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NEUROPSYCHOLOGICAL TEST MEASURES AS PREDICTORS OF LONG-TERM PSYCHOSOCIAL OUTCOME FOLLOWING TRAUMATIC HEAD INJURY

by

Ursula W. Wild

lic. phil. I, University of Zurich, 1977

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Neuropsychological Test Measures as Predictors of Long-Term

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ABSTRACT

Long-range prognosis of psychosocial outcome following traumatic head injury has become a major concern in health care, particularly in view of its clinical utility regarding earlier and more focused rehabilitation planning as well as the evaluation of disability compensation. The present study was undertaken in order to evaluate the single and combined predictive power of i.) medical indices concerning trauma severity, ii.) personal characteristics of the head-injured victim, and iii.) neuropsychological test measures in employment-related outcomes and day-to-day functioning.

Patients who had undergone comprehensive neuropsychological testing were later questioned about their occupational status and perceived problems in daily life. Unemployment rate was very high, irrespective of injury severity: of the 107 subjects, only 48 (46%) were working two to six years post-injury.

The results support the predictive validity of neuropsychological measures in favour of other prognostic indicators. Test performance on the Halstead-Reitan Battery, the Wechsler Adult Intelligence Scale - Revised, and the Minnesota Multiple Personality Inventory were found to relate to employment variables and self-reported problems in daily life efficiency better than did the medical indices of trauma severity and the personal characteristics of the victim.

Special attention was given to the role of executive-control functions and their impact on the long-term psychosocial consequences following head injury. The results suggest that measures of performance effectiveness can be used to quantify more subtle neuropsychological deficits and thus help identify the victims who are at higher risk for psychosocial maladjustment.

The findings further indicate that broad-range appraisal of neuropsychological functioning is required in order to optimize predictive accuracy. Thorough evaluation procedures should include measures of cognitive-intellectual, personality, and possibly, measures of executive-control functions. Lezak's model of neuropsychological functioning was found to provide a good framework for such a comprehensive approach.

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This thesis is dedicated to Sweetie'Ψ', André another of my long-term projects.

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CHAPTER I

INTRODUCTION

In the past, the predominant role of clinical neuropsychologists has been their assistance in the identification and diagnosis of brain impairment. Neuropsychological techniques are an important part of the neurodiagnostic armamentarium, and their usefulness and validity is well established (c.f. Lezak, 1983; Goldstein & Shelley, 1972; Reitan, 1975).

With the high incidence of brain-damaged survivors of traumatic head injuries (THI) (e.g. traffic or work-related accidents, sports injuries), questions concerning an individual's potential for rehabilitation and independent living have become a pressing concern in health care and litigation. Whereas it has been found that physical deficits often tend to improve eventually or can be adjusted to, the neuropsychological consequences of head injuries frequently cause serious and lasting disablement (e.g. Bond & Brooks, 1976; Thomsen, 1984; Goethe & Levin, 1984; Miller, 1985). Impaired neuropsychological functioning is typically evidenced in impaired memory functions, deficient cognition including language, intelligence, perceptual and motor skills, and personality problems. The resulting psychosocial ramifications of THI and the disruptive and often tragic consequences for patient and family are well documented in the literature (c.f. Lezak, 1983; Eiben, Anderson, Lockman, Matthews, Dryia, Martin, Burrill, Gottesman, O'Brian, & Witte, 1984; Vargo, Karpman, & Wolfe, 1985).

More often than not, the neuropsychological consequences of brain impairment are quite subtle, but nevertheless can be equally disturbing to both the patient and the family. As Lezak (1983) states:

> ...their irritability, self-centeredness, impulsivity or apathy create awesome emotional burdens on family members, generate conflicts between family members and with the patient, and strain family ties, often beyond endurance. (p. 11)

For the neuropsychologist practicing in a forensic or rehabilitation setting, accurate assessment of permanent neuropsychological deficits that will affect the THI victim's future livelihood is of vital interest. Many health or legal professionals rely on the neuropsychologist's assistance not so much for diagnostic purposes but in order to obtain a detailed description of the cognitive-behavioral consequences[1] of brain impairment. This includes comprehensive information concerning intellectual and emotional status, memory and ability deficits, as well as personal assets and limitations. Accordingly, the information gained from neuropsychological data should yield a solid basis for answering important clinical questions with regard to psychosocial prognosis including impact on everyday life activities, future work capacity, overall psychosocial and

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[1] For the purpose of this study, "neuropsychological consequences" and "cognitive-behavioral consequences" will be used interchangeably and refer to deficits in functioning resulting from brain trauma.

vocational adjustment, and prospects for rehabilitation.

Unfortunately, however, there is a distinct lack of research evaluating the clinical utility of neuropsychological assessments in predicting brain-damaged patients' everyday functioning and overall adjustment to the disability. As Heaton and Pendleton (1981) stated, this has been a largely ignored research topic, despite its obvious clinical importance. With the current shift of emphasis away from diagnostic and toward prognostic use of neuropsychological assessments, the potential contribution of clinical neuropsychologists towards patient management and rehabilitation becomes apparent. It is generally assumed that neuropsychological data should help delineate cognitive-behavioral consequences following brain injury, predict their likely impact on everyday functioning (Heaton & Pendleton, 1981) and, ideally, aid in the development of training programs that facilitate and optimize psychosocial recovery, but evidence to date is problematical. Hence, there is a clear need to further investigate the predictive validity of present assessment techniques for these purposes. Moreover, it is important to examine homogeneous groups of neurologically impaired patients (e.g. THI, stroke victims, persons with epilepsy) separately, since underlying etiologic factors will result in varying patterns of brain impairment and largely determine the degree and nature of neuropsychological deficits.

The focus of this study was on the residual neuropsychological deficits resulting from THI and their impact on psychosocial adjustment, specifically on occupational status at the time of follow-up, on loss in occupational status, on the disposition of legal proceedings, and on perceived daily life efficiency. In trying to find out more about variables that influence the adjustment process following trauma, this study investigated those cognitive, emotional, and executive-control problems that hinder or preclude return to previous lifestyle. A large neuropsychological data base of patients with a medically documented history of THI allowed confirmation of well-established assessment techniques as useful and informative prognostic indicators of THI victims' psychosocial recovery.

In the following review, different conceptual approaches to outcome prediction have been outlined together with a discussion of research findings and frequently encountered methodological problems. While most previous studies have focused separately on either biomedical markers of severity and secondary factors affecting outcome (such as age, premorbid history) on the resulting cognitive-intellectual loss, or have looked at personality and emotional problems as predictors of psychosocial recovery (outcome), a unifying "neuropsychological systems" model was proposed as an alternative approach. In this, adjustment to daily life was assumed to be determined by the combined impact of trauma data and three broad subsystems of neuropsychological functioning. The latter are intellect and information-handling aspects of behavior, emotionality and personality, and executive-control functions (goal-directed behavior) (Lezak, 1983).

Acute Head Injuries And Their Expected Course Of Recovery

Incidence And Epidemiologic Features Of THI

There is increasing awareness of THI as a serious public health problem. Craniocerebral trauma is associated with a high fatality rate and significant levels of neurologic and neuropsychologic impairment in survivors. In the United States the incidence rate of THI victims who are hospitalized for a minimum of 48 hours is estimated at 410,000 to 500,000 new cases per year (Kraus, Black, Hessol, Ley, Rokas, Sullivan, Bowers, Knowlton, & Marshall, 1984; Brock, 1985), whereof about 100,000 will succumb to their injuries. THI constitutes the third most common cause of death in the United States and the primary cause of death in persons under the age of 40 (Brock, 1985).

Almost 50% of all THI is due to traffic-related causes (motor vehicle, motorcycle, pedestrian, and bicyclist accidents). The next most common causes are falls and sports-related injuries. Young males (15 to 24 years) are at particularly high risk to become THI victims. Overall, it is estimated that males outweigh female victims almost by a ratio of 2:1.

Epidemiological information is of particular interest when placed into a local context. In the province of British Columbia, Canada, for example, Robinson, Dekaban, and Peggie

(1985) have evaluted the main demographic characteristics of 117 severely head-injured patients admitted to a rehabilitation centre. Their findings are consistent with the various international studies, pinpointing the young male at highest risk, particularly when driving under the influence of alcohol.

Biomechanics Of THI And Measures Of Severity

Information about the biomechanical forces causing head injury, together with indicators of their severity generally allow prediction of the expected course of recovery (Lezak, 1983). By its nature, a THI is always the sum of several forces in addition to the impact itself, as a result of which damage is not only limited to the point of impact. Since the brain is sitting on a flexible stem in a liquid medium, the forces of the impact "may literally bounce the brain off the opposite side of its bony container, bruising brain tissue where it strikes the skull" (Lezak, 1983, p. 167)

Depending on direction and speed of the impact, injuries may result in hypertension, hyperflexion, lateral flexion and rotational strains on the musculo-skeletal structure of the neck and head. Together with the movement of the brain within the skull, this can result in microscopic lesions (shearing) throughout the brain tissue (Gurdjian & Gurdjian, 1978). Given a sufficient force on impact, the initial "coup" is often followed by a rebound effect, the "contrecoup", in which the brain is bruised (often referred to as 'contusion') in the area opposite to the blow. Some of the major medical complications are lacerations, skull fractures, intracranial hemorrhage, edema, diffuse brain swelling and raised intracranial pressure, brain shift, and inadequate supply of oxygen to the brain (hypoxia). Due to the nature of the biomechanical and inertial forces involved, the whole brain is affected, resulting in widespread damage. Injuries that involve twisting or rotation of the head and neck (i.e. torsion injuries) are considered to be more serious and frequently cause traumatic unconsciousness (Ommaya & Gennarelli, 1974).

Three commonly used measures of severity in terms of survival and outcome are i) initial level of consciousness, as measured, for example, by the Glasgow Coma Scale (GCS) (Teasdale & Jennett, 1974); ii) duration of loss of consciousness, e.g. time during which a patient fails to obey verbal commands; and iii) post-traumatic amnesia (PTA), that is the length of time the THI victim is unable to consistently remember ongoing events since the time of injury. Neuroradiologic and neurophysiologic procedures such as computerized tomographic scanning (CT scan) and electroencephalogram (EEG), and more recently positron emission tomography (PET) as well as magnetic resonance (MR) are often used in the early management of THI and later diagnostic assessments (c.f. Timming, Orison, & Mikula, 1982; Klove & White, 1963; Rao, Jellinek, Harvey, & Flynn, 1984). However, their usefulness as predictors of long-term outcome is controversial.

Assessment of severity using both the Glasgow Coma Scale (GCS) according to the criteria outlined by Teasdale and Jennett, and duration of PTA as defined by Russell (1971) is generally accepted as the best quantitative index of injury severity. These scales are also considered to be relevant prognostic signs of expected course of recovery when combined with additional factors such as age, etiology, and pre-morbid level of functioning.

More specifically, Becker, Grossman, McLaurin and Caveness (1979) outline the following criteria for diagnosis of severity:

1. A *mild* injury is characterized by transient loss or brief alteration of consciousness. There are no focal neurologic deficits, and the victim's return to alertness and full orientation is fast. Duration of PTA is less than one hour.
2. A *moderate* injury is diagnosed when consciousness remains impaired or the victim is still disoriented one hour after the accident. Normally, the patient is able to follow some commands, or is alert with a focal neurologic deficit. PTA extends from one to twenty-four hours.
3. A *severe* injury is characterized by an extended period of unconsciousness. The patient is unable to follow any commands, he or she may use words but inappropriately. Motor responses are very weak or non-existent. PTA ranges from one to seven days or longer.
4. A *very severe* injury is diagnosed when the patient shows no reaction to intense stimuli and no motor movement or

posturing response can be elicited. Patients with very severe head injuries have very poor prognosis. Many die, and if the patient lives it is frequently in a vegetative state.

Trauma Severity As Predictor Of Long-Term Outcome

Severe Injury

Expected course of recovery is often predicted on the basis of trauma severity. It is undisputed that the prognosis for severe head injuries is poor. Virtually always they cause permanent brain impairment of a diffuse nature which is typically associated with loss of overall intellectual efficiency, poor attention, concentration, memory, planning and problem solving abilities, together with emotional and behavioral problems such as apathy, irritability, impulsiveness, fatiguability, unrealistic self-appraisal, inappropriate interpersonal behavior, social isolation, depression, and anxiety (Goethe & Levin, 1984). Given this cluster of symptoms which is commonly referred to as post-traumatic syndrome (PTS) or post-concussion syndrome (PCS), it is not too surprising that long-term psychosocial adjustment after severe head injury is often problematic and can present formidable problems to family and society.

Miller and Stern (1965), for example, found that even after three to forty years post-injury the degree of social and occupational incapacity in the severely head-injured was considerable. Less than 50% of their sample of 100 patients (PTA greater than 24 hours) were eventually able to resume their previous employment, whereas the majority were either downgraded or unable to return to work. Many of the patients suffered from psychiatric symptoms and showed some degree of intellectual loss. Similar results were reported by Thomsen (1984). He concluded that both work capacity and psychosocial functioning of severely injured patients (N = 40, PTA greater than one month) were seriously compromised, and that intellectual, emotional and behavioral problems persisted even ten to fifteen years after the accident. His study is particularly interesting since it allows comparison of problem areas as rated after the first (2.5 years post-injury) and second follow-up (10 to 15 years post-injury). Most subjects were reported to show persistent problems with memory, personality and emotions, poor concentration and slowness. Moreover, problems with irritability, restlessness, apathy, tiredness, sensitivity and distress, lack of interest, and loss of social contact tended to become increasingly more pronounced with time. Thomsen's data also indicated that there was very little change in work capacity across this time period. That is, if subjects had not returned to work within the first two and a half years, it was highly unlikely that they would return to competitive employment at a later date. In a much larger outcome study regarding the occupational and social status of 479 trauma victims (PTA greater than one week or duration of unconsciousness longer than one week), Lewin, Marshall, and Roberts (1979) found that 49% of the patients had recovered, 39% died and 18% of the sample was totally or severely incapacitated. Interestingly, they concluded that the decline in occupational status was more strongly associated with mental disability including loss of cognitive functions and personality problems, rather than overt neurological deficits such as epilepsy, hemiparesis or cranial nerve injuries. With fair consistency, these results have been confirmed in other long-term studies of survivors of severe head injury (e.g. Fahy, Irving & Millac, 1967; Wedell, Oddy & Jenkins, 1980).

The psychosocial prognosis for the young survivors of severe head trauma is considerably more optimistic. In a two-to-five year follow-up study of adolescents (under 18 years of age), Schmid (1984) found that only 13% of the subjects were unable to find competitive employment. Overall, his findings indicated that THI in a younger population resulted in fewer post-traumatic complaints, such as easy fatiguability, headaches, slowness, and confusion. However, the data suggested that the duration of coma was an important predictor of future occupational status, and those victims who were unconscious for more than two weeks were much less likely to be gainfully employed.

When placed into the local context of our province and the present basic population unemployment rate of over 12%, projections of eventual outcome in terms of possible gainful employment for THI survivors are predictably even grimmer, due to the recent economic recession. In a recent report in the British Columbia Medical Journal, Robinson et al. (1985), for example, estimated that only a third of all severely head-injured patients in their sample (N = 117, duration of coma as severity measure) can be expected to return to full time employment, a fourth will never work again, and the remaining 40 to 45% are projected to suffer from permanent disabilities and perform lesser quality part-time work.

Mild And Moderate Injuries

Statistically, head injuries classified as mild or moderate occur much more frequently than severe injuries. However, much less attention has been paid to the extent and nature of disability caused by mild to moderate brain trauma and the resulting psychosocial ramifications. Particularly in the medical literature, the consequences of such injuries tend to be minimized. Whereas it is acknowledged that moderate trauma may result in some residual deficits, complete recovery is expected in most cases. The course of recovery from mild to moderate trauma may be complicated with some of the symptoms of PTS, but this is expected to be a transitory phenomenon occuring only in a very few cases. Moreover, such symptoms are often attributed to functional rather than organic reasons, and it is widely believed that persisting postconcussional symptoms after mild injury are most likely a reflection and exacerbation of premorbid personality problems. Matthews (1982), for example, states: "The minor closed head injury with brief unconsciousness is usually made too much of, causes disproportionate loss of work, and attracts excessive compensation in courts of law." (p. 142)

This attitude, however, has been challenged by recent findings. In their study on disability caused by minor head injury, Rimel, Giordani, Barth, Boll, and Jane (1981) found that three months post-injury, the majority of their large sample of mildly head-injured patients reported suffering from persistent headaches and problems with their memory. The sample consisted of 424 subjects, and trauma severity was measured on the basis of length and depth of coma (GCS rating between 13 to 15 indicating a nearly normal state of alertness, duration of unconsciousness less than 20 min, and hospitalization for less than 48 hours). Even more strikingly, over a third of those patients who were employed before the accident had not yet returned to work. Although Rimel and her colleagues' work has been criticized for some methodological shortcomings, the implications of their findings are serious enough to cast doubt on the value of conventional trauma severity measures as sole predictors of long-term outcome, particularly in mild to moderate head injuries. Moreover, there is increasing evidence that there may be a significant organic component to even minor head injury. For example, pathologic evidence of microscopic lesions after mild head injury has been found (Gronwall and Wrightson, 1975) and autopsy results have shown widespread shearing and destruction of white matter (Newcombe, 1982). Of course, such procedures cannot be used in conventional neurological examinations and neurological abnormalities are rarely detected in most mild to moderate injuries, even including results of neuroradiologic imaging and neurophysiologic procedures. This is illustrated in the work of Jane and Rimel (1981) who found no clear relationship between presence/absence of lesions on CT scans and neuropsychological impairment. They hypothesized that the basic pathology in all head injury was axonal disruption. They suggested that persisting problems could be interpreted as an indicator of axonal injury which had not only resulted in disruption of processing but actual morphological alterations.

Predictors Of Neuropsychological Impairment Following THI

Biomedical Markers As Predictors Of Long-Term Outcome

Undisputedly, biomedical markers of trauma severity have proven to be useful prognostic indicators of gross outcome measures such as mortality and morbidity. Particularly for the neurosurgeon and the neurologist, survival of the patient and prevention of severe physical and cognitive impairment constitute two of their main concerns and determinants of a 'good' recovery. In contrast, rehabilitation specialists and clinical neuropsychologists are increasingly more concerned about relatively minor, but persisting disabilities that are not life-threatening or devastating, but nevertheless interfere with the patient's psychosocial adjustment and vocational effectiveness. Despite the diversity of opinion as to what constitutes 'good' or 'poor' outcome, it cannot be overlooked that a large percentage of THI victims, regardless of severity, suffers from physical, cognitive, behavioral, and emotional problems that preclude them returning to their previous vocational life. Only in the past few years has this been recognized, and there has been increasing reference made to the 'modern' or 'silent' epidemic (Robinson et al., 1985) or the 'walking wounded' (Murray, 1985). While such terminology is an overdramatization, nevertheless as Robinson et al. put it: "The suffering of the patients as well as their families is obvious, and the financial costs to society is [sic] enormous." (p. 703)

Since neuropsychological assessment procedures have been specifically developed in order to identify even subtle changes in cognitive, memory, and emotional functions, it can be hypothesized that these additional variables of mental funtioning should improve the accuracy of outcome prediction, particularly with regard to the 'gray areas' of mild to moderate THI. Specifically during the later phase of recovery, after most of the natural recovery has taken place, they appear to be the methods of choice. On the basis of their own data and previous findings (e.g. Klonoff, Low & Glark, 1977), Long and Couvier (1986) concluded that many head trauma patients are impaired with regard to higher cortical functions long after more obvious neurological symptoms and signs from medical evaluation techniques such as EEG and CT scans, have returned to normal.

Comparing hit rates for such scans, for neuropsychological evaluation, and for psychological sequelae as a function of injury severity, they found that neuropsychological evaluation and psychological sequelae were far more sensitive measures than the traditional medical diagnostic techniques. For example, of the patients who had suffered mild to moderate head trauma, only 26% were identified on the basis of CT scan, 28% on the basis of EEG, but 60% on the basis of psychological sequelae, and 87% on the basis of neuropsychological evaluation. Accuracy of all measures improved when identifying patients who had suffered severe injury: hit rates were 45% for CT scan, 72% for EEG, 64% for psychological evaluation, and 89% for neuropsychological evaluation, respectively.

Neuropsychological Deficits As Predictors Of Long-Term Outcome

It is generally accepted that neuropsychological deficits immediately after THI are considerably more pronounced than at later stages. However, information about the underlying process of recovery, length of time until optimal recovery has taken place, and the role of the deficits in overall psychosocial outcome is still disjointed and often contradictory. While it is important to gain better understanding of the underlying process of recovery for prognostic and rehabilitation purposes, a review of relevant research can easily lead to more confusion than clarification. This can be mainly attributed to an overall lack of a framework within which investigations are undertaken and the resulting problems with comparability. Some of the major methodological issues are i) the varying schedules of testing; ii) the selection of actual functions to be examined and the assessment tools chosen to measure these; iii) the choice of control groups; iv) the problem of separating recovery from practice effects when serial testing is administered; and last but not least, v) the unavoidable heterogeneity in nature and severity of THI and individual subject characteristics (Brooks, Deelman, Van Zomeren, Van Dongen, Van Harskamp, & Aughton, 1984). The following review will highlight these problems.

Effect On Cognitive Functioning Following Severe Injury

A large group of severely head-injured patients (N = 719) was observed for a period of two years following trauma (Bond & Brooks, 1976). On the basis of two well-known measures of intellectual functioning, namely the Wechsler Adult Intelligence Scale (WAIS) and the Raven Progressive Matrices, the researchers concluded that the greater part of intellectual recovery was taking place during the first six months, with only slight improvement afterwards. Data indicated that verbal skills recovered more quickly than non-verbal skills. Differences in individual recovery curves suggested that the more severely injured patients reached their maximum level of recovery sooner. Increased level of disability as measured by the Glasgow Outcome Scale[2] (GOS) was associated with more severe injury, older age,

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[2] The Glasgow Outcome Scale is a standardized measure of global

and post-injury psychosocial problems.

Based on similar but somewhat more comprehensive assessment tools, Najenson, Groswasser, and Stern (1975) found that six months after severe injury, considerable improvement had taken place on ability-based measures of locomotion, intellectual performance, and communication disorders, although initial patterns of intellectual deficits tended to be preserved. On the other hand, they found that the level of behavioral disturbances was elevated in all 40 patients, and that these presented considerable difficulties for rehabilitation. Since most subjects who showed gross behavior disturbances were also suffering from significant impairment in cognitive functioning, they inferred that it was the latter that presented the major obstacle to social and vocational rehabilitation. Their reasoning was mainly based on their experience with a larger patient group where residual cognitive defects could be pinpointed as playing a crucial role in psychosocial recovery three or more years post-injury. Hence they concluded that residual cognitive deficits were the major obstacles to social and vocational rehabilitation.

Within the context of their study, Najenson's and his colleagues' reasoning can be considered logical, while in a more

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[2](cont'd) outcome developed by Jennett and Bond (1975). An outcome rating is based on the patient's physical and economic dependence, cognitive functioning, and social reintegration and can fall within one of four categories, namely i) persistent vegetative state; ii) severe disability; iii) moderate disability; and iv) good recovery.

general context their inferences have to be questioned. Clearly, the scope of their assessment tools was too narrow to allow such overspecific interpretation. For example, they failed to include measures of personality organization, emotional distress, and executive-control functions in their evaluation procedures. Thus the researchers did not have the necessary data base in order to determine conclusively whether residual cognitive deficits were indeed the only crucial factor that affected social and vocational rehabilitation of their subjects.

