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Factors Related to Patient Report of Cognitive Difficulties Following Head Injury

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VITA

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INTRODUCTION

The experience of traumatic head injury can have profound and lasting effects on physical and psychological functioning. Reports from both clinical observations and empirical studies have described a variety of neurological and behavioral sequelae among the survivors of head injury. The occurrence of post-traumatic seizure disorder, gait disturbance, visual impairment, and motor weakness following head injury have been well documented (Becker & Gudeman, 1989; Gabor, 1982; Jennett & Teasdale, 1981; Lezak, 1983; Pitts, 1982; Reitan & Wolfson, 1986; Sciarra, 1984).

Neurobehavioral deficits such as prominent memory problems, reduced speed of information processing, and general decline of intellectual functioning assessed with neuropsychological measures have been extensively reported in the head-injury literature (Dikmen, McLean, Temkin, & Wyler, 1986; Dikmen, Temkin, McLean, Wyler, & Machamer, 1987; Gronwall & Wrightson, 1974; Haut, Petros, Frank, & Haut, 1990; Levin, 1990; Levin, Benton, & Grossman, 1982; Levin, Papanicolau, & Eisenberg, 1986; Meier, Benton,

& Diller, 1987; Ruesch & Bowman, 1945; Van Zomeren, Brouwer, & Deelman, 1984). Neuropsychological testing has also been shown to effectively document recovery of deficits over time among head-injury patients (Dikmen, Reitan, & Temkin, 1983; Levin, Grafman, & Eisenberg, 1987)

In addition, changes in the emotional and psycho-social status of head-injury patients have received attention with reports of post-traumatic psychosis, depression, social withdrawal, compromised vocational skills, and increased family stress occurring post-injury (Bond, 1984; Brooks, 1991; Dikmen, McLean, & Temkin, 1986; Dikmen & Reitan, 1976; Dikmen, Temkin, & Armsden, 1989; Levin & Grossman, 1978; Lezak, 1989; Lishman, 1973; McLean, Dikmen, Temkin, Wyler, & Gale, 1984; Oddy, 1984; Prigatano & Fordyce, 1986a; Silver & Kay, 1989).

Accurately assessing the severity of the head injury and the degree as well as type of deficits sustained represents an important part of the initial evaluation and recovery process. In evaluating deficits following head injury, the patient's report of cognitive problems often serves as a valuable source of clinical data to assess the patient's perception of cognitive impairment after the injury, as well as in evaluating the psychosocial impact of the injury on daily living. However, inaccurate self-reporting of cognitive difficulties following head injury has been frequently reported in clinical observations of head trauma patients and described as an important factor affecting rehabilitation outcome (Ben-Yishay et al., 1985; Brooks & Lincoln, 1984; Crosson et al., 1989; Prigatano, 1991; Prigatano et al., 1984).

The emerging literature addressing the issue of impaired awareness after head injury has focused on discrepancies between patient and caregiver reports of cognitive difficulties as a means of operationally defining the presence of awareness deficits among head-injury patients. However, some investigators have suggested that caregiver perceptions may not be consistently accurate (McKinlay & Brooks, 1984; McKinlay, Brooks, Bond, Martinage, & Marshall, 1981; Romano, 1974), and neuropsychological test performance has been used in its place as an objective measure of cognitive performance that reflects patients' everyday functioning (Anderson & Tranel, 1989; Heaton & Pendleton, 1981).

From an empirical perspective, the study of the construct of awareness in the head-injury literature has remained rather elusive, highlighting the complexity of factors which have been proposed as interacting to influence the awareness of deficits among head-injury patients. These factors include theories of impaired awareness related to brain lesion localization, most prominently involving frontal lobe pathology (Damasio & Van Hoesen, 1983; Stuss & Benson, 1986). Psychogenic factors related to denial of deficits have also been implicated as a component of the impaired awareness often observed following head injury (Crosson et al., 1989; Deaton, 1986; Nockleby & Deaton, 1987).

Despite the difficulties in defining the construct of awareness, some studies have suggested that discrepant self-reporting of cognitive deficits following head trauma may be related to a greater severity of neuropsychological impairment (Prigatano & Fordyce, 1986b), while the degree of awareness is positively associated with patient reports of emotional distress (Boake, Freeland, Ringholz, Nance, & Edwards, 1987; Prigatano & Fordyce, 1986b). It has also been suggested that some patients exhibiting impaired awareness following head injury continue to show decreased reporting of symptoms for years post-injury (Groswasser, Mendelson, Stern, Shechter, & Najenson, 1977). Yet, few studies have specifically examined patient reports of cognitive difficulties following head injury in relation to performance on measures of cognitive and emotional functioning. Further, these studies have not examined how this relationship changes over time.

In addition, it has long been reported that individuals with head injuries may be more prone to having significant prior neurological or psychiatric histories and possibly lower levels of premorbid functioning. Low socioeconomic status, alcoholism, prior head injuries, neuropsychiatric problems, and other neurological conditions are over-represented in this population (Anneger, Grabow, Kurland, & Laws, 1980; Field, 1976; Kerr, Kay, & Lassman, 1971; Levin et al., 1982; Selecki, How, & Ness, 1968).

Further, these pre-existing conditions are, themselves, likely to be associated with compromised neurological and psychological status, as well as potentially interacting with the effects of an acute head injury. However, the issue of pre-existing neurological or psychiatric problems among head-injury patients has typically not been addressed or controlled in studies examining self-report of cognitive problems in representative, consecutive-series samples of head-injury patients.

The present study investigates the relationship of neuropsychological and emotional functioning to patient reports of cognitive difficulties following head injury, and further, examines how the relationship changes over time. Patients with low- versus high-symptom reporting of cognitive problems, selected from a large, consecutively-admitted sample of head-injury patients, were examined using a series of neuropsychological and emotional measures at one and twelve months post-injury. The head-injury patients were compared to a group of non-head injured trauma patients with other system injuries, but who had similar neurological and psychiatric histories as the head-injury patients. Computed-tomography scans for the two head-injury groups were also examined to assess for differences in the location and frequency of brain lesions related to low- and high-symptom reporting of cognitive difficulties.

REVIEW OF THE RELATED LITERATURE

Self-Report and the Awareness of Cognitive Deficits

The patient's report of problems or complaints following brain injury has traditionally been an important resource for the medical and neuropsychological evaluation process, used both in clinical practice and in research settings. It has long been recognized that individuals who suffer brain damage are sometimes unaware of their deficits, suggesting a dysfunction of the ability to accurately monitor the status of their cognitive functions. This phenomenon has been observed in a variety of neurological disorders, including Alzheimer's Disease, cerebral stroke, amnesia, Multiple Sclerosis, neurotoxicological disorders, and head trauma (Chedru & Geschwind, 1972; Fischer, Chelune, & Rudick, 1990; Forstl, Burns, Jacoby, & Levy, 1991; Peyser & Poser, 1986; Prigatano & Schacter, 1991).

Over the years, a variety of terms have been used to describe this phenomenon of impaired awareness. Babinski (1914) first used the term "anosognosia" to indicate a lack of knowledge or recognition of disease.

This term has been most typically used in describing patients who appear unaware of lateralized body weakness (hemiplegia) or visual field loss (hemianopia), usually following a cerebral stroke (Bisiach, Vallar, Perani, Papagno, & Berti, 1986).

Other terms, such as "lack of insight" (Ford, 1976; Zangwill, 1966), "imperception of disease" (Gerstmann, 1942), and "denial of illness" (Weinstein & Kahn, 1955) have been frequently applied to brain-injured patients who appear unaware of their deficits. Although used inter-changably, each term suggests a slightly different etiol-ogy for the inaccuracies of patient-reporting of symptoms. For example, denial of deficits or illness has been used to describe impaired awareness, but for some authors carries a connotation of being more affectively-based or psychogenic in its origin (e.g., Lewis, 1991). In contrast, Weinstein (1991) views denial as a term which, for him, most accurately represents the integration of cognitive, perceptual, attentional, and affective aspects of the awareness deficit. Thus, in the literature there has been no general consensus or clear theoretically-based definition for this unawareness phenomenon.

<u>Definition of awareness</u>. The construct of awareness has been difficult to define from a theoretical perspective. Several theorists have proposed elaborate cognitive (Schacter, 1990) and neural pathway (Critchley, 1953; Mesulam, 1981) models for the mechanisms of awareness, but due to the inherent complexity of the construct, they have yet to be directly investigated. Others have emphasized the intricate interaction among neural, cognitive, and psychological factors contributing to the impairment of awareness among brain-injured patients (Goldberg & Barr, 1991; Prigatano & Schacter, 1991). The development of a comprehensive definition of impaired awareness in the neuropsychological literature has been complicated by the differing theoretical constructs, clinical populations, and methodologies applied to this growing area of research.

In studies investigating specific, cognitively impaired populations, the construct of awareness has been most often defined, in practical terms, as a discrepancy between a patient's self-report of deficits and the report of caregivers (McGlynn & Schacter, 1989). Some investigators, however, have questioned the accuracy of caregiver reports of patient functioning as the standard for comparison, citing cases where caregivers have either denied or over-reported the difficulties experienced by the patient (McKinlay & Brooks, 1984; McKinlay et al., 1981; Romano, 1974). In turn, the patient's performance on neuropsychological testing has been used as an objective measure for comparison to the patient's report of cognitive difficulties (Anderson & Tranel, 1989). Although most studies examining the issue of impaired awareness following head injury have relied on caregiver reports of deficits as an accurate measure for comparison to patient reports, both caregiver ratings and objective neuropsychological test performance have been used as standards for comparison to patient reports of deficits with no clear consensus as to the preferred approach.

Patient-report of symptoms following head injury. In studies of traumatic head injury, patient's subjective complaints post-injury have been examined, using a variety of symptom checklists and rating scales, to assess the psychosocial and vocational consequences of head injury. It has been reported that many patients with head injuries continue to complain of symptoms for several years post-injury and that these difficulties can often interfere with work and leisure activities (Oddy, Coughlan, Tyerman, & Jenkins, 1985; Oddy, Humphrey, & Uttley, 1978). Even in the case of mild head injury with few or no objective neurological deficits, post-concussional complaints, such as headaches, sensitivity to noise, mood changes, irritability, and fatigue are commonly reported by patients and can significantly interfere with their daily living activities and vocational functioning (Binder & Rattok, 1989; Dikmen et al., 1989; Rutherford, 1989).

In turn, the patient's capacity to accurately assess and report symptoms post-injury can have important effects on the progress of rehabilitation, family adjustment, and the overall course of recovery (Crosson et al., 1989; Lezak, 1978). Ben-Yishay and colleagues (1985) have suggested that lack of awareness or denial of difficulties post-injury can lead to markedly unrealistic expectations concerning appropriate goals for rehabilitation, thereby providing an obstacle to the recovery process. Further, this phenomenon of inaccurate self-reporting of symptoms among survivors of head injury has been reported to be a common occurrence (Anderson & Tranel, 1989; Crosson et al., 1989), which has led to attempts at developing intervention strategies designed to promote a greater self-awareness among these patients (Ben-Yishay, Piasetsky, & Rattok, 1987; Klonoff, O'Brien, Prigatano, Chiapello, & Cunningham, 1989).

Impaired Awareness as a Consequence of Head Injury

A small but growing body of literature has shown support for the common clinical observation of inaccurate self-reporting of deficits among some head-injury patients. These studies have primarily focused on awareness related to three areas of functioning which are often impaired or changed following head injury: memory, personality, and behavior.

In studies by Sunderland, Harris, and Baddeley (1983, 1984), patients with severe head injuries showed significant differences between their ratings of their memory functioning and performance on objective neuropsychologial tests of memory abilities. Although the head-injured patients did not differ from normal controls on the self-report ratings, they performed more poorly on neuropsychological measures of memory functioning. Further, Sunderland and colleagues (1983, 1984) reported that the relatives of the head-injury patients tended to rate the patients' memory functioning more accurately and that these ratings were positively associated with the objective memory test results. These findings were further supported by a later study in which patients with severe head injuries were also shown to report less severe memory problems on self-report ratings than those evidenced on objective measures of memory functioning (Boake et al., 1987).

A large study (Rimel, Giordani, Barth, Boll, & Jane, 1981) examining 429 consecutive patients, evaluated after sustaining mild head injuries, showed that approximately 59 percent of the patients reported some change in memory functioning since the injury. However, ratings by relatives and friends of the patients suggested more severe memory problems for the patients than were indicated by patient ratings. These results provide support for the presence of awareness deficits even in cases of mild head injury.

One criticism of the above studies supporting unawareness of memory deficits following head injury is that by examining only memory functioning, the observed discrepancies between patient and caregiver ratings or objective test performance may simply be a result of the memory deficit itself and not a deficit of awareness, per se. Put more simply, patients may forget the degree of their memory problems, rather than being unaware of them.

This point was noted by McKinlay and Brooks (1984), who emphasized that cognitive deficits which are often associated with head injuries, including impaired memory, attention, and judgment, may contribute to the observed discrepancies between patient and caregiver reports of functioning following head injury. To address this issue, they obtained patient and relative ratings on an 18-item checklist assessing a variety of cognitive and behavioral functions. They reported that the greatest discrepancy between the ratings were in the area of behavioral and emotional difficulties, while reporting good inter-group agreement on items related to sensory-motor impairment, memory functions, and concentration skills. The discrepancies showed no consistent relationship to patient performance on objective neuropsychological measures, leading the authors to suggest that the observed unawareness of deficits was not solely a result of the specific cognitive deficits themselves.

Several studies have examined the awareness issue related to general behavior and personality functioning post-injury. In 1934, Schilder reported from clinical observations that patients with severe head injuries who were examined in the acute stage of the trauma were often "unconcerned" about their injuries and further, seemed to be unaware of their general deficits. In a study of the long-term effects of head injury, Miller and Stern (1965) noted that many severely injured patients showed a significant lack of complaints and tended to minimize the extent of their disability, while mildly injured patients often complained of problems consistent with a post-concussional syndrome (e.g., frequent headaches, irritability, sensitivity to noise, fatigue).

It has also been reported that many severely head-injured patients continue to under-report the severity of their deficits for several years following the injury (Prigatano, and others, 1986). This was supported in a study by Groswasser et al. (1977), which found that those patients who demonstrated impaired awareness of behavioral problems six months after the injury continued to show reduced awareness of their difficulties more than two years later.

In a study investigating patient self-concept following head injury, Tyerman and Humphrey (1984) demonstrated that their sample of severe head-injured patients showed inaccurate self-reporting of deficits, but also exhibited some level of accurate awareness concerning their functioning since the injury. Specifically, they assessed 25 head-injury patients seven months post-injury using self-report measures assessing anxiety level, depression, and attitudes towards physical difficulties since the injury.

In addition, they asked each patient to complete ratings describing their view of their past, present, and future "self," as well as their ratings of the "typical person" and "typical head-injured person," using a semantic differential scale. The results indicated that the patients were frequently in a state of emotional distress, while reporting the experience of a number of physical and behavioral changes since the injury. In contrast, the patients also indicated unrealistic expectations concerning recovery, suggesting a tendency for minimizing the extent and severity of their deficits while maintaining an awareness of the behavioral and physical changes resulting from the injury.

