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The relationship between cognition and functional independence during the early recovery from traumatic head injury

Kaplan, Candia Post, Ph.D.
The Ohio State University, 1993

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The Relationship Between Cognition and Functional Independence During the Early Recovery from Traumatic Head Injury

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Candia Post Kaplan, B.A., M.A.

* * * * *

The Ohio State University
1993

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1993
To My Husband and Children
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**FIELDS OF STUDY**

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Counseling Psychology
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CHAPTER 1

INTRODUCTION

In this chapter, the significance of head injuries will be discussed in terms of epidemiology, and economic burden. Economic sequelae include both the direct cost of medical care and the indirect cost of lost wages. Various functional status scales which measure the ability of individuals who have sustained a head injury to perform functional activities necessary for daily living will be introduced. These functional status scales have been used to assess the relative burden of care for those who received a head injury.

Background of the Problem

The National Center for Health Statistics reported that accidents were the single largest cause of death in Americans ages 1 to 34, and the fourth largest cause of death in persons over age 35. Head injury is estimated to cause 40% of all accident mortalities. The estimated mortality from head injury is 22.3/thousand (Cooper, 1982). Mortality from head injury in the years 1978-1990 exceeded all American battle deaths since the founding of the country. However, advances in
neurotrauma treatment appear to be resulting in greater numbers of individuals who survive severe head injury (Johnson, 1984). Individuals with a head injury who survive what is known as the silent epidemic of head injury, may require lengthy rehabilitation (Goldstein, 1990).

There has been relatively little published research on the economic burden of caring for head injury survivors. The National Head and Spinal Cord Injury Survey (NHSCI) reported annual direct medical cost for the treatment of those hospitalized with head injury was $1.14 billion (adjusted to 1980 dollars). Annual indirect cost, due to lost wages of the head injured, was estimated to be $2.76 billion in 1980 dollars (Kalsbeek, McLaurin, Harris, & Miller, 1980). Different figures for the cost of head injury were obtained by Johnson, 1984. Johnson extrapolated data on all cases of head injury including fatalities and mild injuries in Olmsted County, Minnesota, to the nation as a whole. Annual direct medical costs for head injury were estimated to be $2.76 billion in 1986 dollars. Indirect costs were estimated to be between $25.9 to $34.4 billion in 1986 dollars. Johnson's indirect costs include projections of lifetime loss of earnings, while the NHSCI reported indirect costs during the study period only. Johnson claimed the benefits of intervention have to be balanced against the cost of increased
burden placed on others. Clearly the striking figures for the epidemiology and cost of head injury indicate the importance of head injury to society as a whole. Research in this domain is relevant and timely.

**Rationale for Functional Status Measurement**

There are many qualitative scales that characterize levels of functional status in individuals who have sustained a head injury. These scales are important for several reasons. First, the World Health Organization (WHO) has stated that an intrinsic medical disorder such as traumatic head injury results in: physical impairment in a body organ or system; disability defined as the consequence of the impairment in terms of functional performance; and handicap defined as the social disadvantage experienced as a result of impairment and disability (World Health Organization, 1980). The WHO definitions of impairment, disability, and handicap have been used as the framework in which functional status measures have evolved and in which rehabilitation outcomes have been established (Wilkerson, Batavia, & DeJong, 1992). Scales that measure functional status can be characterized as operational measures of disability (Granger, 1984).

The second major reason for the importance of functional status scales relates to the goals of medical rehabilitation. Medical rehabilitation has been defined as a level of medical attention between acute and chronic care, which has the goal
of moving disabled patients from a dependent state to a more independent and self-sufficient state (Granger & Greer, 1976). Functional scales monitor patient progress toward independence and self-sufficiency.

A third reason why functional scales are important is that these types of assessments can be used in follow-up evaluations after discharge from rehabilitation hospitalization in order to evaluate and compare treatment programs (Forer & Miller, 1980; Gresham & Labi, 1984).

A fourth reason why functional scales are important is that they also enable researchers to better understand the recovery process. These comprehensive scales provide researchers with data that has more explanatory power than mere mortality and morbidity figures. Researchers now have standardized instruments with which they can obtain aggregated data on a sufficiently large number of defined patients to enable statistical analyses and inference on recovery from head injury (Gresham & Labi, 1984).

Functional scales also capitalize the current practice of problem-oriented medical records by extending the defined database beyond history, physical exam and laboratory tests. When these clinical scales are added to the medical record; complex care, comprehensive goals, and ongoing clinical progress can be noted in uniform manner using standardized terminology. Appropriate intervention can be facilitated when treatment
goals are closely identified with problems within functional categories (Granger & Greer, 1976; Granger, 1984). The use of these functional assessment instruments can facilitate establishment of comprehensive rehabilitation goals and awareness of ongoing clinical achievement (Granger & Greer, 1976). Clinical problems and areas of need may be identified more accurately and interventions which maximize personal independence can be developed. Change in status at appropriate intervals should be compared to get a better estimate of recovery and the response to intervention. Communication of patient status among members of the treatment team can be facilitated by the use of functional assessment (Granger, 1982).

The escalation in cost of rehabilitation services has led to greater interest in the allocation of money and in program evaluation. It is believed that functional assessment measures will facilitate program evaluation. However, in the United States, rehabilitation outcome evaluations have not been utilized in decision making about societal resources. There is concern that such a use may occur in the future. There are trends in health care finance that are likely to impact on rehabilitation services and on outcome measurement. As health care shifts to new forms of payment, the effectiveness of rehabilitation will be subject to increased scrutiny. Some current trends include the development of health maintenance
organizations and preferred provider organizations, the development of multifacility health care corporations, the rise of third-party administrators, and particularly the potential for some type of prospective payment system like the diagnostic related groups (DRG's) (DeJong, 1987).