That considerable improvement on neuropsychological measures can also be expected in severely head-injured patients was demonstrated by Drudge, Williams, Gomes, and Kessler (1984). Repeat testing with the Halstead-Reitan Battery (HRB) at two months and one year post-trauma showed large improvement on scores, albeit only partial recovery of neuropsychological functions. At one year post-trauma, seven out of the 15 subjects were unemployed, five had returned tc part-time and the remaining three to full time work. They concluded that overall adaptive recovery such as return to previous lifestyle was indeed correlated with neuropsychological recovery. They cautioned, however, that more research was needed concerning the long-term emotional, social and vocational adjustment.

Mandleberg (1975) and Mandleberg and Brooks (1975) studied cognitive recovery after severe head injury using repeated administration of the WAIS. They concluded that a 'typical' recovery pattern showed lesser initial impairment but more gradual recovery for Verbal subtests, in contrast to greater recovery sustained over a longer period of time for the Performance subtests. Moreover, their results indicated quite clearly that contrary to findings in non-brain-injured groups, practice effects due to repeated testing did not appear to affect scores. They also found that length of PTA was a poor predictor of long-term cognitive outcome. Testing subjects while still suffering from PTA did not improve accuracy in predicting long-term cognitive outcome, although it resulted in significantly depressed scores.

Effects On Cognitive Functioning After Moderate To Severe Injury

In a recent study, Tabaddor, Mattis, and Zazula (1984) attempted to delineate the cognitive sequelae and recovery after moderate to severe head injury. They studied the immediate effects of head trauma on cognitive functioning, and the course of cognitive recovery over a one-year period. The resulting recovery curves showed varying patterns of recovery for different processes, as well as differences in the degree of impairment among the various functions tested. More specifically, both linguistic and memory functions were found to remain defective throughout the one-year period. Ratings of overall outcome on the basis of the GOS were: 44% good recovery, 52% moderate disability, and 4% severe disability. Age, duration of coma, depth of coma, disturbance of brain stem reflexes, and GCS were the best predictors of survival, but they were relatively poor predictors of long-term functional outcome. On the other hand, a measure of the efficiency of intellectual functioning (the Dementia Rating Scale) at the time of discharge from the hospital proved to be the best predictor of long-term outcome. Unfortunately there was a high attrition rate in this study, and only 25 out of 68 patients could be reached at the one-year follow up; this may well have resulted in considerable distortion in interpretation of the actual situation.

Lezak (1979) studied the recovery of memory and learning functions over the first three years following traumatic brain injury in twenty-four male subjects who were tested in six month intervals. Outcome quality was simply dichotomized as impaired or normal. Interestingly, her findings indicated that only those tests measuring simple functions showed systematic improvement over time. The more severely injured subjects (length of coma greater than two weeks) achieved poorer scores, while site of injury or age of subject were not found to be important factors. A major and unusual finding of her study was a recovery curve for tests measuring complex functions that indicated initial improvement, followed by later deterioration. This suggests that there may be a delayed deterioration of the more complex memory and learning functions, an observation which could have far-reaching implications for litigation and rehabilitation.

Effects On Cognitive Functioning Following Mild To Moderate Injury

The studies of Lezak described in the previous section have been disputed by Dikmen, Reitan, and Temkin (1983) who administered a comprehensive neuropsychological battery three times with a testing schedule of approximately 16 days, 12 months, and 18 months after mild to moderate injury. They found that most of their 27 subjects showed considerable improvement within the first year despite a broad range of initial deficits. After 18 months, improvement seemed to continue, but degree of initial deficit appeared to be a significant determinant of the level of subsequent cognitive recovery and residual deficits.

In a study of mildly head-injured subjects, neuropsychological examination three months after trauma revealed problems with attention, concentration, memory or judgment in most of the 69 patients that were evaluated, while the standard neurological examination did not show any abnormalities in nearly all subjects (Rimel et al.,1981). Interestingly, the degree of impairment on the neuropsychological measures was also found to be an important predictor of employment status. In addition, the patients' psychological responses to the injury, and the degree of emotional stress caused by persistent symptoms was found to have a significant role in predicting long-term disability. Because of the possible effects upon recovery from ongoing litigation or compensation procedures, this factor was also studied and it was found that a person's involvement in litigation or compensation procedures appeared to be only a minor factor in determining the psychosocial outcome. While basically agreeing with Rimel and her colleagues' findings that even mild injury had a disruptive impact on a person's psychosocial functioning, McLean, Temkin, Dikmen, and Wyler (1983) came to the conclusion that impaired psychosocial functioning seemed to be unrelated to neuropsychological performance one month post-injury. While their 20 subjects did not seem to perform as well as the control group on neuropsychological tests, the differences were not significant.

Effects Upon Emotional And Personality Functioning

All of the studies discussed so far have focused exclusively on cognitive-intellectual changes, and to a lesser degree on personality aspects of neuropsychological recovery. However it is well known that THI frequently results in marked personality and emotional disturbances which persist long after apparent physical recovery. The assessment of such functions poses many methodological problems, centering mainly around issues of accurate and reliable assessment (McKinlay & Brooks, 1984), because brain-injured patients are often extremely unreliable as informants about themselves. Many of them lack insight into their shortcomings and deny problems; unfortunately close family members and friends have also been found to be quite unreliable and subjective in their assessment of the patient's psychosocial functioning (Klonoff & Costa, 1984). Nonetheless, findings throughout different studies show some consistency, suggesting that behavioral and emotional disturbances are a major component of disability after head injury, and that these contribute to the eventual functional outcome to an extent equal if not greater than the cognitive or physical impairment.

In 1977, Dikmen and Reitan reported their findings on the convergence between neuropsychological deficits as measured by the HRB and related tests, and emotional disturbance based on Minnesota Multiphasic Personality Inventory (MMPI) scores. Serial examination (initial hospitalization, 12 months, 18 months) revealed that those patients with moderate or marked neuropsychological deficits were also reporting greater emotional difficulties than those patients who were found to be normal or only mildly impaired on neuropsychological tests. Initially, the neuropsychologically impaired group showed significantly higher elevations on the Lie and the K Subtle Defensiveness scale as well as on the Hypochondriasis, Hysteria, and Mania scales of the MMPI. At 12 and 18 months, the impaired group continued to endorse more MMPI items relating to depression, anxiety, and somatic concerns resulting in significant differences between normal and impaired groups on the Hypochondriasis, Depression, and Mania scale. These findings led the researchers to conclude that the cognitive impairment in THI victims presenting with emotional problems may have been overlooked by previous investigators. Another important aspect of their findings was the pattern of subjects' neuropsychological test performance, which suggested that older patients did not recover as rapidly as the younger THI victims and that they also complained of more emotional difficulties. They cautioned that the patients who continue to show "neurotic-like complaints" (p. 494) may be those who have experienced more serious injuries, as indicated by their higher levels of impairment on cognitive-intellectual test measures. Based on their findings, they argued that emotional distress symptoms should not be dismissed as psychogenic reaction but followed up by neuropsychological examination so that potential post-traumatic cognitive-intellectual difficulties are not overlooked.

However, Levin, Benton, and Grossman (1982) pointed out that Dikmen and Reitan's findings were based on a very small sample (N = 27) of patients heterogeneous with regard to injury severity and demographic characteristics, and that this "imposes constraints on the causal relationships that may be imputed in their study" (p. 185).

While there is some validity to Levin and his colleagues' criticism, it has to be kept in mind that it was Dikmen and Reitan's intent to study a fairly representative group of head-injured patients, where subjects were not pre-selected according to injury severity or demographic characteristics. The purpose of their study was to examine "the long-term natural history of emotional reactions in head-injured patients and to study the relationship between impairment of cognitive-intellectual abilities and resulting emotional problems of adjustment" (p. 492). It is within this particular context that Dikmen and Reitan's findings should be interpreted and discussed.

In another more recent investigation, the important role of neuropsychological deficits in the emotional adjustment of mild to severely injured patients was also disputed (Novack, Daniel, & Long, 1984). In an attempt to identify factors that are important in the emotional adjustment following head injury as measured by MMPI, it was found that scores on MMPI clinical scales were more closely associated with severity of injury, time since injury, and reported number of post-concussion symptoms than with neuropsychological performance (which accounted for less than 10% of the variance).

While it is generally assumed that emotional problems will subside with time, Fordyce, Roueche, & Prigatano (1983) reported that chronic patients actually were found to be more anxious and depressed, more confused in their thinking, and more socially withdrawn six months or more post-trauma, than more recent victims. At the same time, no differences were found on the few neuropsychological measures that had been administered. This finding implies that, after six months, patients stagnate in their cognitive recovery and worsen in their emotional adjustment. Once more, however, the study was inconclusive because it suffer from a small N (35 chronic, and 17 acute patients) and vague information regarding subject characteristics.

A few studies have been reported that are mainly concerned about the views of family members about the patient's psychosocial adjustment. Results are quite consistent, and indicate the existence of enduring negative changes such as decreased self-reliance and sensitivity, social withdrawal, and increased irritability (Brooks & McKinlay, 1983; Klonoff & Costa, 1984). Furthermore, there is growing evidence that negative behavioral changes persist and often interfere with successful social and/or vocational adjustment, unrelated to injury severity (e.g. McLean, et al., 1983; Klonoff & Costa, 1984; Oddy and Humphrey, 1980).

Neuropsychological Deficits And Specific Outcome Indices

A small number of studies have been carried out to validate the usefulness of neuropsychological tests in the prediction of the likely impact of ability deficits on specific aspects of everyday functioning. Newnan, Heaton, and Lehman (1978), for instance, concluded on the basis of their study that neuropsychological measures of cognitive-intellectual functioning had significant predictive validity not only with regard to future employability, but also with regard to wage income and job skill requirements. Follow-up evaluations six months after neuropsychological assessment (including the WAIS, the HRB and related tests, and the MMPI), revealed that out of their group of 78 male subjects diagnosed with varying neurological conditions, 32% were unemployed for more than three months, with the remaining 68% working in part or full time positions. Specifically, chronic unemployment was best predicted by the test measures that are known to be most sensitive to brain damage, i.e. tests comprising the HRB.

Consistent with these findings, Heaton, Chelune, and Lehman (1978) confirmed the clinical utility of neuropsychological examination procedures that measure both ability deficits and emotional disturbance. Their major conclusion suggested that measures of cognitive-intellectual functioning were strongly related to employment status in a diverse population of patients with and without brain damage. More specifically, they found that tests of current abilities (such as the HRB tests and the Performance subtests of the WAIS) were better predictors of employment status than tests more closely related to past experience and level of education. These researchers concluded that the tests used in their study may provide information which would assist in effective vocational counselling in this patient group, given further study and refinement of methodology.

Two recent studies have focused on the neuropsychological factors related to employability in persons with epilepsy. Again, Dikmen and Morgan (1980) found that performance on a wide range of neuropsychological measures of cognitive-intellectual functioning was directly related to employability and occupational status, in a sample of 108 adult outpatients. In a more comprehensive study, Dodrill and Clemmons (1984) examined the predictive validity of neuropsychological tests with regard to vocational adjustment, independent living and overall adjustment of epileptics. Their findings confirmed what previous research had already indicated, namely that neuropsychological measures of cognitive-intellectual functioning were not only good predictors of employability, but of psychosocial adjustment in general.

There are, however, some potential drawbacks to the outcome studies reviewed above, particularly in terms of the generalizability of the findings to THI victims. Heaton and his colleagues, for example, included persons with various neurological disorders, such as epilepsy, CVA, anoxia, slow-growing tumours and poisoning. Generally, sample characteristics were vague with regard to the nature and degree of neurological impairment, the premorbid level of functioning, and the schedule of testing, i.e. time between neurological incident and neuropsychological assessment, thus limiting the general conclusions that can be drawn from these studies.

Discussion Of The Present State Of Knowledge

Methodological Problems And Concerns

In trying to condense our present knowledge-base concerning neuropsychological recovery and long-term outcome of THI, it becomes obvious that this is a difficult task. Serious methodological problems inherent to most studies, and the apparent lack of a common denominator measuring functioning throughout this research cast doubt on the comparability and generalizability of the findings. Maybe even more than in other behavioral sciences, the researcher is confronted with many methodological 'stumbling blocks'.

As in most clinical research, many sources of variation are introduced due to sample heterogeneity. These are virtually uncontrollable and stem from differences in subjects' age, sex, and other demographic and psychological attributes as well as the varying nature and severity of injury (Parsons & Prigatano, 1978). In addition, small sample sizes, a wide range of variability on many of the neuropsychological measures, and incomplete data are frequently encountered problems due to patient characteristics and the circumstances associated with their impairment (Lezak & Gray, 1984).

Furthermore, some of the psychophysiological phenomena that are commonly used as assessment markers are very difficult to quantify, despite some good guidelines and attempts to standardization. Thus operational definitions of biomedical variables such as duration or depth of coma vary widely from study to study, as illustrated in the previous literature review. Classification of a 'severe' injury, for instance was based on PTA ratings from anywhere between 24 hours and one month in different studies. Other potential shortcomings were due to the often inadequate selection of neuropsychological assessment tools, and many studies have relied on only a few relatively specialized measures (such as intelligence tests), that fail to address the complexity of neuropsychological functioning.

Also, there have been large discrepancies in the schedules of testing, specifically in regard to the injury-test interval. This variation presents a serious problem because during the acute phase of trauma (coma and PTA), neuropsychological functions are seriously compromised, but considerable improvement is expected during the first six to 12 months. Thus, in terms of psychosocial outcome prediction, it is recommended to delay testing until spontaneous recovery has taken place and residual deficits can be identified. Lezak (1983), for example, cautions that predicting a patient's ultimate level of functioning can be a 'very chancy business' (p. 214) for as long as a year or two after trauma. Decisions about legal settlements, compensation benefits, and working arrangements should not be made prematurely because of the time factor. Research has confirmed repeatedly that most of the natural healing will take place within the first 12 to 18 months, after which time improvement starts to slow down to a considerable degree (e.g. Tabador, et al., 1984; Bond, 1979).

The last issues that need to be addressed are the choice of outcome criteria, duration of follow-up period, and high attrition rate. Most outcome studies have focused primarily on cognitive recovery, and on social and vocational adjustment. Follow-up information has been based on personal or telephone interviews, or (more frequently) on mail-out questionnaires to the patient and/or a family member. As mentioned previously, findings have to be interpreted in light of who the source of information was, particularly when it comes to self-report measures. The least problematic outcome criterion in terms of objectivity and reliability is probably 'resumption of work' together with a comparison of pre- and post-trauma employment status. While there are many problems with these measures, such as their dependency on general economic conditions, the local job market, and available social support systems (e.g. family business, availability of sheltered workshop positions), employment status should still provide a fair means of judging a person's adequacy of psychosocial functioning. Although 'return to work' has been a frequently chosen outcome criterion, it is interesting to note that in most studies no explicit comparison between previous employment status and the one at follow-up has been attempted. Moreover, follow-up periods for most studies were relatively short, typically between one and two years. This may be too short a time period to assess long-term psychosocial outcome, particulary when working with severely injured patients where the recovery period can extend over the first two to three years.

In addition, almost all of the previously discussed studies suffered from high attrition rates to such a degree that doubt is cast on the generalizability of the findings. As in most long-term follow up studies, it was often impossible to locate those subjects who have moved or who have changed names. Moreover, head-injured people are known as notoriously unreliable for a variety of reasons including reasons directly related to their damage such as poor motivation, apathy, and forgetfulness.

There is awareness of many of these shortcomings in methods and design. As Heaton and Pendleton (1981) pointed out many researchers have failed to account for the complexity of problems associated with brain impairment. In their comprehensive review of the present state of knowledge in outcome prediction, they cautioned that the clinical value of most studies is still "limited by the fact that most [studies] used only intelligence tests or screening tests with subject groups that are not very representative of the patient population referred for neuropsychological testing." (p. 807)

As in other research areas, selection of appropriate assessment tools is a major concern. While many studies can be criticized as having used measures that were uni-dimensional, adding additional tests will often not resolve the problem. Some of the perennial problems in this research area are the small number of potential subjects together with the multitude of variables derived from comprehensive neuropsychological assessments. Not infrequently, the number of independent measures is close to the size of the actual sample. Frequently, this has been dealt with by entering only a small number of pre-selected 'best' variables into the prediction equation, that is only those measures that correlate most highly with the outcome variable/s. While such an approach will satisfy the statistical requirements for an acceptable variable-to-subject ratio, it is a very artificial procedure that may well lead to loss of important information. One example of the drawbacks of such procedures is the elimination of the so-called suppressor variables, namely those variables that are not directly related to the outcome but will play a critical role in combination with other measures.

Implications For The Present Study

While the preceding literature review indicates with fair consistency that there is a relationship between neuropsychological measures and long-term psychosocial outcome, many questions remain unanswered, and no clear pattern emerges that would allow us to identify those patients who are at high risk with regard to psychosocial morbidity. This is particularly true for patients who fall within the categories of mild to moderate injury. Whereas for the severely head-injured patient with obvious permanent physical and neuropsychological disabilities, an estimate of future social independency and employability is relatively easy to make, we tend to overestimate the level of psychosocial functioning of those THI victims who appear to be well recovered with no obvious physical or neuropsychological deficits. Clinical experience and statistical records strongly suggest that there is indeed a high morbidity rate among THI victims in terms of long-term psychosocial outcome. As discussed previously, frequency of psychosocial maladjustment (i.e. unemployment, emotional and behavioral problems) exceeds our expectations by far, and often appears to be only marginally related to biomedical severity measures or neuropsychological findings.

This is illustrated by Goldstein and Ruthven (1983), who talked about the "triage" of brain-damaged patients and the dilemma the third group presents for the health professional:

> There are those who are so physically and/or mentally debilitated that little can be done other than to provide supportive nursing-oriented care; there are also those who recover well, and, while they may have residual defects, these do not prevent the patient's employment and their adequate adjustment to community life. The third group, the one that provides the difficulty, constitutes those patients who do not have profound residual physical and neurological defects, but who do not make a good adjustment. (p. 15)

According to these authors, it is not uncommon to see patients with histories of brain damage, who seem to have a functionally normal nervous system but also have subtle neuropsychological deficits that significantly influence the individual's psychosocial adjustment. Such usually undetected subtle neuropsychological deficits may indeed be at the heart of the problem in predicting long-term outcome.

In an attempt to identify additional factors that may account for the considerable variability in the long-term psychosocial adjustment of THI victims, several major issues have to be addressed and subjected to systematic investigation.

I. Predicting Future Daily Life Performance From Measures Of Neuropsychological Functioning

It is tacitly accepted that there is a positive association between neuropsychological test performance and 'functional skills', which according to Diller and Gordon (1981) represent those aspects of the behavioral repertoire that are essential in real life situations, although the data base is still small and limited by its heterogeneity of subjects samples, neuropsychological measures and outcome criteria. However, the relationship between test performance and functional efficiency in daily life may not be as simple and straightforward as is often implied. Already in 1979, Newcombe and Ratcliff warned:

> The implicit but inevitable extrapolation from test score to "function" constitutes one of those leaps in the dark that a poet requires of his reader: the student of the neurosciences cannot always afford this willing suspension of disbelief. (p. 469)

The reason for the usual attempt to relate tests to behavior has been attributed the lack of any better procedure. So, while Long and Gouvier (1980) made a convincing case for the use of neuropsychological measures as the appropriate assessment technique during the later phase of recovery, they cautioned that many neuropsychological evaluations were of little value, since they were too narrow in scope and neglected to appraise all aspects of neuropsychological functioning, including intellectual, memory, and personality functions. In a similar vein, Newcombe and Ratcliff (1979) pointed out that the focus of neuropsychological assessment procedures was often limited to the cognitive-intellectual consequences of brain impairment. They argued that this undermined the predictive validity and often led to confusion because in many cases, patients' actual level of daily functioning was vastly different from what would be expected on the basis of their cognitive-intellectual abilities. They speculated that such inaccurate predictions were the result of limited testing procedures, since they failed to evaluate potential personality changes and emotional problems associated with traumatic head injuries which were likely to diminish functional efficiency.

The predictive accuracy of most previous outcome studies is further weakened due to the systematic exclusion of the severely brain-impaired and the very mildly brain-impaired THI victims; the former because they are often untestable, and the latter because they do not appear to have any neuropsychological problems. This leads to a restriction of range problem since both the neuropsychological test findings and the level of adaptive functioning are likely to be restricted to the average to low-average range within which the correlations between the outcome criteria and the overall test scores are only weak. In order to minimize these limiting problems, more specific or model-based predictions have to be developed and tested.

Obviously, any further investigation of the relationship between measures of intermediate-term neuropsychological functioning and long-term psychosocial adjustment requires both more comprehensive assessment procedures and could be further assisted by studies with a coherent underlying rationale. Not only should such an approach result in improved predictive validity, but also in better understanding of the association between neuropsychological measures and future daily life performance.

2. Secondary Factors Affecting Long-Term Psychosocial Outcome

Several studies have examined the effect of secondary factors which may affect outcome, that is factors other than nature and severity of injury, such as the pre-traumatic characteristics and psychosocial adjustment of the victim, and his or her involvement in litigation or compensation procedures. Ziskin (1984), for example, pointed out that there is an intrinsic difference between clinical and forensic evaluations where in the latter case, obvious gains for the litigant make him or her suspect of malingering or exaggerating, and that this should be kept in mind when interpreting the test results. In recent studies, however, involvement in litigation or compensation procedures was not found to significantly affect psychosocial outcome. While advancing age, poorer premorbid personal and social adjustment, and recency of traumatic event appear to enhance the adverse effects of brain damage on behavior (Levin et al., 1981; Lezak, 1983), neither physical disabilities, litigation and compensation have been found to play an important role in determining outcome (Rimel et al., 1981; McKinlay, Brooks & Bond, 1983). However, McKinlay et al. (1983) reported that independently of involvement in litigation, many post-concussional symptoms (PCS) such as poor concentration, depressed mood, irritability, fatigue, and headaches were reported by both groups of severely head-injured patients (21 subjects in each group, PTA greater than 48 hours) and that the problems persisted over the 12-months period of their study. Although their litigation group showed a tendency to complain more, no differences were found in reports of relatives and psychological test scores. They also concluded that the high level of PCS reported by this relatively large group of severely head-injured patients suggested an organic rather than functional basis for these complaints, since their finding of PCS repudiated a long-held assumption that only victims of mild to moderate THI were suffering from this particular symptom cluster.

Overall, there appears to be a general consensus that none of the personal characteristics of the victim are important indices of the long-term consequences of THI. However, very little is known about their specific or overall contribution to the prediction equation.

3. 'Process Of Performance' vs. 'Level Of Neuropsychological Impairment': Introducing Executive-Control Functions

More often than not, poor adjustment cannot be fully explained on the basis of either objective physical and other neurological handicaps, residual cognitive-intellectual impairment, or personality problems.