In a study investigating personality changes after head injury, Ota (1969) found that in a group of 80 head-injured patients, approximately 43 percent did not report emotional or psychological difficulties experienced since the injury. In assessing the long-term consequences of severe head injury, Fahy, Irving, and Millac (1967) found that after six years post-injury, their patients showed some awareness of their cognitive deficits involving memory, speech, and intellectual difficulties, but generally did not report emotional or "temperamental" changes described by family members to be an important result of the injury. This finding was supported by Thomsen (1974), who noted that some severe head-injured patients, in a study of 50 head trauma patients and their families, described concerns about their memory problems since the injury, but seemed unaware of changes in their behavior or interpersonal interactions. However, this study was limited by the use of an unstructured clinical interview rather than standardized measures to assess awareness on specific dimensions of functioning.

In a study by Prigatano and Fordyce (1986b), ratings by patients were compared to ratings by relatives and rehabilitation staff on a patient competency rating scale assessing the patients' ability to conduct everyday activities. In their sample, the patients tended to rate themselves as more capable than did family or staff. Further, the differences between the ratings by the patients and staff were positively associated with severity of neuropsychological deficits and negatively associated with the degree of emotional distress assessed by the Minnesota Multiphasic Personality Inventory. Thus, these findings suggest that patients who are inaccurate in their reporting of deficits after head injury tend to have greater cognitive impairment and experience less emotional distress on formal testing.

In a recent study, Prigatano, Altman, and O'Brien (1990) showed that even head-injury patients who appeared accurate in their report of competency in self-care daily activities compared to relatives' ratings tended to under-estimate emotional and psychosocial difficulties reported by relatives. The authors noted that these patients seemed to have the greatest difficulty in monitoring complex interpersonal skills such as controlling anger in an argument and managing interpersonal conflicts.

Overall, the literature examining impaired awareness of deficits following head injury has provided variable results, likely due to the variety of methods used to assess the construct of awareness as well as the differences in severity among the head-injury samples investigated. Despite this variability, the general consensus from both clinical observations and empirical studies suggest that inaccurate self-reporting of deficits can be a significant consequence of head injury and may be related to the patient's severity of neuropsychological impairment and level of observed emotional distress.

Efforts to identify the specific etiology of the awareness deficit following head injury have focused on the study of two primary factors: the localization of brain lesions sustained during head injuries and emotional or psychological denial as a response to the effects of physical trauma.

Lesion Localization and Unawareness After Head Injury

The relationship between impaired awareness and damage to specific brain regions has been suggested by a number of clinical and empirical researchers. The occurrence of impaired awareness or anosognosia for hemiplegia and hemianopia has often been associated with lesions in the parietal brain region of the right hemisphere, most frequently caused by cerebral stroke (Bisiach & Geminiani, 1991). In these patients, hemispatial neglect and a denial of left-side body weakness has been widely reported as a possible consequence of right parietal cerebral infarcts (Anderson, Damasio, Damasio, & Tranel, 1989; Bisiach et al., 1986; Gerstmann, 1942; Geschwind, 1965; Koehler, Endtz, Te Velde, & Hekster, 1986; Warrington, 1962).

Stuss (1991) has made a distinction between the anosognosias occurring with cerebral stroke and disorders of "self-awareness" which appear related to injuries in the frontal lobes and are more typical of the awareness deficit seen following head injury. From clinical observations, unconcern or unawareness of deficits has been frequently reported among patients with damage or injuries involving the frontal lobes (Blumer & Benson, 1975). Although the specific definition of this form of impaired awareness remains somewhat vague, patients who have sustained frontal lobe injuries related to a wide variety of neurological disorders have often been described as lacking concern about their losses, having impaired self-awareness, denying deficits, and exhibiting poor reality monitoring behavior.

Impaired awareness has been reported among patients who have sustained frontal lobe damage as a result of surgery to remove brain tumors (e.g., meningiomas, glio-blastomas, astrocytomas), infections primarily involving the anterior cortex (e.g., herpes encephalopathy), pre-frontal lobotomies during psychosurgery, as well as traumatic head injuries (Stuss & Benson, 1986). Based on these findings, Stuss (1991; Stuss & Benson, 1986) has proposed an organizational model of brain functioning which places self-awareness, defined as the capacity for self-conscious behavior and self-reflection, at the highest or most integrated level of brain functioning. Further, he has suggested that this cognitive capacity is predominantly related to functions of the frontal cortical regions.

This connection between frontal lobe damage and deficits of self-awareness has been viewed as particularly relevant to the study of impaired awareness following head injury (Bond, 1984; Levin et al., 1982; Stuss & Benson, 1986). The specific mechanisms and pathophysiological effects of traumatic head injury have been extensively studied and shown to be directly related to the neurobehavioral consequences observed on clinical evaluation (Reitan & Wolfson, 1986; Ruff, Cullum, & Luerssen, 1989; Teasdale & Mendelow, 1984). Different types of head injuries have been described and classified, each producing the possibility of brain tissue damage with specific pathophysiological consequences.

In classifying head injuries, distinctions are typically made between open (i.e., penetrating or missile injuries) and closed head injuries. Acceleration injuries describe trauma sustained when the head is held motionless and is struck by a rapidly moving object. Deceleration injuries refer to when the head is moving rapidly and strikes a fixed or solid stationary object. Depressed skull fractures can also occur with skull fragments placing pressure on the brain tissue.

Cortical contusions are the most common types of focal injuries to the brain in head trauma, referring to bruising or crushing of brain tissue producing focal hemorrhagic areas that are overtly visible (Levin et al., 1982; Reitan & Wolfson, 1986). These contusions are often observed in contracoup injuries, where a brain lesion can occur in a region contralateral to the site of the trauma. For example, a patient who was struck on the back of the head during a fall may show evidence of a contusion in the frontal cortex due to the forward dislocation of the brain, causing the frontal cortical region to strike the internal surface of the skull. Shearing or rotational forces can also cause brain tissue damage as the suspended brain moves over the irregular internal surfaces of the skull, as well as through stretching or tearing of neuronal axons in the subcortical white matter (Teasdale & Mendelow, 1984).

These potential effects of head injury typically occur in combination, creating a complex array of tissue damage which can produce both the diffuse and focal brain lesions often observed in these patients. In addition, it has long been reported from both clinical observations and empirical studies, that head-injury patients show a relatively higher preponderance of brain lesions in the anterior cortex, involving the frontal and temporal regions (Levin et al., 1982; Reitan & Wolfson, 1986).

Early work by Holbourne (1943, 1945) helped to identify the type and location of damage to the brain due to its movement within the skull during a head injury. Using gelatin models of the brain enclosed in a skull, he was able demonstrate the importance of brain movement and the internal contours of the skull in producing brain tissue damage during trauma, particularly in the fronto-temporal regions. This finding has been subsequently supported by a number of studies using both animal models of head injury and brain-imaging techniques with human head-trauma patients (Gurdjian, 1975; Jennett & Teasdale, 1981; Ommaya, Grubb, & Naumann, 1970).

The association between the high prevalence of anterior cortical lesions and the tendency for deficits of awareness among head-injury patients has yet to be systematically investigated. However, one study using neuroimaging techniques to examine brain lesions has provided some preliminary support for this association. In this study, Prigatano and Altman (1990) classified 64 head-injury patients into three groups: patients who overestimated their competency in everyday activities compared to ratings by relatives, patients who underestimated their abilities compared to relatives' ratings, and those whose reports of competency were consistent with relatives' ratings.

Although no significant differences were observed between the groups on measures of head-injury severity (i.e., Glasgow Coma Scale) and neuropsychological functioning, those patients who overestimated their abilities compared to family members showed a higher frequency of bilateral brain lesions on computed-tomography and magnetic resonance imaging. The authors did not formally test the question of brain lesion localization among their three head-injury groups, as they felt the group sizes were too small to test reliably. However, they did note that the overestimaters appeared to have a higher occurrence of frontal and parietal lobe lesions than the other head-injury patients.

Overall, the empirical literature investigating the relationship between anterior cortical lesions and impaired awareness following head injury is sparse, with most reports coming from clinical observations. The study by Prigatano and Altman (1990) showed a greater number of brain lesions, involving both hemispheres, for those head-injury patients who under-reported cognitive deficits compared to over-reporters and accurate reporters of their cognitive difficulties. This finding provides some initial support for greater neurological damage among head injury patients with decreased awareness of deficits. Although there was some indication of more frontal and parietal lesions among the low-reporting head-injury group, this preliminary finding was observational and requires further investigation.

Psychogenic Denial and Emotional Changes After Head Injury

In the study of the behavioral sequelae following head injury, it has been difficult to separate the effects of organic brain impairment from psychological or emotional responses to trauma among patients with disorders of awareness. From a theoretical perspective, the role of psychological factors contributing to impaired awareness after head injury has been described as a defensive denial of illness, serving the function of reducing anxiety and maintaining self-esteem in the face of significant personal losses (Lewis, 1991). Drawn from psychodynamic theory, this view of denial proposes a need to avoid the emotional pain associated with the realization of losses in functioning sustained following a traumatic injury.

Denial of deficits or symptoms have been reported in a number of studies examining patients with a variety of medical conditions, including cancer, cardiac disease, and acquired immunodeficiency syndrome (Dimsdale & Hackett, 1982; Levine & Zigler, 1975; Nichols, 1983; Silberfarb & Greer, 1982). In a study by Fordyce (1983), patient reports of deficits were compared to ratings by rehabilitation staff for a group of spinal-cord injured patients. The results showed a discrepancy between the patients' verbal awareness and their actions. Specific-ally, the patients demonstrated verbal denial of their physical deficits, but continued to actively participate in rehabilitation treatment for those deficits. Although some degree of denial appeared adaptive (i.e., anxiety reducing) for these non-cognitively impaired patients, it was noted that psychological denial can result in some patients leaving rehabilitation programs prematurely to avoid facing the realization of their deficits.

The above findings, which suggest that psychological denial is an important factor in the unawareness of deficits in non-neurologically based illnesses, have provided support for the potential role of psychogenic factors in contributing to impaired awareness following head injury (McGlynn & Schacter, 1989). It has also been shown that in the case of life-threatening illnesses, such as terminal cancer and end-stage renal disease, denial of symptoms can prevent the onset of depression and anxiety while also representing a possible symptom of the neurological effects of the disease process (Devins et al., 1986; Dougherty, Templer, & Brown, 1986).

Changes in emotional functioning following head trauma have been frequently reported in the literature as a common clinical manifestation of traumatic head injury. The psychiatric sequelae of head injury have been extensively reported, citing the occurrence of post-traumatic depression, psychosis, and mania among patients with no prior history of psychiatric illness (Bond, 1984; Lezak, 1983; Lishman, 1973). Further, head-injury patients are often described as having difficulties with impulse control, anger management, and social withdrawal.

Emotional adjustment has been reported as an important factor affecting recovery after head injury (Fordyce, Roueche, & Prigatano, 1983; Novack, Daniel, & Long, 1984; McKinlay et al., 1981; Prigatano, 1988). Factors such as age, severity of brain damage, time since injury, number of post-concussional symptoms, and pre-morbid personality styles have all been implicated in affecting the emotional adjustment following head injury (Dikmen & Reitan, 1977; Novack, Daniel, & Long, 1984; Prigatano, 1987).

Recent studies have suggested that the degree of emotional distress (e.g., depression, social withdrawal, anger) experienced after head injury is related to the level of awareness of deficits demonstrated by the patient during the course of recovery (Prigatano, 1991). In a study by Fordyce et al. (1983), the emotional and neuropsychological characteristics of 52 consecutively evaluated head-trauma patients were investigated. Those patients who were referred for evaluation more than six months after the injury showed greater emotional distress on the Minnesota Multiphasic Personality Inventory and Katz Adjustment Scale than did patients who were tested less than six months following the head injury. These differences were not related to the level of neuropsychological impairment or head-injury severity (i.e., length of coma).

The authors suggested that these findings show time since the injury to be an important factor related to the increased levels of emotional distress often observed among head-injury patients. Further, they emphasized the importance of considering the role of premorbid personality characteristics and increased levels of awareness concerning the injury as factors which may be related to emotional changes post-trauma for some head-injury patients.

In a later study, Prigatano, Altman, and O'Brien (1990) showed that a general group of head-injury patients tended to underestimate or minimize their emotional difficulties compared to reports by family members. Further, these patients seemed to demonstrate an impaired perception of the subtle interpersonal interactions required in social situations, while showing relatively better accuracy in their self-report of cognitive deficits.

Applying a grief model to the study of emotional responses and awareness of deficits after head trauma, Nockleby and Deaton (1987) investigated the theory that denial of symptoms is followed by a gradual awareness of deficits over time and that increased levels of emotional distress occur as awareness increases. In this study, they examined a group of 33 head-injury patients evaluated with neuropsychological testing and the Minnesota Multiphasic Personality Inventory, on average five years post-injury.

Using an index of denial, computed as the difference between patient reports of symptoms and those reported by rehabilitation staff, they found the degree of denial to be inversely correlated with scores on the Minnesota Multiphasic Personality Inventory and positively correlated with the Halstead-Reitan Impairment Index. They did not show an effect for time since injury or length of coma for this head injury sample. These findings suggest that higher levels of awareness of deficits after head injury are accompanied by higher levels of emotional distress and relatively less neuropsychological impairment on formal testing. Although the authors did not find a significant effect for time since the injury, this study was not designed to specifically assess changes in awareness and emotional functioning over time. A longitudinal design would be more appropriate to address this latter question.

Overall, the head-injury literature indicates the importance of emotional adjustment in relation to awareness of deficits in the recovery of traumatic head injury. Yet, untangling the relationship between changes in emotional functioning and awareness of cognitive problems post-injury remains difficult, reflecting the complexity of variables which influence emotional behavior and cognitive self-concept. Nevertheless, recent studies suggest that emotional distress may be inversely related to levels of awareness of cognitive deficits following head injury. How this relationship changes during the course of recovery remains unclear. Time since injury may be an important variable affecting patient report of emotional and cognitive functioning post-injury, but this has yet to be adequately assessed.

Demographic and Premorbid Factors in Head Injury

Studies examining the events which typically lead to head injuries in the general population have reported that motor vehicle accidents account for nearly 50 percent of all traumatic head injuries (Annegers et al., 1980; Hawthorne, 1978; Kalsbeek, McLaurin, Harris, & Miller, 1980). Other common causes include domestic accidents or falls, industrial injuries, cases of assault, and sports injuries.

Epidemiological studies have also suggested that there are several factors which seem to be associated with an increased risk for head injury (Levin et al., 1982; Reitan & Wolfson, 1986). Age has been consistently reported as an important factor related to the incidence of head injury. Head injuries are known to occur more frequently among adolescents and young adults with a peak incidence occurring in the range of 15 to 25 years of age, followed by a steady decline until a secondary peak occurs after age 70. Gender differences have also been shown to occur among head-injury patients. Studies have shown young adult males to be four times as likely to suffer a head injury than are females of the same age (Fields, 1976; Kerr et al., 1971; Kraus, 1980; Rowbotham, Maciver, Dickson, & Bousfield, 1954). This gender disparity declines by half for patients over age 70.

It has also been reported that head injuries are more likely to occur among persons of lower socio-economic status. In a study by Kerr et al. (1971), lower socio-economic level was associated with a higher frequency of head injuries in a study of consecutive hospital admissions in Great Britain. This finding was further supported in a study by Selecki et al. (1968), who found a higher incidence of head injuries among laborers and craftsmen compared to clerical workers and homemakers in a six-year retrospective study of consecutive hospital admissions for head injury.

The use of alcohol has been implicated in approximately 30 percent of head injuries among young adult males and 10 percent among females (Field, 1976), and is often associated with injuries in motor vehicle accidents, domestic accidents, and assaults (Kerr et al., 1971). Histories of chronic alcohol abuse have been reported in as many as one-half of the severe head injuries (Field, 1976).