The development of a prospective payment system is particularly important, because until recently, rehabilitation medicine had been exempt from the 1983 Social Security Amendments Act (Public Law 98-21) which stipulated that Medicare would pay a fixed amount per patient based on the patient's diagnostic related group. Many state's Medicaid programs also are based on diagnostic related groups. The rehabilitation medicine exemption was intended to last only as long as was required to devise an alternate formula consistent with the diagnostic related group formula. The 1983 Amendments Act designated the Health Care Financing Administration (HCFA) to study the feasibility of prospective payment for rehabilitation. An initial study indicated the diagnostic related groups did not accurately predict utilization of rehabilitation services, but that a consistent predictor of inpatient utilization was severity of injury and a functional measure based on activities of daily living. Functional outcome assessment began to appear to be a likely candidate to replace diagnostic related groups as a formula for prospective payment (DeJong, 1987; Batavia & DeJong, 1988; Stineman,
Pressure for agreement on the development of a formula for prospective payment was created by the Omnibus Budget Reconciliation Act of 1990, PL 101-508 which required at least a proposal by 1992.

The Commission on Accreditation of Rehabilitation Facilities has set another requirement for rehabilitation hospitals. One standard which must be met for accreditation is demonstration of program evaluation which would account for the degree to which the program succeeds in meeting measurable objectives. Since one major objective in rehabilitation is to improve patients' independent functioning, functional status outcome assessment can aid in documentation during program evaluation (Granger, Barrett, & Kaplan, 1977).

Other types of care review systems such as utilization review, peer review, and audits by the Joint Commission for Accreditation of Healthline Organizations require the demonstration of rehabilitation effectiveness. The usual methods of demonstrating effectiveness that are performed in acute hospital facilities are more often focused on cure. Rehabilitation does not focus on cure. Rather, it is focused on restoration of function to the maximal level that is possible. When a hospital is audited, it needs to provide information in a simple summary form that differs from clinical data in content and level of detail (Carey & Posvac, 1977). The effectiveness of rehabilitation can be demonstrated
by change from admission to discharge in the expected direction on a functional status outcome scale (Melvin, 1984). One group of researchers has also developed a measure to assess rehabilitation efficiency, defined as the proportion of cost that can be related to actual patient gain. Hamilton and Granger (1985) divided the admission to discharge gain in the Barthel Index, the functional status scale that was a precursor of the Functional Independence Measure, by the length of stay in the rehabilitation hospital. Note this calculation still does not produce a standardized score that would permit comparison of scores among different institutions. The denominator is not the variance of the numerator expressed in standard deviation units. Therefore, the quotient is not a standard z score (Anastasi, 1990). Along with the clear need for functional outcome instruments to provide both mandated and clinical assessments, there are efforts to develop instruments and to test their utility in demonstrating rehabilitation effectiveness and efficiency.

Leaders in medical rehabilitation believe that the optimal measure of benefit from rehabilitation is a functional status outcome instrument which measures improvement by increases in function and quality of life, rather then increased life span (Kottke, Lehmann, & Stillwell, 1982). A wide variety of different functional status measures are available. This study will explore some of the most
significant scales which have merited serious consideration as instruments for evaluation, clinical, and research purposes. **An Exemplary Scale for Functional Status**

The Functional Independence Measure (FIM) is a clinical functional status scale with the stated intent of measuring an underlying burden of care for disabled individuals (Hamilton & Granger, 1989). The Functional Independence Measure yields a composite score as well as 18 subscale scores in the areas of self care, sphincter control, mobility, locomotion, communication, and social cognition. The specified areas of rehabilitation goals match those identified by the WHO (World Health Organization, 1980). Scores on each subscale range from one to seven depending on the amount of assistance a patient requires (Uniform Data System, 1990b). Thus the range of total Functional Independence Measure scores that can be achieved by any one patient is 18 to 126. The Functional Independence Measure is used as an assessment instrument in many rehabilitation hospitals throughout the United States. Functional Independence Measure scores from these hospitals are entered into the Uniform Data System at the State University of New York-Buffalo. The Uniform Data System was jointly sponsored by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation as a means of standardizing and improving rehabilitation outcome data (Hamilton & Granger, 1987;
Those function related groups that were used to group Functional Independence Measure subscales, also have been utilized to form a prototype patient classification system. This new classification system was created in response to a congressional mandate that stipulated that the Health Care Financing Administration had to propose an alternative patient payment system for Physical Medicine and Rehabilitation by 1992 (Stineman, 1992). If functional status is accepted for use in the prospective payment of medical rehabilitation services, the Functional Independence Measure scale will have added importance in the rehabilitation of persons who have sustained head injury.

Rationale for Cognitive Measurement

In addition to comprehensive functional status scales such as the Functional Independence Measure, several specialized scales have been constructed to measure specific aspects of impairment. Cognitive loss is a frequently encountered sequela of traumatic head injury (Brooks, Aughton, Bond, & Rizvi, 1980). As many as two-thirds of all patients with severe head injury experience cognitive losses (Jennett & Teasdale, 1981). Memory is most affected, while performance and verbal skills are less affected. Russell, 1932, noted a period of altered consciousness between time of injury and recovery of the patient's continuous memory for events. Russell called this period of coma and clouded
An Exemplary Scale for Early Cognitive Recovery