Lezak (1984) advocates that the real social "cripplers" are behavior problems arising from impaired executive-control functions which are often found in connection with THI. By that, she refers to a person's ability to regulate and plan his or her performance until completion of the task. Thus the focus is on the process of performance, that is how a person performs in terms of effectiveness, rather than the resulting level of neuropsychological impairment. For example, she has cautioned repeatedly (1978, 1982, and 1983) that subtle problems of perplexity, distractibility, and fatigue accompany all kinds of head injuries. Often these symptoms go undiagnosed and result in unnecessary bewilderment, worry, and depression. Lezak also emphasized that these problems do not appear to be related to the severity of injury, and can be observed even with minor brain trauma. Needless to say this leads to unpredicted psychosocial morbidity, particularly with the less severely injured. More specifically, Lezak (1983) stated that as few as 30% of "neuropsychologically recovered" adults were able to hold jobs in the competitive market. Similarly to Goldstein and Ruthven (1983), she attributed this to the fact that brain-damaged patients frequently have behavioral deficits such as problems in the overall organization of task performance which generally do not depress test scores in the conventional neuropsychological examination. According to her view, most tests are tightly structured, so that there is no opportunity for such subtle task management deficits to be revealed.

In this model, no matter how well people do on cognitive-intellectual tests, if they show signs of impaired initiative and apathy, lack of critical capacity, impulsivity, or low frustration tolerance, they are not likely to succeed in their everyday lives. This failure in adaptation may be contrasted to the sometimes-observed adaptive living successes of a small group of THI victims who do not experience these problems in effectiveness although they have suffered considerable loss in intellectual functioning. Social independence is generally not achieved by patients with impaired executive-control functions, regardless of their level of intellectual functioning, and for that reason it seems important to distinguish between the pure ability aspects of neuropsychological assessments, and the task management effectiveness attributes which Lezak has termed executive control.

On the basis of Lezak's reasoning it follows that the assessment and evaluation of executive-control functions in addition to the traditonal methods of neuropsychological deficit measurement, should result in improved outcome estimation. Measures of performance effectiveness should also provide a specific key to the identification of those THI victims who are at higher risk regarding their future psychosocial adjustment.

All the more it can be argued that further exploratory research is needed which attempts to identify the factors that affect both test performance and daily life efficiency. In using comprehensive neuropsychological measurements which include aspects of attention and concentration, intelligence, memory, learning ability, personality, and executive-control functions, some of the drawbacks of previous studies may be overcome. Since the main thrust of conventional neuropsychological testing procedures is the evaluation of cognitive-intellectual deficits and personality problems, many aspects of executive-control functions are not assessed quantitatively, hence they often go unnoticed or have to be inferred on the basis of clinical observation. In attempting to quantify the individual's programming and regulatory problems, it may be possible to tap more directly those functional skills that are generally considered to be essential for effective daily living, such as goal formulation, planning, carrying out of plans, modifying plans when necessary, and effective performance.

Thus executive-control functions have been postulated as one of the missing links in the prediction of long-term psychosocial outcome in the present study. It was expected that predictive accuracy could be improved by including measures of executive-control functions, and at the same time this new kind of factor could result in better understanding of the factors that determine the consequences following head injury.

Existing Models Of Neuropsychological Functioning And The Concept Of Executive-Control Functions

Not surprisingly, Lezak's model of neuropsychological functioning (1983) is one of the few that explicitly differentiates between three functional subsystems of the Central Nervous System (CNS), namely i) cognitive-intellectual functions; ii) emotionality and personality functions; and iii) executive-control functions.

A similar conceptual approach to neuropsychological investigation can be derived from Luria's (1973) work. In his theoretical formulation on the working brain, he proposes the following three principal functional units: i) the unit for regulating tone and waking and mental states; ii) the unit for receiving, analysing and storing information, and iii) the unit for programming, regulation and verification of activity. Lezak's executive-control functions and Luria's third functional unit correspond closely with each other and are based on similar theoretical considerations. More importantly, both models provide a theoretical framework that attempts to account for the complexities of neuropsychological functioning. In particular, they help to address those subtle neuropsychological deficits that are suspected to go unnoticed in conventional assessments, but are implied to play a crucial role in determining adequacy of psychosocial functioning.

More specifically, Lezak (1983) outlines four different aspects of executive-control functions which are all considered to be necessary for appropriate, responsible, and effectively self-serving adult behavior, namely:

1. goal formulation;
2. planning;
3. carrying out goal directed plans; and
4. effective performance.

According to her, defects in programming and regulation in everyday life typically involve a "cluster of deficiences of which one or two may be especially prominent" (p. 507). Often, the resulting difficulties are expressed in a defective capacity for self-control or direction, increased problems in making shifts in attention and ongoing behavior, in impaired capacity to initiate activity, and motivational problems. Frequently this further results in impaired ability to concentrate, perform complex mental operations, confusion and perplexity in thinking, distractibility, irritability, fatigue, anxiety, depression, and perceived inability to do things as well as before the accident (Lezak, 1978, 1983; Gummow, Miller & Dustman, 1983).

In contrast to cognitive deficits which usually involve specific functions or localized areas of the brain, executive-control functions are sensitive to damage in all parts of the brain, including global and diffuse impairment that may affect all aspects of behavior. In the neuropsychological literature, the above-described behavioral symptoms are most often associated with frontal lobe damage. However, as Stuss and Benson (1984) pointed out in their comprehensive review of frontal lobe dysfunction, the frontal lobes are only very rarely damaged selectively, which makes it difficult to attribute specific behavioral problems to frontal malfunction exclusively. At the same time however, it has to be kept in mind that damage to the frontal lobe is one of the most frequent outcomes in THI (Lezak, 1983).

In summary, it can be said that the concept of executive-control or 'programming' functions is closely related to the so-called frontal lobe syndrome, but differently conceptualized in that no assumptions are made concerning the underlying brain mechanisms. Moreover, impaired executive-control functions are not considered to be unique to problems associated with head injury; similar symptom clusters are associated with other mental disorders and physical illness. Brain trauma however, is assumed to be a factor that enhances such problematic behaviors.

From the viewpoint of cognitive psychology, the pervasive negative impact of impaired executive-control functions on all aspects of behavior is not too surprising, given that executive-control functions are generally considered as the basic characteristics of efficient thinking and performance in a wide range of learning situations (e.g. Brown, 1978). Executive-control functions have been defined by Sternberg (1979) as metacomponential processes which determine the components, representations, and strategies that will be applied, and at what rate of execution. Already in 1942, Hebb argued that there were two factors in test performance, namely i) present intellectual power ("reasoning") and ii) lasting changes of perceptual organization and behavior ("skill" or knowledge). He pointed out however, that standard intelligence tests tap skill or knowledge rather than reasoning, whereas intelligent, adaptive behavior in psychosocial adjustment requires both aspects. While standard intelligence tests have broadened their focus somewhat in the intervening years, the general problem still persists. It follows, that in order to capture deficiencies in reasoning processes, neuropsychological assessment techniques should focus more on the source of failure and pattern of error (Newcombe & Ratcliffe, 1979) and less exclusively on the actual scores obtained. Given such an approach, it should be possible to determine those deficits that have gone unnoticed in standard neurological and neuropsychological evaluations and should allow more accurate prediction of long-term outcome.

Practical Issues With Regard To The Assessment Of Executive-Control Functions

As discussed in previous sections, most studies have focused on either cognitive-intellectual, personality, or biomedical measures as predictors of everyday functioning. However, a few studies have been carried out that have investigated some aspects of executive-control functions.

Wolfe, Dennis, and Short (1984), for example, have studied one particular aspect of executive-control functions, namely the role of problem solving in the readjustment of closed head injury patients. They had hypothesized that problem-solving deficits may be a significant contributing factor to poor outcome. Unfortunately, their sample was small (N = 26), nonetheless the results are very interesting. Contrary to their prediction, they found that their measure of overall intellectual ability (WAIS IQ) was the single best predictor of adjustment. Nonetheless, their two more specific problem-solving measures correlated with adjustment independent of IQ (r = .33 and .62, respectively). In view of the previous discussion it is also interesting to note that their qualitative analysis showed that subjects had difficulties in accurately evaluating their own performance. Furthermore, it was shown that those with impaired performance failed to profit from feedback and were unable to revise when this was required because of increased task complexity. Another reason for their results may lie in the considerably changed nature of the intelligence test they used compared with the knowledge-loaded tests Hebb had considered problematical. In another study it was found that brain-damaged subjects showed greater cognitive rigidity than healthy subjects and that their inflexibility affected their performance on a wide range of tests. (Regard, 1983).

If, indeed, it can be shown that executive-control functions are a sensitive indicator of brain impairment following THI and do affect adequacy of psychosocial outcome, this would have important implications for outcome prediction and, possibly, rehabilitation planning. Obviously, the challenge will be to extract and quantify aspects of executive-control functions on the basis of neuropsychological test data. Unfortunately, standard test batteries and examinations of brain dysfunction neglect to focus explicitly on the often subtle signs of impaired executive-control functions. Over time, most THI victims achieve test scores that are within or close to the normal range on most tests of cognitive functions (Lezak, 1983; Dikmen et al., 1983), but at the same time suffer from other seriously disabling performance deficits, such as apathy, lack of initiative, slowed thinking processes, inability to change an ineffective strategy, or mental tracking disability. When such problems go unnoticed, patients who have difficulties in recovering after THI may be unjustly labeled as "malingerers" or "accident neurotics".

In order to overcome this weakness of the traditional neuropsychological testing approach and the interpretation of test results, Lezak's model of neuropsychological functioning has been chosen for the proposed study. While Luria's model presents an alternative choice, substantial differences in Luria's basic approach to the measurement of neuropsychological functioning (Luria & Majovski, 1977) limit its applicability to this study. Furthermore, Newby, Hallenbeck and Embretson (1983) have shown that Lezak's model of cognitive-intellectual functioning is the best fitting-model for the HRB, which is the neuropsychological test battery selected for this investigation. Using confirmatory factor analysis, those authors concluded that this structurally simple conceptual scheme had satisfactory explanatory power and fitted the data better than other models such as Christensen and Luria's, Swiercinsky's, and Royce and co-workers'. Interestingly, they found that the fit could be improved by introducing additional factors, and by reconceptualizing certain variables as multifactorial, resulting in variables fairly close to what could be considered executive-control functions.

Evidently what is needed, is the development and testing of innovative measures that allow us to quantify the effects of impaired executive-control functions. Lezak (1983) recently has addressed the problem of assessing executive-control functions. While emphasizing the importance of these functions in psychosocial outcome, she lamented the lack of good assessment techniques that can be standardized and subjected to statistical analysis. Accordingly, the assessment of the various aspects of executive-control functions has been largely restricted to an observational-anecdotal level, and escaped systematic investigation. Lezak also pointed out that executive-control functions tended to be supramodal and as such were likely to affect all aspects of behavior. However she considered the usual testing procedures during neuropsychological examination as too structured to elicit executive-control functions and thus prevent systematic observation. She suggested some alternative approaches to their assessment that should help elucidate executive dysfunctions: goal formulation abilities, for example, could be evaluated on the basis of an individual's capability to use cues to interpret a situation or to infer a story from pictures and thus help identify deficiences in attention to detail and systematic integration; defective planning and carrying out of activities could be brought out through questionning and tests that require choosing, testing and changing of planning behavior; and finally, impaired performance effectiveness could be measured as a function of a person's ability to correct errors, and to monitor and control the tempo and intensity of goal-directed behavior.

While in agreement with Lezak's emphasis of executive-control functions in psychosocial outcome prediction, a somewhat different stance is taken in the present study. The problem of measuring the effects of executive-control functions is not so much attributed to the assessment methods _per se_ , but to the way tests are scored and interpreted. It is hypothesized that this can be remedied by examining additional aspects or dimensions of test results that will allow us to overcome the previously discussed problems.

Objectives

The main objectives of this exploratory research were to examine the relationship of neuropsychological test measures with long-term psychosocial outcome in THI victims. Due to the inherent complexity of the CNS, it was suggested that outcome prediction should be most effective if based on a comprehensive assessment of cognitive, emotional and executive-control aspects of neuropsychological functioning, in addition to biomedical THI data and premorbid characteristics of the victim. For that purpose, Lezak's model of neuropsychological functioning was chosen as the theoretical framework for this study. More specifically, it was proposed to evaluate the use of intermediate-term neuropsychological data as prognostic indicators of long-term psychosocial outcome; to quantify and study the role of executive-control functions, their impact on the recovery process following trauma, and their discriminatory power in identifying those individuals who are at high risk with regard to psychosocial outcome; and to gain better understanding of the mechanisms that influence the recovery process, and identify variables or patterns which are the most powerful predictors of psychosocial outcome.

Hypotheses

The following hypotheses were tested:

1. The accuracy of long-term psychosocial outcome prediction in

terms of employment status, change in occupational status, and perceived daily life efficiency can be improved by the combined rather than separate use of biomedical markers, premorbid characteristics of the victim, and neuropsychological measures.

Specifically, it is postulated that neuropsychological assessment information will help to pinpoint the more subtle consequences of THI, and hence improve predictive accuracy in identifying those patients who are recovered 'neurologically', but fail to resume work and a normal occupational and social lifes.

2. Executive-control functions are an important factor in psychosocial outcome following head trauma.

Specifically, it is postulated that deficiences in executive-control functions can be identified and that they will undermine effective performance with respect to the test situation and daily life in general. Thus it is postulated that executive-control functions are important predictors of employment-related outcome.

CHAPTER II

METHOD

Subjects

The subject pool consisted of 143 clients who were referred to a forensic and rehabilitation psychologist (A. Posthuma) for assessment of neuropsychological status. They were tested between July 1981 and July 1985, with a follow-up period which extended from May 1985 to Dec 1985. All subjects had a documented history of THI (based on medical reports or records), with the severity of injury ranging from mild to severe. Partial or complete follow-up (FU) information was available from 122 subjects, however 15 of them had to be excluded because of missing or incomplete test data. Thus the final sample was comprised of data collected from a total of 107 subjects, 68 males and 39 females. None of them had a previous history of THI. A detailed summary of patient characteristics is presented in Table 1.

Referral sources included both lawyers of the plaintiff or defense, the Workers' Compensation Board (WCB), and vocational rehabilitation services. At the time of testing, all but seven subjects were involved in legal or compensation proceedings. At the time of FU, legal and financial settlements had been arranged for a further 31 of the subjects.

TABLE 1

Description Of Subjects' Characteristics (N = 107)

AGE: (mean)	31.5	Range: 17 - 68 yrs
SEX:		
male	68	
female	39	
EDUCATION: (mean)	Grade 12	Range: 3 - 18 yrs
TRAUMA SEVERITY:		
mild	23	
moderate	38	
severe	46	
RACE:		
White	100	
Native Indian	2	
Other	5	
HANDEDNESS:		
right	95	
left	12	
EMPLOYMENT STATUS: (prior to injury)		
unemployed	6	
part-time	5	
full-time	96	
EMPLOYMENT STATUS: (at the time of Follow-up)		
unemployed	59	
part-time	14	
full-time	34	
TIME INTERVAL: (mean)		
between injury and assessment	913 days	(approx. 2 1/2 yrs)
between injury and follow-up	1375 days	(approx. 4 yrs)
PHYSICAL DISABILITY: (resulting from injury)		
none	84	
minimal	14	
some	7	
severe	2	

For 81 of the subjects, the interval between THI and testing was between one and three years, while a further 10 were assessed in their fourth year post-injury. In the cases of two subjects, neuropsychological assessment was done after six or nine months, respectively. Only for 16 of the more severely impaired clients, the injury-test interval extended to a three to five year period.

Measures

Independent Variables

There were two important considerations for selection of independent variables in the present research.

First, measures were sought which could provide representative coverage of the dimensions that were considered empirically and theoretically important in the outcome prediction of psychosocial functioning following THI. These included variables representative of three broad dimensions generally assumed to largely determine the long-term consequences of head injuries:

1. Biomedical markers of injury severity;
2. Background characteristics of the victim;
3. Measures relevant to cognitive, personality, and executive-control dimensions of neuropsychological functioning. In choosing these, care was taken to select psychometrically sound test measures that would tap the vast

range of abilities controlled by cerebral functions. Moreover, test measures had to be those widely used both in clinical settings and research, to allow for generalizability and easy dissemination of the findings.

Using those criteria the following measures were included:

Biomedical Markers Of Injury Severity

1. **Trauma severity** (TRAUMA)

   This variable was defined as a combined measure of length of coma and duration of PTA and was rated according to the criteria outlined by Becker et al. (1979) as discussed in an earlier section (see also Appendix A). The ratings were based on the patients' medical records.

2. **Medical Complications Associated with Injuries** (SURGERY)

   Medical complications such as chest injuries causing hypoxia or surgical interventions that required general anaesthesia, were chosen as an additional marker of trauma severity since it was believed that such complications may aggravate neuropsychological dysfunction. This variable was measured dichotomously, i.e. complications present/absent and was based on information from the subjects' medical records.

Secondary Factors Affecting Outcome (Background Characteristics Of The Victim)

1. **Age** (AGE)

   Age has been consistently reported to affect outcome. It is generally assumed that the older the THI victim at the time of injury the poorer the predicted psychosocial outcome.

2. **Pre-Injury Psychosocial/Occupational Adjustment** (PREOCC)

This variable was measured in terms of the person's employment history and occupational status prior to the accident. Because the measure was limited to the person's work situation, it was considered to be the most objective and reliable measure of pre-injury psychosocial adjustment.

3. **Length of Time since THI** (YEAR INJ.)

The length of time since the traumatic event was also considered to be a factor that will affect outcome. As discussed previously, research findings indicate that most of the improvement in neuropsychological functioning almost always happens in the first 12 to 24 months, then slows considerably until it reaches the plateau that marks the highest level of recovery at around 24 to 36 months post-injury (c.f. Lezak, 1983; Gilandas, Touyz, Beumont, & Greenberg, 1984). Thus it was speculated that those subjects who had already reached their plateau in terms of physical and neuropsychological recovery might experience fewer problems with psychosocial adjustment.

4. **Extent of Physical Disability Resulting from the Injury (PHYSDIS)**

Although findings as discussed earlier suggested that the degree of physical disability was not as crucial in eventual psychosocial adjustment, as were cognitive deficits, it was thought that physical disabilities may affect occupational status to a larger extent than generally assumed. The severity of disability was coded according to the potential effect on test performance and/or job performance, ranging from none to severe. (see Appendix A)

Neuropsychological Measures

1. **Measures of Intelligence and Educational Achievement**

   a. Wechsler Adult Intelligence Scale - Revised (WAIS-R): IQ scores as measured by this test reflect an individual's intellectual abilities and are assumed to provide information about overall competency or global capacity (Wechsler, 1981). The Full Scale IQ is known as a "deviation IQ"; it has the same average of 100 and a standard deviation of 15 for every age group in order to permit direct comparison of a person's score with the scores of his or her reference group. The WAIS-R is a standard measure of intelligence; it is one of the most widely used individual tests of intelligence and has good psychometric properties. Average reliability coefficients (split-half) for Verbal IQ, Performance IQ, and Full Scale IQ ranges from .93 to .97 (Wechsler, 1981). Furthermore, the WAIS-R has proven to be a useful instrument both in the field of vocational evaluation and career counselling, as well as in neuropsychological evaluation (Lindemann & Matarazzo, 1984). For the purpose of this study, Verbal and Performance IQ (VIQ and PIQ) were taken as global measures of two broad classes of overall intellectual abilities. Scaled Scores of the six Verbal subtests and of four Performance subtests[1] were hypothesized to be indicators of specific deficits and of impaired executive-control functions.

b. Wide Range Achievement Test (WRAT)

The WRAT is an achievement test designed to provide information regarding basic skills in a few major academic skill areas. Specifically, it tests an individual's abilities in spelling, reading, and written arithmetic. The WRAT subtest scales correlate well with WAIS-IQ measures: standard scores and grade ratings are obtained in each of the three subtest areas which can then be used to compare the achievement level with the actual educational level as well as with the general level of intelligence (Full Scale IQ).

Generally, it has been found that achievement scores are relatively unaffected by many forms of brain impairment (Gilandas et al., 1984), thus they can be used as both diagnostic measures for the purpose of determining learning disability and loss in intellectual functioning, as well as prognostic indicators for vocational success. The psychometric properties of the WRAT are good, with satisfactory validity and reliability (Jastak and Jastak, 1978). Only the Standard Score for Written Arithmetic (ARITSS) was used for

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[1] The Object Assembly subtest was not given in order to reduce total testing time. Not only is it one of the most time-consuming subtests of the WAIS-R but it also has the lowest reliability (split-half) and the highest standard error of measurement.

further analysis, as this particular subtest was believed to measure planning and 'effective performance' aspects of executive-control functions.

2. **Measures of Memory and Learning**

a. Wechsler Memory Scale (WMS) and Revised Wechsler Memory Scale (R-WMS)

The WMS was one of the first scales developed that aimed at time-efficient, simple and practical memory examination. The test consists of seven subtests and provides information on personal and general orientation, mental control, and sustained attention, as well as new learning of visual and verbal information. While it has been often criticized for its relatively poor standardization (e.g. Lezak, 1983; Hamsher, 1984), its limitations regarding to the kinds of memory functions it tests (Russell, 1975), and its validity (Lezak, 1983), it is still widely used and has proven to be popular and useful in the clinical setting (Goodglass & Kaplan, 1979). In using the new revised testing procedures as developed by Russell, the R-WMS overcomes some of the previously mentioned shortcomings and provides a more balanced assessment of verbal and visual memory, including aspects of delayed recall and loss of information over time. For the purpose of this study, the WMS Memory Quotient (WMQ) was taken as a global measure of memory functions and was calculated according to the 1973 Manual (Wechsler & Stone, 1973). In addition, scores on the WMS Associate Learning (LEARNH), and the R-WMS Logical and Visual Reproduction subtests (VMEM and NVMEM) were taken as indices of verbal and nonverbal learning ability, both with respect to speed of learning as well as quantity of material that can be memorized successfully.

3. **Measures of Neuropsychological Functioning**

a. The Halstead Reitan Neuropsychological Battery and Related Tests (HRB)

Early in the history of neuropsychological research, it became obvious that the vast range of psychological abilities controlled by cerebral functions and the effects of brain trauma on neuropsychological functioning could not be evaluated with a single test. In order to fully aprise a person's level of functioning, a variety of different assessment tools had to be selected. The resulting battery of tests that are included in the HRB was developed on the basis of clinical observation and experimental study of subjects with known brain lesions. Experience developed with the performance of brain-injured patients on these tests led to the derivation of the principles on which diagnostic inferences can be based. Individual tests were kept in the battery according to their usefulness and statistical power in discriminating between normal and impaired neuropsychological functions. Reitan (1979) stressed the following three criteria that the HRB was to achieve: 1. Measurement of a broad range of behavioral functions including sensory-perceptual and motor tasks, psychomotor problem solving, simple and complex language tasks, visuospatial manipulation, and abstraction and concept formation abilities. 2. Validity of tests with respect to the effects of cerebral lesions should be based on experimental studies. In other words, test selection was to be based mainly on pragmatic criteria rather than theoretical considerations. 3. Information gathered should provide comprehensive information, but length of testing procedures should not overtax the brain-impaired individual.

While advances in neuropsychology may require replacement or modification of the HRB in the future, it is still the most widely used battery in clinical neuropsychology and in research related to this field (Gilandas et al., 1984). Its psychometric properties are well documented and the findings support its reliability and validity. For example, several studies have indicated good differential diagnostic validity. Presence or absence of brain damage has been predicted with high accuracy (70 to 90 percent) as shown, for example, by Anthony, Heaton and Lehman (1980), Klonoff, Fibiger, and Hutton (1970), and Filskov and Goldstein (1974).