Pre-existing psychiatric and neurological illnesses have also been reported to be over-represented among the head-injured population. Premorbid personality functioning has been described as a significant factor contributing to the occurrence of head injury and the subsequent behavioral difficulties often observed in these patients (Jennett, 1972). Although there are a relatively small number of head-injury patients with documented histories of psychiatric disorders, the occurrence of psychiatric illness is reported to be higher than the base rates seen in the general population (Levin et al., 1982).

It has also been suggested that individuals who sustain head injuries are more likely to have a history of prior neurological disorders. In a study by Annegers et al. (1980), the incidence rates for experiencing subsequent head injuries after an initial traumatic head injury increases by three-fold. After the second head injury, the authors reported that a third head injury is eight times as likely compared to the general population. In addition to prior head injuries, a greater frequency of histories of post-traumatic epilepsy, learning disabilities, and generally lower premorbid intellectual functioning have been observed in the head-injury population (Reitan & Wolfson, 1986).

Based on extensive clinical experience, Levin et al. (1982) indicated that approximately 20 percent of the adult head-injury hospital admissions seen for neuropsychological evaluation have recoveries complicated by previous conditions, such as psychiatric illness, alcohol and drug abuse, and low premorbid cognitive functioning. Thus, from both clinical observations and empirical epidemiological studies, there is significant support for the need to consider premorbid neurological and psychiatric status when examining brain-behavior relationships among head-injury patients. This point has been further noted by Dikmen and Temkin (1987), who emphasized the importance of using adequate comparison groups which control for pre-existing conditions and relevant demographic factors when studying the neurobehavioral effects of head injury.

Statement of the Problem

A growing body of literature has focused on the clinical significance of impaired awareness of cognitive deficits following traumatic head injury. Head-injury patients who demonstrate inaccurate self-reporting of cognitive symptoms often have difficulty in developing and maintaining appropriate goals and expectations for their treatment. Studies investigating the etiology of this deficit in awareness have been complicated by differences in the definition, measurement, and theoretical perspective applied to this question. Although there has been no clear consensus, impaired awareness has been most often viewed as inaccurate patient-reporting of deficits measured in comparison to symptom ratings by family and caregivers or in relation to objective neuropsychological test performance.

Theoretically, impaired awareness has been described as a neurological deficit attributable to damage in relatively specific brain regions, such as the frontal or parietal lobes, or as an emotional response to trauma with a denial of the subsequent loss of cognitive abilities. Much of the research addressing this area has been based on clinical observation. However, some empirical studies have suggested that deficits of awareness following head injury may be associated with greater impairment on neuropsychological measures and lower levels of emotional distress. Further, there has been some indication that patients with impaired awareness may have greater numbers of cortical brain lesions as seen with neuroimaging techniques.

An additional consideration in studies comparing head-injury groups is the importance of taking into account premorbid characteristics and pre-existing conditions which may affect performance on cognitive and self-report measures. Head-injury patients are known to have a higher incidence of prior neurological problems, psychiatric difficulties, and substance-abuse histories. Few studies have attempted to systematically assess neuropsychological and emotional functioning among consecutively-admitted head-injury patients with discrepancies in their reporting of cognitive difficulties while using comparison groups that control for pre-existing conditions. Further, an examination of how these areas of functioning change over time has yet to be specifically addressed. That head injury patients can show varying degrees of recovery over time has been well documented. How this recovery relates to patient reports of cognitive difficulties post-injury remains unclear.

In the current study, differences in neuropsychological and emotional functioning for consecutively-admitted closed head-injury patients with low versus high symptom reporting of cognitive difficulties were examined at one and twelve months post-injury. The head-injury patients were compared to a group of non-head injured patients who had sustained other system injuries (trauma controls), but presented with similar prior neurological and psychiatric histories as the head-injury sample. In addition, the frequency and location of brain lesions were compared for the two head-injury groups derived from results of computed-tomography scans obtained at the time of injury.

Hypotheses

Hypothesis 1. It is hypothesized that the three patient groups will differ on neuropsychological measures at one month post-injury. Specifically:

1a. Both the low- and high-report head-injury groups will show significantly poorer performance on neuropsychological measures at one month post-injury compared to the trauma control group.

1b. The low-report head-injury patients will perform more poorly than the high-report head-injury group at one month post-injury.

Hypothesis 2. It is expected that the three patient groups will differ on measures of emotional functioning at one month post-injury. Specifically:

2a. The low-report head-injury group will report less emotional difficulties at one month post-injury than the high-report head-injury and trauma control groups.

2b. The high-report head-injury group will report more emotional difficulties than the trauma control group at one month post-injury.

Hypothesis 3. It is hypothesized that the two head injury groups will differ on improvement from one month to one year on neuropsychological measures compared to the trauma control group. Specifically:

3a. The low-report head-injury group will show greater improvement from one month to one year on neuropsychological measures compared to the trauma control group.

3b. The high-report head-injury group will show greater improvement from one month to one year on neuropsychological measures than the trauma controls.

Hypothesis 4. It is hypothesized that the two head-injury groups will differ on computed-tomography scans. Specifically:

4a. The low-report head-injury group will have a significantly greater occurrence of brain lesions than the high-report head-injury group.

4b. The low-report head-injury patients will have a greater percentage of the brain lesions involving the frontal cortical region compared to the high-report head-injury group.

METHOD

Subjects

Forty-three head-injury patients, whose ages ranged from 15 to 63 (*M* = 30.7, *SD* = 12.4) and who had a mean of 11.6 (*SD* = 2.1) years of education, were selected from a sample of 242 adult patients accepted into a longitudinal head-injury study. This group was mostly white (67.4%, 20.9% black, 11.6% other) and consisted of 32 males and 11 females. These patients were consecutively enrolled into an ongoing study of behavioral sequelae following closed head injury conducted at a large university-based medical center in the Pacific Northwest.

Each head-injury patient was admitted to the Harborview Medical Center, a Level I Trauma Center in Seattle, Washington following an acute closed head injury. Subjects were included in the large longitudinal sample according to the following selection criteria: a) any length of loss of consciousness, the presence of post-traumatic amnesia for at least one hour, or objective evidence of cerebral trauma even though loss of consciousness and post-traumatic amnesia are not present (e.g., positive neurological signs, skull fracture, hematoma); b) head injury sufficiently serious to require hospitalization; c) at least 15 years of age at the time of injury; and d) English-speaking. Those head-injury patients who demonstrated a significant level of overall cognitive impairment on the Halstead-Reitan Impairment Index (impairment index score ≥ 0.4) and reported either many or no cognitive problems on the Alertness Behavior (AB) and Communication (C) subscales of the Sickness Impact Profile were selected as high-symptom reporting (AB + C ≥ 0.39) and low-symptom reporting (AB + C = 0) head-injury patients for the current study.

Non-head injured patients with other system injuries, referred to here as trauma controls (n = 41), were used as a comparison group. These control subjects ranged in age from 16 to 64 (M = 35.9, SD = 13.8) and had a mean of 11.2 (SD = 2.4) years of education. They were also similar to the head-injury group in the composition of race (61.0% white, 26.8% black, 12.2% other) and gender (27 males, 14 females). This group was selected from a sample of 132 patients with acute injuries to body parts other than the head.

Prospective subjects for the total sample of non-head injured trauma control patients were initially identified through emergency room log sheets at the

University Hospital of the University of Washington Medical Center and were interviewed to rule out any possibility of their sustaining even a mild head injury. Those trauma control patients with a Halstead-Reitan Impairment Index score of 0.4 or greater were selected for comparison with the head-injury groups. All subjects provided informed consent (see Appendix A) and agreed to have the information collected made available for research purposes.

Materials and Apparatus

Cognitive Measures

Wechsler Adult Intelligence Scale (WAIS). (Wechsler, 1955). This is a commonly used measure of general intellectual functions. The Wechsler Adult Intelligence Scale yields Verbal, Performance, and Full Scale IQ scores, representing the subject's verbal intelligence, visuospatial problem-solving, and manipulatory skills. Scores are determined based on normative data from a large sample of adults between the ages of 16 to 74. This measure has often been used in the neuropsychological assessment of decline in cognitive functioning among patients who have sustained neurological illness and injury (Lezak, 1983; Matarazzo, 1972), providing an assessment of deficits in general intellectual skills.

Wechsler Memory Scale. (Form I; Wechsler, 1945). This is a widely used measure of memory and learning. It samples abilities involving orientation, span of attention, mental control, and memory for verbal and visuospatial information. Immediate recall for verbal and visuospatial material are evaluated, as well as verbal associational learning. A Memory Quotient is computed providing an overall estimate of memory functioning. This value has been shown to be associated with performance on the Wechsler Adult Intelligence Scale (Fields, 1971) and useful in the assessment of memory impairment in a variety of patient populations (Franzen, 1989; Lezak, 1983).

In addition, the total scores for the logical memory (i.e., the recall of verbal paragraphs) and visual reproduction (i.e., recall of non-descript visual designs) subtests are reported separately including additional total recall scores after a 30 minute delay. These subtests are frequently used as memory measures with established normative data provided in the literature (Lezak, 1983) and have been used effectively in identifying complex verbal and visual memory deficits among cognitively impaired patients (Franzen, 1989; Russell, 1975).

Category Test. (Reitan, 1955a). Part of the Halstead-Reitan Neuropsychological Test Battery, this complex concept formation task consists of items divided into seven sets. The items are figures of varying shapes and sizes that are organized according to a specific principle. They are presented visually on a screen with the subject indicating his/her response by pressing a lever. A bell-buzzer system informs the subject when his/her response is correct or incorrect. In this task, the subject is required to abstract the organizing principle in each set of items relying only on feedback from correct and incorrect responses. This measure assesses novel problem-solving skills and cognitive flexibility with visuospatial material, and has been shown to be highly sensitive to brain-based cognitive impairment (Filskov & Goldstein, 1974; Franzen & Robbins, 1989; Reitan, 1955a).

Finger Oscillation Test. (Reitan, 1955a). This part of the Halstead-Reitan Neuropsychological Test Battery measures index finger tapping speed utilizing a key attached to a counter. The subject is given consecutive ten-second trials with each hand. The score is obtained by taking the mean number of taps for five trials for each hand. This measure assesses fine motor functions and is sensitive to lateralized and bilateral cortical motor deficits (Boll & Reitan, 1972b; Reitan, 1955a).

Halstead-Reitan Impairment Index. (Reitan, 1955a). This is a summary score of overall brain impairment derived from performance on the Halstead-Reitan Neuro-psychological Test Battery. Index scores range from 0 to 1.0 and are based on the number of Halstead-Reitan test variables in which a subject's performance falls in the range characteristic of brain-damage compared to a normative control group. For example, an index score of 0.5 indicates that 50 percent of the Halstead-Reitan tests included in the index score are in the impaired range.

The impairment index of the Halstead-Reitan Neuropsychological Test Battery is based on several frequently used measures which assess a variety of cognitive functions, including tactual-spatial motor problem-solving (Tactual Performance Test; Reitan, 1955a), speech-sounds perception (Reitan, 1955a), fine motor skills (Finger Oscillation Test; Reitan, 1955a), discrim-ination of rhythmic sounds (Seashore Rhythm Test; Reitan, 1955a), and cognitive flexibility (Category Test; Reitan, 1955a). The impairment index derived from these tests has been shown to be highly sensitive to overall brain impairment, showing very good diagnostic validity in discriminating brain-damaged patients from non-impaired controls (Filskov & Golstein, 1974; Franzen & Robbins, 1989; Klove, 1974; Reitan, 1955a; Reitan & Davison, 1974).

Trail Making Test. (Reitan, 1955b). This is a two part paper and pencil test often included as an adjunct to the Halstead-Reitan Neuropsychological Test Battery (Franzen & Robbins, 1989). Part A requires the subject to connect twenty-five circles numbered 1 through 25, haphazardly distributed over a sheet of paper, as quickly as possible. Part B requires the subject to connect circles on a page with numbers and letters in alternating sequence. The scores obtained are the number of seconds required to finish each part. Part A assesses visuospatial tracking and attention skills, while Part B measures an additional component of cognitive flexibility in alternating between numbers and letters. The Trail Making Test has been shown to be highly sensitive to overall cognitive impairment (Boll & Reitan, 1972a; Reitan, 1955b; Reitan, 1958).

Selective Reminding Test. (Buschke, 1973). This is a multiple trial, free-recall verbal memory and learning test. A group of 10 unrelated words are auditorily presented. The subjects are asked to respond with as many words as they can remember from the list and are subsequently reminded of the words they did not recall. The subjects are then asked to again say as many words as they can think of from the whole list of 10 words. This procedure is repeated for 10 trials.

This test assesses recall, storage, and retrieval from long-term storage for unrelated words. As a test of verbal memory and learning, the Selective Reminding Test is widely used in the assessment of memory impairment (Lezak, 1983), providing useful clinical data concerning a patient's ability to acquire new verbal information and their consistency in recalling verbal material across multiple trials (Squire, 1986). This measure has been shown to be effective in discriminating between patients with memory deficits (e.g., traumatic head injury, Alzheimer's Disease) and non-impaired normal controls (Dikmen et al., 1987; Levin et al., 1982; Masur, Fuld, Blau, Crystal, & Aronson, 1990).

Emotional and Psychosocial Measures

Katz Adjustment Scale. (Patient Form; Katz & Lyerly, 1963). This measure provides a subjective report by patients of their overall emotional adjustment following injury or illness. More specifically, it assesses the extent to which patients are satisfied with their level of functioning. This scale was designed to measure emotional distress and psychiatric symptomatology, as well as social functioning and behavior, providing an overall measure of emotional adjustment or distress.

Three additional scores derived from a factor analytic study (Katz & Lyerly, 1963) provide measures of withdrawn depression (i.e., factor loaded for social withdrawal and helplessness), social obstreporousness (i.e., factor loaded for belligerence, negativism, and verbal expansiveness), and acute psychoticism (i.e., factor loaded for bizarreness, hyperactivity, and anxiety) from subject responses. Subjects respond to each item using either a three or four point Likert-type scale indicating frequency of discomfort and level of participation in activities. In the development of this adjustment scale, Katz and Lyerly (1963) demonstrated good reliability and discriminant validity in the assessment of emotional adjustment among psychiatric patients. This scale has subsequently been used with a variety of patient populations, including neurologically impaired patients (Wilson & Goetz, 1990).

Sickness Impact Profile. (Bergner, Bobbitt, Pollard, Martin, & Gilson, 1976). This is a behavior-based check-list of health status. The Sickness Impact Profile covers 12 areas of living which include mobility, body care movement, ambulation, alertness behavior, communication, social interactions, sleep and rest, emotional behavior, recreation and pastimes, and eating and work. Subjects are asked to endorse those items which describe their health status and psychosocial functioning since the onset of their illness or injury. Based on the consensus of a large sample of health care consumers, each item in the measure has been assigned a weight or scale value indicating its relative importance in the severity of dysfunction. A score for each subscale is computed, representing the weighted percentage of items endorsed for each subtest. Good reliability and validity for the Sickness Impact Profile has been shown in a variety of large patient populations, including acutely and chronically ill adults with a broad range of medical illnesses (Bergner et al., 1976; Gilson et al., 1975; Pollard, Bobbitt, Bergner, Martin, & Gilson, 1976). For the purpose of this study, the Alertness Behavior and Communication subscales were combined to form an index measuring patient self-report of cognitive problems. These two subscales include items which assess patient-report of cognitive difficulties, such as memory, language, concentration, and attention in everyday functioning.