One reliable and valid scale for assessing early cognitive recovery and determining the conclusion of post-traumatic amnesia is the Orientation Group Monitoring System (OGMS) (Corrigan, Arnett, Houck, & Jackson, 1985). The Orientation Group Monitoring System functions as a prospective index of cognitive recovery and of clearing post-traumatic amnesia. The Orientation Group Monitoring System has a weekly aggregate score and various behavioral subscale scores. These subscales assesses orientation to person, place, and time; as well as semantic and episodic memory. These cognitive sequelae are consistent with Russell's description of post-traumatic amnesia. Additionally, Orientation Group Monitoring System subscales assess attention span and the ability to use planning and scheduling aids as compensatory strategies (Jackson, Mysiw, & Corrigan, 1989). Further support for the importance of orientation as a marker of cognitive recovery from post-traumatic amnesia came from High, Levin, & Gary, 1990. They found the majority of severely head injured patients experienced early cognitive recovery in the following sequence: return of orientation to person, followed by orientation to place and then to time.
**Problem Statement**

One problem in understanding the nature of functional status following closed head injury lies in conceptualizing the relative contribution of cognition to functional independence. A search of the literature did not indicate any studies which compared levels of cognition with indices of functional independence early during rehabilitation hospitalization. Knowledge regarding the relative contribution of cognitive skills or of deficits to functional independence has the potential of contributing to a conceptual understanding of recovery from traumatic head injury. An empirical study can also contribute to our knowledge of the scales under study and widen our knowledge of subtle aspects of the recovery process itself. Support for the notion that an understanding of the cognitive and physical contribution to disability is important came from Jennett & Bond, 1975, who noted the co-occurrence of physical and cognitive impairments reduced the individual's ability to cope with either.

This study proposed to investigate the relationship between cognition and functional independence. The first research question which this study addressed was, what is the relationship between both cognition and selected demographic variables known to influence cognition and functional independence? Cognition was operationalized as admission Orientation Group Monitoring System scores. Functional
Independence was operationalized as admission and discharge Functional Independence Measure scores. How much variance in Functional Independence Measure scores obtained at admission to rehabilitation hospitalization can be accounted for by cognition early in the recovery process? The second research question was how much variance in improvement in Functional Independence Measure scores between admission to discharge from rehabilitation hospitalization can be accounted for by cognition early in the recovery process?

The Uniform Data System updated Guidelines (Uniform Data System, May, 1992) began categorization of head injury impairments by the International Classification of Disease (ICD) codes in order to standardize the data input. The categories of interest are traumatic and nontraumatic brain dysfunction. Nontraumatic brain dysfunction can result from encephalitis, brain tumors, and anoxic brain damage from insufficient oxygen supply to the brain. Traumatic brain dysfunction can result from cerebral laceration and contusion, hemorrhage following subdural injury, and fracture of the skull. The older distinction between missile and nonmissile traumatic injuries is no longer stipulated in FIM diagnostic categories. It is the two categories of traumatic and nontraumatic brain dysfunction that this study investigated.
CHAPTER 11
COGNITIVE SCALES

Physical Causes of Cognitive Impairment

Traumatic brain injuries can result from a number of physical effects which can occur in the brain simultaneously. Linear and rotational acceleration forces applied to the brain in an event like a car accident, can cause damage to brain tissue. Linear forces result in laceration and contusion when the brain impacts on the rough inner surface of the skull, both as a result of initial and rebound counter coup brain movement. Commonly such damage occurs on the undersurface of the temporal and frontal lobes and the anterior pole of the temporal lobe. Contusion can result in secondary damage to the brain because edema, swelling, and bleeding are occurring in an enclosed space. The increased compression on brain tissue can result in prolonged coma and tissue necrosis. In addition, rotational acceleration can result in diffuse axonal damage due to twisting and sheering of axons. The most consistent sequela of brain damage which results from acceleration deceleration trauma is altered consciousness. Improvement in the level of consciousness is usually the best indicator of improvement in brain function (Jennett &
Teasdale, 1981). Consequently several scales have been derived to assess levels of consciousness.

**Review of Cognitive Scales**

**Glasgow Coma Scale.**

The Glasgow Coma Scale was one of the earliest scales measuring cognitive functioning in the acute phase of recovery between coma (defined as the inability to open eyes, speak, or obey commands) and orientation (Teasdale & Jennett, 1974). The three Glasgow Coma Scale behavioral criteria scores which contribute to an aggregate score are: motor responsiveness to commands and pain stimuli, verbal performance which demonstrates orientation to self and the environment, and eye opening which is either spontaneous or in response to speech or pain.

Psychometric data for the Glasgow Coma Scale include: inter-rater reliability between nurses and neurosurgeons of .91 for eye movement and verbal scores and .96 for motor scores (Teasdale & Jennett, 1976). Inter-rater reliability for the total score was .92 among neurosurgeons, .93 among surgeons, and .93 among neurosurgical nurses (Teasdale, Knill-Jones, & Van der Sande, 1978). The Glasgow Coma Scale was an improvement over prior unstructured observations of impaired consciousness. However, problems with the Glasgow Coma Scale result when (1) swollen eyes and surgical tracheotomy sometimes makes the eye and speech components difficult to
assess and (2) information provided on patients is too restricted (Eisenberg & Weiner, 1987).

**Disability Rating Scale.**

The Disability Rating Scale (Rappaport, Hall, Hopkins, Belleza, Berrol, & Reynolds, 1977) covers the range from coma to community re-entry. The Disability Rating Scale consists of 8 items within the following four categories: arousability, awareness, & responsiveness; cognitive capacity for toileting and self-care; level of dependence on others; and psychosocial adaptability, defined as employability. The Disability Rating Scale can be considered an expansion of the Glasgow Coma Scale, because the first category on the Disability Rating Scale is simply a modification of the Glasgow Coma Scale. Psychometric data for the Disability Rating Scale include inter-rater reliability of .97-.98 (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982) and .92-.98. Test re-test reliability was .91-.95. Concurrent validity with functional outcome was .80-.92 (Gouvier, Blanton, LaPorte, & Nepomuceno, 1987) and .50-.67 (Hall, Cope, & Rappaport, 1985). Predictive validity from rehabilitation hospital admission to one year follow-up scores on the Disability Rating Scale was .53 (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982), and from acute hospital admission Disability Rating Scale scores to discharge placement was .66. Construct validity between the Disability Rating Scale and acute hospital length of stay was .50 and
with discharge placement it was .40 (Eliason & Topp, 1984).

