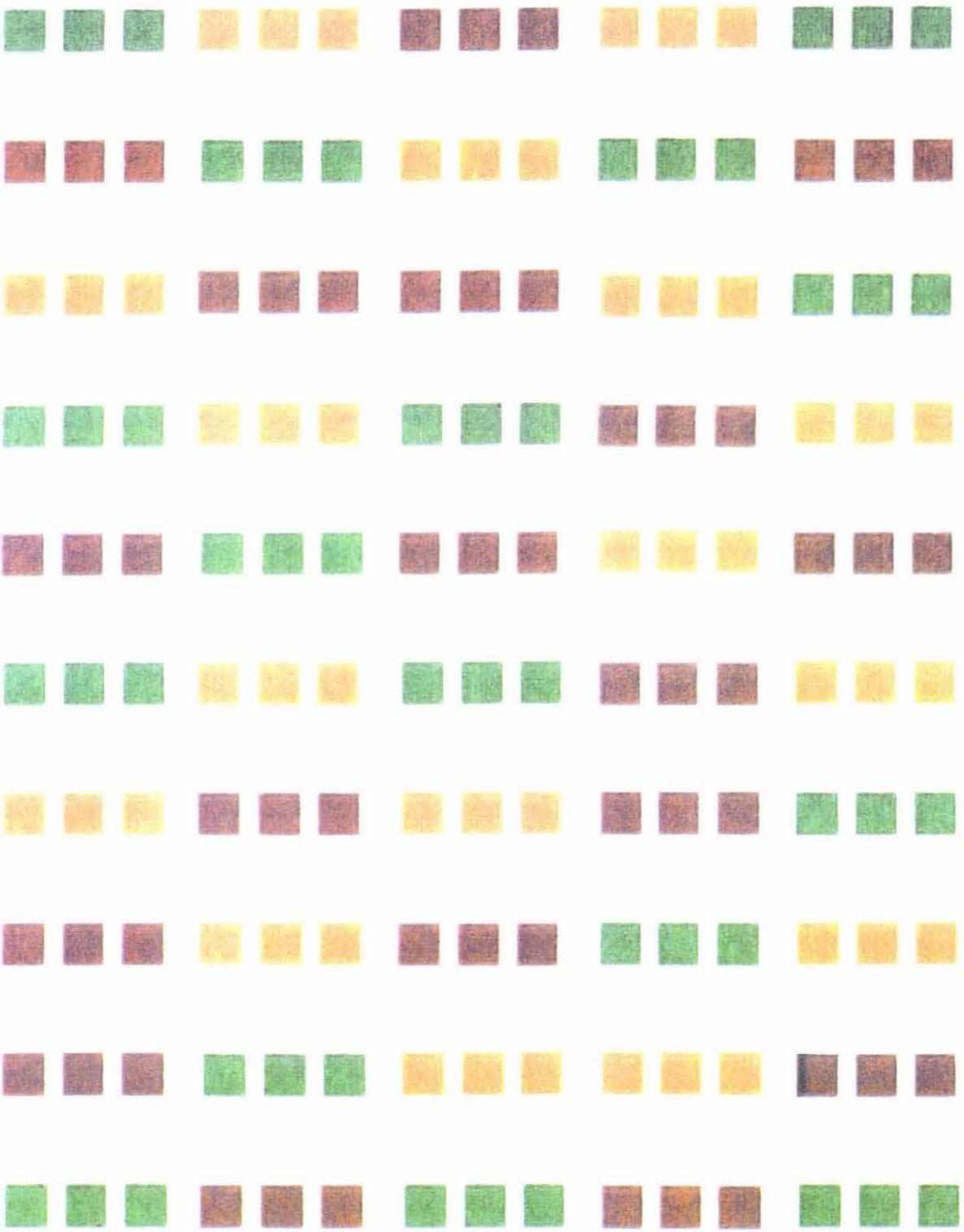
GREEN YELLOW GREEN RED YELLOW

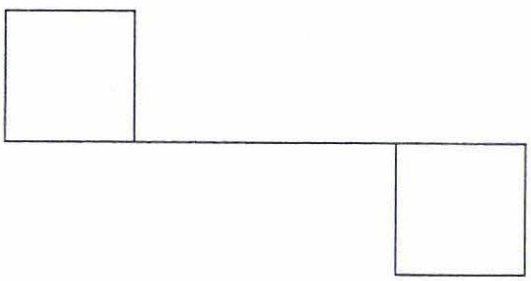
RED GREEN RED YELLOW RED



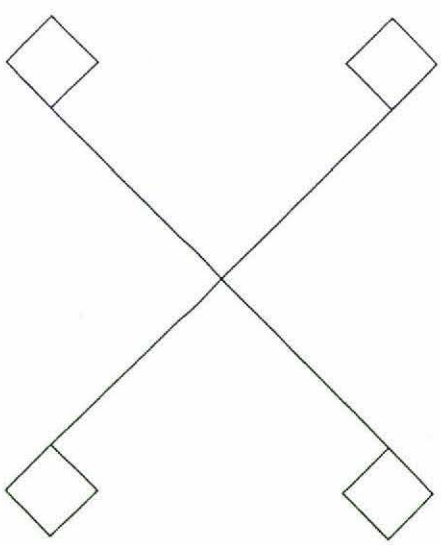

RED GREEN YELLOW RED YELLOW
YELLOW RED GREEN YELLOW GREEN
GREEN GREEN YELLOW RED RED
YELLOW GREEN RED GREEN RED
GREEN YELLOW GREEN RED YELLOW
RED RED YELLOW GREEN RED
GREEN YELLOW RED GREEN YELLOW
YELLOW RED YELLOW YELLOW GREEN
GREEN YELLOW GREEN RED YELLOW
RED GREEN RED YELLOW RED