Head-Injury Outcome Study Interview. Information concerning pre-injury medical and psychiatric histories were obtained using a structured interview developed for the head-injury outcome study. The interview included questions assessing for previous neurological disorders which may affect current cognitive functioning, such as prior head injuries, learning disabilities, and cerebral strokes (see Appendix B). Questions assessing the occurrence of pre-injury emotional and psychiatric difficulties were also included, as well as questions concerning problems with alcohol and substance abuse. Patients were rated as having pre-injury psychiatric, alcohol, and/or substance-abuse problems if one or more questions in these respective categories were endorsed. In addition, the interviewer rated the patient on pre-injury vocational functioning, based on reports from the patient and family concerning their pre-injury vocational activities. The interview was administered by a study physician at the time of hospital admission and all information was obtained from patients and available family members.

Physical and Neurological Measures

Glasgow Coma Scale. (Teasdale & Jennett, 1974). This scale provides a measure of head-injury severity by assessing depth of coma. It is typically measured within 24 hours of injury. The three elements of the coma scale assess the stimulus needed to induce the eyes to open, produce a verbal response, and generate a motor response. Standard neurological stimuli are used to assess the degree of consciousness for each category. The scores for the scale range from 3 to 15 with lower scores representing deeper coma and greater head-injury severity. Scores of 8 or less indicate severe head injury, 9 to 12 suggest a moderate injury, and 13 to 15 indicate mild head injury (Jennett & Bond, 1975; Teasdale & Jennett, 1974). The Glasgow Coma Scale is widely used both clinically and in research as an index of head-injury severity; and has been described as one of the most useful indicators of brain damage sustained during traumatic head injury (Levin et al., 1982; Lezak, 1983).

Time to Follow Commands. This score assesses the length of time from the injury in which the patient is able to follow commands consistently. Based on the motor response component of the Glasgow Coma Scale, this test assesses the patient's response to standard simple commands from the time of injury forward. This measure assesses the duration of impaired consciousness following the injury, providing a measure related to the severity of head injury.

The duration of coma, as assessed by the time taken for a patient to consistently follow commands, has been shown to be associated with brain impairment following head injury (Levin et al., 1982) and may be useful in discriminating differences in the milder ranges of severity of head injury (S. Dikmen, personal communication, September, 1988). Different levels of head-injury severity based on time to follow commands have been used in several head-injury outcome studies (Dikmen et al., 1986; Dikmen et al., 1983; McLean et al., 1984), with less than one hour corresponding to mild head injury, 1 to 24 hours indicating mild to moderate injury, 1 to 6 days indicating moderate to severe head injury, and greater than 6 days suggesting severe head injury.

Injury Severity Score. (Baker, O'Neill, Haddon, & Long, 1974). This score provides a measure of overall severity of physical injury. The score is derived from a physician's rating of injury severity for different body regions. This measure uses scores from the Abbreviated Injury Scale (Committee on Medical Aspects of Automotive Safely, 1971; Petrucelli, States, & Hames, 1981), which provides a physician's injury severity rating of 1 for minor, 2 for moderate, 3 for serious, 4 for severe, 5 for critical, 6 for unsurvivable, and 9 for unknown.

The Injury Severity Score is calculated with the sum of squares of the Abbreviated Injury Scale scores for six specified body regions (i.e., head or neck, face, chest, abdominal or pelvic contents, extremities or pelvic girdle, external) and has been shown to be a useful measure of severity of multiple injuries sustained following trauma (Baker et al., 1974). This score has been modified for use in the current study, by excluding ratings of injuries to the head, to provide an overall measure of other body system injuries separate from head injury.

Computed-Tomography Scan. Computed-tomography scans of the head for patients admitted to Harborview Medical Center and the University Hospital following a traumatic head injury were obtained using a General Electric model

9800 scanner. The tomographic radiological films were read by a board certified neurosurgeon with extensive experience in the clinical and radiological diagnosis of brain injury due to trauma. All scans obtained within 72 hours of the injury were done without contrast material to provide the best quality image with the lowest risk to the patient. Each scan was rated for the presence, size, and location of contusions, focal atrophy, and hematomas based on the clinical impression of the rater (see Appendix B).

It is widely accepted that computed-tomography is an essential part of the acute management of traumatic head injury, providing a highly sensitive tool in the assessment of the neuropathological effects of brain injury (Ruff et al., 1989). The use of qualitative ratings in radiological diagnosis with computed-tomography has been the traditional method for evaluating scan results, both clinically and in research settings. Recent efforts have attempted to use quantitative techniques to assess structural abnormalities in tomographic images (e.g., Cooper, 1985; Roberts, Caird, Grossart, & Steven, 1976). However, these methods have yet to show consistent improvements over qualitative ratings by trained clinicians for diagnostic purposes (Turkheimer, 1989).

Procedure

A series of neuropsychological measures were administered to each subject at one and twelve months post-injury. These measures included the Halstead-Reitan Neuropsychological Test Battery, Wechsler Adult Intelligence Scale, Wechsler Memory Scale, Selective Reminding Test, and the Trail Making Test. They were also given a measure of emotional adjustment, the Katz Adjustment Scale (patient form), as well as a measure of psychosocial functioning, the Sickness Impact Profile at one and twelve months post-injury. The neuropsychological, emotional, and psychosocial measures were administered by trained psychometricians following standardized administration and scoring procedures provided for each test. The battery of tests were administered during a one day session at one and twelve months following the injury.

The head-injury patients were evaluated for depth and length of coma by the hospital's admitting physician using the Glasgow Coma Scale assessed within 24 hours of injury, and time to follow commands, noted from the time of injury forward. The severity of other system injuries, excluding head injury, was assessed for all subjects by the admitting physician using the Injury Severity Score. Table 1 provides an overview of the tests administered to the head-injury and trauma control groups.

Table 1

Measures Used to Assess the Head-Injury (HI) and Trauma Control Groups

Cognitive Measures	
	Wechsler Adult Intelligence Scale (Wechsler, 1955)
	Wechsler Memory Scale (Form I; Wechsler, 1945)
	Category Test (Reitan, 1955a)
	Finger Oscillation Test (Reitan, 1955a)
	Halstead-Reitan Impairment Index (Reitan, 1955a)
	Trail Making Test (Reitan, 1955b)
	Selective Reminding Test (Buschke, 1973)
Emotional and Psychosocial Measures	
	Katz Adjustment Scale (Katz & Lyerly, 1963)
	Sickness Impact Profile (Bergner et al., 1976)
	Alertness Behavior and Communication Subscales
	Head-Injury Outcome Study Interview
Physical and Neurological Measures	
	Glasgow Coma Scale (Teasdale & Jennett, 1974)*
	Time to Follow Commands*
	Injury Severity Score (Baker et al., 1974)
	Computed-Tomography Scans*

*These measures were administered to head-injury groups only.

Patient reports of cognitive difficulties were measured by the sum of the Communication and Alertness Behavior subscales of the Sickness Impact Profile. The distribution of the subscale scores for the entire representative sample of 242 head-injury patients was examined to determine appropriate cut-off scores to form the low-report and high-report head-injury groups. The combined subscale score of zero, where patients endorsed no items on both the Communication and Alertness Behavior subscales was used as a criterion for the low-report group, representing the lower third of the total head-injury sample. A combined score of 0.39 or greater was used in defining the high-report group, which corresponds to the upper third of the total head-injury sample.

In addition, a score of 0.4 or greater on the Halstead-Reitan Impairment Index was used as a cut-off for group membership to ensure that all subjects demonstrated a significant overall level of cognitive impairment in which at least 40 percent of the Halstead-Reitan tests were in the impaired range. Further, this cut-off score corresponds to the upper half of the whole head-injury sample distribution for the impairment index score.

Head-injury patients who were testable at one month following injury, reported no cognitive difficulties on the Communication and Alertness Behavior subscales of the

Sickness Impact Profile, and received a Halstead-Reitan Impairment Index score of 0.4 or greater were included in the low-report head-injury group (n = 19). Head-injury patients who were testable at one month post-injury, scored 0.39 or greater on the combined score for the Communication and Alertness Behavior subscales of the Sickness Impact Profile, and received a Halstead-Reitan Impairment Index score of 0.4 or greater were included in the high-report head-injury group (n = 24).

Of the 242 patients enrolled in the longitudinal head-injury outcome study, 71 patients were not testable at one month post-injury, leaving 171 patients for further selection. One-hundred and four of the remaining patients had Halstead-Reitan Impairment Index scores of less than 0.4 and thus, were excluded by the selection criteria. The 43 head-injury patients included in the current study were selected from the remaining 66 patients based on their scores for the Alertness Behavior and Communication subscales of the Sickness Impact Profile.

Forty-six trauma control subjects were selected from a sample of 132 patients who sustained other system injuries with no evidence of acute head injury and had a Halstead-Reitan Impairment Index score of 0.4 or greater. It is widely accepted that age differences can have significant effects on cognitive performance (Lezak, 1983). To ensure that any observed group differences on the cognitive measures are not a function of age effects, subjects older than age 65 were excluded from the comparison group, producing a trauma control group (n=41) with an age range very similar to the head-injury patients.

Only trauma control subjects with a 0.4 or greater impairment index were selected in order to provide a comparison group with a low premorbid level of cognitive functioning. This low-premorbid functioning comparison group was used to help assess whether observed differences in the low- or high-report head-injury groups are distinguishable from individuals with similar low-premorbid cognitive status or decreased functioning due to pre-existing neurological conditions.

Information concerning relevant medical and psychosocial histories, including prior neurological, psychiatric, and vocational functioning was gathered for all subjects from information obtained from patients and family members during a structured interview conducted as part of the initial hospital assessment (see Appendix B). The interviewing physician assessed for the presence or absence of pre-existing neurological conditions and psychiatric disorders, including substance and alcohol abuse. All patients enrolled in the longitudinal head-injury study received clinical care at the University of Washington Medical Center during the year post-injury. Treatment included acute medical management at the time of injury and involvement in rehabilitation services (i.e., physical therapy, vocational planning) as needed. These patients were free of prescribed medication, with the exception of anti-seizure treatment (i.e., Phenytoin) for those patients who presented with a history of post-traumatic epilepsy.

For group comparisons, a series of variables from the neuropsychological measures administered were selected to adhere to two primary considerations: (1) test variables were selected that have been shown to be highly sensitive to changes in functioning due to brain-based cognitive impairment; (2) variables were chosen to sample a variety of cognitive functions often impaired following head injury, including general intellectual skills, memory, novel problem-solving, cognitive flexibility, attention, and fine motor skills. The cluster total score and the three additional factor scores (i.e., withdrawn depression, obstreporousness, psychoticism) of the Katz Adjustment Scale were used to compare the head injury and trauma control groups on emotional functioning post-injury.

Computed-tomography scans were obtained for each head-injury patient as part of his/her standard clinical assessment upon admission to the University of Washington Medical Center. Each head-injury patient received a scan within 72 hours of admission with the vast majority of patients being tested within 24 hours of their injury. These scans were read by the neurosurgeon for the large longitudinal head-injury outcome study and were rated for scan quality and the presence or absence of focal atrophy, intraparenchymal hematomas, and contusions. The size of the contusions were also rated as small or extensive, and the brain-lobe location (i.e., frontal, parietal, temporal, occipital regions) was noted for both right and left hemispheres (see Appendix B). These ratings were non-quantitative and thus, were based on the clinical and radiological experience of the rater.

RESULTS

Overview of Analyses

Differences on demographic variables and the occurrence of premorbid medical and psychiatric histories among the head injury and trauma control groups were compared using analysis of variance, Kruskal-Wallis, and chi-square tests with continuity correction where appropriate. The chi-square test was also used to compare differences in the frequency of brain lesions on computed-tomography scans for the two head injury groups. Fisher's exact probability test was used in place of the chi-square test for small-sample group comparisons where greater than 20 percent of the cells had frequencies of less than five (Siegel & Castellan, 1988).

Head-injury samples typically demonstrate skewed distributions on neuropsychological measures (Dikmen, McLean, Temkin, 1986; Dikmen, McLean, Temkin, & Wyler, 1986; Dikmen et al., 1987). The normality of the distributions for each dependent variable in the current study was examined using the modified Kolmogorov-Smirnov test to determine appropriate methods of analysis. Since the distributions for measures of injury severity, neuropsychological functioning, and emotional adjustment were not normally distributed, nonparametric statistics (i.e., Kruskal-Wallis and Mann-Whitney U tests) were used to examine group differences.

Analyses to assess group differences were conducted for cognitive and emotional measures at one and twelve months post-injury. In addition, difference scores (one month - twelve months) were computed and compared between groups to assess change in functioning over time. Overall, significant group effects on the Kruskal-Wallis test were followed by pairwise Mann-Whitney U tests to assess specific group differences. All parametric and non-parametric statistics were analyzed using the SPSS/PC+ (1988) statistical software with an IBM compatible personal computer.

Demographics, Pre-injury Functioning, and Injury Severity

The low-report head-injury (n=19), high-report head-injury (n=24), and trauma control (n=41) groups did not differ significantly on distributions of age, years of education, gender, race, and handedness (see Table 2). Chi-square analyses comparing the three groups on the occurrence of pre-injury conditions which might affect cognitive and emotional functioning were also not

Table 2

Demographic Data for Head-Injury (HI) and Trauma Control Groups at Time of Injury

Demographics	Low Report HI n=19	High Report HI n=24	Trauma Controls n=41	p value
	Groups			
Age, yrs.				ns
M	30.9	30.5	35.9	
SD	14.8	10.4	13.8	
Median	27.0	28.5	34.0	
Range	15-63	16-57	16-64	
Education, yrs.				ns
M	11.7	11.5	11.2	
SD	2.5	1.8	2.4	
Median	12.0	11.0	12.0	
Range	7-16	8-16	5-17	
Gender, freq.				ns
Male	14	18	27	
Female	5	6	14	
Race, freq.				ns
white	14	15	25	
black	4	5	11	
other	1	4	5	
Handedness, freq.				ns
Right	19	22	34	
Left	0	2	7	

(continued)

Table 2 (continued)

Demographic Data for Head-Injury (HI) and Trauma Control Groups at Time of Injury

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Note. Group differences for age were assessed using the Kruskal-Wallis test due to skewed distributions for this variable. One-way analysis of variance was used to test for a group effect for education. Chi-square tests assessed group differences on gender and race with the "black" and "other" categories combined due to small cell frequencies. Pairwise group chi-square tests with Yates' continuity correction were performed for handedness due to small cell frequencies, and were not significant. freq. = frequency. Other = Native-American and Asian-American. ns = not significant.

significant (see Table 3). These comparisons were based on the assessment of pre-existing neurological problems (i.e., neurological illnesses and head injuries), alcohol abuse, substance abuse, and psychiatric history.

Examination of the specific types of pre-injury neurological disorders occurring among the head injury and trauma control groups showed previous head injuries, epilepsy, and learning disabilities to be the most prevalent pre-existing neurological problems for these samples. Approximately one half of the patients in each group had one of these three neurological disorders. In addition, individual patients presented with histories of meningitis in the low-report head-injury group and cerebral neoplastic disease in the trauma control group. Chi-square analysis revealed no significant differences between the groups for the types of pre-injury neurological problems present, $\chi^2(10, \underline{N} = 84) = 14.64$, ns.

In addition, the groups did not differ on the number of patients who received special education for learning difficulties nor on distributions of their pre-injury, primary vocational activities (see Table 3). Prior to the time of injury, approximately 60% of each group was either employed, students, or homemakers. The remaining patients in each group were either unemployed, retired, or on worker's disability prior to their injury.