The Disability Rating Scale was more sensitive than the Glasgow Outcome Scale in detecting clinical change. Additionally, it appears to be useful in the identification of patients who might benefit from rehabilitation (Rappaport, Hall, Hopkins, Belleza, & Cope, 1982). The claim that the Disability Rating Scale can predict actual length of hospitalization still needs to be demonstrated. The exploratory study which has been published was marred by extreme sample variability (Eliason & Topp, 1984). It appears that this instrument is more efficacious in the early stages of recovery than after discharge to the community, as data collected two years after trauma were nonsignificant (Hall, Cope, & Rappaport, 1985).

**Rancho Los Amigos Scale.**

The Rancho Los Amigos Hospital Level of Cognitive Function (Rancho) (Malkmus, Booth, & Kodimer, 1980) was based on behavioral observations of categorical levels of patient response to environmental stimuli. Levels range from no response to purposeful-appropriate response. According to the manual, administration of the RLCF does not require cooperation from the patient. Inter-rater reliability among 3 raters was .88-.94 and test re-test reliability was .82. Concurrent validity with functional outcome was .73-.93. Predictive validity from admission to rehabilitation
hospitalization to functional outcome was .57-.68. When administered to the same head injured sample along with the Disability Rating Scale, the Disability Rating Scale surpassed the Rancho Los Amigos Hospital Level of Cognitive Function in almost every regard (Gouvier, Blanton, LaPorte, & Nepomuceno, 1987). When given at clearing of post-traumatic amnesia, the Rancho scale did not demonstrate predictive validity for the rate or level of recovery in reading scores for patients with moderate to severe closed head injury (Kaplan, 1989).

Western Neuro Sensory Stimulation Profile.

The Western Neuro Sensory Stimulation Profile (Ansell & Keenan, 1989) is a cognitive scale which was constructed for use with low functioning severely head injured patients who experience a particularly slow recovery. The authors offered their scale as an alternative to the Glasgow Coma Scale. They did not acknowledge existence of the Disability Rating Scale which also covered the same range of cognitive ability. This is a striking omission, as the Disability Rating Scale had been published for two years when the Western Neuro Sensory Scale Profile was presented. Furthermore, the reliability and validity coefficients of the Disability Rating Scale are higher than those of the Western Neuro Sensory Scale Profile. The inter-rater reliability of the Western Neuro Sensory Scale Profile total score, as well as four of the six subscales was .94-.99. However, reliability for the arousal/attention scale
was .78-.90 and for the tactile/olfactory scale it was .64-.86. Cronbach's alpha, reflecting internal consistency, was .87-.95 for the total score and four of six subscales; .73 for arousal/attention, and .59 for tactile/olfactory. Concurrent validity with the Rancho Levels of Cognitive Functioning was .73. Construct validity for the total score as well as for the auditory comprehension, visual tracking and arousal/attention subscales was demonstrated by discrimination of improved and unimproved groups (Ansell & Keenan, 1989). It appears that the sensory perception tasks of odor detection, touch, & object manipulation that are included on the Western Neuro Sensory Scale Profile, are not as reliable or valid as the rest of the scale items.

**Galveston Orientation and Amnesia Test.**

The Galveston Orientation and Amnesia Test (GOAT) (Levin, O'Donnell, & Grossman, 1979) was developed for prospective serial assessment of cognition during the subacute stage of recovery from closed head injury. The range of the Galveston Orientation and Amnesia Test from confused to cleared post-traumatic amnesia is most similar to that of the Orientation Group Monitoring System. The Galveston Orientation and Amnesia Test consists of 10 questions evaluating temporal orientation, interval to first memory after trauma, and the interval prior to injury for which there is no recall.
The Galveston Orientation and Amnesia Test has the advantage of quick administration at bedside. Inter-rater reliability of the total score and individual items was .99 (Levin, O'Donnell, and Grossman, 1979). In 15 of 21 patients the Galveston Orientation and Amnesia Test corresponded to performance on the Orientation Group Monitoring System. However, 4 of 21 subjects indicated clearing post-traumatic amnesia earlier on the Galveston Orientation and Amnesia Test than the Orientation Group Monitoring System and 2 patients cleared post-traumatic amnesia on the Galveston Orientation and Amnesia Test but did not meet criteria on the Orientation Group Monitoring System. No subject met criteria for clearing post-traumatic amnesia on the Orientation Group Monitoring System who did not meet criteria on the Galveston Orientation and Amnesia Test, and no subject cleared post-traumatic amnesia on the Orientation Group Monitoring System before first clearing on the Galveston Orientation and Amnesia Test (Mysiw, Corrigan, Carpenter, & Chock, 1990). Construct validity was demonstrated between eye, verbal and motor subscales of the Glasgow Coma Scale and the duration of impaired Galveston Orientation and Amnesia Test scores (Levin, O'Donnell, and Grossman, 1979). The Galveston Orientation and Amnesia Test was also diagnostic for co-occurrence of head injury and spinal cord injury (Davidoff, Doljanac, & Berent (1988).
Orientation Group Monitoring System.