Very little research has been done to study the effect of subject variables such as age, education, sex, and examiner characteristics on performance on the tests of the HRB, however there are some indications that they do not appear to play a major role when testing brain-injured subjects (Prigatano & Parsons, 1976; Finlayson, Johnson & Reitan, 1977). While there are only a few studies examining the reliability of the HRB, Matarazzo, Matarazzo, Weins, Gallo, & Klonoff (1976) have documented good reliability, even when used with heterogeneous groups of patients.

<u>Description of the Tests comprising the HRB and related tests:</u>

The *Category Test* (CATEGORY) and the *Trail Making Test* (TRAILAT and TRAILBT) are measures of concept formation and abstract reasoning.

The *Finger Tapping Test* (TAPPDOM), the *Grip Strength Dynamometer Test* (GRIP), and the *Tactual Performance Test - Time* (TPTTOT) are measures of motor functions.

The *Speech Sounds Perception Test* (SPEECH), the *Aphasia Screening Test* (APHASIA) and the *Verbal subtests of the WAIS-R* are measures of verbal abilities.

The *Trail Making Test* and the *Performance subtests of the WAIS-R* are measures of visual - spatial skills.

The *Tactual Performance Test - memory and location* (MEM and LOC) are measures of incidental memory.

The *Seashore Rhythm Test* (RHYTHM) and the *Speech Sounds Perception Test* (SPEECH) are measures of alertness and concentrated attention.

The *Impairment Index* (HRB-II), the *Severity Index*, (SI) and the *Keytest Index* (KEYTEST) are general summative indicators of neuropsychological impairment.

The Impairment Index (HRB-II) is a summary measure indicating the percentage of impaired scores on the seven HRB tests (1. Finger Tapping; 2. Tactual Performance Test (TPT) time; 3. TPT memory; 4. TPT location; 5. Category Test; 6. Seashore Rhythm Test; and 7. Speech Perception Test). The HRB-II ranges from 0 to 1; a score of >= .5 is considered to be in the impaired range.

The Severity Index (SI) averages ratings of impairment across most of the above measures and is based on norms provided by Reitan (unpublished notes).

The Keytest Index (KI) indicates the percentage of impaired tests across four of the most sensitive measures of brain impairment, namely the HRB-II, TPT location, Trail B, and Category Test.

4. **Measures of Personality**

a. *Minnesota Multiphasic Personality Inventory (MMPI)*

The MMPI is one of the most widely used instruments in personality and clinical research. It is considered to be an objective personality inventory that was developed on an empirical basis and standardized on the basis of fairly extensive normative studies. Butcher and Finn (1984) speculated that the MMPI's widespread use is due to its ease of administration, reliability, established validity, and its demonstrated relevance for clinical decision making. The psychometric properties of the MMPI are reviewed by Graham, 1977, and more recently by Butcher and Keller, 1984.

The MMPI is routinely used in conjunction with other neuropsychological tests in order to provide information about the individual's personality organization and to identify changes in personality which may be due to brain damage. Although some authors question its usefulness in clinical neuropsychology (c.f. Lezak, 1983), others consider it an integral part of the HRB (see for example Goldstein, 1984; Gilandas et al., 1984). For the purpose of this study, T-Scores for the three validity scales and ten clinical scales were used for further analyses.

5. **Measures of Executive-Control Functions**

Executive-control functions are defined as those capacities that are necessary for the formulation of goals, the planning and carrying out of plans, and the effective performance of the activities that are necessary to reach the goals. However the major problem with the assessment and evaluation of executive-control functions is that they are 'part and parcel of everything we do' (Lezak, 1982, p. 283), i.e. they are assumed to affect all aspects of behavior. In order to measure executive-control functions, we have to quantify the process or the pattern of performance rather than the level of intellectual functioning, neuropsychological impairment, and personality problems. This includes information pertaining to THI victims' ability to i.) become interested and involved in a task, ii.) attend to a task and ignore distracting elements of the task or the environment, iii.) regulate their performance and demonstrate organized and pre-planned behavior when working on a task, iv.) initiate and stop activities when required, and vi.) work carefully and self-correct errors on an ongoing and consistent basis.

While the neuropsychological test measures used in this study do not constitute any *explicit* measures of executive-control functions, it is assumed that both cognitive-intellectual and personality tests will tap the various aspects of executive-control functions. The major difficulty with this approach is that test scores merely provide summary measures of how well a person does on a task. The more qualitative aspects of a person's test performance, namely the manner with which a test is done, are only captured indirectly in that the deficits in the process of performance are likely to result in an ostensibly erratic or inconsistent pattern of test results. Moreover, it is assumed that certain test scores are more affected by impaired executive-control functions than others. It is postulated that many of the 'performance' tests, i.e. tasks that require more than acquired knowledge and verbal skill, provide an indirect measure of the cognitive-behavioral dimensions of executive-control functions, while motivational-emotional aspects can be extracted mainly from the MMPI subscales.

It is an empirical question if certain subtests might call upon the various aspects of executive-control functions and to what degree they will do so, but on the basis of Lezak's (1982, 1983) conceptualization some individual tests were tentatively marked as likely sources of information about executive-control functions.

a. Goal Formulation Abilities

Goal formulation abilities were operationally defined as the process of determining one's needs or wants, and the ability to conceptualize what is needed to fulfill them. This ability to formulate a goal, or form an intention is believed to be influenced by motivational-emotional factors, such as impulsivity, passivity, or level of frustration tolerance. It was speculated that existing motivational problems could be extracted from the MMPI subscales, and that the resulting impairment in goal formulation abilities would affect many of the test scores. Tests that measure how well a person performs following relatively vague instructions such as are given for the WAIS-R Picture Arrangement subtest or for the HRB Category test were hypothesized to be particularly sensitive to impaired goal formulation abilities.

b. Planning and Carrying Out Of Plans

According to Goodglass and Kaplan (1979), impaired conceptual thinking or planning abilities are reflected in reduced ability to deal with relationships between objects and their properties as well as to abstract superordinate concepts, while reduced attention span will result in a limited capacity to apprehend and manipulate multiple aspects of a given situation. The subsequent carrying out of plans requires mental flexibility, that is, the capacity to shift a course of action or thought, rapid re-orientation, and if necessary, switching from an attempted solution to a new approach.

Thus, aspects of planning and carrying out of plans were assumed to be measured through those tests that require intact capacity for sustained attention and concentration, as well as the ability to weigh and make choices and to conceptualize the task requirement. It was speculated that tests such as WAIS-R Block Design (BD), Similarities (SIM) and Digit Backwards (DB) subtests, the HRB Seashore Rhythm Test (RHYTHM), Speech Perception Test (SPEECH), and the Tactual Performance Test (TPT) might provide measures for this particular aspect of executive-control functions.

c. Effective Performance

Effectiveness of performance was defined as a person's ability to monitor and control intensity, tempo, and other aspects of delivery such as self-correction of errors and consistency of performance. It was hypothesized that both cognitive-behavioral and motivational-emotional attributes of an individual would affect performance effectiveness. It was speculated that tests requiring purposive behavior and flexibility in thinking, as well as control of speed and consistent performance such as the WAIS-R Digit Symbol (DSY) subtest and the WRAT Arithmetic subtest would provide measures of the cognitive-behavioral aspects of performance effectiveness, whereas some of the MMPI subscales such as Mania, Psychopathic Deviate, Paranoia, and Masculinity-Femininity were believed to provide information about the motivational-emotional aspects that are likely to influence performance effectiveness.

Dependent Variables (Outcome Measures)

1. **Occupational Status at Follow-Up** (POSTOCC)

   Occupational status was rated on a scale from 10 to 90 (coded in steps of 10) according to the occupation categories outlined by Wechsler (1981), but slightly modified to include categories such as 'employment in a sheltered workshop' as well as an indication of part-time or full-time employment status (see Appendix B).

2. **Change In Occupational Status** (OCCDIFF)

   Both pre- and post-injury occupational status (PREOCC and POSTOCC, respectively) were rated according to the operational definition outlined above. Change in occupational status was calculated by subtracting the occupational status rating at the time of the follow-up interview from the pre-injury rating, i.e. the variable POSTOCC was subtracted from the variable PREOCC.

3. **Daily Life Efficiency (DAILY)**

At the end of the interview, the subjects were given an adaptation of the 'Daily Life Activities Schedule' developed by Ben-Yishay and Diller, 1983. As part of this questionnaire, they were asked to answer 15 questions relating to their perceived efficiency in daily functioning such as 'do you have problems with your memory in everyday routines (remembering or forgetting things)?' or 'do you have problems with moodiness, control of temper?'. (For a complete listing see Appendix B)

Each of the questions was rated on a 5-point scale, where '1' indicated no problems and '5' indicated that it presented almost always a problem. A global measure of daily functioning (DAILY) was calculated as the sum of all the values.

4. **Disposition Of Legal Proceedings (LAW)**

The disposition of legal proceedings was measured dichotomously, i.e. legal proceedings still in progress / settled.

Procedures

Intermediate-Term Neuropsychological Assessment : Overview

Assessment procedures included a one-hour semi-structured interview covering relevant background information (symptoms and complaints related to accident, medical and life history). This was followed by a comprehensive battery of neuropsychological, educational, and personality tests and included the

1. Wechsler Adult Intelligence Scale - Revised (WAIS-R) by Wechsler (1981);
2. Wechsler Memory Scale (WMS) by Wechsler, 1945;
3. Revised Wechsler Memory Scale (R-WMS) as described by Russell, 1975;
4. Wide Range Achievement Test (WRAT) by Jastak and Jastak, 1978;
5. Halstead Reitan Neuropsychological Battery (HRB) and related tests as described in Russell, Neuringer, & Goldstein, 1970; and
6. Minnesota Multiphasic Personality Inventory (MMPI) by Hathaway and McKinley, 1951.

The average time to complete the neuropsychological assessment procedures was between eight to ten hours.

Long-Term Follow-Up Procedures : Overview

At some point during the eight-month FU period, subjects were contacted either by mail or telephone in order to conduct a follow-up interview. This included determination of their present occupational status (POSTOCC), change in occupational status (OCCDIFF), and the disposition of legal proceedings (LAW).

At the end of the interview, they were given the Daily Life Questionnaire (see Appendix C) and asked to rate each question according to their own perception.

Unfortunately, twenty-one potential subjects could not be located, since they had moved to an unknown address.

<u>Missing Data Estimation</u>

In those situations where subjects were unable to complete all neuropsychological test measures relating to intelligence, memory, personality, or neuropsychological impairment, missing data were replaced by estimates computed by the BMDP PAM program (twostep method). This particular procedure involved a method where each missing value was estimated by regressing that variable on up-to two correlated variables selected by stepwise regression according to the strength of their relationship with the variable to be estimated.

Cases where missing data exceeded five out of the total of 42 test measures were not included in further analyses.

Statistical Analysis

All data analyses were carried out using BMDP statistical software programs (University of California Press, 1985 Reprinting). Statistical analyses were done to examine the role of biomedical markers of injury severity, background characteristics of THI victims, and their performance on neuropsychological tests in the prediction of long-term psychosocial outcome.

The main purpose of this exploratory research was to identify variables or patterns which are the most powerful prognostic indicators of employment status, change in occupational status, and perceived problems in daily life following THI. The utility of the concept of 'executive-control functions' and their role in psychosocial outcome prediction was of special interest.

The first and preliminary step of data analysis was to document the psychosocial recovery process of THI victims and compare the findings with previous research. Simple and detailed data description programs (BMDP P1D and P2D) and two-way cross-tabulations were used to summarize these aspects and to examine them in relation to previous findings.

As a next step, the 42 neuropsychological test scores were subjected to a Principal Component Analysis (BMDP P4M) in order to transform this large and unwieldy set of individual variables into a much smaller set of composite variables (or principal components). This data reduction procedure was chosen in order to

1. determine the relationship between neuropsychological test measures, and examine the use of different components as quantifiable measures of executive-control functions;
2. facilitate further analyses of data;
3. minimize loss of information without introducing potential sources of bias stemming from the often arbitrary selection of 'best' predictor variables on the basis of their high correlation with the dependent variable/s.

After the initial factor extraction, orthogonal rotation was performed. The resulting orthogonal factor structure, i.e. the eight factors summarizing different aspects of neuropsychological functioning together with the six medical or demographic descriptors were used in all subsequent analyses. Multiple linear regression equations (BMDP P9R) were calculated for each of the outcome variables using all possible subsets of predictor variables. This was done in order to examine the predictive power of the measures chosen for this study, and to identify those variables or factor scores which best predict long-term psychosocial outcome of THI.

CHAPTER III

RESULTS

Premorbid Characteristics And Trauma Severity

In order to ensure that this particular sample was indeed representative of THI victims in general, important demographic information was cross-tabulated with Trauma Severity, and measures of independence were calculated (chi-square test of independence, BMDP·P4F). Not too surprisingly, results revealed that the younger age groups (16 - 39) were much more likely to have suffered a head injury, with almost half of the sample (N = 52) in their twenties (*Pearson Chi square* = 18.98, *D.F.* = 10, *p* = .04).

No significant associations were found between Trauma Severity and race, level of education, occupational status prior to injury, and handedness, respectively. Male to female ratio was approximately 2:1 (64% males, 36% females), and the frequency distribution suggested that women were more likely to suffer 'milder' injuries, while men were more likely to be seriously injured (*Pearson Chi square* = 5.41, *D.F.* = 2, *p* = .07).

A clear positive relationship was found between Trauma Severity and the necessity for surgical intervention or complications due to respiratory distress (*Pearson Chi square* = 9.54, *D.F.* = 2, *p* = .008). Examination of the frequency with which THI was associated with subsequent physical disability indicated that the latter appeared to be more often a result of moderate to severe injury, but also can occur with mild head injury.

No association was found between the Trauma Severity Rating and the time between 'injury-neuropsychological testing' or 'injury-FU' suggesting that differences in long-term psychosocial outcome cannot be attributed to the differences in time interval during which the data for this study was collected.

In summary, these findings indicated that the present study was based on data from a sample which appears representative in terms of the literature on THI victims. The sample consisted of individuals from all 'walks of life'; their backgrounds were comparable with other studies and epidemiological findings in general.

Descriptive Analysis Of Test Measures

For the total sample of subjects (N = 107), the means and standard deviations for all the independent test measures are presented in Table 2.

The mean score on the Full Scale IQ (WAIS-R) for this sample was 95.2 (*S.D.* = 11.4), indicating that subjects' level of intellectual functioning fell within the average range. The Mean HRB-II was .55 (*S.D.* = .26), indicating moderate impairment of

TABLE 2

Means And Standard Deviations Of Test Measures

Variable Name	Mean	Standard Deviation
VERBAL IQ (VIQ)	94.23	11.78
PERFORMANCE IQ (PIQ)	98.23	13.52
INFORMATION (INFO)	8.21	2.70
VOCABULARY (VOC)	8.89	2.52
ARITHMETIC (ARITH)	9.13	2.46
COMPREHENSION (COMP)	9.65	2.72
SIMILARITIES (SIM)	9.18	2.47
PICTURE COMPETION (PC)	9.30	3.01
PICTURE ARRANGEMENT (PA)	10.34	5.95
BLOCK DESIGN (BD)	10.00	2.63
DIGIT SYMBOL (DSY)	8.05	2.63
DIGIT FORWARD (DF)	5.98	1.44
DIGIT BACKWARD (DB)	4.37	1.31
APHASIA SCREENING (APHASIA)	1.49	1.31
WRAT ARITHMETIC (ARITSS)	90.65	12.24
TPT MEMORY (MEM)	6.41	1.62
R-WMS STORY MEMORY (VMEM)	66.53	27.13
R-WMS FIGURE MEMORY (NVMEM)	72.58	29.78
WMS 'HARD' PAIRS (LEARNH3)	6.13	3.36
TPT LOCATION (LOC)	3.34	2.44
SEASHORE RHYTHM TEST (RHYTHM)	25.39	3.48
TRAIL A, TIME (TRAILAT)	39.28	24.39
TRAIL B, TIME (TRAILBT)	86.06	44.29
CATEGORY TEST, ERRORS (CATEGORY)	61.63	30.70
TPT, TOTAL TIME (TPTTOT)	14.35	5.16
SPEECH PERCEPTION (SPEECHSC)	9.40	4.67
TAPPING, DOMINANT HAND (TAPDOM)	43.08	9.74
KEYTEST INDEX, % (KEYTEST)	56.07	35.99
WMS MEMORY QUOTIENT (WMQ)	96.87	17.13
MMPI SCALES:		
L	53.41	8.82
F	63.06	13.75
K	51.90	9.20
SCALE 1 (HS)	69.82	15.79
SCALE 2 (D)	77.20	16.86
SCALE 3 (HY)	70.18	12.25
SCALE 4 (PD)	66.37	14.95
SCALE 5 (MF)	56.78	11.94
SCALE 6 (PA)	62.57	13.22
SCALE 7 (PT)	68.53	15.17
SCALE 8 (SC)	72.60	17.25
SCALE 9 (MA)	63.37	12.57
SCALE 10 (SI)	57.26	11.60

neuropsychological functioning.

The average test scores with regard to IQ and severity of impairment confirm previous observations, namely that after the acute stage has passed, many THI victims tend to achieve scores close to the average with fewer, but distinct residual problems (e.g. Lezak, 1983; McFie, 1976). Moreover, the neuropsychological summary indexes for this particular group of brain-injured adults are comparable with those found in other studies (e.g. Long & Gouvier, 1980; Dikmen, Reitan & Temkin, 1983).

Personality measures revealed clinically elevated mean scores (i.e. T-score > 70) on the following MMPI scales (in descending order): Depression (Scale 2) (*Mean* = 77.2, *S.D.* = 16.9), reflecting subjects' depressed mood, low self-esteem and feelings of inaedequacy; Schizophrenia (Scale 8) (*Mean* = 72.6, *S.D.* = 17.2), suggesting unconventional life styles, problems with confusion, tension, moodiness and poor judgment; and Hysteria (Scale 3) (*Mean* = 70.2, *S.D.* = 12.2), associated with a coping style that relies on repression and denial for dealing with conflicts. Mean scores on Hypochondriasis (Scale 1), Psychosthenia (Scale 7), and Psychopathic Deviate (Scale 4) were high, but did not reach clinically significant elevations of T-scores above 70. High scores on these scales can be interpreted as revealing high levels of distress, and maladjustment in general.

Overall, these findings on personality measures are consistent with previous research findings in that they reveal a general response pattern of distress characteristic for head-injured patients (e.g. Heaton, Smith, Lehman & Vogt, 1978; Lezak, 1983).

Correlations Of Test Measures With Outcome Measures

Table 3 presents bivariate correlations between test measures and the three dependent variables. All correlations were quite low, with correlation coefficients ranging from -.28 to .35 for present occupational status (POSTOCC), -.30 to .26 for loss in occupational status (OCCDIFF) and -.30 to .47 for severity of problems encountered in daily life (DAILY). All significant correlations were in the direction of linking poor ability scores or elevated distress scores with unemployment, loss in level of employment, and daily efficiency.

Global Ratings Of Severity And Their Association With Selected Outcome Criteria

In order to examine their impact on post-injury intermediate-term neuropsychological functioning, ratings of Trauma Severity were cross-tabulated with the HRB-II and the Keytest Index. Interestingly, neither of the tests of independence revealed any significant association, suggesting that information on Trauma Severity alone provides a poor

TABLE 3

Correlations Between Test Measures And Outcome Criteria

Variable Name	Return to Work N=107	Daily Problems N=75	Change in Job N=107
Age	-.10	.07	.14
Occupation prior THI	.18	.13	.41**
Year of Injury	-.10	-.03	.04
VIQ	.16	.17	-.03
PIQ	.33	-.01	-.20*
INFO	.06	.13	.00
VOC	.15	.12	-.07
ARITH	.05	.19	-.03
COMP	.12	.20*	.00
SIM	.20*	.15	-.12
PC	.24*	-.03	-.23*
PA	.21*	.05	-.17
BD	.24*	-.02	-.13
DSY	.35**	-.08	-.26**
DF	.02	-.06	-.03
DB	.12	.14	-.07
APHASIA	-.09	-.08	.09
ARITSS	.10	.10	-.08
CATEGORY	-.25**	-.09	.09
TPT, tot. time	-.12	-.09	.19
TPT, MEM	.30**	.12	-.23*
TPT, LOC	.20*	.03	-.24*
RHYTHM	.12	.08	.00
SPEECH PERCEPTION	-.16	-.02	.14
TAPPING, DOM. HAND	.06	.12	-.21*
TRAIL A	-.18	.12	.22*
TRAIL B	-.19	-.06	.17
IMPINDEX	-.28**	-.13	.18
KEYTEST INDEX	-.26**	.00	.14
WMQ	.16	.02	-.11
VMEM (% loss)	.16	-.09	-.30*
NVMEM (% loss)	.03	.06	-.11
LEARNH3	.09	-.08	-.13

TABLE 3 (Continued)

MMPI SCALES:			
L	-.04	-.30**	-.09
F	-.08	.11	.19
K	-.01	-.18	-.08
SCALE 1 (HS)	-.21*	.40**	.22*
SCALE 2 (D)	-.18	.47**	.26**
SCALE 3 (HY)	-.19	.42**	.23*
SCALE 4 (PD)	-.22*	.27**	.15
SCALE 5 (MF)	-.15	.17	.21*
SCALE 6 (MA)	-.15	.13	.25*
SCALE 7 (PT)	-.19	.33**	.22*
SCALE 8 (SC)	-.23*	.32**	.21*
SCALE 9 (MA)	-.15	-.01	.11
SCALE 10 (SI)	.13	.12	.04
POSTOCC	1.00		
DAILY	-.23*	1.00	
OCCDIFF	-.61**	.40**	1.00

p = .05 is indicated with *
p <= .01 is indicated with **

indicator of post-injury neuropsychological impairment. (See Tables 4 and 5)

Moreover, examination of the frequency table for Trauma Severity and Resumption of Work (see Table 6) revealed no clear pattern between severity of injury and work status at the time of FU. Overall outlook for return to work is grim, with 63% of the severely injured unemployed or unable to work, and with 47% of the moderately and 52% of the mildly injured THI victims failing to resume work.

In contrast, a much clearer relationship could be established between global indicators of neuropsychological impairment and the resumption of work. Tests of indpendence for Keytest Index and HRB-II with Employment Status at the Time of FU reached statistical significance, suggesting that these global measures of brain impairment were indeed predictive of the future likelihood with which a person would return to work. (See Tables 7 and 8 for a summary of these findings.)

A closer examination of work-related information both prior to the injury and at the time of FU revealed a significant relationship between the two (*Pearson Chisquare* =46.57, *D.F.* = 25, p = .006). For example, none of the six THI victims who were unemployed prior to their injury reported any success in finding work. Overall, the pattern of the frequency distribution suggested that subjects were most likely to return to a job similar to the one they had before, or entirely failed to resume

TABLE 4

The Relationship Between Trauma Severity And Level Of Neuropsychological Impairment (HRB-II)

HRB-II	TRAUMA SEVERITY			
	MILD	MODERATE	SEVERE	TOTAL
NOT IMPAIRED	12	18	18	48
IMPAIRED	11	20	28	59
TOTAL	23	38	46	107

STATISTIC	VALUE	D.F.	PROB.
PEARSON CHISQUARE	1.205	2	n.s.