Table 3

Frequency of Pre-Injury Conditions and Functioning for the Head-Injury (HI) and Trauma Control Groups

History	Groups: Low Report HI n=19	High Report HI n=24	Trauma Controls n=41	p value
Neurological Problems				ns
% Yes	42.1	50.0	56.1	
Alcohol Abuse				ns
% Yes	42.1	37.5	53.7	
Substance Abuse				ns
% Yes	15.5	20.8	12.2	
Psychiatric Disorders				ns
% Yes	21.1	12.5	17.1	
Special Education				ns
% Yes	10.5	20.8	19.5	
Vocational Activities				ns
Working ≥ 50%	7	12	22	
Working < 50%	0	1	0	
Unemployed	5	8	9	
Student	5	1	3	
Homemaker	0	0	2	
Other	2	2	5	

(continued)

Table 3 (continued)

Frequency of Pre-Injury Conditions and Functioning for the Head-Injury (HI) and Trauma Control Groups

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Note. Group comparisons were conducted using the chi-square test. Pairwise group chi-square tests with Yates' continuity correction were performed for psychiatric history due to small cell frequencies, and were not significant. Categories for vocational history were combined due to small cell frequencies to form "Working", "Unemployed", and "Other" categories for the test comparison. Neurological Problems = the presence or absence of pre-injury neurological illnesses and/or head injuries. Alcohol Abuse = the presence or absence of pre-injury alcohol abuse and/or treatment. Substance Abuse = the presence or absence of pre-injury substance abuse and/or treatment. Psychiatric Disorders = the presence or absence of pre-injury psychiatric diagnosis and/or hospitalization. Special Education = the presence or absence of pre-injury special education for learning difficulties. Vocational Activities = interviewer rating of pre-injury vocational functioning. Working ≥ 50% = employed at 50% of time or greater. Working < 50% = employed at less than 50% time. ns = not significant.

Since pre-injury conditions, such as neurological problems and alcohol and substance abuse are potentially important in terms of their possible effects on cognitive performance post-injury, the groups were further examined for differences in the co-occurrence of pre-injury neurological problems and alcohol and/or substance abuse. Table 4 shows the group frequencies of neurological problems for both patients with and without a history of alcohol and/or substance abuse. Chi-square analyses indicated no significant differences between the groups for the presence or absence of neurological problems for those with, $\chi^2(2, \underline{N} = 44) = 0.79$, ns, and without, $\chi^2(2, \underline{N} = 40) = 0.40$, ns, alcohol and/or substance abuse histories.

The distributions for the injury severity measures were skewed, with most patients scoring in the milder ranges of severity across the three measures. Given the non-normal distributions for these variables, nonparametric tests (i.e., Mann-Whitney $\underline{U}$ and Kruskal-Wallis tests) were used to assess differences between the groups. The two head injury groups did not differ significantly on either the Glasgow Coma Scale, assessed at time of injury, or time to follow commands, measured from the time of injury forward (see Table 5). Although the time to follow commands had a broader range of scores for the high-report head-injury group, both groups had similar distributions

Table 4

Frequency of Pre-Injury Neurological Conditions by History of Alcohol and/or Substance Abuse for the Head-Injury (HI) and Trauma Control Groups

	Groups		
	Low Report HI	High Report HI	Trauma Controls
History	n=19	n=24	n=41
No History of Alcohol and/or Substance Abuse			
Neurological Problems			
None	6	7	10
Illness	1	2	1
Head Injury	1	4	4
Both	1	0	3
History of Alcohol and/or Substance Abuse			
Neurological Problems			
None	5	5	8
Illness	3	2	6
Head Injury	0	3	2
Both	2	1	7

(continued)

Table 4 (continued)

Frequency of Pre-Injury Neurological Conditions by History of Alcohol and/or Substance Abuse for the Head-Injury (HI) and Trauma Control Groups

Note. Chi-square analyses after combining the "Illness", "Head Injury", and "Both" categories due to small cell frequencies revealed no significant differences between the groups. Neurological Problems refers to the pre-injury occurrence of neurological disorders, head injuries, or both. Illness = neurological disorders, including learning disability, epilepsy, meningitis, and neoplastic disease.

Table 5

Descriptive Statistics and Comparisons of Injury Severity for the Head-Injury (HI) and Trauma Control Groups

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Severity	n=19	n=24	n=41	Test
Glasgow Coma Scale				-0.38
M	12.6	12.1	----	
SD	3.8	3.4	----	
Median	15.0	14.3	----	
Mode	15.0	15.0	----	
Range	3-15	6-15	----	
Time to Follow Commands, hrs.				-1.55
M	22.8	75.3	----	
SD	57.8	153.5	----	
Median	2.0	10.0	----	
Mode	1.0	1.0	----	
Range	0-240	1-576	----	
Injury Severity Score				4.49
M	5.1	6.5	6.4	
SD	6.3	6.7	4.8	
Median	4.0	4.0	5.0	
Mode	1.0	1.0	5.0	
Range	0-22	0-24	1-29	

Note. Group comparisons for the Glasgow Coma Scale and time to follow commands were conducted with Mann-Whitney U tests computed as a z score corrected for ties. The Kruskal-Wallis test, computed with the chi-square statistic corrected for ties, was used to assess group differences for the Injury Severity Score. Higher scores indicate greater severity for all measures. All group comparisons were not significant.

with the majority of patients scoring in the mild to moderate range. In addition, the low-report head-injury, high-report head-injury, and trauma control groups did not differ significantly on the Injury Severity Score, assessing severity of injury to body systems excluding the head (see Table 5).

Cognitive and Emotional Measures at One Month Post-Injury

Since the scores for the neuropsychological and emotional adjustment measures were not normally distributed, the head-injury and trauma control groups were compared using the Kruskal-Wallis (K-W) nonparametric analysis of variance. Table 6 shows median scores and comparisons for the neuropsychological measures. There were significant group effects for the WAIS Full Scale IQ, WAIS Performance IQ, Wechsler Memory Scale - Memory Quotient, total recall and consistent long-term retrieval of the Selective Reminding test, and both parts A and B of the Trail Making Test. No group differences were observed for the other neuropsychological measures assessed at one month post-injury.

Significant group effects were followed by pairwise comparisons using the Mann-Whitney (M-W) U test. The pairwise tests indicated that the high-report head-injury group performed significantly more poorly on the WAIS Full

Table 6

Median Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups at One Month Post-Injury

Measures	Low Report HI n=19	High Report HI n=24	Trauma Controls n=41	K-W
WAIS				
FSIQ	92.0	86.0[a]***	93.0	7.78***
VIQ	93.0	85.5	91.0	4.43
PIQ	94.0	89.0[a]**	97.0	9.21***
WMS				
MQ	94.0	84.5[a]*	94.0	7.67***
Log. Memory	18.0	15.0	16.0	0.77
30' Delay	13.0	9.0	12.0	3.19
Vis. Reprod.	9.0	7.0	8.0	0.64
30' Delay	7.0	5.0	7.0	3.64
SRT				
Total Recall	82.0	71.5[b]****	83.0	10.25****
CLTR	66.0	43.5[b]****	67.0	8.17***
Trail Making Test				
Part A, sec.	36.0	43.5[a]**	31.0	6.97**
Part B, sec.	73.0	114.0[a]**	88.0	8.01***
Category Errors	51.0	66.5	71.0	3.29
Finger Oscillation				
Dom Hand	48.0	48.0	49.5	1.59
NDom Hand	47.0	46.5	46.0	0.77
Impairment Index	0.7	0.7	0.6	5.08

(continued)

Table 6 (continued)

Median Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups at One Month Post-Injury

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Note. Median scores are presented in place of mean values due to skewed distributions for the dependent variables. The Kruskal-Wallis test was used to assess group differences. Significant group effects were followed by pairwise Mann-Whitney U tests. Higher scores indicate poorer performance for the Impairment Index, Trail Making Test, and Category Errors. Lower scores indicate poorer performance for all other tests. WAIS = Wechsler Adult Intelligence Scale. WMS = Wechsler Memory Scale. MQ = Memory Quotient. Log. Memory = Logical Memory subtest. Vis. Reprod. = Visual Reproduction subtest. 30' Delay = delayed recall after 30 minutes. SRT = Selective Reminding Test. Dom = dominant. NDom = non-dominant. Impairment Index = Halstead-Reitan Impairment Index. K-W = Kruskal-Wallis test computed with the chi-square statistic corrected for ties.

[a]This group differs significantly from the other two groups.

[b]This group differs significantly from the trauma controls.

*$p < .05$

**$p < .04$

***$p < .02$

****$p < .006$

scale IQ, WAIS Performance IQ, Wechsler Memory Scale - Memory Quotient, and both parts A and B of the Trail Making Test than the other two groups. In addition, the high-report head-injury group performed significantly more poorly on the total recall and consistent long-term retrieval scores of the Selective Reminding test compared to the trauma controls, but did not differ from the low-report head-injury group (see Table 6). No differences on the neuropsychological measures were observed between the low-report head-injury group and the trauma controls.

Table 7 shows median scores and comparisons for the Katz Adjustment Scale. Significant group effects were found for the withdrawn depression, psychoticism, and cluster total scores. The groups did not differ significantly on the obstreporousness score. Pairwise comparisons using the Mann-Whitney U test indicated that the low-report head-injury group scored significantly lower on the withdrawn depression, psychoticism, and cluster total scores than both other groups, while the high-report head-injury group scored higher on the withdrawn depression score compared to the trauma controls (see Table 7).

Consistent with hypothesis 1a, the high-report head-injury patients demonstrated poorer performance at one month post-injury on several neuropsychological measures, including the Wechsler Adult Intelligence Scale,

Table 7

Median Scores and Comparisons of Emotional Adjustment Measures for the Head-Injury (HI) and Trauma Control Groups at One Month Post-Injury

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Measures	n=19	n=24	n=41	K-W
Katz Adjustment Scale				
Depression	14.0[b]**	21.5[a]***	17.0	23.30****
Obstreporousness	22.0	23.5	26.0	5.23
Psychoticism	18.0[a]*	21.5	21.0	6.61*
Cluster Total	59.0[a]**	67.5	62.6	12.88***

Note. Median scores are presented in place of mean values due to skewed distributions of the dependent variables. The Kruskal-Wallis test was used to assess group differences. Significant group effects were followed by pairwise Mann-Whitney U tests. Higher scores indicate more emotional problems. Depression = withdrawn depression score. K-W = Kruskal-Wallis test computed with the chi-square statistic corrected for ties.

[a]This group differs significantly from the other two groups.

[b]This group differs significantly from the trauma controls.

(continued)

Table 7 (continued)

Median Scores and Comparisons of Emotional Adjustment Measures for the Head-Injury (HI) and Trauma Control Groups at One Month Post-Injury

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*p < .04

**p < .01

***p < .002

****p < .0001

Wechsler Memory Scale, Selective Reminding Test, and Trail Making Test compared to the trauma control group. However, hypothesis 1a was not fully supported by the data, as the low-report head-injury group did not differ significantly from the trauma controls on any cognitive measures at one month post-injury. Further, hypothesis 1b was clearly not supported by the current results, with the high-report head-injury group showing significantly poorer performance than the low-report head-injury patients on several neuropsychological measures at one month post-injury. In contrast, hypothesis 2a was supported by the current results, with the low-report head-injury group reporting less emotional difficulties at one month post-injury on the withdrawn depression, psychoticism, and cluster total scores of the Katz Adjustment Scale compared to both the high-report head-injury and trauma control groups. Support was also shown for hypothesis 2b, with the high-report head-injury group reporting more emotional difficulties on the withdrawn depression score of the Katz Adjustment Scale at one month post-injury than the trauma control group.

Cognitive and Emotional Measures at One Year Follow-Up

Preliminary Analyses. At one year post-injury, five patients from the high-report head-injury group, four from the low-report head-injury group, and four trauma controls declined to return for follow-up evaluations. These patients had either moved out of the Seattle area since their first evaluation or were unwilling to travel to the medical center to continue their participation in the longitudinal study.

Examination of the groups on age for this follow-up sample of head-injury and trauma control patients revealed an age difference, K-W, $\chi^2(2, N = 71) = 8.52$, $p<.01$, with the trauma controls significantly older than the low-report head-injury group, M-W, $z = -2.68$, $p<.007$. The two head injury groups did not differ significantly from each other on age, M-W, $z = -1.41$, ns. To match the groups on distributions of age, six additional trauma control patients with ages greater than 57 were excluded from the group, producing similar age ranges for the low-report head-injury (n=15), high-report head-injury (n=19), and trauma control (n=31) groups at one year post-injury. The three groups also did not differ significantly on distributions of years of education, gender, race, and handedness (see Table 8).

Table 8

Demographic Data for Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Demographics	*n*=15	*n*=19	*n*=31	*p* value
Age, yrs.				ns
M	26.1	29.7	32.6	
SD	10.8	10.2	11.1	
Median	24.0	29.0	32.0	
Range	15-48	16-57	16-55	
Education, yrs.				ns
M	11.1	11.6	11.2	
SD	2.3	2.0	2.5	
Median	11.0	11.0	12.0	
Range	7-16	8-16	5-16	
Gender, freq.				ns
Male	11	14	20	
Female	4	5	11	
Race, freq.				ns
white	11	13	16	
black	3	3	11	
other	1	3	4	
Handedness, freq.				ns
Right	15	17	24	
Left	0	2	7	

(continued)

Table 8 (continued)

Demographic Data for Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

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Note. One-way analysis of variance was used to test group effects for age and education. Chi-square tests assessed group differences for gender and race with the "black" and "other" categories combined due to small cell frequencies. Pairwise group chi-square tests with Yates' continuity correction were conducted for handedness comparisons between the head-injury and trauma control groups due to small cell frequencies, and were not significant. Fisher's exact test was used for the handedness comparison between the head-injury groups due to a small sample size (n < 40) and low cell frequencies, and was not signif-icant. freq.= frequency. Other = Native-American and Asian-American. ns = not significant.

To ensure that the follow-up patients were representative of the initial patient sample seen at one month post-injury, the follow-up groups were similarly compared on the occurrence of pre-injury conditions and injury severity. Table 9 shows the relative frequencies for pre-existing conditions and pre-injury vocational functioning for the head-injury and trauma control groups seen at one year post-injury. No significant differences were observed for pre-injury neurological problems, alcohol abuse, substance abuse, psychiatric disorders, special education, and major vocational activities. Further, there was no significant difference between the groups for the presense or absence of neurological problems for those patients with, $\chi^2(2, \underline{N} = 34) = 0.76$, ns, and without, $\chi^2(2, \underline{N} = 31) = 0.89$, ns, prior alcohol and/or substance abuse histories.