The Orientation Group Monitoring System (Corrigan, Arnett, Houck, & Jackson, 1985; Jackson, Mysiw, & Corrigan, 1989) scores were an independent variable in this study. The Orientation Group Monitoring System was developed to assess cognitive function in the range from cognitive confusion after coma to the return of memory and continuous orientation that mark the conclusion of post-traumatic amnesia.

Scores on the Orientation Group Monitoring System behavioral objectives are obtained during a half hour daily meeting of the Orientation Group. Seven behavioral goals are assessed: (1) orientation to time; (2) orientation to place; (3) knowledge of group members and therapists; (4) attention span; (5) associative learning; (6) episodic memory; (7) use of scheduling aids as compensatory strategies. Examples of behavioral objectives for meeting these goals are: accurate orientation to day, date, and year 80% of the time over two weeks; the correct name of the institution, city, state, and treatment room location with 100% accuracy over two weeks; identification of therapists and other group members 80% of the time over two weeks; repetition of five paired associates with 100% accuracy; and correct recall of significant events for the previous day or weekend 100% of the time over two weeks. Several objectives are scheduled for each group meeting. Targeted objectives are rated each time the patient
has the opportunity to perform the task. Subscale scores range from 1-3. A score of 1 is given when the patient fails to correctly perform the objective. A score of 2 indicates the patient had an opportunity to perform the desired behavior, but it was unclear whether they performed correctly. A score of 3 indicates the patient performed the correct behavior. An aggregate score of 2.75 on two consecutive weeks indicates clearing post-traumatic amnesia. Unobtrusive daily ratings are made by one of the two therapists leading the group and scores are aggregated by a psychology staff member. Minimal criteria for entry into the Orientation Group include ability for verbal communication and purposeful motor behavior. Patients with nonviolent agitated behavior are included, however those with behavioral problems necessitating one-on-one staff supervision are excluded.

Therapists from psychology, speech pathology, and occupational therapy staff the group on a regularly assigned basis. Inter-rater reliability for the weekly aggregate Orientation Group Monitoring System score was .87 (Corrigan, Arnett, Houck, & Jackson, 1985). Construct validity was demonstrated by sensitivity to clinical improvement with higher scale scores paralleling clinical gain (Corrigan, Arnett, Houck, & Jackson, 1985); a negative correlation with agitation -.53 and the observation that low Orientation Group scores had to improve before agitation diminished (Corrigan &
Mysiw, 1988). Further construct validity was demonstrated by a reduction of Orientation Group Monitoring System scores, in excess of the standard error of measurement, that was highly sensitive and specific to medical complications (Jackson, Mysiw, & Corrigan, 1989). The Orientation Group Monitoring System demonstrated concurrent validity by correspondence with the Galveston Orientation and Amnesia Test (Mysiw, Corrigan, Carpenter, & Chock, 1990) and a correlation of .87 with the Mini-Mental State Exam (Corrigan & Mysiw, 1988). Predictive validity was indicated by week one rehabilitation hospitalization aggregate Orientation Group Monitoring System score together with time post trauma serving as the best predictors of whether and when post-traumatic amnesia would clear during rehabilitation hospitalization (Saneda & Corrigan, 1992).

Earlier, it was observed that the length of post-traumatic amnesia was seldom utilized in Britain outside of Oxford University and was rarely used in continental Europe or North America (Jennett, 1976). Jennett stated the reason for this omission was a shared belief in the difficulty of assessing post-traumatic amnesia. Both the Galveston Orientation and Amnesia Test and the Orientation Group Monitoring System can be used to remedy this problem, as both scales are reliable and valid prospective measures of post-traumatic amnesia (see Fig.1).
There are several differences that can be noted between the Orientation Group Monitoring System and the Galveston Orientation and Amnesia Test in their relative ability to assess cognitive change through the period of post-traumatic amnesia. The Orientation Group Monitoring System has several advantages over the Galveston Orientation and Amnesia Test in assessing cognitive change through the period of confusion and clearing of post-traumatic amnesia. The core of the Galveston Orientation and Amnesia Test is the assessment of temporal orientation. This proportionally greater emphasis provides opportunity for potential error in judgements regarding time of clearing post-traumatic amnesia when disorientation is not contiguous with the duration of impaired continuous memory. In addition, the Galveston Orientation and Amnesia Test asks for the first episode recalled after trauma, while the Orientation Group Monitoring System asks for memories of the previous day or weekend and yields a more accurate record of continuous memory. Since approximately 39% of traumatically brain injured patients have islands of intact memory while lacking continuous memory, the Galveston Orientation and Amnesia Test can result in a more favorable estimate of clearing post-traumatic amnesia than the Orientation Group Monitoring System. Repeated administrations of the Galveston Orientation and Amnesia Test could result in domain specific learning. The combination of week one rehabilitation hospitalization
aggregate Orientation Group Monitoring System score and time post injury have been demonstrated to be the best predictor of whether and when post-traumatic amnesia will be cleared during rehabilitation hospitalization (Saneda & Corrigan, 1991). The Orientation Group Monitoring System is effective and more conservative than the Galveston Orientation and Amnesia Test in estimating time of clearing post-traumatic amnesia. The Orientation Group Monitoring System also has the advantage of incorporation into a daily therapeutic group established to remedy cognitive deficits (Mysiw, Corrigan, Carpenter, & Chock, 1990). Daily assessment and weekly aggregate scores are adventitious, particularly when contrasted with scales such as the Rancho Levels of Cognitive Function which may not be actually administered on a regular basis. Erratic time intervals between assessments can be problematic for the clinician and researcher (Kaplan, 1989). Disadvantages of the Orientation Group Monitoring System relate to the cost in time and the demand on staff that is required to conduct a daily half hour orientation group (Mysiw, Corrigan, Carpenter, & Chock, 1990).
CHAPTER 111
FUNCTIONAL STATUS SCALES

Just as there have been a number of scales developed to assess cognitive status following moderate to severe head injury, there also have been a number of scales developed to assess the functional status of patients. The goal of rehabilitation is to enable individuals who have experienced an injury to regain as much independent function as their physical condition permits. Functional status scales can measure patient progress toward the attainment of this goal.