VISUAL REPRODUCTION

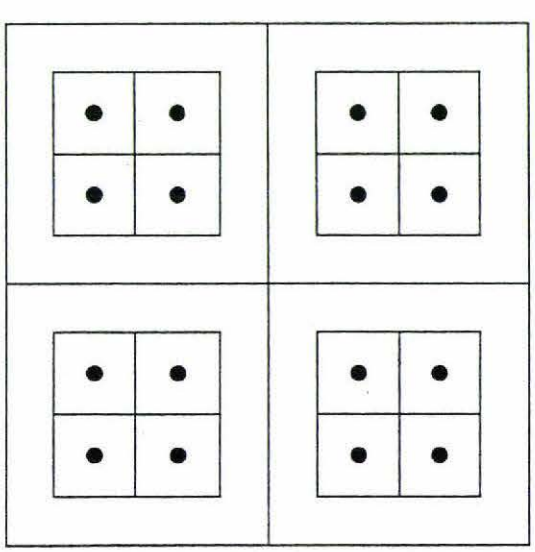
Design A



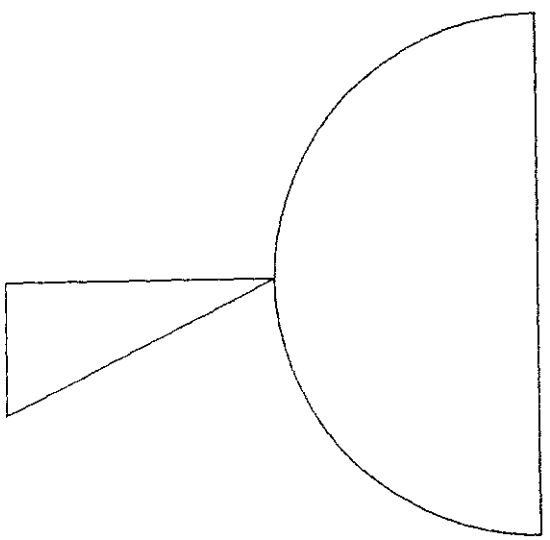
Design B

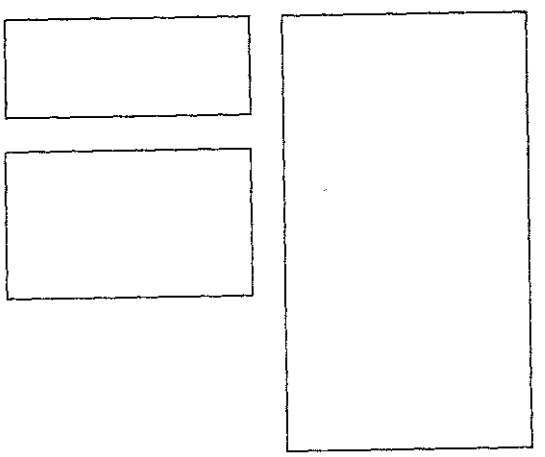


Design C

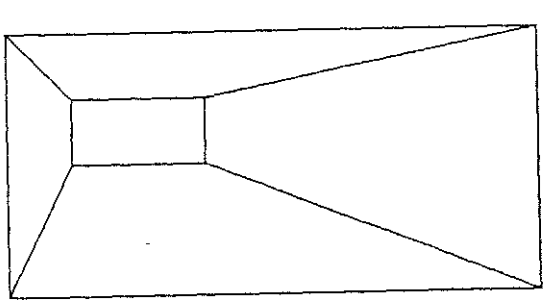


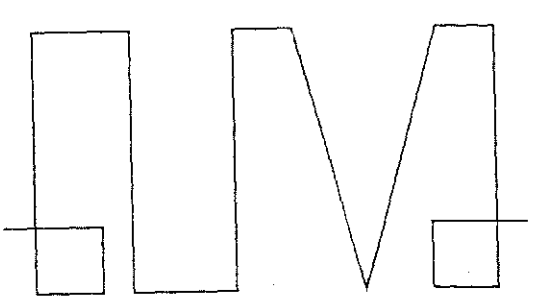
Design D





Design E



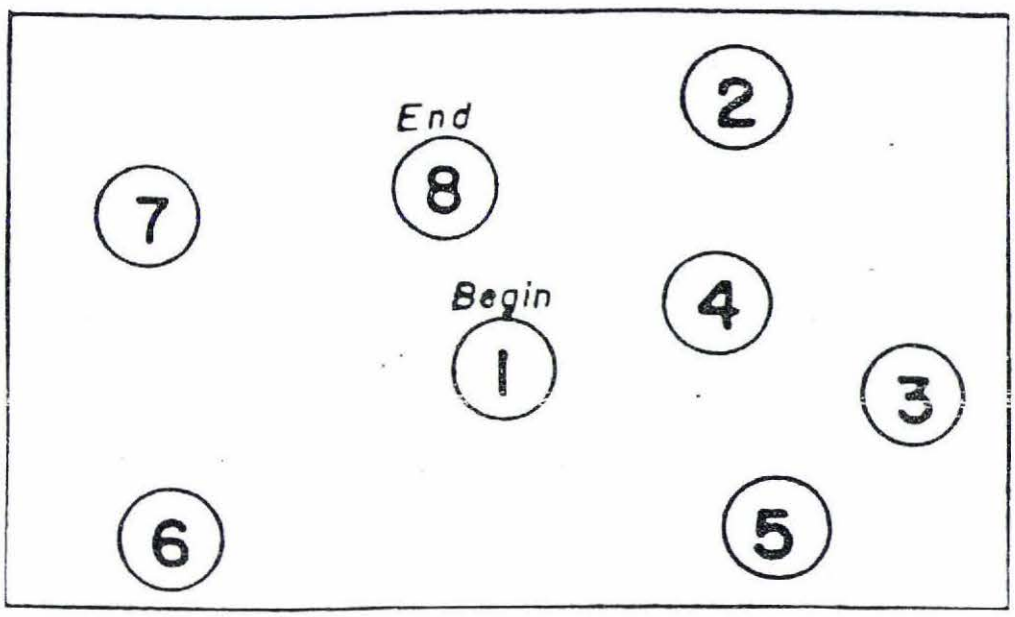


Rey Auditory Verbal Learning Test - Recognition

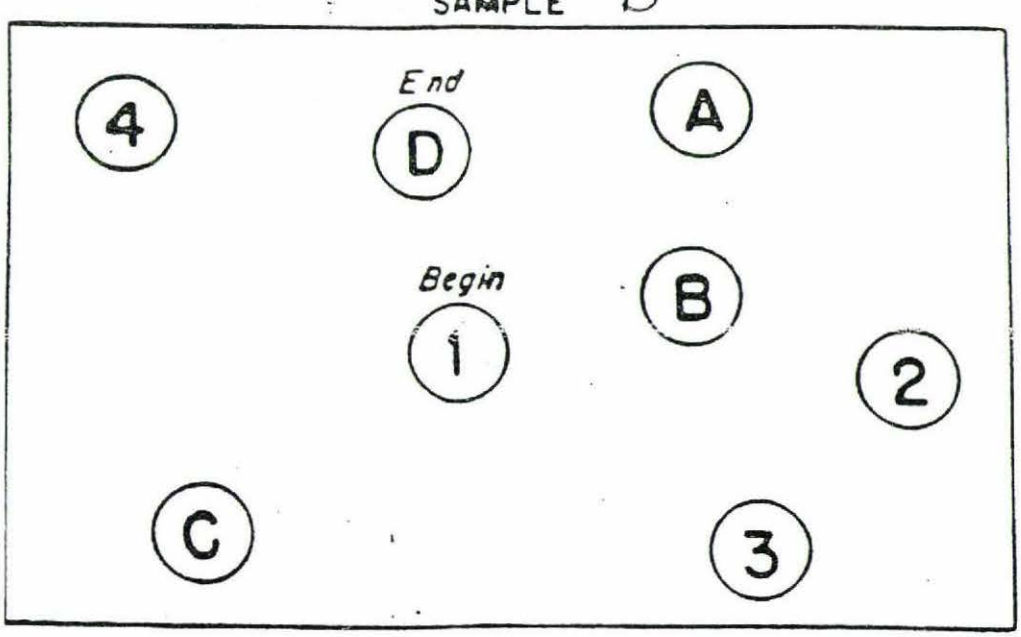
bell	**home**	**towel**	**boat**	**glasses**
window	**fish**	**curtain**	**hot**	**stocking**
hat	**moon**	**flower**	**parent**	**shoe**
barn	**tree**	**colour**	**water**	**teacher**
ranger	**balloon**	**desk**	**farmer**	**stove**
nose	**bird**	**gun**	**rose**	**nest**
weather	**mountain**	**crayon**	**cloud**	**children**
school	**coffee**	**church**	**house**	**drum**
hand	**mouse**	**turkey**	**stranger**	**toffee**
pencil	**river**	**fountain**	**garden**	**lamb**