TABLE 5

The Relationship Between Trauma Severity And Keytest Index

KEYTEST INDEX	TRAUMA SEVERITY			
	MILD	MODERATE	SEVERE	TOTAL
0% IMPAIRED	6	8	5	19
25% IMPAIRED	2	6	8	16
50% IMPAIRED	4	5	10	19
75% IMPAIRED	6	7	13	26
100% IMPAIRED	5	12	10	27
TOTAL	23	38	46	107

STATISTIC	VALUE	D.F.	PROB.
PEARSON CHISQUARE	5.836	8	n.s.

TABLE 6

The Relationship Between Trauma Severity And Resumption Of Work

RESUMPTION OF WORK	TRAUMA SEVERITY			
	MILD	MODERATE	SEVERE	TOTAL
UNEMPLOYED	12	18	29	59
P-T TIME WORK	2	6	6	14
F-T TIME WORK	9	14	11	34
TOTAL	23	38	46	107

STATISTIC	VALUE	D.F.	PROB.
PEARSON CHISQUARE	3.119	4	n.s.

TABLE 7

The Relationship Between Keytest Index And Resumption Of Work

KEYTEST INDEX	RESUMPTION OF WORK			
	UNEMPLOYED	WORK, P-T	WORK, F-T	TOTAL
0% IMPAIRED	6	3	10	19
25% IMPAIRED	8	2	6	16
50% IMPAIRED	8	1	10	19
75% IMPAIRED	20	1	5	26
100% IMPAIRED	17	7	3	27
TOTAL	59	14	34	107

STATISTIC	VALUE	D.F.	PROB.
PEARSON CHISQUARE	21.492	8	0.01

TABLE 8

The Relationship Between The HRB Impairment Index (HRB-II) And Resumption Of Work

HRB-II	RESUMPTION OF WORK			
	UNEMPLOYED	WORK, P-T	WORK, F-T	TOTAL
NOT IMPAIRED	18	6	24	48
IMPAIRED	41	8	10	59
TOTAL	59	14	34	107

STATISTIC	VALUE	D.F.	PROB.
PEARSON CHISQUARE	14.034	2	0.001

TABLE 9

Subjects' Occupational Status Before And After THI

OCCUPATION AT FOLLOW-UP	TOTAL	OCCUPATION PRIOR TO THI: NO WORK	P-T WORK	UN-SKILLED	SKILLED	CLERICAL	PRO FESSIONAL
NO WORK	59	6	2	10	25	6	10
P-T WORK	14	0	2	1	6	1	4
UNSKILLED	6	0	0	2	1	0	3
SKILLED	17	0	0	1	11	4	1
CLERICAL	7	0	0	1	1	4	1
PROFESSIONAL	4	0	1	0	0	0	3
TOTAL	107	6	5	15	44	15	22

work (see Table 9). It was much rarer for subjects to opt for a job below their previous level, and in a few rare exceptions (N = 3) some were successful in upgrading their skills.

While complete data was only available for 94 out of the 107 subjects, no association was found between resumption of work and status of legal proceedings or compensation settlement (*Yates Corrected Chisquare* = .37, *D.F.* = 1, *p* = .54). This would appear to refute the argument that typical THI victims delay the resumption of work in expectation of a more advantageous financial settlement.

<u>Data Reduction Procedure : Principal Components Analysis</u>

Examination of the relationships between test variables was based on a series of Principal Component Analyses (BMDP P4M, Varimax Rotation). A total of nine were performed, whereby the number of factors was decreased successively from 12 to 4. This procedure was chosen in order to reduce the number of predictor variables and to facilitate the examination of those aspects of neuropsychological functioning that are critically related to the outcome measures.

An optimal solution yielding eight orthogonal factors was chosen after visual inspection of the resulting factor structures. This included plotting of i.) the variance explained by each of the 42 variables, ii.) the variance explained by each of the 12 factors, and finally, iii.) the communalities obtained from the one-factor solution through to the twelve-factor solution for each of the 42 variables. The last step was taken in order to ensure that each variable would indeed contribute to the eight factor solution that was finally chosen as the best factorial structure. This solution accounted for 28% of the total variance and all eigenvalues exceeded 1.3. Rotated factor loadings and eigenvalues are presented in Table 10. Unrotated factor loadings, correlations of factor loadings with the three outcome criteria, as well as a summary of the means and standard deviations for factor scores for the total sample and broken down into groups with respect to trauma severity, occupational status at FU, and sex, are tabled in Appendix D. Figure 1 provides a graphic representation of the factor structure (Inside-Out Plot of Variable Loading Pattern) and was used as an aide in interpreting the 'meaning' of the eight factors.[1]

Factor 1, which was labelled Neuropsychological Functioning, appeared to reflect the cognitive-intellectual aspects of neuropsychological functioning and can be interpreted as a summary measure of intellectual impairment and problems with executive-control functions. Whereas none of the personality measures loaded on this factor, it shows substantial loadings for tests that require good cognitive abilities as well as intact planning and efficient task performance (i.e. Performance subtests of the WAIS-R, and TPT), good mental flexibility and problem solving skills (i.e. Trail B, and Category Test), good

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[1] Variables whose loadings were below .2 are indicated with a blackened circle only.

TABLE 10

Rotated Factor Loadings And Eigenvalues

Variable	Factor 1	2	3	4	5	6	7	8
BD	.817	.076	-.075	.021	.067	.075	-.091	.035
PIQ	.807	.367	-.077	.001	-.071	-.024	.098	-.126
PA	.759	.145	.088	-.001	-.017	-.116	.053	.024
KEYTEST	-.755	-.119	.048	-.256	.085	-.112	-.197	-.174
LOC	.679	-.046	-.011	.126	.019	.117	.300	.198
MEM	.670	.089	.004	.207	.002	.061	.250	.047
PC	.626	.393	-.122	-.131	.152	-.039	.008	-.137
TRAILBT	-.610	-.094	-.015	-.524	-.108	.028	-.148	.135
DSY	.604	.039	-.089	.223	-.042	.072	.373	-.173
CATEGORY	-.592	-.155	.002	-.063	.056	-.041	-.045	-.365
TPTTOT	-.571	.126	-.083	-.239	.377	-.021	.091	.061
VIQ	.100	.900	-.039	.331	-.064	-.030	.088	.069
VOC	.019	.833	-.051	.249	-.084	-.159	.080	.028
COMP	.168	.815	.033	.052	.043	-.213	.039	.013
INFO	.014	.771	.040	.213	-.005	-.111	.050	.040
SIM	.249	.739	-.067	-.043	-.132	.023	.216	.038
ARITH	.211	.580	-.023	.457	-.046	.039	.235	.012
WWQ	.139	.532	-.085	.489	-.086	.012	.432	-.075
ARITSS	.387	.517	0	.185	-.074	.020	-.338	-.002
Scale 2 (D)	-.015	-.001	.871	.079	-.004	.190	-.134	.097
Scale 1 (HS)	.017	-.067	.868	-.064	-.028	.016	.002	.044
Scale 3 (HY)	-.115	.103	.866	-.040	.087	-.153	.144	-.038
Scale 7 (PT)	.037	-.100	.735	.007	.330	.360	-.027	.019
Scale 8 (SC)	.009	-.237	.618	-.078	.538	.356	-.005	.184
DF	-.044	.240	-.109	.727	-.046	.001	.133	.148
DB	.105	.338	.040	.682	.083	.072	.109	.123
TRAILAT	-.531	-.008	-.044	-.555	.200	.188	-.045	.213
RHYTHM	.308	.288	.071	.551	.117	.018	-.026	.296
SPEECHSC	-.353	-.244	.225	-.542	-.141	.084	-.030	-.077
Scale 9 (MA)	-.001	-.139	-.008	.186	.742	.039	-.085	.041
Scale 4 (PD)	0	.020	.575	-.001	.596	-.052	.016	-.016
K (MMPI)	-.067	.191	.009	-.085	-.098	-.822	.018	.115
Scale10 (SI)	.049	-.102	.294	-.058	-.325	.727	-.163	.081
F (MMPI)	-.076	-.302	.238	-.259	.488	.516	.067	.171
L (MMPI)	-.121	-.019	-.016	-.480	-.170	-.516	-.073	.304
LEARNH3	.280	.168	-.023	.269	.085	.084	.685	.112
VMEM	.266	.086	.058	.051	-.104	-.135	.654	-.050
Scale 5 (MF)	-.032	.024	.222	.070	.388	-.097	-.125	.672
APHASIA	-.248	-.359	.107	-.463	-.031	-.004	-.207	.052
Scale 6 (PA)	-.085	-.034	.389	-.262	.477	.465	.206	.120
TAPDOM	.438	.040	-.096	.287	.386	-.207	-.130	-.077
NVMEM	.187	.089	.027	.286	-.113	-.016	.288	.435
% VARIANCE	6.5	5.3	4.0	4.0	2.6	2.5	2.0	1.4

Factor 1: NEUROPSYCHOLOGICAL FUNCTIONING
2: VERBAL SKILLS
3: EMOTIONAL DISTRESS
4: CONCENTRATION

Factor 5: IMPULSIVENESS
6: ALIENATION
7: LEARNING
8: FLEXIBILITY

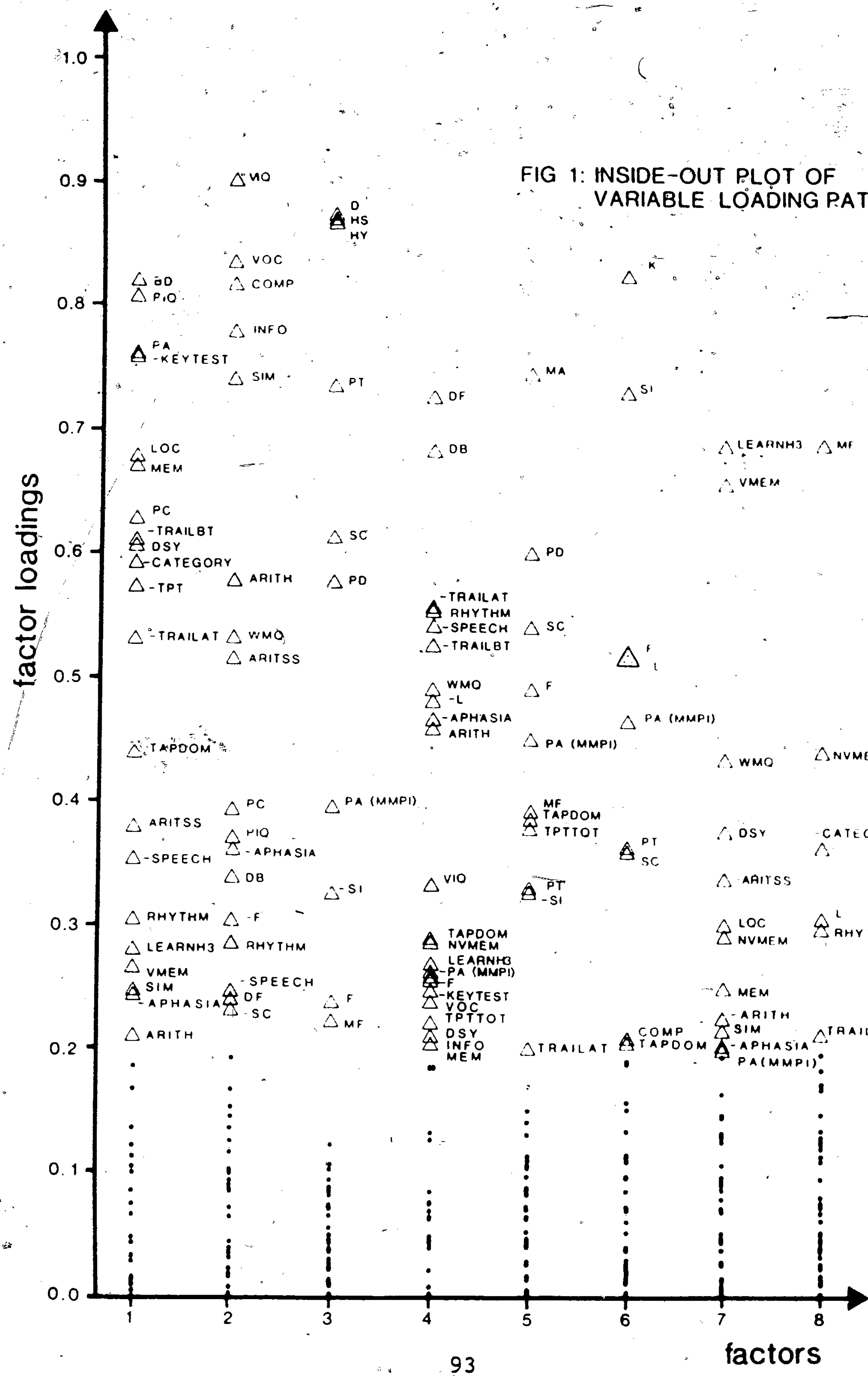

FIG 1: INSIDE-OUT PLOT OF VARIABLE LOADING PATTERN

task concentration (freedom from distractibility), and motor speed (e.g. Trail A, Finger Tapping Test, Speech Perception and Seashore Rhythm Test). Conceptually, most of the tests loading on the Neuropsychological Functioning factor were hypothesized to provide sensitive measures of executive-control functions, however they remain so closely intertwined with cognitive-intellectual functions that it is impossible to separate the degrees to which each of them contributed to the factor.

When interpreted within the proposed model of neuropsychological functioning, this factor provides information about both cognitive-intellectual and executive-control functions. This suggests that the data used for this study do not allow clear separation between the three functional subsystems. Conceptually, this finding supports the speculation that deficient executive-control functions affect all other aspects of behavior. In practical terms, it means that the Factor 1 can be only used as a global rather than distinct measure of neuropsychological functioning.

Factor 2, labelled <u>Verbal Skills</u>, primarily reflected subjects' ease of dealing with verbal material and their verbal expressiveness, with the highest loadings for Verbal IQ (WAIS-R), and for those Verbal subtests of the WAIS-R that require good 'common sense' knowledge and reasoning, as well as awareness of social appropriateness (i.e. Vocabulary, Comprehension, Information, and Similarities subtests of the

WAIS-R). The more moderately-loading variables were the Arithmetic subtests of the WAIS-R and WRAT, and the WMS-MQ. The lowest loadings were found for the Performance IQ, the Picture Completion and Digit Span (backward) subtests of the WAIS-R, the Aphasia Screening Test, the Rhythm Test, and the F scale of the MMPI.

Whereas some degree of conceptual thinking and a relatively intact capacity for sustained attention are required to perform well on these subtests, this factor measures primarily acquired knowledge and skills as indicated by the nature of the tests loading on it, and it is considered to be essentially independent of the attributes which were hypothesized to constitute executive-control functions. Within the proposed model of neuropsychological functioning, it can be used as a measure that provides information about the cognitive-intellectual functions subsystem.

Factor 3, labelled Emotional Distress, appeared to provide an indicator of those aspects of personality organization that measure self-esteem, emotional stability and coping style. The only variables that contributed to this factor were from the MMPI, with high positive loadings on Depression (Scale 2), Hypochondriasis (Scale 1), Hysteria (Scale 3), and Psychasthenia (Scale 7), and moderate loadings on Schizophrenia (Scale 9), Psychopathic Deviate (Scale 4), Paranoia (Scale 7), and Social Introversion-Extraversion (Scale 10). For the purpose of this study, this factor would therefore seem to provide a measure of subjects' emotional reaction to their particular life situations (i.e. chronic recovery phase after THI) both in terms of the distress they experience and their way of coping with the changes in their lives.

All the variables loading on the Emotional Distress factor appear to capture those personality aspects that provide information about an individual's emotionality and self-awareness. As such, the factor fits as a measure of the emotionality and personality subsystem of the proposed model. However, it is speculated that increased levels of emotional distress may affect executive-control functioning and result in patterns of erratic or decreased performance effectiveness.

Factor 4, <u>Concentration</u> (Freedom from Distractibility), appeared to reflect those aspects of a test situation that require uninterrupted attention to the task-at-hand over a given time period. The highest-loading variables were the WAIS-R Digit Span subtest (separate scoring for forward and backward), with moderate loadings for the Trail Making Test, Rhythm and Speech Perception Test, WMS-MQ, Aphasia Screening, Arithmetic (WAIS-R), and the L scale of the MMPI.

Given the diverse nature of the test measures loading on this factor, it is speculated that the Concentration factor might be related to all three subsystems of neuropsychological functioning. However, the data do not allow us to measure the degree of this association. This necessitates that this factor has to be used as a global rather than specific measure of neuropsychological functioning.

Factor 5, Impulsiveness (affecting quality of performance), appeared to reflect those aspects of executive-control functions that are crucial for effective performance with regard to both the test situation and to daily life in general. Test variables that were hypothesized to measure both cognitive-behavioral and motivational-emotional aspects of executive-control functions contributed to this factor, with the highest loading on the Mania scale, moderate loadings on the Psychopathic Deviate, Schizophrenia, Fake Bad (F), and Paranoia scales of the MMPI, with additional loadings on the MMPI Masculinity-Femininity scale, the Finger Tapping Test, and total time for TPT (HRB subtests), and the Psychasthenia and Social Introversion-Extraversion scales of the MMPI. Visual examination of the loading pattern on this factor suggested a MMPI profile that is commonly known as the 4-9 type with elevated scores on the Psychopathic Deviate and the Mania scales. Individuals with this profile type are described as immature, hostile, rebellious, impulsive and restless. The latter are characteristics that are often considered to be typical of the young 'macho' male who is at particularly high risk to become a THI victim. The issue of premorbid personality vs. personality changes due to the head injury, however, was not considered to be important for the purpose of this study. Overall, this factor would therefore seem to provide a measure of the manner with which an individual approaches and solves a task, and thus give information about his or her likely performance effectiveness, as determined by impulsivity and frustration tolerance, and his or her ability to monitor and control speed, recognize and correct errors, and make judgments.

The Impulsivity factor provides information about personal attributes that are assumed to be major determinants of how a person goes about doing something, i.e. the qualitative aspects of performance. As such, this factor is regarded as a measure of the executive-control function subsystem.

Factor 6, <u>Alienation</u> was interpreted as a good source of information about subjects' perception of how their surroundings or circumstances impinge on their lives. The only variables loading on this factor were from the MMPI, with a high negative loading for the K Subtle Defensiveness scale and a high positive loading for the Social Introversion-Extraversion scale. Moderate to low loadings were found for the Fake Bad, Lie (negative loading), Paranoia, Psychasthenia and Schizophrenia scales of the MMPI. This factor would appear to measure subjects' tendency to view themselves as victims of their circumstances. They are complaining and argumentative but feel that nobody listens to them, and they perceive themselves as social 'outcasts'. Accordingly, they may behave in socially unaccepted ways to get the attention of others.

Similarly to the Emotional Distress factor(3), the pattern of variables found in this factor appears to capture subjects' personal attributes, particularly those that provide information about an individual's tendency to over-react to a difficult life situation. As such, the factor fits as a measure of the emotionality and personality subsystem of the proposed model. It is speculated that increased feelings of alienation may result in motivational problems associated with impaired executive-control functions.

Factor 7, Learning (Acquisition of New Information), primarily reflected subjects' ability to learn and retain newly acquired information both with regard to verbal and nonverbal material. Implicitly, this requires good concentration and attention, as well as access to a fund of already existing information. Total number of 'hard' word pairs (Paired Association subtest, WMS) learned after three trials, and percentage of verbal information retained after 30 min (R-WMS, memory for stories) were the highest loading variables, with moderate-to-low loadings on the WMS-MQ, WAIS-R Digit Symbol subtest, Written Arithmetic (WRAT), TPT Location and Memory socre, and percentage of figural information retained after 30 to 40 min (R-WMS, Visual Reproduction). Although a relatively intact capacity for sustained attention is required to do well on these subtests, this factor seems to measure primarily a person's ability to memorize new information or retrieve 'old' acquired knowledge. Almost all the variables loading on the

Learning factor are derived from traditional memory and intelligence testing, hence the factor is considered to be measuring aspects of the cognitive-intellectual functions subsystem and essentially independent of the attributes which were hypothesized to constitute executive-control functions.

Factor 8, Flexibility was primarily loaded on by the MF scale of the MMPI, with moderate to low loadings on percentage of figural information retained (R-WMS), the Category test, the MMPI L scale and the Rhythm test. Conceptually, this was the hardest factor to interpret as it was difficult to extract a 'common denominator' for this particular set of variables that is a mixture of both, HRB and MMPI scores. However it would seem that this factor is a reflection of subjects' sensitivity and flexibility in coping with the demands of tests that require good attention and concentration as well as 'quick' thinking.

Similarly to the Impulsivity factor, this factor is considered to provide information about the qualitative aspects of a person's performance, i.e. his or her mental flexibility, and ability to adjust and cope with the demands of the environment both generally and the test situation in particular. As such it can be used as a measure of executive-control functions.

Factor Structure Of Neuropsychological Test Measures: Summary

Exploratory factor analysis was performed in order to a) examine the relationship among neuropsychological test measures; and b) determine whether the data could be separated along meaningful dimensions that were conceptually consistent with the proposed 'neuropsychological systems' model.

The findings are both interesting and thought-provoking. The search for relationships in this complex set of data has revealed a factor structure that provides tentative empirical support for the model. Each of the eight factors can be fitted within the three subsystems of neuropsychological functioning, that is most of the factors can be interpreted as relatively distinct measures of one or the other of the three functional subsystem, whereas two of the extracted factors appear to provide a combined, global measure of neuropsychological functioning.

More specifically, the Verbal Skills and the Learning factors appear to reflect cognitive-intellectual functions, the Emotional Distress and the Alienation factors are essentially considered to be measures of emotionality and personality functions, and the Impulsivity and the Flexibility factors are interpreted as measures of executive-control functions subsystem. Finally, the Neuropsychological Functioning factor is considered to be a measure of both the cognitive-intellectual and the executive-control system, while the Concentration factor appears to be related to all three subsystems.

On the basis of these empirical findings, some modifications of the originally proposed model are required. Specifically, the findings suggest that there is some overlap between the three functional subsystems indicating an interdependency between cognitive-intellectual, emotionality-personality, and executive-control functions.

Overall, the resulting factor structure reveals a pattern that fits the proposed neuropsychological systems model reasonably well. The findings suggest that the eight factors discussed above can be used as relatively sensitive measures of the various aspects of neuropsychological functioning. As postulated, two factors could be interpreted as probable measures of executive-control functions, while two other factors are considered to be combined measures of the executive-control subsystem and the other functional subsystems.

Although it was possible to provide empirical support for the proposed model and the executive-control functions construct in particular, the clinical usefulness of the findings remains somewhat limited. Clearly, one of the major obstacles of the present research continues to be the indirect approach that had to be taken in order to extract the measures of executive-control functions. Most of the test variables that were believed to be sensitive to impaired executive-control functions were also found to be sensitive measures of either cognitive-intellectual or emotionality-personality functions. Contrary to what was hoped to be achieved, none of the individual tests that were used in this study could be identified as an explicit and direct measure of executive-control functions.