Assumptions in Functional Status

There is a large literature on functional outcome measures that can be utilized in assessing the efficacy of rehabilitation. Functional assessment instruments are designed to measure the abilities and disabilities of impaired individuals on a variety of skills necessary for daily life.

Functional outcome literature shares basic underlying assumptions with the literature on cognition in persons with head injuries. One implicit assumption is that a decrease in scores indicates poorer performance, either poorer cognitive performance or a decrease in independence. With the exception of the Corrigan group, researchers have not specifically
accounted for score changes which were due to other events, such as medical complications or drug effects (Jackson, Mysiw, & Corrigan, 1989). Published studies did not account for natural intrinsic brain recovery as an additive or perhaps interactive effect with therapeutic gains that result from rehabilitation interventions. Published studies also did not employ control groups to reduce threats to internal and construct validity of causes or effects. Consequently generalization of findings is limited (Cook & Campbell, 1979). Studies which have been reported are based on groups of individual patients with a variety of injury characteristics such as type, location within the brain, severity as measured by length of post-traumatic amnesia, and multiple trauma including other body systems.

Occasionally researchers who were beginning to work in this area forgot their assumptions and made the claim that comparison of outcome measure scores among different field settings would indicate relative effectiveness and efficiency of the programs (Granger & Greer, 1976). While it is helpful to have standardized terminology, scoring, and data protocols, these improvements in functional outcome data collection do not result in equivalent samples with equal variability in assessment. They do not result in scores which have been transformed into standardized score form. Any comparison of scores obtained in different settings needs to be made with
caution paid to patient characteristics, type and intensity of rehabilitation interventions, the patient's social environment, as well as the additive nature of both natural recovery and rehabilitation interventions (Susset, Vobecky, Black, & Dii, 1979). The early enthusiasm about the utility of functional outcome assessment, that can be readily detected in the literature, needs to be tempered by realistic limits imposed by the nature of the data. Researchers and clinicians who utilize the literature on functional assessment should take into consideration the evolving level of psychometric sophistication when reading research reports.

With these considerations in mind, a review highlighting important functional outcome measures frequently used with persons who are recovering from traumatic head injury will elucidate the choice of the Functional Independence Measure, that was the dependent variable in this study. There are several applications for functional outcome measures in the rehabilitation of head injured patients. Historically, the first use of functional status measurement was as a method of measuring patient disability and improvement. Clinicians and researchers need to be mindful that there is no one-to-one correlation between injury and the resultant disability (Stolov, 1982). Diagnosis of a physical impairment is very different from assessment of the resulting disability. More individuals are surviving serious trauma due to recent
innovations in surgical and medical care. However, the development of functional outcome measures has lagged behind improvements clinical care (DeJong, 1987).

Until fairly recent efforts at developing functional status scales as instruments for measuring disability, knowledge of the effects of injury and treatment had remained intuitive. Over the last two decades improved assessment instruments have provided a means for more objective measurement (Rubenstein et al., 1989). One of the earliest types of functional status scales was based on measuring aspects of individuals ability to perform activities of daily life. This has been a popular approach. By 1967 there already were 12 activities of daily life scales published for use in medical rehabilitation settings (Bruett & Overs, 1969).

Review of Functional Status Scales

Katz Index of Activities of Daily Life.

Katz and Chinn were the two principal investigators in the seminal Benjamin Rose Hospital Staff study of illness in elderly persons that resulted in a new classification of functional status in Activities of Daily Life (Staff of Benjamin Rose Hospital, 1959). This classification system was based on the specific type of assistance which patients required. It was anchored in the actual status of the patient, not in their ability. For example, a patient who was able to perform an activity, but who refused to perform it,
would be rated as not demonstrating achievement of that function. The scale itself was comprised of hierarchical classes A-G and Other. Class A was at the top of the hierarchy, representing individuals who were independent in feeding, continence, transfer, toileting, dressing, and bathing. Each successive class represented individuals who were independent in fewer functions. The class labeled "other" included individuals who were dependent in at least one function, but who were not classifiable in A-G. The advantage of this functional status scale was that it was graded and was more precise than earlier versions.

Katz continued research on developing a functional outcome scale (Katz, Ford, Moskowitz, Jackson, & Jaffe, 1963). The term assistance was clarified to mean "supervision, direction, or personal assistance" (Katz, Downs, Cash, & Grotz, 1970). The various classes such as bathing and continence were operationalized with great clarity. A correlation was described between inpatient Index of ADL and proportions of discharged patients who lived in nursing homes and other protective residences, however, no correlation coefficient figures were given. Among hemiplegic patients who were graded D-G at discharge, 79% were receiving nonfamily attendant care 1 year following their stroke (Katz, Downs, Cash, & Grotz, 1970).
The Katz Index of Activities of Daily Life was originally intended for use with elderly patients with hip fractures and strokes. However, the Index has been adopted for use with a wider patient population. Presumably the underlying theoretical assumption still applies. Katz believed that his patients passed through sequential stages of recovery. First, they experienced return of independence in feeding and continence, then transfer and toileting, and only later in dressing and bathing. He felt this sequence paralleled functional development during childhood and reflected functions of biological primacy, as well as the adequacy of neurological and locomotor response. When admission and one month post admission data were entered into a computer which had been programmed to analyze data according to three functional outcome scales: the Katz Index of Activities of Daily Life, the Barthel Index and the Kenny Self Care Evaluation; the Katz Index indicated the least change while the Kenny indicated the most change. The Barthel score change was intermediate. This finding was interpreted to mean that of the three functional status scales, the Katz was the least sensitive and the Kenny the most sensitive to clinical change (Donaldson, Wagner, & Gersham, 1973). Concurrent validity was demonstrated by a .77 Kappa coefficient of agreement between the Katz Index of ADL and the Barthel Index in a group of long term survivors of stroke (Gresham, Phillips, & Labi, 1980).
Many clinicians, particularly those who work with elderly patients, have found the Katz Activities of Daily Life to be a satisfactory functional outcome scale. However, there have been other clinicians who have not been satisfied with the relatively focused scope of the Katz scale. Some researchers believed it would be helpful to develop a measure which would widen the scope of the definition of function to include salient contributors to function such as social support.