The types of pre-injury neurological problems for these patients were consistent with those seen in the one month sample, with previous head injuries, epilepsy, and learning disability being the most prevalent. The individual cases of pre-injury meningitis and neoplastic disease remained in the groups at one year follow-up. A chi-square test to assess for differences between the groups for the types of pre-injury neurological problems present among those patients seen at one year was also not

Table 9

Frequency of Pre-Injury Conditions and Functioning for the Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
History	n=15	n=19	n=31	p value
Neurological Problems				ns
% Yes	53.3	47.4	61.3	
Alcohol Abuse				ns
% Yes	40.0	31.6	58.1	
Substance Abuse				ns
% Yes	13.3	26.3	16.1	
Psychiatric Disorders				ns
% Yes	13.3	10.5	16.1	
Special Education				ns
% Yes	13.3	21.1	25.8	
Vocational Activities				ns
Working ≥ 50%	6	10	16	
Working < 50%	0	1	0	
Unemployed	4	6	8	
Student	5	1	3	
Homemaker	0	0	1	
Other	0	1	3	

(continued)

Table 9 (continued)

Frequency of Pre-Injury Conditions and Functioning for the Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

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Note. Group comparisons were conducted using the chi-square test. Categories for vocational history were combined due to small cell frequencies to form "Working", "Unemployed", and "Other" categories. Pairwise group chi-square tests with Yates' continuity correction were performed between the head-injury and trauma control groups for psychiatric, special education, and vocational histories due to small cell frequencies, and were not significant. Fisher's exact test was used for comparisons between the two head-injury groups for psychiatric, special education, and vocational histories due to small sample sizes (n's < 40) and low cell frequencies, and were not significant. Neurological Problems = the presence or absence of pre-injury neurological illnesses and/or head injuries. Alcohol Abuse = the presence or absence of pre-injury alcohol abuse and/or treatment. Substance Abuse = the presence or absence of pre-injury substance abuse and/or treatment. Psychiatric Disorders = the presence or absence of pre-injury psychiatric diagnosis and/or hospitalization. Special Education = the presence or absence of pre-injury special education for learning difficulties. Vocational Activities = rating of pre-injury vocational functioning. Working ≥ 50% = employed at 50% of time or greater. Working < 50% = employed at less than 50% time. ns = not significant.

significant, $\chi^2(10, N = 65) = 13.53$, ns.

The two head-injury groups were not significantly different on the Glasgow Coma Scale and time to follow commands; and the three groups did not differ significantly on the Injury Severity Score (see Table 10). In addition, performance on the neuropsychological and emotional measures at one month post-injury were examined for those patients included in the one year follow-up groups. The overall pattern of findings for the follow-up groups was generally consistent with the results observed for the whole head-injury and trauma control sample evaluated at one month. Specifically, overall significant group effects were found for the Halstead-Reitan Impairment Index, K-W, $\chi^2(2, N = 65) = 9.17$, $p<.01$, the total recall, K-W, $\chi^2(2, N = 65) = 9.46$, $p<.009$, and consistent long-term retrieval, K-W, $\chi^2(2, N = 65) = 8.33$, $p<.02$, scores of the Selective Reminding test, both parts A, K-W, $\chi^2(2, N = 65) = 6.61$, $p<.04$, and B, K-W, $\chi^2(2, N = 65) = 6.50$, $p<.04$, of the Trail Making Test, and the withdrawn depression, K-W, $\chi^2(2, N = 65) = 16.35$, $p<.0003$, and cluster total, K-W, $\chi^2(2, N = 65) = 7.61$, $p<.02$, scores of the Katz Adjustment Scale at one month post-injury for the one year follow-up sample.

Follow-up pairwise comparisons indicated that the high-report head-injury group performed more poorly than

Table 10

Descriptive Statistics of Injury Severity for the Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Severity	*n*=15	*n*=19	*n*=31	Test
Glasgow Coma Scale				-0.07
M	12.0	11.9	----	
SD	4.1	3.7	----	
Median	13.5	15.0	----	
Mode	15.0	15.0	----	
Range	3-15	6-15	----	
Time to Follow Commands, hrs.				-0.90
M	26.9	88.5	----	
SD	62.8	168.5	----	
Median	3.0	8.0	----	
Mode	1.0	1.0	----	
Range	0-240	1-576	----	
Injury Severity Score				0.85
M	6.0	7.2	6.4	
SD	6.8	7.2	5.2	
Median	4.0	4.0	5.0	
Mode	5.0	1.0	4.0	
Range	0-22	0-24	1-29	

(continued)

Table 10 (continued)

Descriptive Statistics of Injury Severity for the Head-Injury (HI) and Trauma Control Groups Used for Comparisons at One Year Follow-Up

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Note. Group comparisons for the Glasgow Coma Scale and time to follow commands were conducted with Mann-Whitney U tests computed as z scores corrected for ties. The Kruskal-Wallis test, computed with the chi-square statistic corrected for ties, was used to assess group differences for the Injury Severity Score. Higher scores indicate greater severity on all measures. All group comparisons were not significant.

the low-report head-injury and trauma control groups on the total recall, M-W, $z = -2.19$, $p<.03$ and $z = -2.95$, $p<.003$, respectively, and consistent long-term retrieval, M-W, $z = -2.15$, $p<.03$ and $z = -2.75$, $p<.006$, respectively, scores of the Selective Reminding Test. The high-report head-injury group also scored more poorly than the trauma controls on the impairment index, M-W, $z = -2.99$, $p<.003$, and part A of the Trail Making test, M-W, $z = -2.52$, $p<.01$, and more poorly than the low-report head-injury group on part B of the Trail Making Test, M-W, $z = -2.41$, $p<.02$.

In addition, the low-report head-injury group scored lower than the high-report head-injury and trauma control groups on the cluster total score, M-W, $z = -2.41$, $p<.02$ and $z = -2.48$, $p<.01$, respectively, of the Katz Adjustment Scale, while the high-report head-injury group scored higher than the low-report head-injury, M-W, $z = -3.82$, $p<.0001$, and trauma control, M-W, $z = -2.80$, $p<.005$, groups on the withdrawn depression score.

Group Differences. Comparison of the groups on the neuropsychological measures at one year post-injury revealed no significant differences between the groups (see Table 11). There were also no significant differences for the groups on the Katz Adjustment Scale scores at one year

Table 11

Median Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups at One Year Post-Injury

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Measures	n=15	n=19	n=31	K-W
WAIS				
FSIQ	95.0	94.0	95.0	0.34
VIQ	94.0	93.0	88.0	0.41
PIQ	95.0	94.0	99.0	0.94
WMS				
MQ	92.0	92.0	93.0	0.96
Log. Memory	14.0	16.0	16.0	0.47
30' Delay	12.0	11.5	14.0	1.76
Vis. Reprod.	11.0	8.0	8.0	0.86
30' Delay	9.0	6.0	7.0	1.94
SRT				
Total Recall	82.0	71.5	82.0	2.36
CLTR	66.0	55.0	66.0	2.97
Trail Making Test				
Part A, sec.	29.0	30.0	26.0	1.24
Part B, sec.	74.0	91.0	96.0	2.22
Category Errors	36.0	43.0	53.0	2.07
Finger Oscillation				
Dom Hand	48.0	51.0	52.0	2.53
NDom Hand	47.0	47.0	49.0	1.10
Impairment Index	0.4	0.4	0.6	0.13

(continued)

Table 11 (continued)

Median Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups at One Year Post-Injury

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Note. Median scores are presented in place of mean values due to skewed distributions of the dependent variables. The Kruskal-Wallis test was used to assess group differences. All group comparisons were not significant. Higher scores indicate poorer performance for the Impairment Index, Trail Making Test, and Category Errors. Lower scores indicate poorer performance for all other tests. WAIS = Wechsler Adult Intelligence Scale. WMS = Wechsler Memory Scale. MQ = Memory Quotient. Log. Memory = Logical Memory subtest. Vis. Reprod. = Visual Reproduction subtest. 30' Delay = delayed recall after 30 minutes. SRT = Selective Reminding Test. Dom = dominant. NDom = non-dominant. Impairment Index = Halstead-Reitan Impairment Index. K-W = Kruskal-Wallis test computed with chi-square statistic corrected for ties.

post-injury (see Table 12). Difference scores (i.e., one month - one year) were computed for each subject on the dependent measures to examine change in functioning over time. The distributions for the difference scores were skewed, so group comparisons were performed using the Kruskal-Wallis and Mann-Whitney U tests.

Overall significant group effects were observed for the difference scores on part A of the Trail Making test, the Finger Oscillation test with the dominant hand, and the Halstead-Reitan Impairment Index (see Table 13). No significant differences were observed on the difference scores for the other neuropsychological measures. However, trends towards significance were found for the WAIS Verbal IQ and the total recall score of the Selective Reminding test.

Pairwise comparisons using the Mann-Whitney U test were conducted for those neuropsychological variables showing significant group effects on the difference scores. The high-report head-injury group showed greater change with improved performance on part A of the Trail Making Test and the Halstead-Reitan Impairment Index compared to the trauma controls, as well as greater improvement on the Finger Oscillation Test with the dominant hand than both the low-report head-injury and trauma control groups (see Table 13).

Table 12

Median Scores and Comparisons of Emotional Adjustment Measures for the Head-Injury (HI) and Trauma Control Groups at One Year Post-Injury

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Measures	n=15	n=19	n=31	K-W
Katz Adjustment Scale				
Depression	14.0	17.0	14.0	1.16
Obstreporousness	25.0	24.0	28.0	1.09
Psychoticism	19.5	19.0	20.0	0.01
Cluster Total	58.5	59.0	65.0	1.09

Note. Median scores are presented in place of mean values due to skewed distributions of the dependent variables. The Kruskal-Wallis test was used to assess group differences. Higher scores indicate more emotional problems. All group comparisons were not significant. Depression = withdrawn depression score. K-W = Kruskal Wallis test computed with the chi-square statistic corrected for ties.

Table 13

Median Difference Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups for One Month Minus One Year

Measures	Groups: Low Report HI *n*=15	High Report HI *n*=19	Trauma Controls *n*=31	K-W
WAIS				
FSIQ	-3.0	-4.0	-2.0	3.55
VIQ	-1.0	-4.0	-1.0	5.27+
PIQ	-3.0	-2.0	-2.0	0.94
WMS				
MQ	-3.0	0.0	0.0	0.83
Log. Memory	0.0	-0.5	1.0	1.47
30' Delay	1.0	-1.0	-1.0	3.42
Vis. Reprod.	0.0	1.0	0.0	0.23
30' Delay	-1.0	1.5	-1.0	1.06
SRT				
Total Recall	-1.0	-4.0	1.0	5.26+
CLTR	-4.0	-8.0	-3.0	3.12
Trail Making Test				
Part A, sec.	7.0	9.0[b**]	1.0	6.14*
Part B, sec.	-7.0	0.0	-5.0	3.20
Category Errors	10.0	18.0	10.0	1.00
Finger Oscillation				
Dom Hand	0.0	-3.0[a*]	-1.0	6.05*
NDom Hand	-2.5	-3.0	-1.0	1.38
Impairment Index	0.1	0.2[b***]	0.1	7.35**

(continued)

Table 13 (continued)

Median Difference Scores and Comparisons of Neuropsychological Measures for the Head-Injury (HI) and Trauma Control Groups for One Month Minus One Year

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Note. Median difference scores are presented in place of mean values due to skewed distributions of the dependent variables. The Kruskal-Wallis test was used to assess group differences. Significant group effects were followed by pairwise Mann-Whitney U tests. Positive median values indicate improvement over time for the Impairment Index, Trail Making Test, and Category Errors. Negative median scores indicate improvement for all other tests. WAIS = Wechsler Adult Intelligence Scale. WMS = Wechsler Memory Scale. MQ = Memory Quotient. Log. Memory = Logical Memory subtest. Vis. Reprod. = Visual Reproduction subtest. 30' Delay = delayed recall after 30 minutes. SRT = Selective Reminding Test. Dom = dominant. NDom = non-dominant. Impairment Index = Halstead-Reitan Impairment Index. K-W = Kruskal-Wallis test computed with chi-square statistic corrected for ties.

[a]This group differs significantly from the other two groups.

[b]This group differs significantly from the trauma controls.

*$p < .05$

**$p < .03$

***$p < .008$

+$p = .07$, trend

Table 14 shows the median difference scores and group comparisons for the Katz Adjustment Scale. Overall significant group effects were observed with the difference scores for the withdrawn depression and cluster total scores. No significant differences were found for the other emotional adjustment scores. Mann-Whitney *U* pairwise comparisons indicated that the high-report head-injury group differed significantly from both other groups on the withdrawn depression score, while only differing from the low-report head-injury group on the cluster total score (see Table 14). Examination of the distributions of the difference scores for the significant Katz Adjustment Scale variables indicated that the high-report head-injury group showed a greater change than the other groups, with a decrease in reporting of emotional difficulties over time.

In addition to several neuropsychological and emotional adjustment measures, the groups differed significantly on the difference score for the sum of the Communication and Alertness Behavior subscales of the Sickness Impact Profile, K-W, $\chi^2(2, N = 65) = 27.99$, $p<.0001$. Pairwise Mann-Whitney *U* tests indicated that each group differed significantly from each other, with the high-report head-injury group showing the greatest change over time (Median difference score = 0.48),

Table 14

Median Difference Scores and Comparisons of Emotional Adjustment Measures for the Head-Injury (HI) and Trauma Control Groups for One Month Minus One Year

	Groups			
	Low Report HI	High Report HI	Trauma Controls	
Measures	n=15	n=19	n=31	K-W
Katz Adjustment Scale				
Depression	0.0	6.0[a]**	2.0	10.13***
Obstreporousness	-1.0	-1.0	0.0	1.00
Psychoticism	-1.5	0.0	2.0	2.78
Cluster Total	-2.5	8.0[b]*	3.0	5.91*

Note. Median scores are presented in place of mean values due to skewed distributions of the dependent variables. The Kruskal-Wallis test was used to assess group differences. Significant group effects were followed by pairwise Mann-Whitney U tests. Positive median values indicate a decrease in emotional problems over time. Depression = withdrawn depression score. K-W = Kruskal-Wallis test computed with chi-square statistic corrected for ties.

[a]This group differs significantly from the other two groups.

[b]This group differs significantly from the low-report head-injury group.

(continued)

Table 14 (continued)

Median Difference Scores and Comparisons of Emotional Adjustment Measures for the Head-Injury (HI) and Trauma Control Groups for One Month Minus One Year

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*$p < .05$

**$p < .01$

***$p < .006$

followed by the trauma controls (Median difference score = 0.08) and the low-report head-injury (Median difference score = 0.0) groups, respectively. Further, comparison of the groups show no significant difference for the combined score of the Communication and Alertness Behavior subscales of the Sickness Impact Profile at one year post-injury, K-W, $\chi^2(2, \underline{N} = 65) = 3.83$, ns. Although these latter findings are limited by floor effects on this measure for the low-report head-injury and trauma control groups, they do suggest a decrease in self-report of cognitive difficulties for the high-report head-injury group over time.

These results do not support hypothesis 3a, with the low-report head-injury group showing no significant difference for the change in performance on the neuropsychological measures from one month to one year compared to the trauma controls. However, hypothesis 3b was supported by the current findings, with the high-report head-injury group showing a significantly greater change than the trauma controls with improved performance on the Halstead-Reitan Impairment Index, Finger Oscillation Test with the dominant hand, and part A of the Trail Making Test. Further, the results indicated that the high-report head-injury group showed a decrease in the report of cognitive and emotional difficulties from one month to one year.

Computed-Tomography Scans for the Head-Injury Groups

The computed-tomography scans received good quality ratings for all patients in head-injury groups. Approximately 53% of the low-report head-injury group and 29% of the high-report head-injury group presented with contusions on the computed-tomography scans, but this difference was not significant, $\chi^2(1, N = 43) = 1.55$, ns, with Yates' continuity correction. Examination of the distributions of contusions for both groups revealed no systematic difference in the occurrence of contusions by hemisphere or by the size of the contusions (i.e, small versus extensive). Due to the relatively low number of contusions present, the frequencies for each patient were collapsed across the hemisphere and size variables. Examination of contusions by brain-lobe location (i.e., frontal versus other) showed that the low-report head-injury group had more contusions in the frontal cortical regions than the high-report head-injury patients, but this difference was not significant, Fisher's exact probability test, ns, one-tailed (see Table 15). Neither the low- nor high-report head-injury patients showed evidence of hematomas or focal atrophy on the computed-tomography

Table 15

Frequency of Cortical Contusions on Computed-Tomography Scans for the Head-Injury (HI) Groups at Time of Injury

	Groups	
	Low Report HI	High Report HI
Location	n=19	n=24
Frontal	4	2
Frontotemporal	3	0
Frontoparietal	1	1
Temporal	2	0
Temporoparietal	0	2
Parietal	0	2
Occipital	0	0
None	9	17

Note. Frequencies for each lobe location were collapsed across hemispheres due to the low numbers of contusions for each group. Fisher's exact test was used to compare frontal versus other contusions between the groups and was not significant.

scans.