Prediction Of Long-Term Psychosocial Outcome Following THI

In order to determine whether long-term psychosocial outcome prediction could be improved through the combined use of medical and demographic information, and neuropsychological test measures, multiple linear regression procedures were performed for each of the three outcome measures using the eight neuropsychological factor scores, the two measures of trauma severity, and the four demographic variables (Age, Occupational Status prior to Injury, Physical Disability, and Time since Injury) as predictors. For that purpose, an 'all possible subsets' regression was employed (BMDP P9R). This particular program calculates regression equations for all possible combinations of the 14 predictor variables (including the neuropsychological factor scores, the biomedical data and the demographic characteristics) beginning with a single, then two predictors, and so on, until all of them are entered. As such, this method was well suited for analysing the separate and combined predictive power of the independent measures selected for this study.

Subsequently, results were examined with respect to those variables which could be identified as the most important predictors for each of the three outcome measures, and in order to determine which combination of variables would result in the best predictive accuracy. Summary tables for each of the three analyses indicate the variance explained (adjusted $\underline{R}^2$) by the different subsets of predictor variables[2], and as such serves as a measure of the predictive power of that particular set of predictors. Selection of best predictors was based on the frequency of occurrence of a particular variable as subsets of increasing size were generated. Since the probability of inclusion in a particular subset increases with the number of variables included in the subset, an important predictor was expected to be present in all the larger subsets. An important predictor was also expected to be consistently present in all or most of the smaller-sized subsets. Thus the 'best' subset of predictors was selected according to which of the variables and/or factor scores recurred most often in the subsets.

Prediction Of Occupational Status At Follow-Up

Variance accounted for in the prediction of occupational status ranged from 0 to 16%. The best 'single' predictor was the Neuropsychological Functioning factor(1) which accounted for 8.7% of the variance. Inspection of Table 11 revealed that,

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[2] The adjusted $\underline{R}^2$ is similar to the $\underline{R}^2$, after a correction has been made for the number of variables entered into the analysis and the total number of cases the calculations are based on.

overall, the most important predictors of occupational status at follow-up were the Neuropsychological Functioning factor(1), the Emotional Distress factor(3), the Impulsiveness factor(5), the Physical Disability rating, and subjects' 'Occupational Status prior to THI' (PREOCC). This particular set of five predictor variables accounted for 15.3% of the variance and was identified as the best combination of predictors (see Table 12).

Prediction Of Loss In Occupational Status

Variance accounted for in the prediction of loss in occupational status at the time of Follow-Up ranged from .5% to 38.2%. The best 'single' predictor was subjects' 'Occupational Status prior to THI' which accounted for 16.2% of the variance. While this suggested that this particular measure was indeed a reasonably good predictor of change in occupational status, a closer examination of the results revealed that prediction accuracy could be doubled by including the Neuropsychological Functioning factor(1), the Emotional Distress factor(3), the Flexibility factor(8) , and the Trauma Severity rating in the regression equation. This particular combination of predictor variables accounted for 36.2% of the variance and was identified as the best set of measures in the prediction of loss in occupational status. See Tables 13 and 14 for a summary of these findings.

TABLE 11

Summary Of All Subsets Regression With Occupational Status

At Follow-Up As Dependent Variable

Adj.R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Sur-gery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.160	6(1)			x			x	x	x	x		x			
.160	7(1)			x			x	x	x	x		x			x
.160	6(2)			x				x	x	x		x			x
.159	8(1)	x		x	x		x	x		x	x	x			
.158	7(2)			x	x		x	x	x	x		x			
.158	7(3)			x				x	x	x		x	x		x
.158	7(4)	x		x			x	x	x	x		x			
.158	7(5)			x			x	x	x	x	x	x			
.158	8(2)			x			x	x	x	x	x	x			x
.158	9(1)	x		x	x		x	x		x	x	x	x		
.158	8(3)	x		x	x		x	x	x	x		x			
.158	9(2)	x		x	x		x	x	x	x	x	x			
.158	7(6)	x		x	x		x	x		x		x			
.158	8(4)	x		x	x		x	x		x		x	x		
.158	8(5)			x	x		x	x	x	x	x	x			
.157	8(6)			x			x	x	x	x		x	x		x
.157	8(7)			x	x		x	x	x	x		x			x
.157	9(3)	x		x	x		x	x	x	x		x	x		
.157	8(8)			x	x		x	x	x	x		x	x		
.157	8(9)	x		x			x	x	x	x	x	x			
.157	9(4)			x	x		x	x	x	x	x	x			x
.156	10(1)	x	x	x	x		x	x	x	x	x	x			
.156	7(7)			x			x	x	x	x		x	x		
.156	8(10)			x			x	x	x	x		x			x
.156	10(2)	x		x	x		x	x	x	x	x	x	x		
.156	5(1)						x	x	x	x		x			
.156	6(3)						x	x	x	x		x			x
.156	11(1)	x	x	x	x		x	x	x	x	x	x	x		
.156	10(3)				x		x	x	x	x	x	x	x		x
.155	9(5)			x	x		x	x	x	x	x	x	x		
.155	7(8)			x	x		x	x		x	x	x			
.155	6(4)				x		x	x	x	x		x			
.155	9(6)	x		x			x	x	x	x	x	x			x
.155	9(7)	x	x	x	x		x	x	x	x		x			
.155	10(4)	x	x	x	x		x	x	x	x		x	x		
.155	10(5)	x		x	x		x	x	x	x	x	x			x
.155	9(8)			x			x	x	x	x	x	x	x		x
.155	6(5)	x		x			x	x		x		x			
.155	6(6)			x	x		x	x		x		x			
.155	7(9)	x		x			x	x		x	x	x			

TABLE 11 (Continued)

Adj.R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Sur-gery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.154	7(10)	x		x	x			x		x		x	x		
.154	11(2)	x		x	x		x	x	x	x	x	x	x		x
.154	6(7)	x		x			x	x	x	x					
.154	5(2)			x				x	x	x		x			
.154	9(9)		x	x	x		x	x	x	x	x	x			
.154	6(8)	x		x	x			x	x	x					
.154	6(9)	x		x				x	x	x		x			
.153	5(3)	x					x	x	x	x					
.153	5(4)			x			x	x		x		x			
.153	9(10)	x	x	x			x	x	x	x	x	x			
.153	11(3)	x	x	x	x		x	x	x	x	x	x		x	
.153	10(6)		x	x	x		x	x	x	x	x	x	x		
.152	12(1)	x	x	x	x		x	x	x	x	x	x	x	x	
.152	6(10)			x			x	x		x	x	x			
.152	10(7)	x	x	x	x		x	x		x	x	x	x		
.152	4(1)						x	x	x	x					
.152	12(2)	x	x	x	x		x	x	x	x	x	x	x		x
.152	11(4)	x	x	x	x		x	x	x	x		x	x	x	
.152	5(5)						x	x	x	x					x
.152	10(8)		x	x	x		x	x	x	x	x	x			x
.152	10(9)	x		x	x		x	x		x	x	x	x	x	
.152	11(5)		x	x	x		x	x	x	x	x	x	x		x
.151	10(10)	x		x	x		x	x	x	x	x	x		x	
.151	5(6)	x		x				x		x		x			
.151	5(7)	x		x			x	x		x					
.150	5(8)			x			x	x	x	x					
.149	5(9)			x	x			x		x		x			
.148	5(10)						x	x	x	x			x		

TABLE 12

The Best Set Of Predictors For Occupational Status at FU

SQUARED MULTIPLE CORRELATION	0.194
MULTIPLE CORRELATION	0.444
ADJUSTED SQUARED MULT. CORR.	0.153
RESIDUAL MEAN SQUARE	0.212
STANDARD ERROR OF EST.	0.460
F-STATISTIC	4.80
NUMERATOR DEGREES OF FREEDOM	5
DENOMINATOR DEGREES OF FREEDOM	100
SIGNIFICANCE (TAIL PROB.)	0.001

VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	0.150	0.296	0.301	0.51	0.613		
FACTOR1	0.129	0.047	0.252	2.72	0.008	0.939	0.060
FACTOR3	-0.111	0.046	-0.215	-2.39	0.018	0.997	0.046
FACTOR5	-0.071	0.047	-0.143	-1.35	0.130	0.924	0.019
PHYSDIS	-0.087	0.067	-0.119	-1.29	0.201	0.942	0.013
PREOCC	0.006	0.004	0.145	1.52	0.133	0.885	0.018

TABLE 13

Summary Of All Subsets Regression With Loss in Occupational Status As Dependent Variable

Adj.R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Surgery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.382	9(1)	x	x	x	x		x	x	x	x		x			x
.380	10(1)	x	x	x	x	x		x	x	x		x			x
.378	10(2)	x	x	x	x		x	x	x	x		x			x
.376	8(1)	x	x	x	x			x		x		x			x
.376	10(3)	x	x	x	x			x	x	x		x	x		x
.376	10(4)	x	x	x	x			x	x	x	x	x			x
.376	11(1)	x	x	x	x	x	x	x	x	x			x		x
.376	10(5)	x	x	x	x			x	x	x		x		x	x
.375	9(2)	x	x	x	x	x		x		x		x			x
.374	11(2)	x	x	x	x	x		x	x	x		x	x		x
.374	11(3)	x	x	x	x	x		x	x	x	x	x			x
.374	11(4)	x	x	x	x	x		x	x	x		x		x	x
.372	9(3)	x	x	x	x		x	x		x		x			x
.372	8(2)	x	x	x	x			x	x	x					x
.371	8(3)	x	x	x				x	x	x		x			x
.370	9(4)	x	x	x	x			x		x	x	x			x
.370	9(5)	x	x	x	x			x		x		x	x		x
.370	12(1)	x	x	x	x	x	x	x	x	x		x	x		x
.370	9(6)	x	x	x	x			x		x		x		x	x
.370	12(2)	x	x	x	x	x	x	x	x	x	x	x			x
.370	7(1)	x	x	x	x			x		x					x
.370	11(5)	x	x	x	x			x	x	x	x	x		x	x
.369	12(3)	x	x	x	x	x	x	x	x	x		x		x	x
.368	6(1)	x		x	x			x		x					x
.368	8(4)	x	x	x	x	x		x		x					x
.367	7(2)	x	x	x				x	x	x					x
.366	7(3)	x		x	x	x		x		x					x
.366	8(5)	x	x	x	x		x	x		x					x
.366	7(4)	x		x	x			x		x		x			x
.365	7(5)	x		x	x			x	x	x					x
.364	8(6)	x	x	x	x			x		x			x		x
.364	13(1)	x	x	x	x	x	x	x	x	x	x	x	x		x
.364	7(6)	x		x	x			x	x	x					x
.364	12(4)	x	x	x	x			x	x	x	x	x	x	x	x
.363	7(7)	x		x	x			x		x			x		x
.363	13(2)	x	x	x	x	x	x	x	x	x		x	x	x	x
.363	8(6)	x	x	x	x			x		x	x				x
.363	13(3)	x	x	x	x	x	x	x	x	x	x	x		x	x
.363	8(7)	x	x	x	x			x		x				x	x
.363	7(8)	x		x	x			x		x				x	x
.363	5(1)	x		x				x		x					x

TABLE 13 (Continued)

Adj.R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Surgery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.362	7(9)	x		x	x			x		x	x				x
.362	6(2)	x	x	x				x		x					x
.362	6(3)	x		x				x	x	x					x
.362	13(4)	x	x	x	x	x		x	x	x	x	x	x	x	x
.360	13(5)	x	x	x	x		x	x	x	x	x	x	x	x	x
.357	6(6)	x		x			x	x		x					x
.357	14(1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x
.357	6(7)	x		x				x		x				x	x
.356	6(8)	x		x				x		x	x				x
.354	7(10)	x	x	x	x			x		x		x			
.354	12(5)	x	x	x	x		x	x		x	x	x	x	x	x
.351	13(6)	x	x	x	x	x	x	x		x	x	x	x	x	x
.347	13(7)	x	x	x	x	x	x	x	x	x	x		x	x	x
.346	6(9)	x	x	x	x			x		x					

TABLE 14

The Best Set Of Predictors For Loss In Occupational Status

SQUARED MULTIPLE CORRELATION	0.393
MULTIPLE CORRELATION	0.627
ADJUSTED SQUARED MULT. CORR.	0.362
RESIDUAL MEAN SQUARE	375.906
STANDARD ERROR OF EST.	19.388
F-STATISTIC	12.940
NUMERATOR DEGREES OF FREEDOM	5
DENOMINATOR DEGREES OF FREEDOM	100
SIGNIFICANCE (TAIL PROB.)	0.000

VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	-50.520	11.730	-2.080	-4.31	0.000	.	
FACTOR1	-7.963	1.973	-0.322	-4.04	0.000	0.957	0.099
FACTOR3	5.652	1.973	0.226	2.86	0.005	0.975	0.050
FACTOR8	-4.676	1.990	-0.185	-2.35	0.021	0.978	0.034
TRAUMA	5.354	2.494	0.171	2.15	0.034	0.953	0.028
PREOCC	0.892	0.150	0.474	5.91	0.000	0.945	0.212

TABLE 15

Summary Of All Subsets Regression With Severity Of Daily

Problems As Dependent Variable

Adj. R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Surgery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.353	8(1)	x		x	x	x	x			x			x		x
.350	7(1)	x		x	x	x				x			x		x
.348	6(1)	x		x	x					x			x		x
.346	9(1)	x	x	x	x	x	x			x			x		x
.345	7(2)	x		x	x	x				x			x		x
.345	7(3)	x		x	x		x			x			x		x
.344	8(2)	x	x	x	x	x				x			x		x
.343	9(2)	x		x	x	x	x	x		x			x		x
.343	9(3)	x		x	x	x	x			x		x	x		x
.343	9(4)	x		x	x	x	x			x			x		x
.342	9(5)	x		x	x	x	x		x	x			x		x
.342	9(6)	x		x	x	x	x			x	x		x		x
.341	8(3)	x		x	x	x				x		x	x		x
.341	8(4)	x		x	x	x				x			x	x	x
.340	8(5)	x		x	x	x		x		x			x		x
.340	8(6)	x		x	x	x			x	x			x		x
.340	8(7)	x		x	x	x				x	x		x		x
.340	5(1)	x			x					x			x		x
.340	6(2)	x			x		x			x			x		x
.340	6(3)	x			x	x				x			x		x
.339	7(4)	x	x	x	x					x			x		x
.339	7(5)	x		x	x				x	x			x		x
.338	7(6)	x		x	x					x			x	x	x
.338	7(7)	x		x	x					x		x	x		x
.338	7(8)	x		x	x					x	x		x		x
.338	7(9)	x		x	x			x		x			x		x
.337	10(1)	x	x	x	x	x	x			x			x	x	x
.336	10(2)	x	x	x	x	x	x		x	x			x		x
.336	10(3)	x	x	x	x	x	x	x		x			x		x
.336	10(4)	x	x	x	x	x	x			x		x	x		x
.336	10(5)	x	x	x	x	x	x			x	x		x		x
.335	7(10)	x		x		x				x			x		x
.334	6(4)	x		x		x				x			x		x
.331	6(5)	x	x		x					x			x		x
.331	5(2)	x		x						x			x		x
.331	6(6)	x			x					x		x	x		x
.331	6(7)	x			x					x			x	x	x
.330	6(8)	x			x					x	x		x		x
.330	6(9)	x			x			x		x			x		x
.330	6(10)	x			x				x	x			x		x

TABLE 15 (Continued)

Adj.R-squared	Set(Pos)	Trauma Sev.	Age	Pre Occ	Year Inj.	Sur-gery	Phys. Dis.	Factors 1	2	3	4	5	6	7	8
.326	11(1)	x	x	x	x	x	x	x		x			x	x	x
.326	11(2)	x	x	x	x	x	x		x	x			x	x	x
.326	11(3)	x	x	x	x	x	x			x		x	x	x	x
.326	11(4)	x	x	x	x	x	x			x	x		x	x	x
.321	5(3)	x			x	x				x			x		
.319	5(4)				x		x			x			x		x
.319	5(5)			x	x					x			x		x
.318	5(6)	x				x				x			x		x
.318	4(1)				x					x			x		x
.318	4(2)	x								x			x		x
.315	12(1)	x	x	x	x	x	x	x	x	x			x	x	x
.315	12(2)	x	x	x	x	x	x	x		x		x	x	x	x
.315	12(3)	x	x	x	x	x	x	x		x	x		x	x	x
.315	4(3)			x						x			x		x
.313	5(7)		x		x					x			x		x
.310	5(8)				x	x				x			x		x
.310	5(9)				x				x	x			x		x
.310	4(3)						x			x			x		x
.310	3(1)									x			x		x
.309	5(10)				x					x	x		x		x
.305	4(5)	x				x				x			x		
.305	4(6)		x							x			x		x
.305	4(7)								x	x			x		x
.304	3(2)			x						x			x		
.304	13(1)	x	x	x	x	x	x	x	x	x		x	x	x	x

TABLE 16

The Best Set Of Predictors For Severity Of Daily Problems

SQUARED MULTIPLE CORRELATION	0.355
MULTIPLE CORRELATION	0.596
ADJUSTED SQUARED MULT. CORR.	0.318
RESIDUAL MEAN SQUARE	78.083
STANDARD ERROR OF EST.	8.836
F-STATISTIC	9.51
NUMERATOR DEGREES OF FREEDOM	4
DENOMINATOR DEGREES OF FREEDOM	69
SIGNIFICANCE (TAIL PROB.)	0.000

VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	STAND. COEF.	T-STAT	2TAIL SIG.	TOL-ERANCE	CONTRI-BUTION TO R-SQ
INTERCEPT	41.844	3.385	3.911	12.36	0.000		
FACTOR3	5.731	1.122	0.498	5.11	0.000	0.983	0.244
FACTOR6	-2.351	1.011	-0.225	-2.33	0.023	0.998	0.050
FACTOR8	-1.950	1.106	-0.174	-1.76	0.082	0.958	0.029
TRAUMA	-1.917	1.419	-0.134	-1.35	0.181	0.945	0.017

Prediction Of Self-Reported Severity Of Daily Problems

Using Severity of Daily Problems as the criterion measure (see Table 15 and 16), the amount of variance accounted for by the all-subsets regression equations ranged from 0% to 35.2%. The best 'single' predictor was the Emotional Distress factor(3) which explained 25.2% of the variance. The Alienation factor(6), the Flexibility factor(8), and the Trauma Severity rating were identified as the next most important predictor variables. When entering this particular combination of measures into the regression equation, the total amount of variance explained was 31.8%. Again, this set of four predictor variables was identified as the best combination, both in terms of parsimony and predictive power.

Prediction Of Long-Term Psychosocial Outcome: Summary

The Clinical Usefulness Of Intermediate-Term Neuropsychological Measures As Prognostic Indicators Of Outcome (Hypothesis 1)

The results of this study provide empirical support for the hypothesis that the accuracy of long-term psychosocial outcome prediction can be improved by the combined rather than separate use of biomedical markers, premorbid characteristics of the victim, and neuropsychological measures.

Moreover, the findings demonstrated that the predictive validity of neuropsychological factor scores with respect to long-term psychosocial outcome following THI is quite respectable. Overall the predictive power of factor scores measuring Neuropsychological Functioning (Factor 1), Emotional Distress (Factor 3), Impulsivity (Factor 5), Alienation (Factor 6), and Flexibility (Factor 8) was superior to the predictive power of biomedical markers. Measures of pre-morbid occupational status and physical disability enhanced the predictive accuracy of outcome with respect to the employment measures. Contrary to some previous research findings, age and 'Time since Injury' were not found to be important predictor variables in long-term psychosocial outcome.

The Clinical Usefulness Of Executive-Control Functions As Prognostic Indicators Of Outcome (Hypothesis 2)

One of the major objectives of this investigation was to study the role of executive-control functions, and their usefulness in the prediction of long-term psychosocial outcome following THI. The results of the present study suggested that factor-analytic methods allow the extraction of executive-control functions from conventional measures of neuropsychological functioning, such as the WAIS-R, the HRB and related tests, and the MMPI.

It is of particular interest that the two factors that were interpreted as measures of executive-control functions, namely the Impulsivity factor(5) and the Flexibility factor(8), were identified as relatively important contributors in the prediction of employment-related outcome. While the global measure of neuropsychological functioning (Factor 1) was found to be an important prognostic indicator of both the resumption of work and loss in occupational status following THI, the predictive accuracy could be improved by introducing the two specific executive-control functions measures. This provides further support for the potential usefulness of the construct and suggests that the additional information gained through its assessment will indeed help to identify those subtle consequences of THI that prevent many head-injured victims to resume their previous lifestyles.

Overall, the preliminary findings suggest that executive-control functions represent an integral aspect of neuropsychological functioning and can provide a quantitative measure of more subtle and diffuse deficits. These can be considered as additional determinants of overall performance effectiveness and this in turn affects long-term psychosocial outcome.

The Advantages Of Comprehensive Assessment Procedures In The Prediction Of Outcome

As discussed previously, the results of these analyses also suggest that the accuracy of long-term psychosocial outcome prediction can be improved considerably by the combined rather than separate use of biomedical or demographic measures, or neuropsychological factor scores, particularly when predicting employment-related criteria. More specifically, the proportion of variance explained by regressing the 'optimal' set of predictors on each of the three outcome criteria ranged from 15.3% for Occupational Status at Follow-Up, through 31.8% for Severity of Daily Problems to 36.2% for Loss in Occupational Status; single biomedical and demographic measures were found to be only minor contributors to these regression equations. It is interesting to observe that the predictive accuracy of employment-related outcome varied considerably depending on the specificity of the question asked. While the long-range prediction of actual employment status on the basis of biomedical, demographic, and neuropsychological measures contained a fair degree of uncertainty, the same measures provided a good estimate of a subject's loss in occupational status.

It was also confirmed that different aspects of subjects' medical and personal history, and neuropsychological functioning have to be considered when predicting long-term impact on daily life or employment-related outcome following THI. Thus measures such as the Emotional Distress factor, the Alienation factor, the Flexibility factor, and the Trauma Severity rating were the most crucial predictors of daily life problems, while the prediction of employment status at Follow-Up was more influenced by measures of cognitive-intellectual and executive-control functions such as the Neuropsychological Functioning and the Impulsivity factors, and to a lesser degree by subjects' occupational status prior to and the degree of physical disability due to injury. In comparison, subjects' occupational status prior to injury had a crucial role in the prediction of loss in occupational status, but accuracy of prediction was enhanced by including the measures of the Neuropsychological Functioning, the Emotional Distress, the Flexibility factors, and the Trauma Severity rating.

CHAPTER IV

DISCUSSION

Long-range prognosis of psychosocial outcome following THI has become a major concern in health care and litigation for two major reasons. First, accurate prediction of THI victims' future potential both in terms of independent living and work capacity would allow implementation of more specific and more focused rehabilitation or retraining programs relatively early in the chronic recovery phase (i.e. 12 to 18 months post-trauma).

Another potential advantage of early prognostic indicators of the likely impact on future daily efficiency would be the possible acceleration of legal or other compensatory proceedings. In many cases, these have to be extended over several years due to the imposed 'wait-and-see' period during which the THI victim's recovery can be observed. While often necessary to ensure a fair settlement, the costs of such delays are high both with respect to psychosocial and financial aspects.

The present study was undertaken in order to document the long-term consequences of head injury on the basis of a relatively large and homogeneous sample of THI victims, and to evaluate the prognostic utility of various factors that are assumed to determine outcome, including the predictive validity of comprehensive neuropsychological test data as measured through composite scores (factor scores) of neuropsychological functioning.