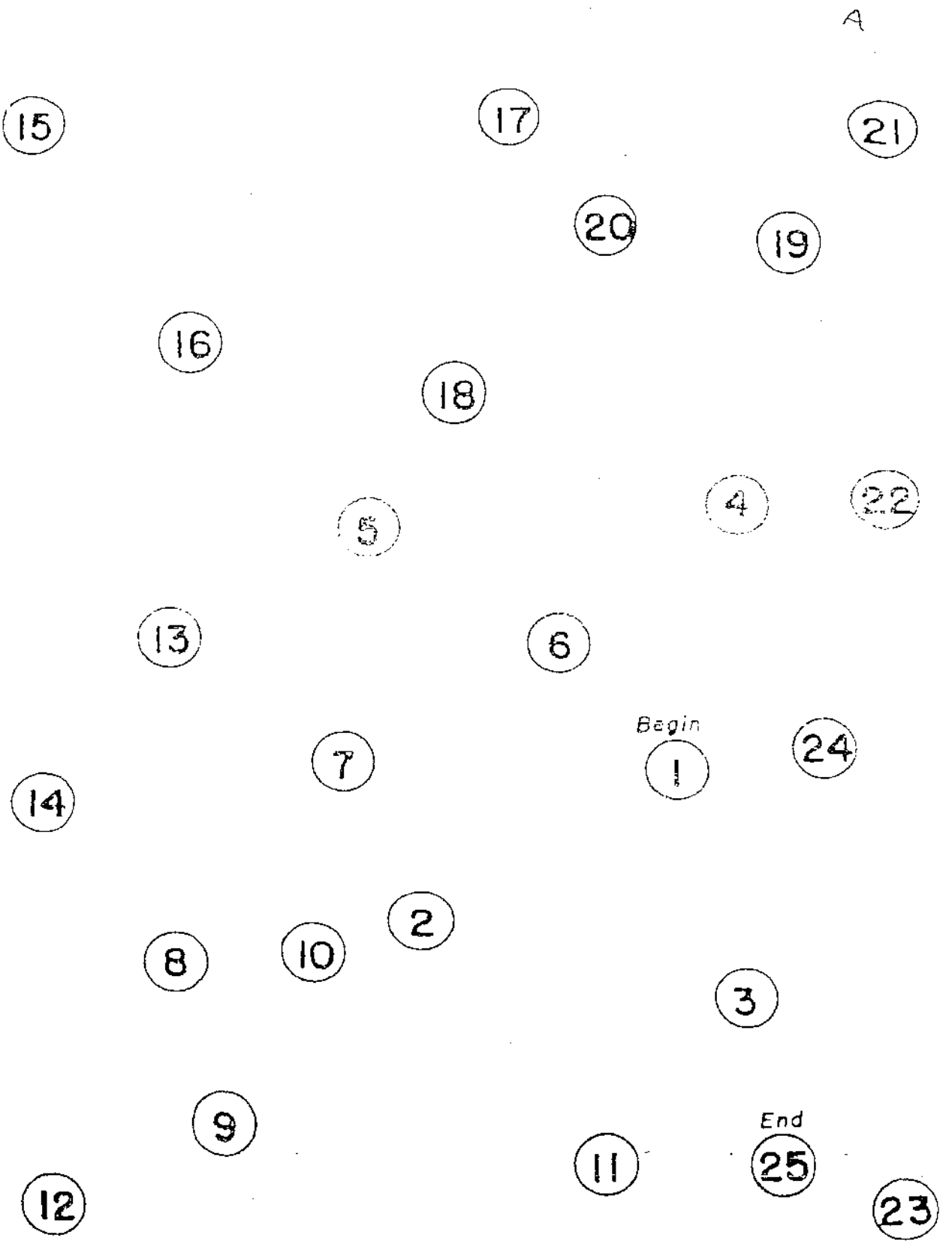
TRAIL MAKING TEST

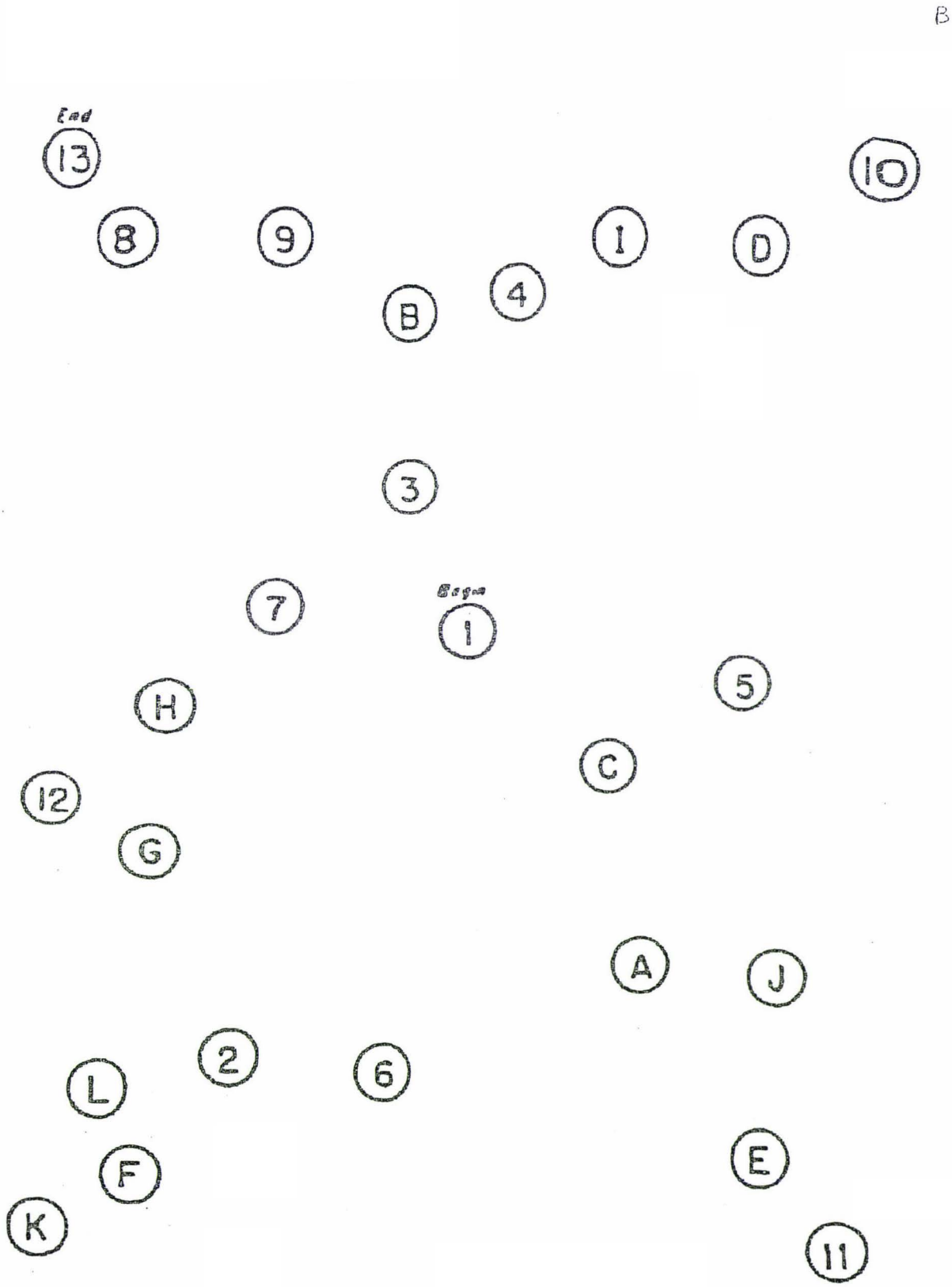
SAMPLE A



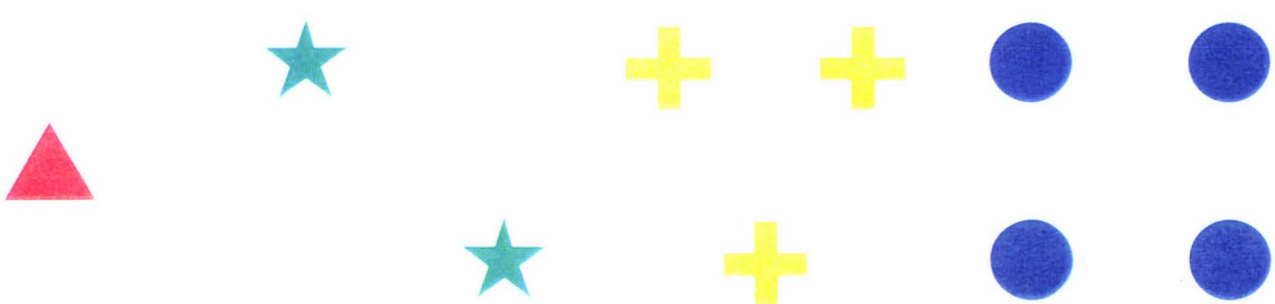
SAMPLE B




A
15
17
21
20
19
16
18
4
22
5
13
6
Begin
24
7
1
14
2
8
10
3
9
End
11
25
12
23


B
End
13
10
8
9
1
D
4
B
3
7
Begin
1
5
H
C
12
G
A
J
2
6
L
E
F
K
11

WISCONSIN CARD SORTING TEST – 64



PATIENT COMPETENCY RATING (PATIENT'S FORM)

Instructions

The following is a questionnaire that asks you to judge your ability to do a variety of very practical skills. Some of the questions may not apply directly to things you often do, but you are asked to complete each question as if it were something you "had to do." On each question, you should judge how easy or difficult a particular activity is for you and mark the appropriate space.

Competency Rating

	Can't do	Very difficult to do	Can do with some difficulty	Fairly easy to do	Can do with ease
1 How much of a problem do I have in preparing my own meals?	_____	_____	_____	_____	_____
2 How much of a problem do I have in dressing myself?	_____	_____	_____	_____	_____
3 How much pf a problem do I have in taking care of my personal hygiene?	_____	_____	_____	_____	_____
4 How much of a problem do I have in washing the dishes?	_____	_____	_____	_____	_____
5 How much of a problem do I have in doing the laundry?	_____	_____	_____	_____	_____
6 How much of a problem do I have in taking care of my finances?	_____	_____	_____	_____	_____
7 How much a problem do I have in keeping appointments of time?	_____	_____	_____	_____	_____
8 How much of a problem do I have in starting conversation in a group?	_____	_____	_____	_____	_____
9 How much of a problem do I have in staying involved in work activities even when bored or tired?	_____	_____	_____	_____	_____
10 How much of a problem do I have in remembering what I had for dinner last night?	_____	_____	_____	_____	_____
11. How much of a problem do I have in remembering names of people I see often?	_____	_____	_____	_____	_____
12 How much of a problem do I have in remembering my daily schedule?	_____	_____	_____	_____	_____
13 How much of a problem do I have in remembering important things I must do?	_____	_____	_____	_____	_____

14 How much of a problem would I have driving a car if I had to?	____	____	____	____	____
15 How much of a problem do I have in getting help when I'm confused?	____	____	____	____	____
16 How much of a problem do I have in adjusting to unexpected changes?	____	____	____	____	____
17 How much of a problem do I have in handling arguments with people I know well?	____	____	____	____	____
18 How much of a problem do I have in accepting criticism from other people?	____	____	____	____	____
19 How much of a problem do I have in controlling crying?	____	____	____	____	____
20 How much of a problem do I have in acting appropriately when I'm around friends?	____	____	____	____	____
21 How much of a problem do I have in showing affection to people?	____	____	____	____	____
22 How much of a problem do I have in participating in group activities?	____	____	____	____	____
23 How much of a problem do I have in recognising when something I say or do has upset someone else?	____	____	____	____	____
24 How much of a problem do I have in scheduling daily activities?	____	____	____	____	____
25 How much of a problem do I have in understanding new instructions?	____	____	____	____	____
26 How much of a problem do I have in consistently meeting my daily responsibilities?	____	____	____	____	____
27 How much of a problem do I have in controlling my temper when something upsets me?	____	____	____	____	____
28 How much of a problem do I have in keeping from being depressed?	____	____	____	____	____
29 How much of a problem do I have in keeping my emotions from affecting my ability to go about the day's activities?	____	____	____	____	____
30 How much of a problem do I have in controlling my laughter?	____	____	____	____	____

APPENDIX V

ADMINISTRATION INSTRUCTIONS FOR NEUROLOGICAL MEASURES

Note: Instructions are in standard type whilst italics delineates text to be read to participants

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INFORMATION SHEET

This information sheet tells you about the research. Please read the sheet carefully and make sure you are happy with what it says. You can keep this sheet.

Allow time to read information sheet.

As it says on the information sheet, this second stage of the research involves activities to do with things like memory and attention. We are assessing these areas because sometimes people experience difficulty with these things after a fall. We are asking fallers and non-fallers to participate because we are interested in comparing the results of these two groups. Do you have any questions you'd like to ask me about the research?

Answer any questions.

For most of the activities you will notice that I write down your responses. For others, you may simply tick your response in the appropriate box. It is important to realise that you can complete today's assessment at your own pace, there is no hurry. We'll also have breaks if you want. There are a couple of activities where you will need to go as fast as you can. When we get to these, I'll let you know. Is that OK?

You may find some of these activities easy, whereas others may be more difficult and you are not expected to answer them. Please don't be concerned about this. Also, most people don't answer every question correctly or finish every activity, but please give your best effort on all of the activities.

Do you have any questions?

Answer any questions.

If you wish, we can provide a summary of the results of the research. This would be sent out in about six months. If you would like to receive a summary, you will need to indicate this on the last page of the consent form (point to consent form) *by ticking the box and writing your name and address in the space provided.*

CONSENT FORM

This consent form says that the research has been explained to you, that you understand what will be happening and that you wish to participate in this part of the research. Do you wish to participate in the study?

Ensure participant understands the content of the consent form and the consent form is completed before continuing.

(Timed)

VISUAL REPRODUCTION I

Place page 2 of the Response Booklet in front of the participant so that the words Design A face the participants. Say:

> *I am going to show you some designs, one page at a time. You will have just 10 seconds to look at each design. Then I will cover it and ask you to draw the design from memory here on this sheet (point to Response Booklet). Don't* begin to draw until I tell you to. Are you ready?

Turn the page, expose Design A for 10 seconds and then turn the page. Say:

> *Now go ahead and draw the design.*

If it appears the participant requires some encouragement, say *Don't worry about your artistic ability; just draw it as best you can* or similar words. If the participant indicates a memory difficulty, say *Well, just draw it as well as you can remember.*

When the participant has completed drawing the Design, turn the Response booklet to the next page. Say:

> *Now I will show you a new design. Just like before, I want you to remember the design and draw it on this sheet (point to the Response Booklet). Ready?*

Designs B & C were presented to the participant using Design A instructions. On completion of Design C, say:

> *This next one is a little harder because it has two designs on it. I want you to look at both of them carefully. Again, you will have just 10 seconds to look at the designs. Draw the left design here* (point to the left half of the area labelled Design D). *Draw the other drawing on the right side here* (point to the right half of the area labelled Design D). *Ready?*

Turn the page, expose Design D for 10 seconds and then turn the page. Say:

> *Now go ahead and draw the design.*

Present Designs E to the participant using Design D instructions. On completion of Design E, say:

> *Later on I will ask you to draw all the designs again, from memory, so try to remember them.*

REY AUDITORY VERBAL LEARNING TEST

> *Now I am going to read a list of words. Listen carefully, for when I stop you are to say back as many words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can.*

Read List A words, at a rate of one word per second. Record all words participants recall, in the order recalled, including repeated words and words not listed.

When the participant indicates they cannot recall any more words, say:

> *Now I am going to read the same list again, and once again when I stop I want you to tell me as many words as you can remember, including the words you said*

the first time. It doesn't matter in what order you say them. Just say as many words as you can remember whether or not you said them before.

Reread the list for Trials 3 through 5 using the instructions for Trial 2 (see above paragraph).

Upon completion of Trial 5, read List B, with the following instructions:

Now, I'm going to read a second list of words. Listen carefully, for when I stop you are to say back as many words as you can remember. It doesn't matter in what order you repeat them. Just try to remember as many as you can.

Upon completion of List B trial, ask the participant to recall as many words from the first list (List A) as possible:

Now tell me all the words that you can remember from the first list.

(Timed)

COAST

For this task, one of the things that can affect how people perform is if they are colour-blind. Are you colour-blind?

Place Sheet 1 in front of the participant. Say:

On this page are some words. I would like you to read these words aloud as quickly as you can, starting at the top of this first column. When you finish this column, go to the top of the next column and so on (point to the top of the columns and indicate that the participants should read all the columns in the same manner). *Read the words aloud as quickly and as accurately as you can. If you make a mistake, just correct yourself and keep on going. Ready? Begin.*

At the end of 45 seconds, say *Stop*.
Record participant's ID number on top of C Stimulus Sheet. If participant completes the entire page in less than 45 seconds, record this shortened time.

Place Sheet 2 in front of the participant. Say:

Here is a page with squares on it. This time, I would like you to name aloud the colour of the square – green, red or yellow (point to the words printed in these colours) *– in which the squares are printed. Go as quickly as you can, going down the columns just as you did before. For this first one you would say "GREEN". Understand? If you make a mistake, just correct yourself and keep on going. Name the colour of the square as quickly and as accurately as you can. Ready? Begin.*

At the end of 45 seconds, say Stop.
Record participant's ID number on top of C-W Stimulus Sheet. If participant completes the entire page in less than 45 seconds, record this shortened time.

Place Sheet 3 in front of the participant. Say:

Here is a page with more words on it. This time, I would like you to name aloud the colour of the ink – green, red or yellow (point to the words printed in these colours) *– in which the words is printed. Go as quickly as you can, going down*

the columns just as you did before. For this first one you would say "GREEN". Understand? If you make a mistake, just correct yourself and keep on going. Name the colour of the ink as quickly and as accurately as you can. Ready? Begin.