Although the difference between the head injury groups for the relative frequency of contusions by brain-lobe location did not reach significance, it does suggest the possibility of a subgroup of low-report head-injury patients with frontal contusions who may show a difference in the pattern of performance or greater severity on the neuropsychological measures in relation to the high-report head-injury group. To test this possibility, the group of low-report head-injury patients having, but not limited to, frontal contusions (n=8) was compared on the neuropsychological and emotional adjustment measures at one month post-injury to all the high-report head-injury patients presenting with contusions (n=7).

Although the sample sizes for these comparisons were small, the findings were consistent with those found for the whole sample of patients at one month post-injury. Specifically, the high-report head-injury group performed more poorly than the low-report head-injury group on several neuropsychological measures at one month post-injury, including the WAIS Verbal IQ, M-W, $z = -1.97$, $p<.05$, total recall score of Selective Reminding Test, M-W, $z = -2.09$, $p<.04$, and part B of the Trail Making Test, M-W, $z = -1.97$, $p<.05$. On the Katz Adjustment Scale at one month post-injury, the high-report head-injury group scored higher on the withdrawn depression, M-W, z = -2.97, p<.003, and cluster total, M-W, z = -2.03, p<.04, scores compared to the low-report head-injury group.

As with the whole head-injury sample, the groups did not differ significantly on the Glasgow Coma Scale, M-W, z = -0.12, ns, time to follow commands, M-W, z = -1.81, ns, and Injury Severity Score, M-W, z= -0.06, ns. They also did not differ on distributions of age, M-W, z = -1.57, ns, years of education, M-W, z = -0.95, ns, gender, Fisher's exact probability test, ns, two-tailed, race, Fisher's exact probability test, ns, two-tailed, and handedness, Fisher's exact probability test, ns, two-tailed.

These results do not support hypothesis 4a, as the low-report head-injury group did not differ from the high-report head-injury patients on the relative frequency of cortical contusions seen on computed-tomography scans. Further, the low-report head-injury patients did not show a significantly higher relative frequency of contusions in the frontal brain regions compared to the high-report head-injury group. This latter finding indicates that hypothesis 4b was not supported. In addition, follow-up analyses for those head-injury patients who showed cortical contusions revealed a pattern of test performance similar to that seen for the whole head-injury sample. Specifically, the high-report head-injury patients with contusions showed poorer performance on several neuropsychological measures and reported more emotional difficulties at one month post-injury than the low-report head-injury patients with frontal contusions.

DISCUSSION

The purpose of the present study was to examine the neurobehavioral and emotional consequences of inaccurate self-reporting of cognitive difficulties following traumatic head injury. The head-injury literature has suggested that patients who are inaccurate in their report of cognitive problems or unaware of their deficits may have greater impairment on objective measures of cognitive functioning (Prigatano & Fordyce, 1986b), while showing less emotional distress than patients who are more accurate in their self-report of cognitive symptoms (Prigatano, 1991). Further, it has been theorized that this form of impaired self-monitoring behavior may occur more frequently among patients with specific brain injuries in the region of the frontal cortex (Stuss, 1991).

The current study sought to examine inaccurate self-report of cognitive functioning in terms of neuropsychological, emotional, and structural brain-imaging variables. Patients who were testable at one month after the injury and who had a documented and significant overall level of cognitive impairment were selected from a large consecutively-admitted, representative sample of head-injury patients. Within this selected sample, those patients who reported no cognitive difficulties resulting from their recent head injury were compared at one month and one year post-injury to patients who had a high number of complaints concerning cognitive problems occurring since the injury.

To control for the potential cognitive effects of pre-existing neurological and psychiatric conditions in this consecutive-series sample, a comparison group of patients who experienced acute traumatic injury to body systems other than the head, but presented with similar medical and psychosocial histories as the head-injury patients were included.

Group Differences at One Month Post-Injury

It was hypothesized that both the high- and low-report head-injury groups would perform more poorly on neuropsychological measures than the trauma controls at one month post-injury. Only partial support for this prediction was shown. The high-report head-injury group scored significantly more poorly than the trauma controls on several neuropsychological measures, but the low-report head-injury patients did not differ significantly from the trauma controls.

Further, it was expected that the low-report head-injury patients would perform more poorly on the neuropsychological measures than the high-report head-injury group at one month post-injury. In sharp contrast to this hypothesis, the low-report head-injury group performed better than the high-report head-injury patients on five measures of neuropsychological functioning, including tests assessing general intellectual functions, memory, cognitive flexibility, and attention. This suggests that the differences between the two head-injury groups on the neuropsychological measures are not isolated to one specific area of cognitive functioning, but rather are indicative of a generally higher level of overall cognitive impairment among the high-report head-injury patients as assessed at one month post-injury.

In addition, it was hypothesized that the low-report head-injury group would report less emotional difficulties than both the high-report head-injury patients and trauma controls, while the high-report head-injury group would report more emotional difficulties than the trauma control group at one month post-injury. Consistent with this hypothesis, the low-report head-injury patients did report significantly fewer emotional difficulties on the withrawn depression, psychoticism, and cluster total scores of the Katz Adjustment Scale at one month following the injury compared to the other head-injury and trauma control groups. Further, the high-report head-injury group reported more emotional difficulties on the withdrawn depression score at one month post-injury compared to the trauma controls. Thus, those head-injury patients who reported no cognitive difficulties at one month post-injury also reported fewer emotional difficulties at that time compared to the head injury patients who reported a high number of cognitive problems one month after the injury.

It is possible that these latter significant effects are not specifically related to differences among patients based on reporting of cognitive problems, but rather are a function of a general low versus high report style, irrespective of the self-report measure used. However, the three groups did not differ significantly on the obstreporousness score, and the high-report head-injury and trauma control groups did not differ on the psychoticism and cluster total scores. Thus, the possibility that the observed differences between the groups on emotional adjustment measures at one month post-injury are due to a general report bias among the groups seems unlikely.

In contrast to previous studies (McKinlay & Brooks, 1984; Prigatano, Altman, & O'Brien, 1990; Prigatano &

Fordyce, 1986b; Rimel et al., 1981), the current findings suggest that there appears to be a good correspondence between patient reports of cognitive difficulties and performance on neuropsychological and emotional measures for head-injury patients at one month post-injury. Although the low-report head-injury patients had significant overall cognitive impairment, as indicated by the 0.4 or greater selection criterion on the Halstead-Reitan Impairment Index, they performed better on several neuropsychological measures than the high-report head-injury group, reported fewer emotional difficulties, and could not be distinguished in terms of cognitive performance from control patients who had similar premorbid medical and vocational histories, but no acute head injury. In contrast, high-symptom reporting of cognitive problems in the high-report head-injury group was consistent with greater impairment on cognitive testing as well as greater reports of emotional distress at one month post-injury.

The current findings are not consistent with previous reports (McKinlay & Brooks, 1984; Prigatano & Fordyce, 1986b) of greater cognitive impairment among low-symptom reporting head-injury patients. It should be noted that the current study differs from most studies reported in the literature addressing inaccurate self-reporting of cognitive symptoms or impaired awareness following head injury. The head-injury sample in the current study included two groups of relatively mild head-injury patients who were matched on general measures of head-injury severity and were selected from a representative sample of patients evaluated in consecutive series. Previous studies (McKinlay & Brooks, 1984; Prigatano & Fordyce, 1986b) reporting greater impairment among head-injury patients with inaccurate reporting of symptoms have typically included patients with more severe head injuries. That the low-report head-injury group in the current sample did not show greater cognitive impairment than the high-report head-injury and trauma control groups may be, in part, a function of the milder level of head-injury severity in the current sample.

In addition, most studies addressing the question of inaccurate symptom reporting following head injury have defined the head-injury groups in terms of patient versus family or caregiver perceptions of cognitive problems. The use of family or caregiver reports as a standard for comparison has been questioned (McKinlay & Brooks, 1984; McKinlay et al., 1981; Romano, 1974), but remains the most commonly used method for identifying head-injury patients with impaired awareness of cognitive deficits. In the current study, the low- and high-symptom reporting head-injury groups were formed using patient perceptions of cognitive difficulties in relation to an overall measure of cognitive impairment. The use of objective test performance, rather than family ratings, as the standard for comparison with patient reports of cognitive symptoms likely represents a more reliable and valid measure of the patients' cognitive functioning.

Formal cognitive testing is also likely to be more sensitive to the subtle impairment of cognitive functions than family ratings. It may be that studies which show greater impairment for patients with low reporting of symptoms in relation to family ratings are identifying head-injury patients with the greatest disparity between patient reports and actual cognitive functioning. This suggests that these studies may be selecting an extreme subsample of head-injury patients with decreased reporting of symptoms which excludes those patients who under-report cognitive problems and have significant cognitive impairment, but whose inaccuracy of reporting is far less pronounced to the family. Thus, the greater degree of discrepancy between patient reports of symptoms and their cognitive functioning, as assessed by family ratings, may be required to observe greater cognitive impairment on formal testing for low-symptom reporting head-injury patients.

For the current sample, the difference in cognitive performance between the low-report and high-report head-injury groups suggests that the neurobehavioral consequences of the acute head injury for the low-report head-injury patients was less severe than for the high-report head-injury group. Further, the similarity between the low-report head-injury and trauma control patients on the objective cognitive measures at one month post-injury indicates that the effects of the head injury for the low-report patients are difficult to separate from those effects related to the pre-existing conditions and low premorbid functioning, which naturally occur in consecutive patient samples.

In turn, this suggests that the low-report head-injury patients did not experience significant cognitive problems following the acute head injury over and above what would be expected given their pre-injury status due to pre-existing conditions, and that the low report of cognitive difficulties is consistent with less cognitive impairment on objective testing when compared to the high-report head-injury patients at one month post-injury.

It is possible that the lack of reporting of cognitive difficulties in the low-report head-injury group in this sample is indicative of impaired awareness following head injury; but that this reduced awareness of deficits is not necessarily associated with greater impairment on cognitive testing. This explanation would be more plausible, however, if the low-report head-injury group had demonstrated significantly greater cognitive impairment than the the trauma controls, but less impairment than the high-report head-injury group. Since the low-report and trauma control groups did not differ on cognitive measures, a more direct and likely interpretation suggests that the low-symptom reporting in this head-injury sample is not a reflection of the disorder of impaired awareness, but rather represents less severe cognitive effects of the head injury, which cannot be distinguished from effects related to pre-existing conditions. The lower level of emotional distress among the low-report head-injury patients suggests that these patients show less concern about cognitive deficits which are likely to be not appreciably different from what they experienced prior to the acute head injury.

In addition, it may be that the relationship between patient reporting of cognitive difficulties and objective cognitive performance is more consistent for relatively mild head injury patients than for patients with more severe head injuries, even for those patients who appear to be inaccurate in their self-report of cognitive problems while showing significant levels of impairment on cognitive testing. Further research specifically addressing the question of differences between mild and severe head injury patients for self-report of cognitive deficits is warranted.

It may also be argued that the apparent consistency between the patients' neuropsychological performance at one month post-injury and self-report of cognitive difficulties is related to the effects of the patients' mood on the cognitive testing. The greater cognitive impairment found in the high-report head-injury group may be simply a function of the effects of depressed mood, suggested by their greater level of emotional distress on the withdrawn depression score. However, the magnitude of scores for all three patient groups on the Katz Adjustment Scale was relatively low and is felt to be not sufficient to significantly affect the patients' cognitive performance. Further, the scores for the high-report head-injury group appear to be markedly less than scores reported among psychiatric populations (Katz & Lyerly, 1963).

Thus, it seems unlikely that the relatively small but significantly greater report of emotional difficulties on the withdrawn depression score could account for the markedly greater degree of cognitive impairment observed on neuropsychological testing among the high-report head-injury patients. In addition, the two head-injury groups did not differ on the relative frequency of pre-injury psychiatric illness, with only a few patients presenting with prior psychiatric problems among the groups.

Change in Cognitive and Emotional Functioning Over Time

At one year post-injury, there were no significant differences between the groups for either the neuropsychological or emotional adjustment measures, suggesting a change in functioning over time from the one month post-injury group comparisons. Although there was evidence of some attrition at the one year post-injury assessment, the follow-up groups were matched on all demographic and pre-injury variables and appeared to be representative of the whole sample seen at one month post-injury.

It was hypothesized that both the low-report and high-report head-injury groups would show greater improvement from one month to one year on the neuropsychological measures compared to the trauma control group. Partial support for this prediction was found with the high-report head-injury patients showing greater change over time in the form of improved performance on several neuropsychological measures, including the Halstead-Reitan Impairment Index, Finger Oscillation Test with the dominant hand, and part A of the Trail Making Test compared to the trauma controls.

Further, the high-report head-injury group showed greater improvement than the low-report head-injury patients on the Finger Oscillation Test with the dominant hand. Thus, the high-report head-injury group showed distinct improvement over time for cognitive measures assessing attention, fine motor skills, and general cognitive impairment compared to the trauma controls; and improvement of fine motor skills compared to the low-report head-injury group. In addition, the high-report head-injury group showed a significant decline in their report of emotional difficulties, with greater difference scores on the withdrawn depression score compared to both other groups and on the cluster total score compared to the low-report head-injury group.

Overall, these results indicate that the differences between the groups when observed at one month post-injury were reduced to nonsignificance at one year follow-up, with the high-report group accounting for the change over time by showing improvement on several cognitive and emotional measures. The improvement over one year for the high-report head-injury group is in support of previous studies (Dikmen et al., 1983; Levin et al., 1987) providing evidence for recovery from the effects of head injury over time.

The neuropsychological performance for the low-report head-injury group at one month and one year post-injury did not differ from the trauma controls, and the groups did not differ significantly on the change scores for the cognitive and emotional measures over the one year period. This suggests that, although the low-report group experienced an acute head injury, they performed at a level consistent with the expected pre-injury cognitive status defined by the trauma controls.

That the high-report group showed a significantly greater change on cognitive testing than the trauma controls suggests that the improvement in performance by the high-report head-injury group at one year follow-up is not a result of test-retest practice effects, but rather a reflection of recovery from more severe cognitive deficits related to their head injuries.

Although the trauma control group was matched on demographics and the occurrence of pre-injury neurological and psychiatric conditions to both head-injury groups at one month and one year post-injury, it may be argued that the trauma controls experienced more severe cognitive effects from their pre-injury conditions than the low-report head-injury patients. This explanation could account for the similarity of cognitive performance between the trauma control and low-report head-injury groups, but is unlikely, as both groups were selected from consecutively-admitted, representative samples of patients, leaving no reason to suspect a systematic difference between the groups in the severity of cognitive deficits from pre-existing conditions. That the groups were similar on pre-injury vocational functioning further supports this latter position suggesting that the groups were equally functional prior to their respective injuries.