In contrast to other outcome studies, investigation of the recovery process followed a 'multi-step' approach:

1. Information was gathered on the major factors which have traditionally been identified as largely determining the consequences of head injury. These included the nature of the injury, demographic characteristics of the victim, and the time elapsed since injury.
2. The neuropsychological consequences of THI were assessed between one and three years post-injury. This particular testing schedule was chosen in order to assure that the subjects in this sample could be considered as relatively stable with regard to their neuropsychological functioning, since most of the spontaneous recovery was expected to take place in the first 12 to 18 months. Evaluation procedures included measures of intelligence, academic achievement, memory and learning, global and specific deficits attributed to brain impairment, and changes or problems in personality organization.

Executive-control functions such as organization and planning, goal-directed activities, motivation, etc. were assumed to be measured implicitly through those subtests of the neuropsychological battery that required efficient and effective performance rather than on subtests which were based largely on previously acquired knowledge and verbal skill.

These test results were considered to delineate the subjects' level of intermediate-term neuropsychological functiong which, in turn, was then taken as an additional predictor of long-term psychosocial outcome.

3. Long-term psychosocial outcome was evaluated between six months and four years after the neuropsychological assessment; on the average, the follow-up data was gathered approximately three years post-injury. Psychosocial outcome criteria were measured in terms of three variables: employment status at the time of Follow-Up; loss in occupational status; and self-reported frequency of problems interfering with day-to-day efficiency.

Additional questions referred to the status of legal proceedings / compensatory settlements and any other changes attributed to the accident.

The study was designed as exploratory research and followed a descriptive approach. The aim was not to provide any definitive answers, but rather to close some of the gaps in our knowledge regarding the psychosocial consequences of head injury. For those reasons it was decided to study not only the subjects who had suffered severe THI, but also those with mild and moderate injuries. This was felt to be of particular importance due to a growing uneasiness among health professionals about the commonly-held assumption that victims of milder head injuries should recover almost completely with no serious lasting problems. With increasing frequency, professionals are confronted with clinical and statistical findings revealing 'inexplicable' and often puzzling discrepancies between the expected (good) and the actual (poor) psychosocial outcome in THI victims who otherwise appear to be fully recovered.

The following discussion will address and, hopefully, clarify some of these important issues.

Predictors Of The Intermediate-Term Neuropsychological Consequences Of Head Injury

The Relationship Between Biomedical Markers Of THI Severity And Neuropsychological Functioning (1 to 3 years post-injury).

Neither the trauma severity measure nor the indicator of medical complications used in this study showed any significant association with intermediate-term neuropsychological deficit measures, although such a relationship has been often suggested and has led to the working assumption that such biomedical measures are valid and reliable prognostic indicators of the eventual level of neuropsychological functioning.

While it cannot be disputed that the expected severity of neuropsychological deficits is broadly related to the severity of the injury, wide individual variations can be found and previous research provides little support for the prognostic accuracy of 'trauma data'. Brooks (1984), for example, states clearly:

...whereas a patient with a PTA [post-traumatic amnesia] of more than 4 weeks is almost certain to have a persisting severe learning and memory defect, there is no guarantee that a patient with a PTA of a matter of days will *not* have cognitive defects. Each case has to be evaluated on its own merit. (p. 69)

This apparent incongruency between the traditional assumption that biomedical markers of trauma severity are significant determinants of the cognitive-intellectual consequences following THI, and more recent research findings that do not confirm the validity of such a claim, may be the result of the methodological weaknesses inherent to many studies and a hasty overgeneralization of existing research that is based on short-term findings, to long-term outcome. Most studies that focus on cognitive recovery have shown that during the acute stage of recovery (i.e. first few months after injury) the impact of severe THI on cognitive functions will be much more dramatic than the impact of milder injuries. In terms of long-term prediction, however, it has been found repeatedly that considerable recovery of neuropsychological functions takes place and that for example, recovery of intelligence to within the average range is common for most THI victims irrespective of trauma severity (see Levin et al., 1982).

In terms of emotional-personality aspects of neuropsychological functions, the present study found no clear relationship between the Trauma Severity rating and the Emotional Distress factor(3) or the Alienation factor(6). Interestingly, however, there was a significant correlation between the Trauma Severity rating and the Impulsiveness factor(5) (r = .27, p = .01) and the Flexibility factor(8) (r = -.20, p = .05). A significant negative relationship was also found between the indicator of medical complications resulting from the injury and the Flexibility factor(8) (r = -.25, p = .05). These findings suggest that the more severely ill THI victims are more likely to experience serious and persisting problems with motivational and organizational aspects of functioning. These aspects may be considered as important parts of the "executive-control" functions discussed by Lezak. If it can be confirmed that impaired executive-control functions such as increased impulsivity and decreased flexibility will indeed undermine a person's psychosocial adjustment, it would follow that serious medical complications at the time of injury enhance the negative behavioral consequences of head injury and therefore have to be taken into consideration when estimating future level of psychosocial adjustment.

In summary, it can be concluded that there is only a weak link between the Trauma Severity rating (based on coma duration and length of PTA) and intermediate-term neuropsychological functioning (1 to 3 years post-injury). Evidently, the prognostic accuracy of medical information about acute neurologic deficits with regard to eventual cognitive and emotional impairment is poor, whereas these biomedical measures do provide somewhat better prognostic indicators of an individual's future problems with impulsivity and flexibility, both of which are assumed to represent executive-control functions.

Overall, these findings are consistent with other recent studies (e.g. Brooks & McKinlay, 1983; Gummow, Miller, & Dustman, 1983; Tabaddor, Mattis, & Zazula, 1984). In practical terms, they should be used to strengthen the argument that the predictive power of 'trauma data' alone does not provide a sound basis for outcome prediction. The significant, albeit somewhat tenuous association between the Trauma Severity rating and executive-control functions is of much greater interest, particularly with regard to the conceptual and practical implications. It can be speculated that executive-control functions may indeed be one of the keys to improved long-term outcome prediction. While for the majority of the subjects the glaring deficits in cognitive as well as in emotional functioning tend to diminish over time and test results can be expected to show a regression to the mean, problems due to impaired executive-control functions appear to be both more persistent and more closely related to trauma severity. If it can now be shown that impaired executive-control functions will indeed affect day-to-day functioning, it may become possible to identify those individuals who are at highest risk with regard to problematic psychosocial adjustment.

The Relationship Between Demographic Characteristics Of THI Victims And Intermediate-Term Neuropsychological Functioning (1 to 3 years post-injury).

Examination of the association between an individual's age, occupational status prior to injury, time since injury and neuropsychological factor scores, revealed that cognitive, emotional and control characteristics were influenced by a person's age, but only marginally by the other two variables. Specifically, age was found to correlate significantly with the Neuropsychological Functioning factor(1) (r = -.47, p = .01), the Verbal Skills factor(2) (r = .32, p = .01), the Impulsiveness factor(5) (r = -.37, p = .01), and the Learning factor(7) (r = .25, p = .05).

These findings are consistent with previous research suggesting that older THI victims show more pronounced neuropsychological deficits and recover more slowly than younger people. Whereas older subjects were found to retain much of their previous level of skill and knowledge as shown by the relatively strong positive correlation between age and the Verbal Skills Factor, they showed impaired performance on tests that require goal formulation abilities, organizing and planning, as well as the cognitive-behavioral aspects of effective performance. This particular performance pattern suggests that older patients may be more deficient in their executive-control functions and thus suffer more from the negative consequences of head injury. In terms of the implications of these findings, it has to be kept in mind, however, that the majority of the subjects (N = 86) were less than 40 years old and that only 13 of the subjects were older than 50.

A significant negative correlation was found between Time Since Injury and the Impulsiveness factor(5) ($r = -.30$, $p = .01$). This negative correlation appears to indicate that impulsiveness becomes less prominent as time goes on, and that most THI victims will regain somewhat better executive-control and improve in their performance effectiveness over the years. At worst, this finding could be interpreted as a sign of resignation and increasing apathy, where any spontaneous effort, however poorly planned, becomes pointless. The meaning of this negative association should be examined more closely and most importantly, in the context of overall neuropsychological test performance.

Prior Occupational Status was also significantly correlated with post-injury Impulsiveness ($r = .28$, $p = .01$). Why a person's occupational status prior to injury should be associated with the degree of later impulsiveness is difficult to interpret, particularly since the correlation is positive, showing that the better the vocational training or education the more pronounced the problems with impulsiveness. It could possibly be argued that these people are more aware of their neuropsychological problems and more self-conscious about their slowness and confusion, and thus tend to overcompensate with speedy and poorly planned actions.

In conclusion, it can be said that some background characteristics of THI victims (in particular age), appear to have some association with the neuropsychological consequences of head injury. While one can speculate with regard to the meaning of these relationships, at this point their usefulness as prognostic indicators of long-term neuropsychological functioning remains controversial.

Predictors Of The Long-Term Psychosocial Consequences Of Head Injury

The Usefulness Of Intermediate-Term Neuropsychological Data As Prognostic Indicators

The results of this study provide further evidence for the prognostic validity of neuropsychological test measures in the prediction of the long-term psychosocial consequences of THI. All three aspects of neuropsychological functioning, namely level of cognitive impairment, emotional disturbance, and executive-control functions, were shown to correlate not only with present occupational status, but also with loss in occupational capacity and daily life efficiency in general. Predictive power was further increased by including THI biomedical data and premorbid characteristics of the victim as additional measures. Several major conclusions can be drawn from these results:

1. Predicitng THI victims' potential work capacity, future work status, and quality of psychosocial adjustment is most accurate if it is done on the basis of a comprehensive assessment which includes medical, historical, and neuropsychological information in order to optimize prognostic accuracy.
2. The contribution of individual predictors varies with different outcome criteria and they have to be weighted accordingly.
3. Generally, neuropsychological test data were more sensitive to subjects' present levels of functioning in their daily lives than medical or historical information.
4. Executive-control functions as measured in this study were identified as additional contributors to predictive accuracy.

The Usefulness Of Executive-Control Functions As Prognostic Indicators

As discussed in previous sections, quantification of executive-control functions on the basis of conventional neuropsychological assessment data has always posed a major problem in the outcome prediction of the psychosocial consequences of THI. Whereas traditional methods of interpreting neuropsychological test results have relied on measures of deficit and overall level of cognitive-intellectual performance, we have assumed that executive-control functions would provide measures of the overall process of performance, i.e. *how* the subjects were performing during the evaluation procedures.

Transformation of the 42 neuropsychological test scores into a much smaller set of eight factors allowed us to study the relationships between the test measures, and to differentiate between factors that provided probable measures of executive-control functions, global measures of neuropsychological impairment, and specific measures of cognitive-intellectual deficits and personality problems.

The data confirmed the usefulness of the construct of executive-control functions in the prediction of psychosocial outcome, in that measures of these helped to identify subtle problems with performance effectiveness that are often overlooked in conventional approaches to neuropsychological evaluation. In the following section, the nature of these factors and their roles as prognostic indicators will be discussed in more detail.

The Most Powerful Prognostic Indicators: Patterns Indicative Of Higher Psychosocial Risk

The following are the three different best 'sets' of prognostic indicators which were established for the three outcome indices.

'Return to Work' was best predicted by the level of Neuropsychological Functioning, a factor which was comprised primarily of those mental ability test measures which are known to be most sensitive to brain damage. These included the Block Design and Picture Arrangement subtests of the WAIS-R, the HRB

Keytest Index, and a number of subtests of the HRB (Gilandas et al., 1984; Lezak, 1983; Russell et al., 1970). Predictive accuracy could be doubled by including measures of emotional distress (Factor 3) and measures of impulsivity we have described as executive-control functions (Factor 5). To a lesser degree, the prediction could be further improved by including subjects' occupational status prior to the injury and their Physical Disability ratings. Intuitively, these findings follow 'common sense'. It comes as no surprise that measures of cognitive impairment, emotional difficulties and distress, and impaired performance effectiveness together with the pertinent information regarding a person's vocational history and present physical disabilities would provide a sound basis for predicting future work status.

While level of neuropsychological functioning has been consistently implicated as a significant correlate of current occupational status, only a few other studies have examined the role of neuropsychological tests in the prediction of *future* work capacity. Obviously, this is a much more difficult and challenging task, since a variety of other factors related to the subjects' particular life situation and the socio-economic conditions in general may influence future employment to an equal or more crucial degree than subjects' personal strengths and limitations. Hence, it would be unrealistic to expect a 'foolproof' prediction formula. Within these given restraints, the predictive usefulness of the neuropsychological data established in this study is quite respectable.

When comparing these results with the only other comparable study, namely the one undertaken by Newnan and his colleagues in 1978, the overall findings are relatively consistent despite considerable differences in conceptual approach and methodology. Interestingly, their results revealed generally higher correlations between test measures and work status, suggesting a stronger association between the two. Some of the differences in findings are of interest. Newnan et al. found that only 32% of their sample of 78 brain-impaired subjects were unemployed at the time of Follow-Up (which occured 6 months or more after testing for 81% of their subjects), while the results of the present study indicate an overall unemployment rate of 54%. Two possible explanations can be offered for these considerable discrepancies. First, the findings of Newnan et al. were based on a heterogeneous sample of brain-impaired patients, including brain disorders that may be more localized in their effects than traumatic injuries. Generally such disorders result in specific and less pervasive patterns of impairment in neuropsychological functioning. Frequently, the resulting deficits can be coped with more easily, be it with the help of focused compensatory strategies or avoiding those situations where the impaired abiltity is needed for successful task completion. Thus it is likely that they will less interfere with vocational potential.

Also, severity of neuropsychological deficit as measured by the HRB-II was less serious in their subjects, and the subjects were generally older and better educated than in the present study. Unfortunately, no indication was made as to the time course of brain impairment or subjects' occupational status at the time of neurological diagnosis or testing. Thus, the above-mentioned discrepancy in findings may well be due to other differences in sample characteristics.

Other important sources of variation that have to be considered when comparing the two studies, are the time factor and the drastically changed socio-economic conditions since the mid-seventies. While at that time the basic population unemployment rate was quite low in the United States, the recent recession and the resulting high unemployment rate in this province has made it increasingly more difficult for the mentally or physically disadvantaged to obtain competitive employment.

In most previous outcome studies, the unemployment resulting from severe THI is estimated between 30% to 50%, while mild to moderate THI is expected to lead to a much lower unemployment rate. The present survey of a relatively large sample, however, reveals a much higher rate irrespective of trauma severity. Specifically, 63% of the severely, 47% of the moderately, and 52% of the mildly head-injured subjects were either unable to work or were looking for work. Again, this difference may be due to a variety of factors, including the changing local socio-economic conditions and the increasing number of survivors of THI. On the basis of our present knowledge we can only speculate why these unemployment rates are as high as they are, nonetheless, the practical implications are crucial: irrespective of trauma severity, THI victims are at high risk for chronic unemployment and the psychosocial problems associated with it. In an attempt to identify those who are at highest risk, predictive accuracy can be improved by taking all three aspects of effective personal functioning (cognitive-intellectual, personality, and executive-control functions) into consideration and weighting them accordingly.

'Loss in Occupational Status' was highly correlated with subjects' occupational status prior to injury. This is not an unexpected finding and can be explained as the result of a flow effect originating from the way in which the variable was calculated, i.e. individuals with lower status jobs were given lower pre-trauma ratings than those with higher status occupations and thus could not lose as much as individuals with high pre-trauma ratings. However, this finding also suggests that in terms of the relative loss in occupational status there are no differences across the various job categories.

Additional inclusion of variables reflecting level of neuropsychological functioning, emotional distress, problems with flexibility, and trauma severity in the regression equation led to considerable improvement of the prediction accuracy (from 16% to 36% of the variance explained). What is noteworthy is that the combined information on specific aspects of neuropsychological functioning based on the Neuropsychological

Functioning, Emotional Distress, and the Flexibility factors along with some marginal contribution from Trauma Severity will double the predictive accuracy. This provides further support for the prognostic usefulness of neuropsychological data in identifying those individuals who are at higher risk with regard to their post-trauma vocational adjustment.

Potentially, these findings could provide an effective basis for vocational counselling following recovery from THI. As previously discussed, a comparison of pre- and post-injury employment patterns revealed that few subjects were willing to accept a 'downgraded' position (below their previous level of employment), but preferred to keep looking for a position that was the same or very similar to their pre-injury job, even when this meant continued unemployment. For more effective vocational rehabilitation and counselling, it may thus be necessary to educate THI victims to a realistic appreciation of their personal limitations (with the assistance, for example, of neuropsychological test data), help them to assess their abilities more realistically, and establish clear goals with regard to vocational potential and interests, as well as to outline and facilitate opportunities for vocational retraining and rehabilitation.

'Severity of Daily Problems' was best predicted by the level of emotional distress reported at the time of assessment (Emotional Distress factor(3)). Clearly, this was the single most important factor in the prediction equation which could only be slightly improved be including the Alienation factor(6), the Flexibility factor(8) and the Trauma Severity rating. A closer examination of the relationship between these predictor variables and the outcome criterion reveals that Trauma Severity, Alienation, and Flexibility are all inversely related to self-reported severity of daily problems. This suggests that victims with milder injuries tend to be more upset and distraught emotionally and are much more aware or concerned about their difficulties with day to day functioning. This self-reported ineptness and inability or inadequacy to cope with 'simple' problems in daily life, along with an extraverted interest in rejoining normal life and decreased flexibility can more easily explain why so many mildly injured victims fail to resume work and return to their previous level of functioning despite reasonably good cognitive-intellectual recovery. Indeed, a strong positive correlation was shown between a person's reported severity of daily problems and loss in occupational status ($r = .40$), suggesting an interdependency of the two outcome criteria. It is likely that high levels of emotional distress will enhance feelings of inadequacy, confusion, and distractability and contribute to impaired performance effectiveness, thus contributing a further stumbling block in successful psychosocial recovery as pointed out repeatedly by Lezak (1978, 1983), Fordyce et al. (1983), and Novack et al. (1984).

The present findings show good consistency with several other recent studies. For example, they provide support for Rimel et al.'s (1981) conclusions that the psychological response to, and the emotional stress resulting from mild head injury have a significant role in predicting long-term disability. They also confirm findings of previous studies that identified enduring negative changes in self-esteem and sensitivity, social withdrawal and irritability, and persisting negative behavioral changes as major contributors to poor psychosocial and vocational adjustment (as discussed in the previous literature review).

In terms of practical implications, these results should be interpreted as additional support for the clinical utility of comprehensive neuropsychological assessment in the prediction of psychosocial outcome. They imply that the concerns and emotional distress symptoms of patients have to be taken seriously in treatment planning in order to reduce emotional suffering and prevent or mitigate the impact of negative behavioral changes on overall psychosocial adjustment.

Summary And Conclusions

The Theoretical Implications Of The Present Findings

While still at the exploratory stage, the findings suggest that Lezak's model of neuropsychological functioning may indeed provide a good framework for further research. In subjecting neuropsychological test data to factor analytic procedures, eight factors could be established that allowed fairly clear distinction of the postulated three aspects of neuropsychological functioning.

As outlined in a previous section, the Verbal Skills and the Learning factors, and to some (presently undetermined) degree the Concentration and Neuropsychological Functioning factors all appeared to capture important aspects of cognitive-intellectual functions. More specifically, the Verbal Skills factor is postulated to represent the acquired 'skill' or 'knowledge' aspect of intelligence as discussed by Hebb (1942) and others. The Learning and Concentration factors were interpreted as measures of those aspects in cognitive-intellectual functioning that provide information about memory and learning abilities, including basic aspects of attention and concentration, as well as an individual's ability to learn and remember new information. Finally, the Neuropsychological Functioning factor is comprised of those measures that have been found particularly sensitive to brain impairment and the resulting deficits in intellectual functioning.

The Emotional Distress and the Alienation factors were interpreted as measures of emotionality and personality organization; they provided information about the levels of emotional distress individuals were experiencing as well as their reactions and coping styles in dealing with their particular life circumstances.

The Impulsiveness and the Flexibility factor, and to some (presently undetermined) degree the Neuropsychological Functioning factor were thought to comprise those aspects of test measures and response style that Lezak has referred to as executive-control functions. They are taken as indicators of impaired capacity for self-control or direction, including poor planning and organization, defective mental flexibilty and problem solving skills, and problems with initiative, motivation, and regulation of behavior. These measures are believed to be important determinants of performance effectiveness.

These findings lead to some interesting speculations concerning the theoretical implications with regard to the role of executive-control functions and their relationship to both the cognitive-intellectual and the emotionality-personality subsystems, as well as to daily efficiency. As previously discussed, a possible explanation for the apparent overlap between the three subsystems is that executive-control functions will indeed affect all directed mental activities and thus have a considerable impact on daily efficiency. In such a model, executive-control functions could be postulated as the mediators between the other two subsystems, i.e. emotionality and personality factors are not directly, but indirectly related with cognitive-intellectual functioning. This would mean, for example, that increased level of depression and loss in self-esteem would affect cognitive functioning only to the degree that they undermine executive-control functions, and *vice versa*. Given this role of executive-control functions, it could be explained more easily why some severely brain-impaired individuals show relatively few problems with emotional distress or psychosocial adjustment, while some less impaired THI victims are experiencing considerable problems both emotionally and functionally. In order to test this model it will be necessary to measure executive-control functions directly and examine their relationship with standard cognitive-intellectual and personality measures.

Most interestingly, the factors that were interpreted as probable measures of executive-control functions have indeed been found to play an important role in psychosocial outcome prediction. Although the findings need to be replicated, the results of the present study provide some initial support for the usefulness of the 'executive-control function' construct and warrant more explicit attention to this aspect of neuropsychological functioning.

It is of particular interest to note that neither age, abilities relating to knowledge and skills, nor the time since injury could be identified as important predictors of employment-related outcome. These factors have been often implied to determine outcome to a significant degree, but this could not be confirmed in the present study. It also is surprising to find that in comparison to other aspects, learning ability *per se* was of relatively poor predictive value. However, these particular findings may have to be interpreted in light of subjects' apparent reluctance to retrain or look for another job than the one for which they were originally qualified. In that sense the findings are consistent, since job applicants are more likely to be selected on the basis of their past work experience, performance effectiveness, and degree of physical disability rather than general knowledge or learning ability.

With regard to impaired day-to-day functioning, it is most striking to observe that neither level of cognitive-intellectual impairment, deficiences in executive-control functions nor demographic characteristics could be established as significant prognostic signs. The findings instead suggest that irrespective of the latter aspects, self-reported daily life problems are most strongly a function of the victim's emotional reaction to the injury and his or her general personality organization. Given this, self-reported level of daily efficiency may be extremely prone to subjective distortion. The results suggest that this distortion may go in both directions, with extreme overreaction, considerable loss of confidence and self-esteem as one pole, and carefree optimism, denial of any problems and unrealistic expectations at the other end. The consequences of such distorted self-perceptions are of particular importance, since the results of this study also reveal a pattern between trauma severity and emotional distress that suggests a tendency of the less severely injured to overreact and 'catastrophize' their situation, while denial and unrealistic optimism appears to be more characteristic of the severely injured. In view of the previous discussion about the role of executive-control functions, this finding would suggest that emotional distress can indeed result in impaired performance effectiveness which undermines daily efficiency. Unfortunately, these specific difficulties with executive-control functions could not be extracted from the neuropsychological data base used in this study, possibly because of the tightly structured test situation. This would support Lezak's claim that executive-control functions have to be measured on the basis of the subject's performance during less structured situations.