At the end of 45 seconds, say *Stop*.
Record participant's ID number on top of Stimulus Sheet. If participant completes the entire page in less than 45 seconds, record this shortened time.

WISCONSIN CARD SORTING TEST-64

Set out the four stimulus cards and place the pack of cards in front of the participant. Say:

This activity is a little bit different to the ones we have done already. I am not allowed to give you much information on how to do it. What you need to do is to place each of these response cards (point to response cards) *directly underneath one of the four stimulus cards* (point to each stimulus card, starting with the red triangle). *You need to take one card at a time and place it underneath whichever stimulus card you think it matches. I cannot tell you how to match the cards, but I can tell you whether your choice is right or wrong. If you are wrong, simply leave the card where it is and try and place the next one correctly. There is no time limit on this test. Are you ready? Let's begin.*

We're now about half way through the tasks we'll be doing today. Would you like to take a break at this point?

If participant declines a break proceed to Digit Symbol and Trails prior to administration of RAVLT and VRII

REY AUDITORY VERBAL LEARNING TEST B (DELAYED RECALL AND RECOGNITION TRIALS)

Earlier, I read to you a list of words five times and you had to repeat the words back. Can you tell me the words from that list?

After the list has been recalled, place the recognition response card in front of the participant, and say:

This list shows a whole lot of words, some are from the first list that I read five times. Please circle all the words on this page that are from the first list.

VISUAL REPRODUCTION II

Recall
Turn to page 7 (Visual Reproduction II – Recall Item 1) in the Visual Reproduction response Booklet and place it in front of the participant. Say:

Earlier, I showed you pages of designs. You looked at the designs and then drew them in this booklet (point to the response page).

I want you to draw the designs again in this booklet, from memory. You don't have to draw them in the same order as you did before. If one design was on a page, just draw one design. If two designs were on a page, draw both designs just as you remember them. Now, draw one of the designs here (point to Page 7 in the Response Booklet).

Repeat these instructions until the examinee has drawn as many designs as he or she can remember.

Recognition

Now I am going to show you some more designs, one on each page. I want you to look at each design and say Yes if it is any one of those I asked you to remember, even if it was on a page with another design. Say No if it is not one of those I asked you to remember. You may see some designs more than once.

DIGIT-SYMBOL CODING

In this activity I'm going to ask you to copy some symbols.

Place the record form in front of the participant.

Look at these boxes. Notice that each has a number in the upper part and a special mark in the lower part. Each number has its own mark.

Point to 1 and its mark in the key, then 2 and its mark. Then point to the seven squares located to the left of the heavy black line and say:

Now look down here where the squares have numbers in the top part but the squares at the bottom are empty. In each of the empty squares, put the mark that should go there. Like this.

Point to the first Sample Item, then point back to the key to show its corresponding mark, and say:

Here is a 2; the 2 has this mark. So I put it in this empty square, like this.

Write in the symbol. Point to the second Sample item and say:

Here is a 1; the 1 has this mark (point to the second Sample Item, then to the mark below the 1 in the key), *so I put it in this square.*

Write in the symbol.

Point to the third Sample Item and say:

This number is a 3; the 3 has this mark (point to the third square and to the mark below the 3 in the key). *So I put it in the square* (write in the symbol).

After marking the first three Sample Items, say:

Now you fill in the squares up to this heavy line.

If the participant makes an error on any of the Sample Items, correct the error immediately and review the use of the key. Continue to provide help if needed. Do not proceed with the subtest until the examinee clearly understands the task. When the

participant completes a Sample Item correctly, offer encouragement by saying *Yes* or *Right*. When all the Sample items have been completed, say:

Now you know how to do them. When I tell you to start, you do the rest of them.

Point to the first square to the right of the heavy line and say:

Begin here and fill in as many squares as you can, one after the other without skipping any. Keep working until I tell you to stop. Work as quickly as you can without making any mistakes.

Sweep across the first row with your finger and say:

When you finish this line go on to this one.

Point to the first square in the second row. Then point to the heavy black line and say:

Go ahead.

Begin timing.

If the participant omits an item or starts to do only one type (e.g., only the 1's), say:

Do them in order. Don't skip any.

Point to the first item omitted and say:

Do this one next.

Provide no further assistance except to remind the examinee to continue until instructed to stop.

At the end of 2 minutes (120 seconds), say *Stop*.

If the participant has not completed four rows at this point, mark their ending point (i.e., the time completed at 120 seconds) and then allow additional time for him or her to work to the end of the fourth row. If participant completes the entire page in under 120 seconds, record the time to completion.

Remove Digit-Symbol Coding form and record ID number at top of page.

TRAIL MAKING TEST

Place Part A test sheet (sample side up, bottom of test approximately six inches from participant's edge of table), in front of the participant. Say:

On this page (point) *are some numbers. Begin at number one* (point to 1) *and draw a line from one to two* (point to 2), *two to three* (point to 3), *three to four* (point to 4) *and so on, in order, until you reach the end* (point to the circle marked 'END'). *Draw the lines as fast as you can. Do not lift the pencil from the paper. Ready? Begin!*

If participant makes a mistake, the following responses are appropriate:

1. *You started with the wrong circle. This is where you start* (point to 1).

2. *You skipped this circle* (point to the one omitted). *You should go from number one* (point) *to two* (point), *two to three* (point), *and so on, until you reach the circle marked 'END'* (point).
3. *Please keep the pencil on the paper, and continue right on to the next circle.*

After the mistake has been explained, the examiner marks out the wrong part and says:
Go on from here (point to the last circle completed correctly in the sequence).

If the participant still cannot complete Sample A, take their hand and guide the pencil (eraser end down) through the trail. Say:
Now you try it.

If the sample item is completed correctly. Say:
Good! Let's try the next one.

Turn the test sheet over to display Part A. Say:
On this page are numbers from one to twenty-five. Do this the same way. Begin at number one (point), *and draw a line from one to two* (point to 2), *two to three* (point to 3), *three to four* (point to 4) *and so on, in order until you reach the end* (point). *Remember, work as fast as you can. Ready! Begin!*

Start timing.
When participant has finished, record participant's ID number of top of sheet, time taken to completion (in seconds). Say:
That's fine. Now we'll try another one.

Place Part B test sheet (sample side up, as per instructions for Part A) in front of participant. Say:
On this page are some numbers and letters. Begin at number one (point,) and draw a line from one to A (point to A), *A to two* (point to 2), two to B (point to B), *B to three* (point to 3), *three to C* (point to C), *and so on, in order until you reach the end* (point to circle marked 'END'). *Remember, first you have a number* (point to 1), *then a letter* (point to A), *then a number* (point to 2), *then a letter* (point to B), *and so on. Draw the lines as fast as you can. Ready? Begin!*

If the sample item is completed correctly. Say:
Good! Let's try the next one.

Turn the test sheet over to display Part B. Say:
On this page are both numbers and letters. Do this the same way. Begin at number one (point), *and draw a line from one to A* (point to A), A to two (point to 2), *two to B,* (point to B), *B to three* (point to 3), *three to C* (point to C), *and so on, in order, until you reach the end. Remember, first you have a number* (point to 1), *then a letter* (point to A), *then a number* (point to 2), *and so on. Do not skip around, but go from one circle to the next in the proper order, draw the lines as fast as you can. Ready? Begin!*

Start timing.
If participant makes an error, immediately call it to their attention, and have them proceed from the point at which the mistake occurred. Do not stop timing.

When participant has finished, record participant's ID number of top of sheet, time taken to completion (in seconds).

PATIENT COMPETENCY RATING SCALE

This is the last task we're going to do today. This one asks you to judge your ability to do a variety of very practical skills. Some of the questions may not apply directly to things you often do, but you are asked to complete each question as if it were something you "had to do". On each question, you should judge how easy or difficult a particular activity is for you and mark the appropriate space.

WIND-UP

Thank you very much for participating in this study.

APPENDIX VI
RESEARCH DATA SHEET

DEMOGRAPHICS

Code Number:	_____				**CODE**
Age:	_____				**AGE**
Gender:	Male	1	Female	2	**GEN**
Ethnicity:	Pakeha	1	Asian	4	**ETH**
	Maori	2	Other	5	
	Pacific Islander	3			
Education:	No High School Education	1	University (Undergraduate)	5	**EDU**
			University (Postgraduate)	6	
	High School (1-3 years)	2	Other	7	
	High School (6th Form)	3			
	High School (7th Form)	4			
Location:	Browns Bay (NH)	1	Browns Bay (RV)	4	**LOC**
	Crestwood (NH)	2	Crestwood (RV)	5	
	Roskill (NH)	3	Roskill (RV)	6	
Diagnosis:	Head Injury (hospital)	1	Anxiety	6	**DIAG**
	Dementia	2	Depression	7	
	Stroke/Learning Disorder	3	Schizophrenia	8	
	Drug/Alcohol Problem	4	PTSD	9	
	Other	5	OCD	10	
Medication:	Yes	1	No	2	**MED**
Alcohol:	Daily	1	Less than once a month	4	**ALC**
	Weekly	2	Never	5	
	Once a month	3			
Category:	Fall 1		Non-fall	2	**CAT**
Timing	In the last three weeks	1	3-6 months ago	4	**TIM**
	3-6 weeks ago	2	6-12 months ago	5	
	Less than 3 months ago	3	More than 12 months ago	6	
No of Falls	One	1	Three	3	**NOF**
	Two	2	Three or more	4	
Seriousness:	No injury	1	Sprain or strain injuries	5	**SER**
	Abrasion	2	Pain or swelling	6	
	Bruising	3	Fracture	7	
	Laceration	4	Other	8	
Cause:	Slipping	1	Stumbling	3	**CAUS**
	Tripping	2	Other	4	

Activity:	Getting into or out of bed	1	Stand still (just went down)	5	**ACT**
	Getting up from sitting	2	Walking	6	
	Sitting down	3	Unknown	7	
	Reaching, bending, performing daily activity	4	Other	8	
Location:	Same level	1	One level of another	3	**LOC**
	Stairs or steps	2	Other	4	
Head Injured:	Yes	1	No	2	**HI**
LOC:	Yes	1	No	2	**LOC**
LOC Duration:	Five minutes or less	1	More than 20 minutes	3	**LOCD**
	20 minutes or less	2			
Memory:	Yes	1	No	2	**MEM**
Anterograde:	Less than 24 hours	1	More than 24 hours	2	**ANT**
Retrograde:	Less than 24 hours	1	More than 24 hours	2	**RET**
Mental State:	Yes	1	No	2	**MS**
Attention:	None	1	Nurse	6	**ATT**
	Family member	2	GP or family doctor	7	
	First aid officer	3	ED without hospitalisation	8	
	Chemist or Pharmacist	4	Admitted to hospital	9	
	Physiotherapist	5	Other	10	
Meet Criteria:	Yes	1	No	2	**MC**
Diagnosed:	Yes	1	No	2	**DIAG**
Non-brain Injury:	Severe	1	Mild	2	**NBI**