**PULSES.**

The PULSES scale is the best known example of a functional outcome scale that included items measuring social support. PULSES is credited with being the first global functional status scale (Moskowitz & McCann, 1957). Each of the six PULSES functional subscales were represented by a letter in the scale name: physical, upper extremity, lower extremity, sensory component, excretory component, and support from family. Each subscale was given a rating based on four possible levels of severity. One potential problem with PULSES is the lack of clear conceptualization of each item. For example, the subscale represented by U, included both an assessment of upper limb impairment and independence in self care through the use of the upper limbs (Jette, 1985).

Test re-test reliability over an unspecified interval for PULSES was reported to be .87 and inter-rater reliability was .95. Scores on both PULSES and the Barthel Index were
very similar. Correlation coefficients between the two outcome scales were -.79, -.74, -.80 for admission, discharge and 2 year follow-up respectively (Granger, Albrecht, & Hamilton, 1979). The correlations were negative because the two scales are inversely scored. The high correlations between the two scales are not unexpected, as 15 Barthel Index items on self care, sphincter control and mobility are included in PULSES. Initial construct validity for PULSES was inferred when patient classification based on PULSES indicated disability classification (Moskowitz, Goldman, Randall, Fox, & Brumfield, 1960). Granger adapted PULSES so that the severity ratings would reflect the degree of assistance which patients required. The higher the score, the more dependent the individual. A global score which summed the subscale scores was included and subscale descriptions were modified to focus more on function than on anatomy (Granger, Greer, & Liset, Coulombe, & O'Brian, 1975). Concurrent and predictive validity were demonstrated in three rehabilitation hospitals. Both PULSES discharge scores and Barthel Index admission and discharge scores were closely correlated with discharge outcome (Granger & Greer, 1976). Further concurrent validity was indicated when 307 discharged rehabilitation patients from 10 hospitals whose admission PULSES scores were 12 or greater were assessed two years after discharge. It was notable that the only two types of patient groups that showed modest
increases in scale scores were the miscellaneous neurologic and lower limb amputee groups. Further spontaneous recovery in patients with head injuries and continued learning in patients with amputations were offered as explanations for improvement (Granger, Albrecht, & Hamilton, 1979).

The PULSES scale was particularly useful in rehabilitation settings. It was adapted by Granger in 1975 so that criteria for each category was clarified and a new numerical global score was added. This global score was based on the four levels within each of the six PULSES categories. The value of the global score ranged from 6 (for full independence) to 24 (for maximal dependence). These changes meant that PULSES scores would be conducive to statistical analyses (Gresham & Labi, 1984). However, the unusual numerical anchors of the PULSES global score led to confusion on the part of workers in rehabilitation settings. Some rehabilitation clinicians felt a less cumbersome scale would be beneficial. The frustration over the PULSES' awkward scoring contributed to the popularity of the numerically simple Barthel Index. Scores on the Barthel vary from 0 (total dependence) to 100 (total independence) in increments of 10.

Barthel Index.

The Barthel Index has been used since 1955 to assess patients' capacity for independence in discrete areas of self
care, sphincter control, and mobility (Mahoney & Barthel, 1965). It did not assess social support. Weighted values were assigned to each item which reflected the time required from an attendant, if patients could not manage by themselves. Full credit was not given if the patient required the presence of staff in order to perform the task with adequate safety. Patients' need for staff assistance in order to deal with environmental barriers also would be reflected in a lower score. Ten weighted subscale scores based on behavioral observations or judgements were summed for a total score. Continence was heavily weighted with 30 out of 100 points due to the time required for assistance in this area. Patients with total scores of 61 or more were regarded to be in a range of less severe impairment. However, even patients obtaining the maximal score of 100 might still need help with food shopping, keeping house and other activities of life which are not on the scale. The Barthel score would indicate that they would be able to get along without live-in attendant care. Validity studies were conducted on the Barthel (also known as the Maryland Disability Index) in three Maryland chronic disease hospitals. Validity was indicated when greater improvement in nursing home patients' Barthel scores paralleled clinical improvement (Wylie, 1967). Stroke patients with low admission scores had less incremental gain in their scores than patients whose admission scores were higher. Any
improvement they experienced tended to take longer to accomplish. The proportion of patients dying within the first six months after admission decreased as Barthel scores increased. When the difference between admission and live discharge Barthel scores was compared with clinical impressions of improvement extracted from hospital charts, it was observed that when the difference was just 5 points or fewer the clinical impression was that the patient's condition was unchanged. When the difference in Barthel scores was ten or more points the clinical impression noted in charts was that the patient's condition was improved. There were however, 6 of 177 patients with a difference of 30 or more points between admission to discharge Barthel scores whose clinical charts indicated no change. These cases were further evaluated and it was observed that one patient's difference score was incorrect and five of the patients had experienced significant improvement in speech or mental function. Although gains in speech and mental function contribute to functional status, they were omitted from the Barthel Index. Additionally, 0 and 100 were not true end points for the scale. Both further deterioration and improvement had been noted. Furthermore, changes in the same number of points did not reflect the same amount of patient improvement (Wylie & White, 1965).
There was increased interest in the Barthel Index when Granger's research group incorporated the scale into rehabilitation outcome evaluation studies. New uses for the Barthel Index were explored. These included establishing normative data for rehabilitation programs, and the study of predictable relationships between inpatient functional status and discharge outcome. For example, a range of Barthel scores was determined in which researchers could predict maximal patient recovery from acute stroke. Those patients with acute stroke unit admission scores of 21 or more and rehabilitation transfer scores of 41 or more were found to have the greatest clinical gain from rehabilitation hospitalization (Granger, Sherwood, & Greer, 1977). The Barthel Index has been called a reliable and valid measure sensitive to temporal change and useful with a wide variety of physical disabilities (Gresham & Labi, 1984).