The Practical Implications Of Present Findings For Health Professionals

There has been a decided reluctance among health professionals, (and particularly within the medical community) to consider other than the traditional, medically-oriented prognostic indicators when predicting the expected course of recovery following THI, despite an increasing awareness of their poor predictive validity concerning such crucial outcome criteria as work potential and day to day efficiency. However, enough data has now been accumulated to challenge the conventional wisdom. As a consequence, there is a definite need for new approaches to outcome prediction which can make use of scientifically-derived measures that are clinically useful and show established predictive validity.

The steadily growing body of empirical evidence, including the results of the present study provides strong support for the validity of neuropsychological measures in predicting the long-term psychosocial consequences of head injury. Test performance has been found to relate to work-related criteria as well as functional efficiency in daily life. Moreover, the results of this study confirm the need for comprehensive assessment procedures and suggest that neuropsychological evaluation should include measures of cognitive-intellectual functioning, personality organization, and executive-control functions in order to optimize predictive validity. Strong arguments for thorough neuropsychological evaluations have been made already more than five years ago (e.g. Newcombe & Ratcliffe, 1979; Long & Gouvier, 1980), but tended to be overlooked or ignored by many members of the professional community. Broad-range appraisal of neuropsychological functioning is both time consuming and costly, and the interpretation of test scores can become very complex and demanding, however the long-term benefits of improved predictive accuracy certainly outweigh those concerns.

Another important advantage of comprehensive assessment methods is their clinical utility in identifying those THI victims who are at high psychosocial risk. Close examination of the test patterns will help the examiner to decide which patients are more vulnerable with regard to their future work capacity or their functional efficiency in daily life. This will allow for better rehabilitation planning as well as the development and implementation of specific intervention strategies.

Generalizability Of The Findings And Implications For Further Research

As with most research, the present study can be criticized on the basis of methodological problems and drawbacks. While one of the aims was to collect comprehensive information on all those aspects that have been discussed in the literature as relevant prognostic signs of the expected course of recovery, this has led to the collection of an extremely large and unwieldy set of data with a resulting imbalance between sample size and number of variables. This, in turn, led to the use of statistical procedures to condense the data and reduce the number of predictor variables to a size that allowed further statistical analysis and facilitated interpretation of the results.

There may be the objection that such data reduction procedures have led to a 'washing out' of individual variations and removed test score interpretation from the concrete to the realm of statistical abstraction. This can be countered with the argument that, unfortunately, there is no ideal solution to this dilemma. Another approach which could have been used to deal with this particular imbalance between number of independent variables and sample size would have been to 'pre-select' those variables that were identified as the most promising, either on the basis of theoretical or empirical considerations or on the basis of their strength of association with the dependent variables. In my judgment that pre-selection is likely to result in a considerably greater loss of valuable information. Moreover, it can easily lead to an oversight of important patterns that in themselves may be better prognostic indicators than single variables. For those reasons, the factor-analytic approach presented itself as the method-of-choice. Examination of the underlying factor structure made it possible to study the relationships among the test measures and to interpret the empirical findings within the framework of the proposed model of neuropsychological functioning and provide support for the executive-control functions construct.

At this point, the findings are only tentative and have to be considered as a first step in the validation of the model and the executive-control functions construct. However the results of this study are encouraging enough to warrant further research. For both theoretical and practical reasons, what has to follow next is the testing of direct, explicit measures of executive control functions in order to examine their value independently of or in addition to standard neuropsychological measures.

Another of the perennial problems in clinical neuropsychology has always been the relatively small samples on which the findings had to be based. Although the number of surviving THI victims is steadily increasing, the basic population incidence rate is still fairly small. For the same reason, THI samples will almost always include people of all walks-of-life, with considerable differences concerning their trauma history, time since injury, and their backgrounds, introducing many additional sources of error. Although the present study is based on a fairly large and reasonably homogeneous sample, the generalizabiltiy of the findings will still be hampered by these problems. Again, it can be argued that this is an unavoidable dilemma inherent to the area and it should not preclude further research. On the contrary, consistent research findings over several different studies can be interpreted as even better support for the results, since their impact can be measured irrespective of many of these individual background characteristics. If such a pattern can be established, this will lead to an increase in the degree of confidence with which the findings can be generalized to the THI population in general.

One of the major difficulties with many studies has been the considerable variability in the selection of assessment tools, large variations in the schedules of testing, operational definitions of trauma severity that varied from study to study, and the different choices in outcome criteria. These differences in design have made it difficult to compare the studies with each other, to find common patterns, and to bring the findings onto a common denominator.

The design of the present study was aimed at overcoming some of these problems and hence, ensuring good generalizability of the findings. For instance, assessment tools were chosen according to their breadth in scope and their widespread use in clinical settings as well as their established psychometric properties. The testing schedule was selected such that all subjects were evaluated at a time when they could be considered neurologically and neuropsychologically stable, (i.e. after most spontaneous recovery had taken place, for most subjects 12 to 24 months post-injury). The operational definition of trauma severity was based on recent medical guidelines that provided a relatively clear and quantifiable 'composite measure' concerning both duration of coma and PTA. Contrary to many of the other outcome studies, subjects were not pre-selected according to trauma severity. It was hoped that the inclusion of subjects with varying degrees of trauma severity would help to overcome the previously discussed restriction of range problem. And finally, outcome criteria were selected according to their relevance to psychosocial outcome and their objectivity. Both the two work-related outcome criteria were reasonably straightforward and objective; even the most unreliable THI victims were able to understand and answer the question 'Are you working right now? ' and able to indicate the nature of the work that they were doing. The 'Problems of Daily Life' questionnaire was deliberately developed as a self-report instrument as it was felt to be important to get subjects' own perception of their daily life efficiency, however distorted or biased.

The results of this study are considered to describe the intermediate-term neuropsychological consequences of THI (with the exception of very severe head injuries) and their effect on long-term psychosocial adjustment. Therefore they can be generalized to those THI victims who are at least one year post-injury.

There is an obvious need to replicate the findings in this study, particularly in view of their direct relevance to clinical and forensic psychologists and other health professionals. With each additional study extending and refining the present findings, the predictive validity of neuropsychological test measures as prognostic indicators of psychosocial outcome following THI can be further consolidated and used as a sound basis for rehabilitation planning and counselling as well as for evaluation of disability compensation.

Further research is also needed to examine to role of executive-control functions more closely and determine their usefulness in clinical neuropsychology. Specifically, it is suggested that a set of tests consisting of direct measures of executive-control functions be added to the standard neuropsychological battery. This could comprise the measures suggested and outlined by Lezak (1982, 1983) such as the Rey's Complex Figure Test (Rey, 1941), tests of verbal fluency, free writing or drawing, and the Tinkertoy Construction Test (Lezak, 1983). Another test that also suggests itself as an alternative measure of executive-control functions is the Rorschach Inkblot test (Rorschach, 1921). In scoring the formal aspects of the basic Rorschach task according to Exner's (1978) Comprehensive System, it should be possible to obtain a measure of an individual's ability to structure and organize an ambiguous stimulus and thus obtain information about his or her performance effectiveness.

APPENDIX ~~A~~

Trauma Severity Rating: Operational Definition

RATING		
1	mild	no loss of consciousness duration of post-traumatic amnesia <= 1 hrs
2	moderate	brief loss of consciousness (<= 24 hrs) duration of post-traumatic amnesia <= 24 hrs
3	severe	prolonged loss of consciousness (> 24 hrs) duration of post-traumatic amnesia > 24 hrs)

Physical Disability Rating: Operational Definition

RATING		
1	none	able to do all tests - no problems
2	minor	minor slowing - stiffness in hand/s
3	some	decreased motor speed or dexterity due to physical injuries to extremities
4	moderate	unable to do a number of tests due to physical injuries to extremities
5	severe	incomplete test data due to physical disability

APPENDIX B

Occupational Status Rating: Operational Definition

RATING	
10	unable to work or go to school for reasons of health - not actively seeking employment
20	works in sheltered workshop
30	volunteer work - unpaid or token pay
40	unemployed - actively looking for work
50	homemaker or part-time work
60	unskilled or manual work - full time e.g. service worker, operatives, laborer
70	semi-skilled work - full time e.g. clerical, sales
80	skilled or senior clerical work - full time e.g. technician, executive secretary, manager, proprietor
90	professional or post-secondary student - full time e.g. teacher, lawyer, engineer

Daily Life Efficiency

DAILY LIFE ACTVITIES

RATING

NEVER A PROBLEM	ONLY RARELY A PROBLEM	SOMETIMES A PROBLEM	FREQUENTLY A PROBLEM	ALMOST ALWAYS A PROBLEM
1	2	3	4	5

4. DO YOU HAVE PROBLEMS WITH (please use above scale for rating)

- looking after yourself (e.g. dressing, grooming)? ____
- doing basic household chores (e.g. cooking, doing dishes, mowing the lawn)? ____
- starting doing things? (e.g. taking initiative, "getting your act together", making decisions, start activity) ____
- getting lost or confused within a familiar environment? ____
- getting lost or confused within an unfamiliar environment? ____
- your memory in everyday routines (remembering or forgetting things)? ____
- coping with practical situations outside the home? (e.g. using public transportation, driving, asking for directions, using public telephone) ____
- getting along with your family or close friends? ____
- getting along with people you don't know well? (e.g. neighbors, work colleagues) ____
- figuring out, planning and organizing regular routines of daily life? (e.g. grocery shopping, house cleaning, repair projects, keeping track of finances) ____
- figuring out, planning and organizing your activities when new activities are introduced or new instructions given? (e.g. voting in an election, arranging a new mortgage, moving to new accomodations) ____
- moodiness, control of temper? ____
- headaches? ____
- feelings of inadequacy? ____
- feeling close to others? ____

APPENDIX C

Daily Life Activities Questionnaire

We would like you to take a few minutes to complete the following questionnaire. Some time ago you completed a battery of vocational and psychological tests. These tests were used to make predictions as to your vocational future. We would like you to be part of a research project designed to see how useful these tests were in predicting your vocational future. This project is part of a Ph.D. thesis for a Simon Fraser University student in the Department of Psychology (Ursula Wild). The study has been approved by the SFU Ethics Review Committee. Your responses will be private and confidential as your name is not put on the questionnaires.
If you would like to find out the research results please send this page back separately from the returned questionnaire and we will ensure that you will obtain a copy of the results, which should be available in the fall of 1985.

Thank you for your cooperation in helping us with this project.

Ursula Wild, M.A., Ph.D. student

Allan Posthuma, Ph.D.

Marilyn Bowman, Ph.D.

-------------------------- TEAR OFF --------------------------

I wish to participate in the study described above. Please send me a copy of the results :

Name: ______________________________

Street: ______________________________

City: ______________________________

Postal code: ______________________________

(mail this in one of the return envelopes that have been enclosed)

WORK - OCCUPATIONAL STATUS

The first few questions are about your present employment situation.

1. PRESENTLY, ARE YOU (please check off the one that applies to you)

- unable to perform any occupational task or go to school [ ]
- employed within a sheltered workshop environment [ ]
- doing unpaid work, or paid only very little [ ]
- working part-time, with limited responsibilities [ ]
- working part-time, with full responsibilities [ ]
- working full-time, unskilled or manual work [ ]
- working full-time, clerical, sales, or semi-skilled [ ]
- working full-time, senior clerical or skilled [ ]
- working full-time, professional [ ]
- studying part-time toward degree / diploma [ ]
- studying full-time toward degree / diploma [ ]
- homemaker / housekeeper [ ]
- currently unemployed, looking for a job as (please indicate) ______________________ [ ]

2. IN TOTAL, FOR HOW LONG HAVE YOU BEEN WITHOUT WORK IN THE PAST 2 YEARS?

[ ] 1 to 3 months
[ ] 4 to 6 months
[ ] 7 to 12 months
[ ] more than 12 months
[ ] no work in the past 2 years
[ ] not applicable

3. COMPARED TO 2 YEARS AGO, HAS YOUR INCOME

[ ] considerably decreased
[ ] slightly decreased
[ ] remained the same
[ ] slightly increased
[ ] considerably increased
[ ] not applicable

DAILY LIFE ACTVITIES

RATING

NEVER A PROBLEM	ONLY RARELY A PROBLEM	SOMETIMES A PROBLEM	FREQUENTLY A PROBLEM	ALMOST ALWAYS A PROBLEM
1	2	3	4	5

4. DO YOU HAVE PROBLEMS WITH (please use above scale for rating)

- looking after yourself (e.g. dressing, grooming)? _____
- doing basic household chores (e.g. cooking, doing dishes, moving the lawn)? _____
- starting doing things? (e.g. taking initiative, "getting your act together", making decisions, start activity) _____
- getting lost or confused within a familiar environment? _____
- getting lost or confused within an unfamiliar environment? _____
- your memory in everyday routines (remembering or forgetting things)? _____
- coping with practical situations outside the home? (e.g. using public transportation, driving, asking for directions, using public telephone) _____
- getting along with your family or close friends? _____
- getting along with people you don't know well? (e.g. neighbors, work colleagues) _____
- figuring out, planning and organizing regular routines of daily life? (e.g. grocery shopping, house cleaning, repair projects, keeping track of finances) _____
- figuring out, planning and organizing your activities when new activities are introduced or new instructions given? (e.g. voting in an election, arranging a new mortgage, moving to new accomodations) _____
- moodiness, control of temper? _____
- headaches? _____
- feelings of inadequacy? _____
- feeling close to others? _____

--- IF THE NEXT SECTION DOES NOT APPLY TO YOU STOP HERE ----

PERCEIVED CHANGE SINCE THE ACCIDENT

If you have experienced a head injury in the past, please indicate in what way this has affected your life. (If the change is a positive one for you, please circle the "+" beside your rating.)

RATING

NO CHANGE AT ALL	JUST A VERY LITTLE CHANGE	SOME, BUT NOT MUCH CHANGE	CONSIDERABLE CHANGE	VERY, VERY MUCH CHANGE
1	2	3	4	5

5. THE ACCIDENT HAS AFFECTED MY:

	RATING	circle if change positive
- independence and efficiency in everyday life activities	_____	+
- physical agility and manual skills	_____	+
- attention and concentration	_____	+
- persistence and patience	_____	+
- memory	_____	+
- work ability and habits	_____	+
- thinking (logic)	_____	+
- learning new things	_____	+
- confidence, self-esteem, morale	_____	+
- personal and social relations	_____	+

6. SINCE THE ACCIDENT, HAVE THERE BEEN ANY CHANGES IN YOUR OCCUPATIONAL STATUS OR ACADEMIC PERFORMANCE?

[ ] occupational upgrading - better grades
[ ] no change
[ ] some occupational downgrading - somewhat lower grades
[ ] considerable occupational downgrading - considerably lower grades
[ ] unable to perform any occupational task - unable to go to school

7. IF YOUR ACCIDENT INVOLVED A LAWSUIT, HAS IT BEEN SETTLED?

[ ] yes - Date: ______________________
[ ] no

8. IF YOUR ANSWER TO 7. WAS 'YES', DID THE SETTLEMENT RESULT IN ANY CHANGES IN YOUR LIFE?

[ ] considerable change for the better
[ ] slight change for the better
[ ] no change
[ ] slight change for the worse
[ ] considerable change for the worse

9. IF YOUR LIFE HAS CHANGED SINCE THE ACCIDENT, PLEASE INDICATE HOW:

Please return the completed questionnaire at your earliest convenience, in one of the enclosed envelopes.

Your participation in this project is much appreciated.

APPENDIX D

Unrotated Factor Loadings And Eigenvalues

Variable	Factor 1	2	3	4	5	6	7	8
VIQ	.738	-.184	.567	.013	-.097	-.122	.151	.011
PIQ	.749	.138	-.249	.363	.056	-.121	.134	-.115
INFO	.541	-.161	.560	.060	.008	.085	.121	-.026
VOC	.625	-.281	.553	.064	-.022	-.061	.120	-.024
ARITH	.623	-.058	.320	-.098	-.058	-.345	-.148	-.001
COMP	.591	-.151	.493	.231	.153	-.108	.196	-.052
SIM	.598	-.125	.298	.281	-.125	-.047	.350	.008
PC	.559	.097	-.150	.284	.228	-.231	.269	-.138
PA	.569	.274	-.254	.360	.166	-.025	-.027	.013
BD	.558	.304	-.408	.214	.139	-.242	.030	.062
DSY	.590	.207	-.352	.023	-.100	.195	.075	-.177
DF	.495	-.091	.241	-.475	-.161	.123	-.223	.114
DB	.577	.118	.296	-.397	-.100	.035	-.157	.057
APHASIA	-.625	.001	-.107	.211	.062	-.068	-.009	.087
ARITSS	.554	-.006	.158	.162	.023	-.450	-.100	.011
MEM	.615	.310	-.272	.086	-.017	.103	.032	.028
VMEM	.372	.086	-.073	.145	-.089	.568	.171	-.109
NVMEM	.370	.115	.056	-.063	-.113	.284	-.050	.397
LEARNH3	.519	.220	-.013	-.153	-.134	.488	.278	.032
LOC	.518	.382	-.367	.083	-.027	.159	.085	.183
RHYTHM	.633	.034	.097	-.179	-.102	-.063	-.222	.288
TRAILAT	-.606	-.240	.172	.206	-.241	-.062	.303	.254
TRAILBT	-.706	-.282	.191	.158	-.070	-.062	.179	.169
CATEGORY	-.507	-.243	.164	-.201	-.026	.049	-.024	-.362
TPTTOT	-.400	-.158	.359	-.217	.197	.057	-.397	.006
SPEECHSC	-.657	.005	.027	.312	-.132	.040	.099	-.063
TAPDOM	.419	.150	-.168	-.177	.448	-.133	-.106	-.155
KEYTEST	-.711	-.302	.309	-.098	.083	-.036	.004	-.174
WMQ	.707	-.088	.269	-.184	-.221	.238	.107	-.133
L	-.263	-.331	.053	.474	.319	.161	-.014	.324
F	-.435	.618	-.053	-.192	-.002	-.083	.358	.109
K	.104	-.431	.234	.327	.487	.314	-.210	.085
HS	-.222	.585	.375	.337	-.060	.149	-.296	-.076
D	-.234	.648	.415	.314	-.130	-.050	-.253	-.013
HY	-.137	.420	.534	.385	-.044	.304	-.269	-.180
PD	-.118	.594	.354	-.051	.402	.055	.022	-.173
MF	-.038	.318	.297	-.131	.368	-.006	-.030	.582
PA	-.292	.628	.189	-.062	-.044	.009	.425	.013
PT	-.209	.808	.274	.007	-.042	-.063	-.053	-.108
SC	-.329	.847	.176	-.113	.124	-.036	.078	.055
MA	-.054	.341	.014	-.498	.470	-.107	.117	-.034
SI	-.174	.403	-.045	.108	-.664	-.325	-.043	.118
%VARIANCE	1.6	5.2	3.7	2.4	2.0	1.7	1.5	1.2

Correlations Between Predictor Variables And Outcome Criteria

	Return to Work (N=106)	Daily Problems (N=74)	Change in Work (N=106)
BIOMEDICAL MARKERS:			
TRAUMA	-.10	-.16	.21*
SURGERY	-.01	.12	.14
SUBEJCT CHARACTERISTICS:			
AGE	-.10	.06	.14
PREOCC	-.18	.12	.41**
YI	-.10	-.06	.04
PHYSDIS	-.19	-.10	.08
NEUROPSYCHOLOGICAL MEASURES:			
FACTORS:			
1	.31**	.01	.24*
2	-.15	.12	.00
3	-.23*	.51**	.21*
4	-.05	.05	.04
5	-.12	.05	.20*
6	.08	-.22*	-.08
7	.07	-.10	.07
8	.13	-.16	-.20*

* indicates p = .05
** indicates p <= .01

Means And Standard Deviations Of Predictor Variables And Summary Indices (Total Sample)

NEUROPSYCHOLOGICAL MEASURES:

FACTORS	MEAN	STANDARD DEVIATION
1	.08	.98
2	-.01	.99
3	-.01	.97
4	-.02	.98
5	-.03	1.00
6	-.01	.97
7	-.01	1.02
8	.01	.96

SUMMARY INDEXES:

WAIS-R FULL IQ	95.22	11.37
HRB IMPAIRMENT INDEX	.55	.26

Means And Standard Deviations Of Predictor Variables And Summary Indices (By Trauma Severity)

NEUROPSYCHOLOGICAL MEASURES:

FACTORS		MEAN	STANDARD DEVIATION
1	mild (N=23)	.02	1.03
	moderate (N=38)	.16	1.05
	severe (N=45)	.04	.92
2	mild	.44	1.06
	moderate	-.24	.91
	severe	-.03	.96
3	mild	.05	1.03
	moderate	.20	1.00
	severe	-.22	.88
4	mild	-.04	.74
	moderate	.08	1.07
	severe	-.10	1.02
5	mild	-.26	.94
	moderate	-.31	.86
	severe	.32	1.04
6	mild	-.15	.81
	moderate	.15	.81
	severe	-.07	1.20
7	mild	-.18	.89
	moderate	.05	1.23
	severe	.02	.89
8	mild	.20	.97
	moderate	.03	.83
	severe	-.10	1.06

SUMMARY INDEXES:

		MEAN	STANDARD DEVIATION
WAIS-R FULL IQ			
	mild	99.74	13.81
	moderate	93.84	10.42
	severe	94.09	10.41
HRB IMPAIRMENT INDEX			
	mild	.53	.26
	moderate	.53	.28
	severe	.57	.24

Means And Standard Deviations Of Predictor Variables And Summary Indices (By Occupational Status At FU)

NEUROPSYCHOLOGICAL MEASURES:

FACTORS		MEAN	STANDARD DEVIATION
1	employed	.42	1.00
	unemployed	-.19	.88
2	employed	.15	1.08
	unemployed	-.14	.89
3	employed	-.25	.97
	unemployed	.19	.93
4	employed	-.08	.81
	unemployed	.02	1.12
5	employed	-.16	1.02
	unemployed	.08	.98
6	employed	-.09	.91
	unemployed	.06	1.02
7	employed	.06	.93
	unemployed	-.07	1.10
8	employed	.15	.81
	unemployed	-.10	1.07

SUMMARY INDEXES:

WAIS-R FULL IQ			
	employed	98.73	11.66
	unemployed	92.36	10.37
HRB IMPAIRMENT INDEX			
	employed	.46	.26
	unemployed	.61	.24

Means And Standard Deviations Of Predictor Variables And Summary Indices (By Sex)

NEUROPSYCHOLOGICAL MEASURES:

FACTORS		MEAN	STANDARD DEVIATION
1	male (N=68)	.09	.86
	female (N=38)	.07	1.18
2	male	.15	1.06
	female	-.05	.85
3	male	.07	1.05
	female	-.16	.80
4	male	.05	.95
	female	-.17	1.03
5	male	.22	.94
	female	-.48	.96
6	male	.08	.99
	female	-.17	.92
7	male	-.20	.86
	female	-.33	1.19
8	male	-.23	.87
	female	.45	.98

SUMMARY INDEXES:

		MEAN	STANDARD DEVIATION
WAIS-R FULL IQ			
	male	94.26	11.50
	female	96.87	11.09
HRB IMPAIRMENT INDEX			
	male	.55	.25
	female	.54	.28

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