VISUAL REPRODUCTION I

Hand used: ☐ *Right* ☐ *Left*

Design A

1. Main line and flags	0 1 2	3. Flags	0 1 2	5. Rotation	0 1 2
2. Flags	0 1 2	4. Flags	0 1 2		0 1 2
				Design A Total Score	____

Design B

1. Staffs and Flags	0 1 2	3. Flags	0 1 2	5. Rotation	0 1 2
2. Staffs	0 1 2	4. Flags	0 1 2		
				Design B Total Score	____

Design C

1. Large figure	0 2	5. Med-Sized Figures	0 1 2	9. Med-Sized Figures	0 2
2. Large Figure	0 1 2	6. Med-Sized figures	0 2		
3. Rotation	0 1 2	7. Med-sized figures	0 1 2		
4. Dots	0 1 2	8. Med-sized figures	0 1 2		
				Design C Total Score	____

Design D

1.	Rectangles	0 1 2	7.	Rectangles	0 2	13. Circle Segment	0 2
2.	Rectangles	0 1 2	8.	Large Rectangle	0 1 2	14. Triangle	0 2
3.	Rectangles	0 1 2	9.	Small Rectangle	0 1 2	15. Triangle	0 1 2
4.	Small Rectangles	0 2	10.	Circle Segment	0 2	16. Triangle	0 1 2
5.	Small Rectangles	0 1 2	11.	Circle Segment	0 2	17. Triangle	0 1 2
6.	Rectangles	0 1 2	12.	Circle Segment	0 1 2		

Design D Total Score _____

Design E

1.	Staffs and Flags	0 1 2	7.	Bases	0 1 2	12. Small Rectangle	0 1 2
2.	Flags	0 1 2	8.	Rotation	0 1 2	13. Small Rectangle	0 1 2
3.	Flags	0 1 2	9.	Large Rectangle	0 1 2	14. Small Rectangle	0 1 2
4.	Triangle and Rectangle	0 1 2	10.	Large Rectangle	0 1 2	15. Connecting Lines	0 1 2
5.	Internal Figures	0 1 2	11.	Large Rectangle	0 1 2	16. Connecting Lines	0 2
6.	Staffs	0 1 2					

Design E Total Score _____

Total Score

REY AUDITORY VERBAL LEARNING TEST A

List A	A1	A2	A3	A4	A5	List B	B1	A6	
Drum						Desk			Drum
Curtain						Ranger			Curtain
Bell						Bird			Bell
Coffee						Shoe			Coffee
School						Stove			School
Parent						Mountain			Parent
Moon						Glasses			Moon
Garden						Towel			Garden
Hat						Cloud			Hat
Farmer						Boat			Farmer
Nose						Lamb			Nose
Turkey						Gun			Turkey
Colour						Pencil			Colour
House						Church			House
River						Fish			River

Correct								
Intrusions								

Total A1 to A5 = _____
Total A6 – A5 = _____

COAST OLDER ADULT STROOP TEST

Sheet 1				
Red	Green	Yellow	Red	Yellow
Yellow	Red	Green	Yellow	Green
Green	Green	Yellow	Red	Red
Yellow	Green	Red	Green	Red
Green	Yellow	Green	Red	Yellow
Red	Red	Yellow	Green	Red
Green	Yellow	Red	Green	Yellow
Yellow	Red	Yellow	Yellow	Green
Green	Yellow	Green	Red	Yellow
Red	Green	Red	Yellow	Red

Sheet 2				
Green	Red	Green	Red	Green
Red	Yellow	Yellow	Green	Red
Yellow	Green	Red	Yellow	Red
Green	Red	Yellow	Red	Yellow
Yellow	Red	Green	Yellow	Green
Red	Yellow	Red	Green	Red
Yellow	Red	Green	Yellow	Green
Green	Yellow	Red	Red	Yellow
Red	Green	Yellow	Green	Red
Green	Yellow	Red	Yellow	Green

Sheet 3				
Green	Yellow	Red	Yellow	Green
Red	Green	Yellow	Green	Red
Yellow	Red	Red	Yellow	Green
Green	Yellow	Green	Red	Yellow
Red	Green	Red	Yellow	Red
Green	Yellow	Green	Red	Yellow
Yellow	Red	Yellow	Red	Green
Red	Yellow	Red	Green	Yellow
Red	Green	Yellow	Yellow	Red
Green	Red	Green	Red	Green

WISCONSIN CARD SORTING TEST

___ 1. C F N O	___ 17 C F N O	___ 33 C F N O	___ 49 C F N O
___ 2. C F N O	___ 18 C F N O	___ 34 C F N O	___ 50 C F N O
___ 3. C F N O	___ 19 C F N O	___ 35 C F N O	___ 51 C F N O
___ 4. C F N O	___ 20 C F N O	___ 36 C F N O	___ 52 C F N O
___ 5. C F N O	___ 21 C F N O	___ 37 C F N O	___ 53 C F N O
___ 6. C F N O	___ 22 C F N O	___ 38 C F N O	___ 54 C F N O
___ 7. C F N O	___ 23 C F N O	___ 39 C F N O	___ 55 C F N O
___ 8. C F N O	___ 24 C F N O	___ 40 C F N O	___ 56 C F N O
___ 9. C F N O	___ 25 C F N O	___ 41 C F N O	___ 57 C F N O
___ 10 C F N O	___ 26 C F N O	___ 42 C F N O	___ 58 C F N O
___ 11 C F N O	___ 27 C F N O	___ 43 C F N O	___ 59 C F N O
___ 12 C F N O	___ 28 C F N O	___ 44 C F N O	___ 60 C F N O
___ 13 C F N O	___ 29 C F N O	___ 45 C F N O	___ 61 C F N O
___ 14 C F N O	___ 30 C F N O	___ 46 C F N O	___ 62 C F N O
___ 15 C F N O	___ 31 C F N O	___ 47 C F N O	___ 63 C F N O
___ 16 C F N O	___ 32 C F N O	___ 48 C F N O	___ 64 C F N O

	Raw scores	Standard score	T score	Percentile score
Number of Trials Administered				
Total Number Correct				
Total Number of Errors				
Percent Errors				
Perseverative Responses				
Percent Perseverative Responses				
Perseverative Errors				
Percent Perseverative Errors				
Nonperseverative Errors				
Percent Nonperseverative Errors				
Conceptual Level Responses				
Percent Conceptual Level Responses				

	Raw score	Percentile range
Number of Categories Completed		
Trials to Complete First Category		
Failure to Maintain set		

BREAK: Yes/No

REY AUDITORY VERBAL LEARNING TEST

List A	A7	Recognition A	Recognition B
Drum		Drum	Desk
Curtain		Curtain	Ranger
Bell		Bell	Bird
Coffee		Coffee	Shoe
School		School	Stove
Parent		Parent	Mountain
Moon		Moon	Glasses
Garden		Garden	Towel
Hat		Hat	Cloud
Farmer		Farmer	Boat
Nose		Nose	Lamb
Turkey		Turkey	Gun
Colour		Colour	Pencil
House		House	Church
River		River	Fish

Correct			
Intrusions			

Recognition # targets correctly identified ____
distracters correctly identified ____

VISUAL REPRODUCTION II – RECOGNITION

1.	Y	N	14.	Y	N	27.	Y	N	40.	Y	N
2.	Y	N	15.	Y	N	28.	Y	N	41.	Y	N
3.	Y	N	16.	Y	N	29.	Y	N	42.	Y	N
4.	Y	N	17.	Y	N	30.	Y	N	43.	Y	N
5.	Y	N	18.	Y	N	31.	Y	N	44.	Y	N
6.	Y	N	19.	Y	N	32.	Y	N	45.	Y	N
7.	Y	N	20.	Y	N	33.	Y	N	46.	Y	N
8.	Y	N	21.	Y	N	34.	Y	N	47.	Y	N
9.	Y	N	22.	Y	N	35.	Y	N	48.	Y	N
10.	Y	N	23.	Y	N	36.	Y	N			
11.	Y	N	24.	Y	N	37.	Y	N			
12.	Y	N	25.	Y	N	38.	Y	N			
13.	Y	N	26.	Y	N	39.	Y	N			

Total Score: _____

VISUAL REPRODUCTION II

Hand used: ☐*Right* ☐*Left*

Design A

1. Main line and flags	0 1 2	3. Flags	0 1 2	5. Rotation	0 1 2
2. Flags	0 1 2	4. Flags	0 1 2		0 1 2
				Design A Total Score	____

Design B

1. Staffs and Flags	0 1 2	3. Flags	0 1 2	5. Rotation	0 1 2
2. Staffs	0 1 2	4. Flags	0 1 2		
				Design B Total Score	____

Design C

1. Large figure	0 2	5. Med-Sized Figures	0 1 2	9. Med-Sized Figures	0 2
2. Large Figure	0 1 2	6. Med-Sized figures	0 2		
3. Rotation	0 1 2	7. Med-sized figures	0 1 2		
4. Dots	0 1 2	8. Med-sized figures	0 1 2		
				Design C Total Score	____

Design D

1. Rectangles	0 1 2	7. Rectangles	0 2	13. Circle Segment	0 2
2. Rectangles	0 1 2	8. Large Rectangle	0 1 2	14. Triangle	0 2
3. Rectangles	0 1 2	9. Small Rectangle	0 1 2	15. Triangle	0 1 2
4. Small Rectangles	0 2	10. Circle Segment	0 2	16. Triangle	0 1 2
5. Small Rectangles	0 1 2	11. Circle Segment	0 2	17. Triangle	0 1 2
6. Rectangles	0 1 2	12. Circle Segment	0 1 2		
				Design D Total Score	____

Design E

1. Staffs and Flags	0 1 2	7. Bases	0 1 2	12. Small Rectangle	0 1 2
2. Flags	0 1 2	8. Rotation	0 1 2	13. Small Rectangle	0 1 2
3. Flags	0 1 2	9. Large Rectangle	0 1 2	14. Small Rectangle	0 1 2
4. Triangle and Rectangle	0 1 2	10. Large Rectangle	0 1 2	15. Connecting Lines	0 1 2
5. Internal Figures	0 1 2	11. Large Rectangle	0 1 2	16. Connecting Lines	0 2
6. Staffs	0 1 2				
				Design E Total Score	____
				Total Score	

DIGIT SYMBOL CODING

Digit-Symbol Coding	☐	(2 minutes + to end of 4th line)		Raw Scores:	_____ DS
Incidental Learning	☐	(No time limit)			_____ IL
Free Recall	☐	(No time limit)			_____ FR