The comparison of change in report of cognitive difficulties on the Alertness Behavior and Communication subscales of the Sickness Impact Profile among the groups was limited by floor effects. The low-report head-injury patients reported no cognitive difficulties at one month post-injury and continued do so at one year follow-up. However, the high-report head-injury group by definition reported a high number of cognitive problems at one month post-injury, but did not differ from the low-report head-injury group at one year post-injury. Even with the inherent limitations of this group comparison, these findings suggest that the reports of cognitive difficulties among the high-report head-injury patients decreased with improvement on cognitive testing over time, showing even greater consistency between patients' subjective reports of cognitive difficulties and performance on neuropsychological measures for this group.

Group Findings on Computed-Tomography Scans

It was hypothesized that the low-report head-injury group would have a greater relative frequency of brain lesions as seen on computed-tomography scans compared to the high-report head-injury group. This hypothesis was not supported by the data. There was no significant difference between the groups on the total frequency of cortical contusions and no patients from either group showed evidence of hematomas or focal atrophy.

It was also expected that a higher percentage of brain lesions would be located in the frontal cortical regions for the low-report head-injury group as compared to the high-report head-injury group. Although the low-report head-injury group appeared to have more contusions involving the frontal cortical regions than the high-report head injury patients, this difference did not reach significance. Thus, the data does not provide support for the view that inaccurate reporting of cognitive difficulties is related to a higher occurrence of frontal lobe damage. It is important to note that both head-injury groups had relatively few contusions exclusively located in the frontal lobes. This suggests that the current findings are even further complicated by the co-existence of contusions in adjacent brain regions, making any attribution of the relationship between inaccurate self-report of cognitive difficulties and frontal brain damage difficult for this sample.

It is also noteworthy that approximately 60% of the low-report head-injury patients showed no contusions in the frontal cortex, with only an additional 10% of the patients having contusions in other brain regions; while approximately 70% of the high-report head-injury group showed no contusions present. These findings indicate that approximately 50% or more patients from both head-injury groups showed no evidence of brain lesions on computed-tomography scans, which is consistent with the relatively mild severity of the head injuries in this patient sample.

It is possible that the low-report head-injury patients with frontal contusions represent a subgroup who may be more characteristic of patients with impaired awareness. However, comparisons between this low-report head-injury subgroup and high-report head-injury patients with general contusions revealed a pattern of differences between the groups consistent with results for the whole head-injury sample assessed at one month post-injury. Specifically, the high-report head-injury patients scored more poorly on several neuropsychological measures and reported more emotional difficulties than the low-report head-injury patients at one month post-injury.

It is important to note that the two head-injury subgroups used for these comparisons remained similar on demographic and pre-injury variables, as well as on measures of severity of head injury. That the apparent consistency between patient reports of cognitive problems and performance on cognitive and emotional measures was maintained for even these small subsamples of head injury patients further strengthens the findings supporting a good correspondence between patient reports of cognitive difficulties and performance on neuropsychological and emotional measures for these relatively mild head injury patients.

Implications of the Current Findings for Clinical Practice and the Study of Awareness Following Head Injury

In contrast to the growing body of literature which presents head-injury patients as frequently having problems related to inaccurate self-reporting of functioning or impaired awareness, the current study supports the validity of patients' self-report in evaluating the cognitive effects of head injuries. By selecting patients from a representative, consecutive-series sample of head-injury patients, and thereby not excluding patients with pre-existing neurological or psychiatric conditions, this study has sampled a range of patients presenting with low and high reporting of cognitive difficulties that is representative of two head-injury groups typically seen in clinical settings: patients who subjectively report no problems following a head injury, but have significant cognitive impairment and those who have many complaints consistent with their overall level of significant cognitive impairment.

Since the low-report head-injury group was less impaired than the high-report head-injury group on several neuropsychological measures, but did not differ from the comparison group matched on pre-injury variables, it seems most likely that the low-report head-injury patients do not have a disorder of awareness per se, but rather are subjectively reporting no cognitive difficulties which is not inconsistent with their lower level of impairment. The implications of this finding for the study of impaired awareness in the head-injury population is that there is a need to distinguish between a true disorder of awareness attributable to an acute head injury and low reporting of cognitive problems in the presence of significant cognitive impairment, which may represent pre-injury functioning rather than the direct effects of the acute head injury. In this latter case, the low reporting of cognitive symptoms is an accurate representation of the effects of the acute head injury.

Thus, the current study suggests that among relatively mild head-injury patients, a true impairment of awareness of cognitive problems may not be as widespread as the literature has previously indicated. Further research using a standardized definition of impaired awareness and appropriate control groups in consecutive-series head-injury samples may provide a better estimate of the prevalence of this problem in this patient population.

In addition, the current results have implications for clinical practice in the evaluation of head injury. Differences on neuropsychological measures were observed between the high-report and low-report head-injury groups despite equivalent head-injury severity scores on the Glasgow Coma Scale and time to follow commands. This finding suggests that these severity measures do not appear to be sensitive to the group differences that were identified by the neuropsychological measures and subjective reports of the patient. Although these two measures of head-injury severity are universally used in documenting the potential effects of head injuries, the current findings support the use of neuropsychological testing in conjunction with patient-reports of cognitive difficulties as a more sensitive measure of the potential cognitive effects of head injuries, and especially for those patients in the mild to moderate ranges of severity where more sensitive measures would have greater utility.

A noteworthy finding of the current study is the magnitude of pre-existing conditions in all three patient groups. By imposing selection criteria of a Halstead-Reitan Impairment Index of 0.4 or greater, but testable at one month post-injury, the head-injury groups included relatively mild head-injury patients whose cognitive difficulties are likely the result of a combination of the acute head injury and their pre-existing low cognitive status. The selection criterion of 0.4 or greater on the impairment index for the trauma controls selected a comparison group whose cognitive functioning reflects their low and stable cognitive status with no acute head injury. That the two head-injury groups demonstrated a high prevalence of pre-existing neurological and psychiatric conditions is consistent with epidemiological studies (Annegers et al., 1980; Kalsbeek et al., 1980) reporting that prior neurological disorders, head injuries, alcohol abuse, substance abuse, and psychiatric disorders occur at a higher rate among head-injury patients than in the normal population. This finding further emphasizes the need to consider the effects of pre-injury neurological and psychosocial factors when evaluating the cognitive effects of an acute head injury. Further, these results highlight the necessity of using appropriate comparison groups that adequately control for pre-injury factors which can potentially confound observed group differences in empirical studies using representative, consecutive-series head-injury samples.

Conclusions

In conclusion, the results suggest that for this sample of relatively mild head-injury patients, self-report measures of cognitive difficulties following head injury seem to provide a relatively accurate assessment of functioning consistent with performance on neuropsychological measures. Thus, in contrast to previous literature reporting the occurrence of impaired awareness as a frequent outcome of head injury, the current findings support the validity of patients' complaints of cognitive problems following head injury. Further, these findings emphasize that patient reports of cognitive difficulties, as well as neuropsychological testing, appear to be sensitive to changes in cognitive functioning over time.

The general accuracy of the head-injury patients in reporting cognitive problems consistent with their test performance further supports the use of self-report measures in the evaluation of head injury. In addition, these results highlight the importance of taking into account pre-injury functioning and prior neurological and psychatric histories in comparing group performances on cognitive measures for consecutive head-injury patients. Although these findings support the validity of patients' subjective complaints, it is important to note that these results are really applicable to patients who are seen in consecutive series with relatively mild head injuries and thus, may not apply to patients who have more severe head injuries, are seen much later in the course of injury, or present with complicated recoveries. Further research addressing the relationship between patient self-report of cognitive functioning and neuropsychological performance among these subgroups within the head-injury population is warranted.

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Appendix A

Consent Form for Head-Injury Subjects
Head-Injury Outcome

Investigators' Statement

The following information is given as a basis for you to decide whether you wish to volunteer as a participant in a study to be conducted at the University of Washington on the recovery process after hospitalization for a head injury. Your decision to volunteer or not to volunteer is completely up to you and in no way will affect any other clinical evaluations or procedures that might be carried out.

Our study will require the administration of an extensive battery of tests to participating subjects. This battery includes a variety of measures which examine abilities such as one's vocabulary and ability to solve new problems and learn new material. A number of the measures are questionnaires and will inquire about whether head trauma has affected you in a general sense as well as in specific areas such as your ability to move, think, and interact with others. Other questions will ask about how you have been dealing with your health problems, whether you have been receiving help from others, and how satisfied you are with this help. Another measure attempts to examine how you feel, such as whether you feel sad, nervous, or irritable. Most of the questions are straight forward but there are a few that are more personal. Examples of the most sensitive questions include whether you have problems controlling your temper, whether you have been in trouble with the law, and whether you have had thoughts of suicide. However, you are free not to answer questions you may find objectionable. Other procedures will measure motor coordination, strength, and speed. For example, we will measure your strength by asking you to squeeze a hand dynamometer with your right and left hands. Motor speed will be examined by asking you to tap as fast as possible with the index fingers of your right and left hands. Other tests will examine various senses such as the ability to hear, see, and identify fingers touched or objects placed in the hand. All such information will be kept strictly confidential. The majority of these measures have been in use for over 20 years. From our experience, we have found that many people find the tests interesting. Occasionally, however, some persons may feel tired, or find some of the tests a little difficult. The purpose of our study is to find out if you have any difficulties, what they are, and how you recover from them. You are free not to answer any questions you find objectionable or which you feel are invading your privacy. Even if you volunteer to participate, we want you to know that you are free to discontinue the entire testing at any time without jeopardizing the clinical evaluations and care to which you would otherwise be entitled.

The purpose of this investigation is to follow and carefully examine the progress of your recovery. In order to do this it will be necessary for you to undergo very brief neurological examinations at several points in time during the first week after your injury. The neurological examination will take less than five minutes and will examine principally physical sorts of functions such as motor strength, eye movements, and your ability to follow very simple instructions. Your agreement to participate will not increase the length of your hospital stay. These evaluations will be done only if you are still hospitalized. At one month and 12 months after your injury, we will examine you with the extensive battery of tests just described. At 3, 6, and 9 months post injury, we would like to contact you to see how you are doing. These examinations do not represent a form of treatment, but rather are designed to provide information about the pattern and rate of recovery which occurs after a head injury. The 3 and 9 month contacts will be by mail, while at 6 months we will call you. The one and 12-month examinations will take about one full day. These tests can all be done on an outpatient basis and will take place at Harborview Medical Center or the University of Washington Hospital.

If you decide to participate in the study, we will use your medical records. The reason for this is to obtain information regarding your head injury and your medical difficulties. We are interested in information such as whether you were rendered unconscious and for how long, and your course of recovery over time. As with the rest of your results, this information will be kept strictly confidential.

Consent Form: Investigators' statement (continued)

The information to be obtained from this study will be used for publication in professional journals and for presentations at professional meetings. In both data analysis and publications, your results will be assigned a number code with no specific data to identify you as a subject who participated in the project. Your results will be kept in locked files and will be available only to project personnel working on this study. We are planning to continue our research efforts in the area of head injury after the completion of the present study. The results to be gathered in this study will be valuable and necessary for our future projects and consequently will not be discarded. However, at all times your results will be kept strictly confidential, will be kept in locked files, and will be identified only by code numbers.

You will receive $50 upon completion of your 1-month post-injury exam, if you are discharged from the hospital by then and return for our evaluation. In other words, you will receive $50 if you are discharged and return for our 1-month exam but not if you are still hospitalized at the time of our 1-month evaluation. With your consent, we will also provide feedback for your treating physician(s), which we feel may well be of value to her/him in your treatment. You will also receive $75 upon completion of our 12-month post-injury evaluation. It is important to be sure that you understand that the examination we propose is not a form of treat. Instead, it is intended to develop new knowledge and information regarding the recovery process following injury to the head. You should feel free to ask any questions you have either now or in the future.

____________________________ ______________

Signature of Investigator Date

Consent Form (continued)

Subject's Statement

The study described above has been explained to me, and I voluntarily consent to participate in this activity. I have had an opportunity to ask questions and understand that future questions I may have about the research or about subjects' rights will be answered by one of the investigators. I understand that I am free not to participate and may withdraw from the study at any time without penalty or loss of benefits to which I am entitled.

______________________________ ______________

Signature of Subject Date

____

Subject's name (Please print)

______________________________ ______________

Signature of parent/legal Guardian Date

______________________________ ______________

Signature of subject advocate Date

____

Relationship

Appendix B

Interview Questions for the Head-Injury Outcome Study

Major Vocational Activities - Pre-Injury
(rated by interviewer)

1. Working (50% or more)
2. Working (less than 50%)
3. Unemployed
4. Student
5. Homemaker
6. Medical Leave of Absence
7. Other: ________________

Psychiatric History

Have you ever been hospitalized for emotional or psychiatric reasons?

Have you ever received a psychiatric diagnosis?

Have you ever had any serious emotional problems for which you did not seek help?

Have you ever taken any medication for emotional problems?

Alcohol-Abuse History

Do you have a drinking problem?

Have you ever been treated for a drinking problem as an inpatient in either a hospital or an alcohol treatment center, or as an outpatient in a structured treatment center, attended multiple alcohol schools, in Detox, or attended AA meetings?

Have you ever had a period of time when you were not able to stop drinking when you wanted to? When? How long?

Interview Questions (continued)

Have you ever felt your drinking was not normal? (by this we mean that you drank more than most other people)

Substance-Abuse History

Have you ever been in trouble at school, work, or with the law because of drugs?

Have you ever had a drug addiction problem?

Have drugs ever interfered with your work or school?

Neurological History

Code: 1 = No
2 = Yes

Have you ever had any of the following:

1. Brain surgery ______
2. Brain tumor ______
3. Encephalitis ______
4. Meningitis ______
5. Multiple Sclerosis ______
6. Alzheimer's Disease ______
7. Parkinson's Disease ______
8. Epilepsy ______
9. Stroke ______
10. Learning Disability ______
11. Other (poisoning, polio, Huntington's Disease, etc...) ______

Describe:

Interview Questions (continued)

Code: 1 = No
2 = Yes, significant

Have you ever had a previous head injury? ______

Describe:

Computed-Tomography Scan Report

Name ______________________ Study No. _____

Date of Injury ___________ Scan Date _____

<u>Scan Quality</u>: 1. Good 2. Poor 3. Not Done _____

<u>Focal Abnormalities</u>

1.Not observed 2. Observed, small 3. Observed, extensive

	Contusion	Focal Atrophy	Intraparenchymal Hematoma
Right Frontal	______	______	______
Left Frontal	______	______	______
Right Temporal	______	______	______
Left Temporal	______	______	______
Right Parietal	______	______	______
Left Parietal	______	______	______
Right Occipital	______	______	______
Left Occipital	______	______	______

<u>Hematomas</u>

1. No 2. Yes, Right 3. Yes, Left 4. Both 9.Unknown

Subdural _____

Epidural _____

Subarachnoid _____

Approval Sheet

The dissertation submitted by Gene E. Alexander has been read and approved by the following committee:

Dr. Patricia A. Rupert, Director
Associate Professor, Psychology, Loyola

Dr. James E. Johnson
Professor, Psychology, Loyola

Dr. Alan S. DeWolfe
Professor, Psychology, Loyola

Dr. Raymond H. Dye
Associate Professor, Psychology, Loyola

The final copies have been examined by the director of the dissertation and the signature which appears below verifies the fact that any necessary changes have been incorporated and that the dissertation is now given final approval by the Committee with reference to content and form.

The dissertation is therefore accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

October 11, 1991
Date

Patricia A. Rupert
Director's Signature