TRAIL MAKING TEST

Part A _____ (time in seconds)
Part B _____ (time in seconds)

APPENDIX VII
COMPARISON OF POST-CONCUSSIVE SYMPTOMS BETWEEN MTBI GROUP AND CONTROLS

Item		MTBI Group (n = 15)		Control Group (n = 16)			
		M	SD	M	SD	*t*	*p*
	1	1.33	0.49	1.50	0.52	-0.92	0.36
	2	1.20	0.41	1.44	0.51	-1.42	0.17a
	3	1.20	0.41	1.19	0.40	0.09	0.93
	4	1.47	0.52	1.63	0.50	-0.87	0.39
	5	1.47	0.52	1.56	0.51	-0.52	0.61
	6	1.20	0.41	1.13	0.34	0.55	0.59
	7	1.53	0.52	1.69	0.48	-0.86	0.40
	8	1.00	0.00	1.19	0.40	-1.86	0.08a
	9	1.20	0.41	1.38	0.50	-1.06	0.30a
	10	1.67	0.49	1.75	0.45	-0.50	0.62
	11	1.40	0.51	1.31	0.48	0.50	0.63
	12	1.13	0.35	1.38	0.50	-1.56	0.13a
	13	1.27	0.46	1.50	0.52	-1.33	0.20
	14	1.07	0.26	1.25	0.45	-1.41	0.17a
	15	1.33	0.49	1.31	0.48	0.12	0.91
	16	1.07	0.26	1.25	0.45	-1.41	0.17a
	17	1.60	0.51	1.69	0.48	-0.50	0.63
	18	1.47	0.52	1.38	0.50	0.50	0.62
	19	1.13	0.35	1.44	0.51	-1.94	0.06a
	20	1.20	0.41	1.44	0.51	-1.42	0.17a
	21	1.47	0.52	1.50	0.52	-0.18	0.86
	22	1.00	0.00[b]	1.00	0.00[b]		
	23	1.53	0.51	1.63	0.50	-0.50	0.62
	24	1.33	0.49	1.50	0.52	-0.92	0.36
	25	1.20	0.41	1.69	0.48	-3.02	0.01*
	26	1.07	0.86	1.13	0.34	-0.53	0.60
	27	1.13	0.35	1.19	0.40	-0.41	0.69

* $p < 0.05$

[a] Equal variances not assumed

[b]. t cannot be computer because the standard deviations of both groups are 0

APPENDIX VIII
ASSESSMENT OF DATA FOR VIOLATION OF MULTIPLE REGRESSION ASSUMPTIONS

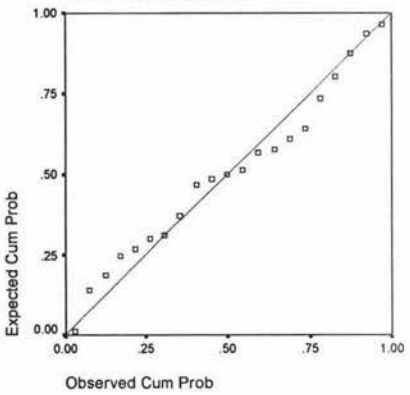
Boxplots revealed that six of the tests (Visual Reproduction II, Visual Reproduction Recognition, COAST Colour Task, Trails A & B and Digit Symbol) had one outlier. Another three tests (RAVLT Trial 1 and 2 and three of the Wisconsin subtests) had two outliers (none of these outliers were from the same participant). Considering the nature of the study (neuropsychological impairment due to brain injury) outliers were not unexpected. Consequently, these outliers were retained in the data set.

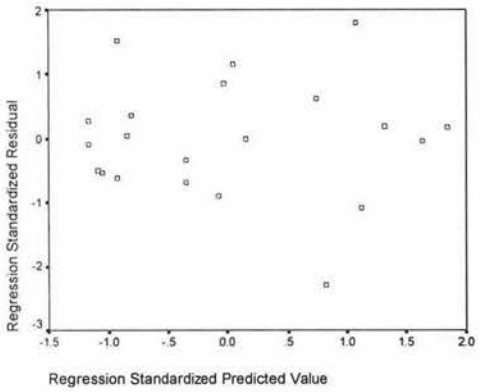
An examination of the correlation matrix revealed no concerns with multicollinearity or singularity.

From the normal plots of regression standardised residuals for the dependent variable (neuropsychological measures), there was indication of a relatively normal distribution. Furthermore, the scatterplot of residuals against predicted values, indicated no clear relationships between the residuals and the predicted values, consistent with the assumption of linearity.

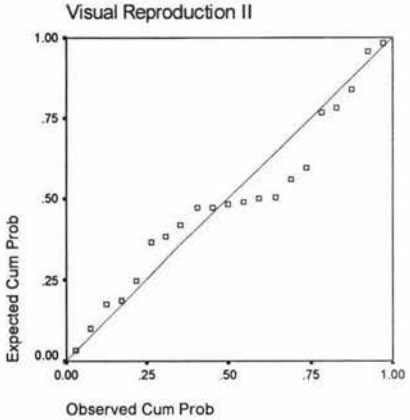
Normal P-P Plots of Regression Standardised Residual and Scatterplots for each dependent variable follow.

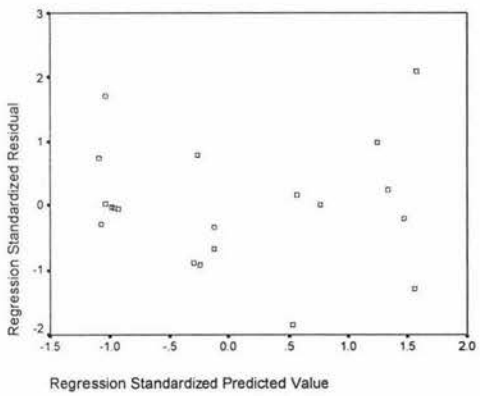
Visual Reproduction I



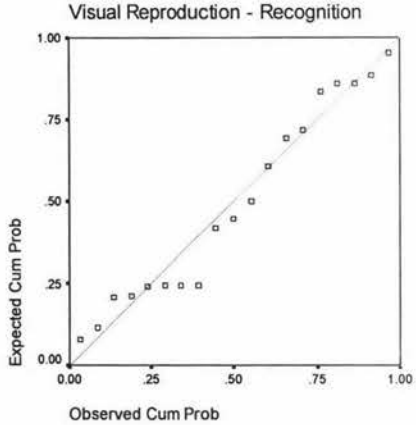


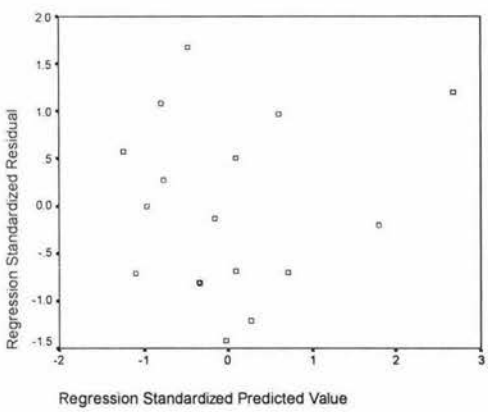
Visual Reproduction II



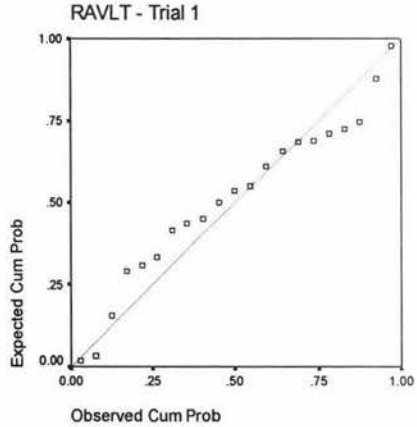


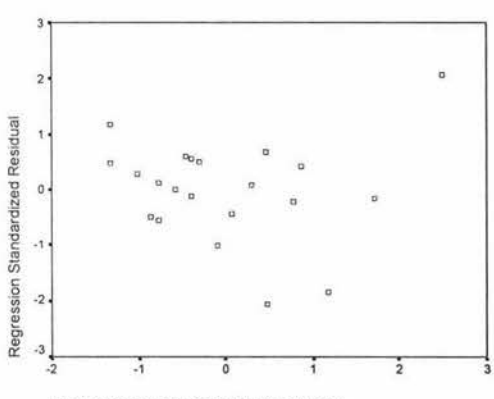
Visual Reproduction - Recognition



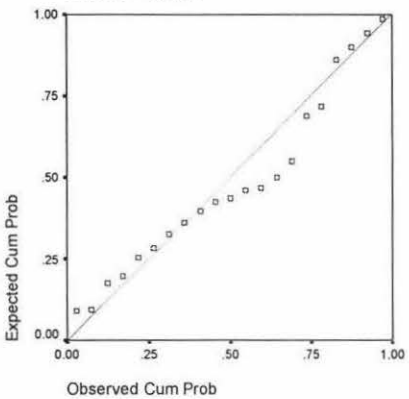


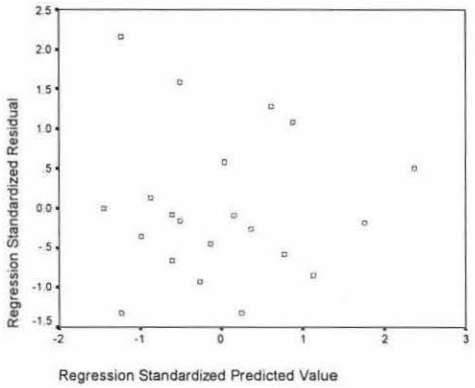
RAVLT - Trial 1



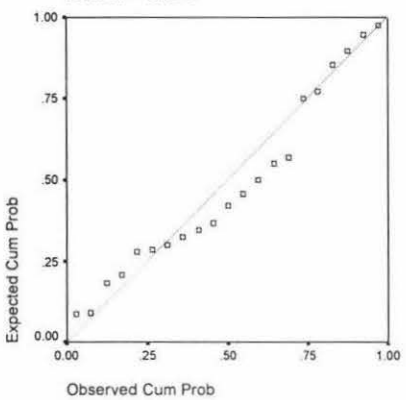


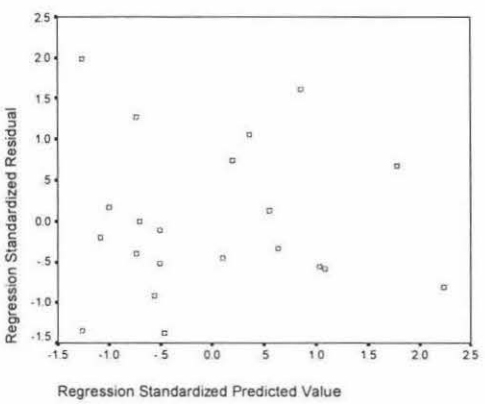
RAVLT - Trial 2



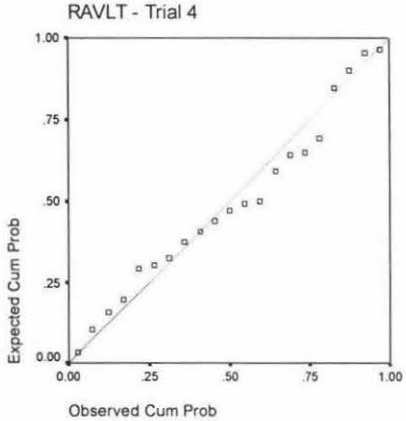


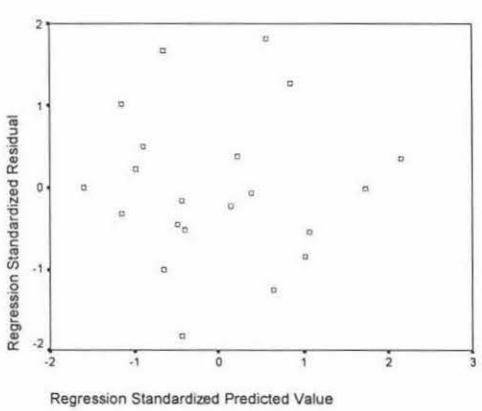
RAVLT - Trial 3



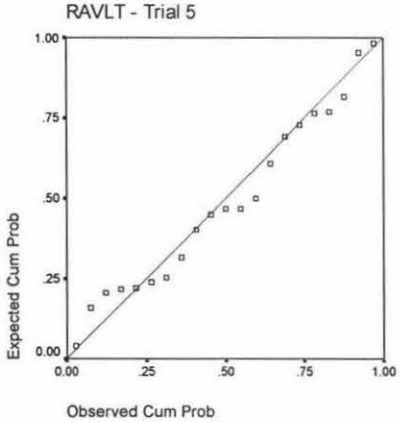


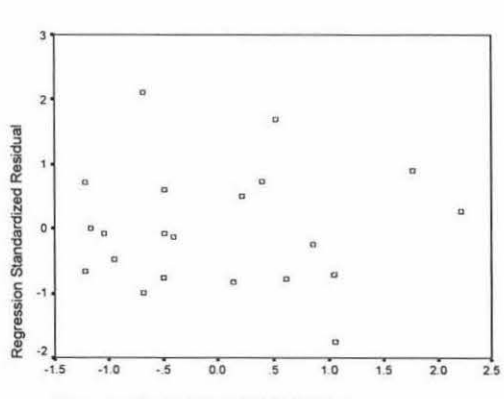
RAVLT - Trial 4



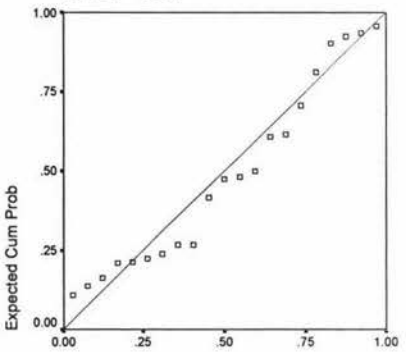


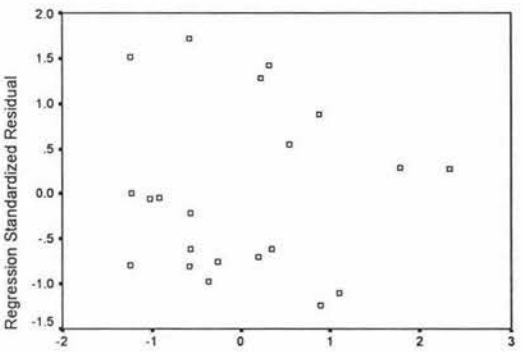
RAVLT - Trial 5



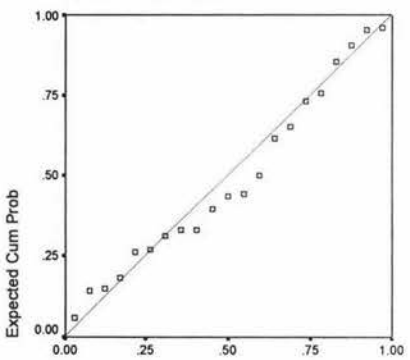


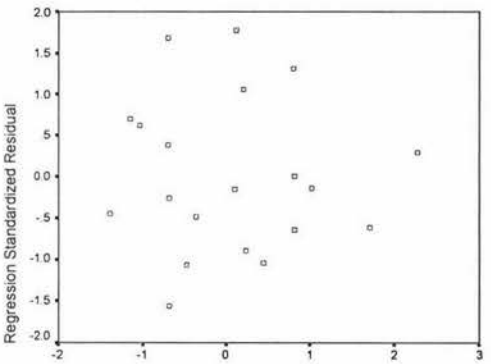
RAVLT - Total



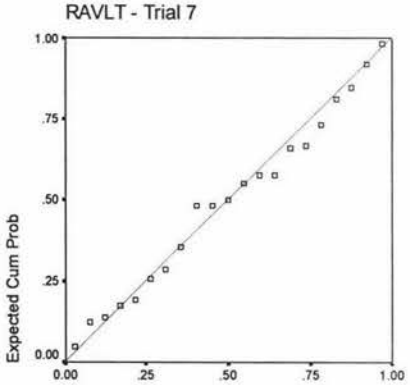


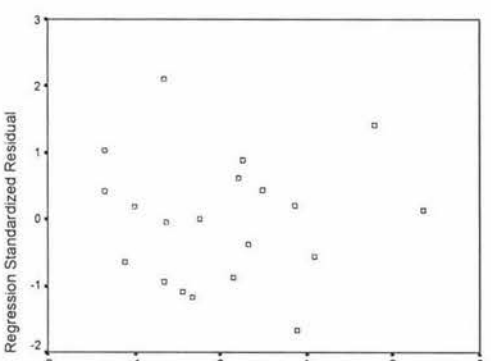
RAVLT - Interference



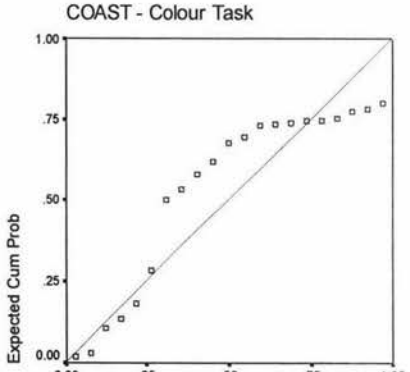


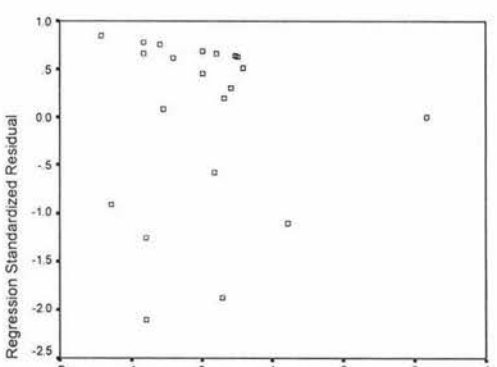
RAVLT - Trial 7



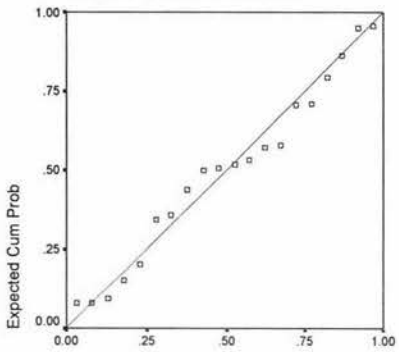


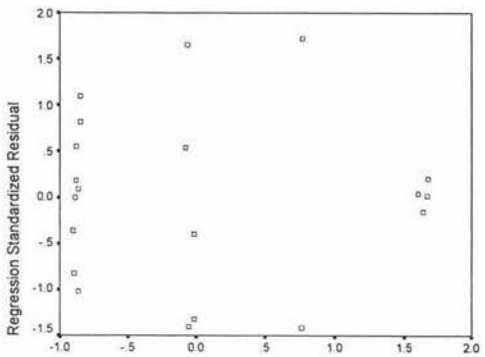
COAST - Colour Task



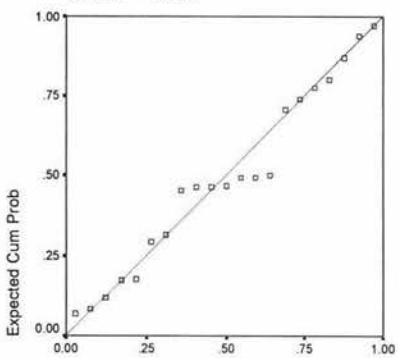


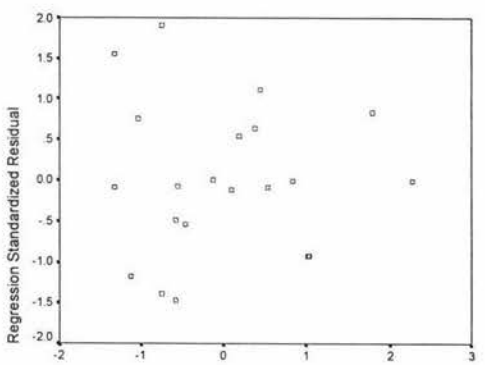
COAST - Colour Word Task



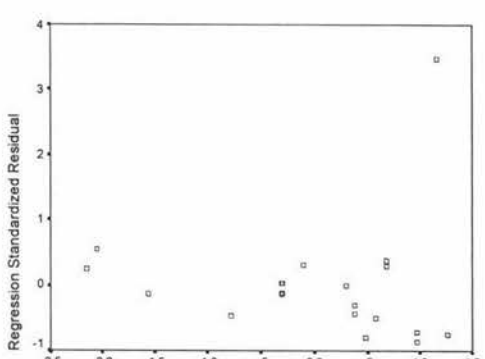


RAVLT - Trial 6

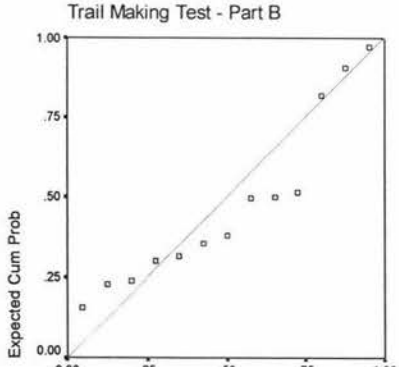


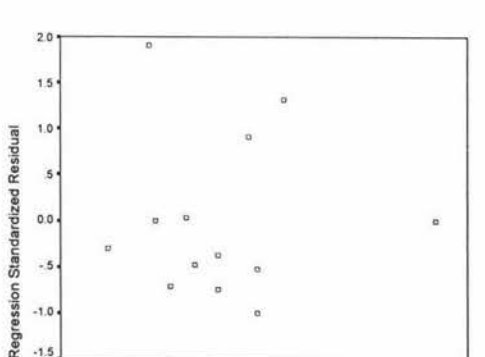


Trail Making Test - Part A

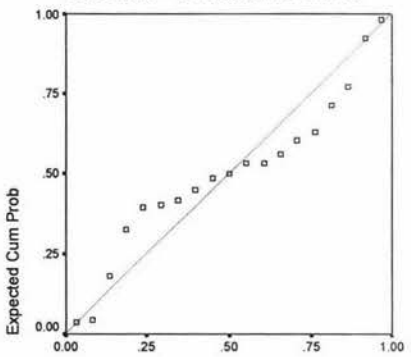


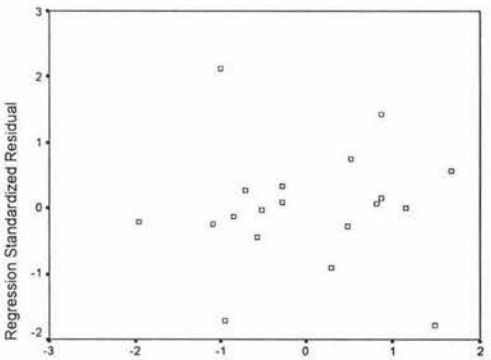
Trail Making Test - Part B



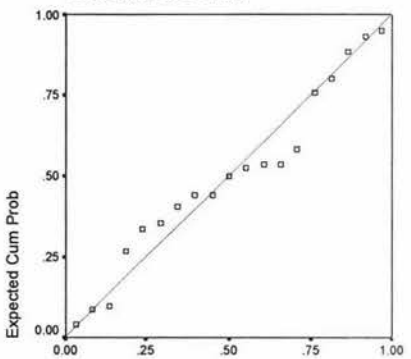


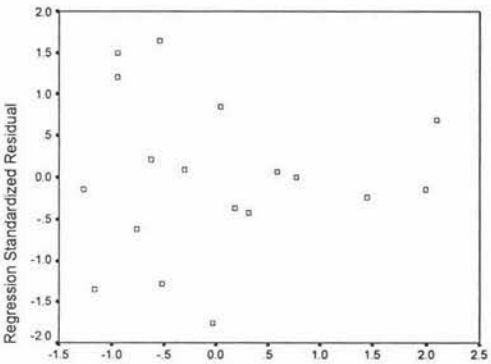
Wisconsin - Total Number Correct



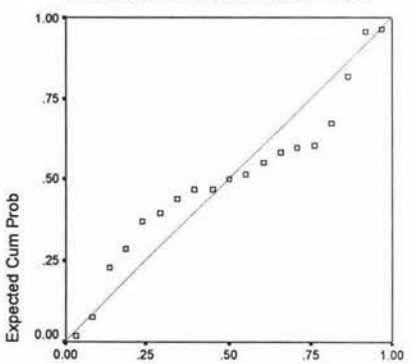


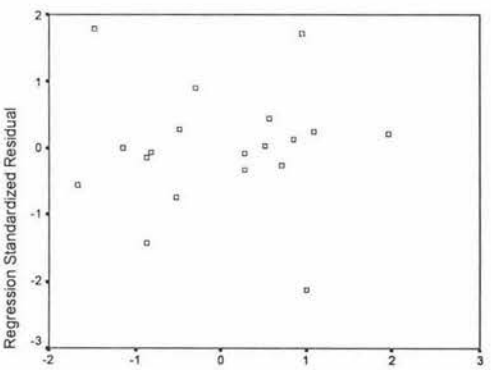
Digit Symbol Coding



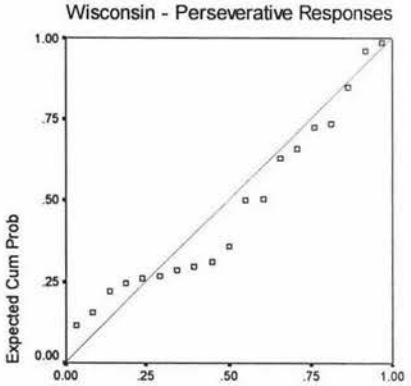


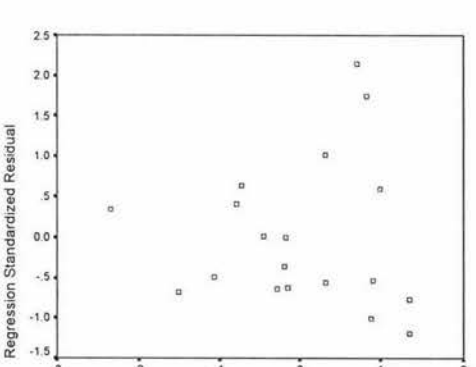
Wisconsin - Total Number of Errors



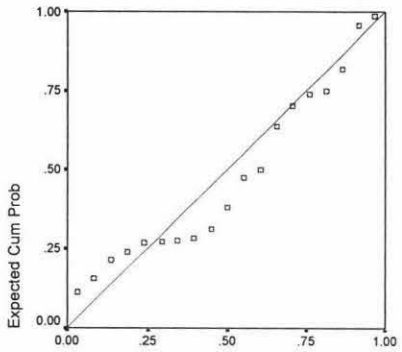


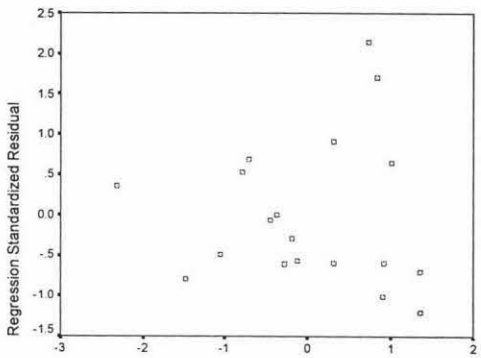
Wisconsin - Perseverative Responses



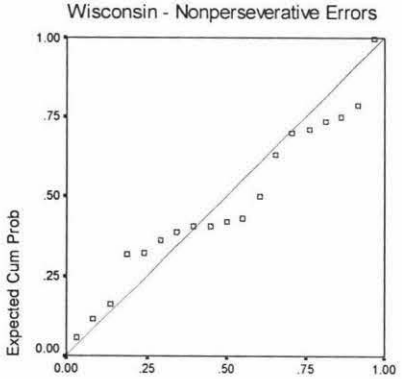


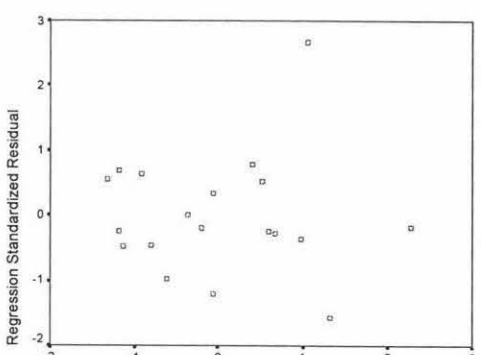
Wisconsin - Perseverative Errors



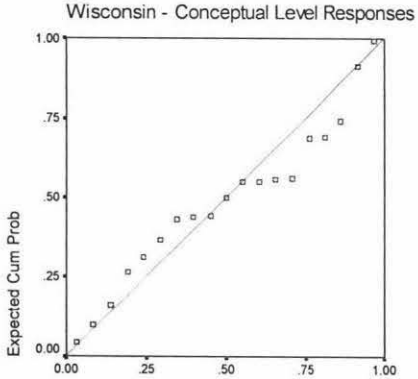


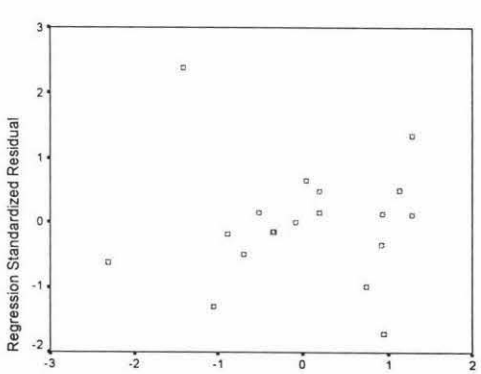
Wisconsin - Nonperseverative Errors



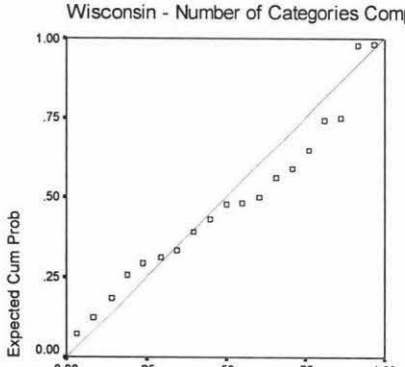


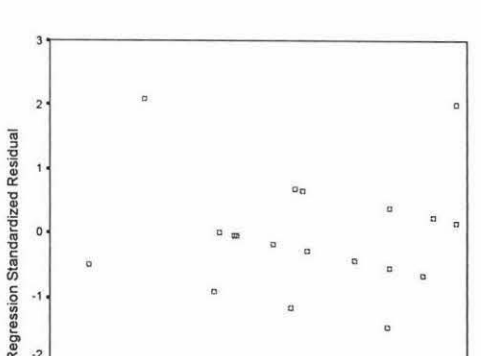
Wisconsin - Conceptual Level Responses



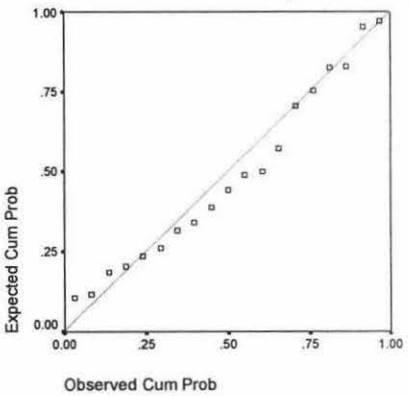


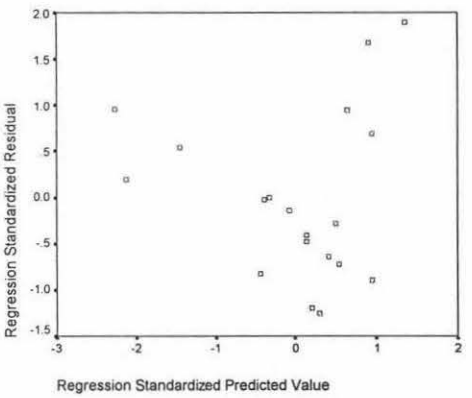
Wisconsin - Number of Categories Completed





Wisconsin - Trials to Complete First Category





Wisconsin - Failure to Maintain Set