A high level of agreement was seen when the Barthel Index was compared with the Katz Activities of Daily Living and the Kenny Self Care Evaluation. Full independence percentages in 148 Framingham Stroke Study patients were 35.1%, 39.2%, and 41.9% for the different scales respectively. Differences were nonsignificant. The three scales classified independence in activities of daily living in a very similar manner (Gresham, Phillips, & Labi, 1980).
In a multicenter study of stroke patients, three mobility scales (transfer, walking, and ascending/descending stairs) representing 40 of the total 100 Barthel points were dropped to create a shorter four-function model. A logistic regression analysis compared the original full Barthel model and the shorter unweighted four-function Barthel model in order to predict discharge status. The four-function model was 16 times better at predicting satisfaction with life and 75 times better at predicting living in the community status. Apparently this was appropriate because individuals who were independent on the four functions: bowel control, bladder control, eating, and grooming at admission, had a 90% likelihood of discharge back to the community. This finding is not surprising. However, the full Barthel model was 10,000 times better at predicting a discharge Barthel Index score of 61 or higher than the four-function model. This finding is also not surprising as more than 95% of stroke patients who were admitted with a Barthel Index score of 61 were living in the community at six month follow-up (Granger, Hamilton, Gresham, & Kramer, 1989). This study can be used to raise the question of whether patients in a comprehensive rehabilitation center who have different diagnoses will have different Barthel score patterns. More research is indicated to elucidate this issue.
Barthel Index test-retest reliability over an unspecified interval was .89 and inter-rater reliability was .95. Concurrent validity was indicated with the PULSES Profile with Pearson product moment correlations of -.79, -.74 & -.80 at admission, discharge, and 2 year followup respectively (Granger, Albrecht, & Hamilton, 1979). Predictive validity was indicated when 96% of stroke patients with acute hospital admission Barthel scores of 65-100 were able to be discharged to home and 4% to continuing care facilities, whereas only 64% of stroke patients with admission scores of 5-40 were discharged to home and 36% to continuing care. Additionally just 33% of stroke patients with acute hospital Barthel scores of 65-100 had a hospital stays over 6 weeks duration, while 93% of stroke patients with admission Barthel scores of 5-40 had hospital stays over 6 weeks in duration (Granger, Dewis, Peters, Sherwood, & Barnett, 1979). Predictive validity also was indicated in a multicenter stroke outcome study where of 71% patients with discharge Barthel scores of 61-80 were living in the community at six month follow-up (Granger, Hamilton, & Gresham, 1988). A cross cultural study compared Barthel Index data from 343 stroke patients in Keiko University Hospital, Japan with the mean of Barthel scores from hospitals in the United States, United Kingdom and Japan and found correlation coefficients of .77, .78, .92 respectively. Bathing and eating items were removed for a
second analysis which found correlations of .88, .83, 1.00 respectively; indicating that bathing and eating items are influenced by culture (Chino, 1990).

The mathematical simplicity and attention given to weights for tasks which staff often found less pleasant to perform contributed to the acceptance and use of the Barthel Scale in a great number of rehabilitation settings. This acceptance probably facilitated the development of functional outcome studies for rehabilitation settings. The scope of functional outcome studies widened when some rehabilitation facilities decided that they preferred to have an outcome scale which was based on a more narrow patient group than the general rehabilitation population for which the Barthel Scale was devised.

Kenny Self Care Evaluation.

The Kenny Self Care Evaluation was constructed at the Kenny Rehabilitation Institute in Minneapolis as a rating system for the evaluation of functional status in persons with physical disabilities. The assumption was that the patient's functional level was the inverse of the amount of nursing care which they would require. The Kenny contains six equally weighted categories: bed care, transfers, locomotion, dressing, personal hygiene, and feeding. Each item received a functional status score from zero (for complete dependence) to four (for independence). The intent was not to create five
equal appearing intervals. The Kenny is essentially a seven point scale with the middle three intervals collapsed into a catch all two rating. Criteria were established for the two end positions of the scale 0 and 4 as well as the 1 and 3 positions. Any performance which did not meet these criteria was rated as a two. Patients at level two experience accelerated progress which then begins to slow down at about the midpoint of the interval. Scale construction reflected clinical experience that recovery was sigmoidal not linear (Schoening & Iversen, 1968).

A study which compared the Kenny Scale rating with the amount of time spent by staff assisting patients in transfer tasks supported the construct validity of this scale (Schoening, Anderegg, Bergstrom, Fonda, Steinke, & Ulrich, 1965). Patients who were independent in all self care activities on the Kenny Scale required 152 minutes of staff care during an observed period. Patients who were dependent in four out of six activities on the Kenny Scale required 2547 minutes of staff time during the same observation period. A second study supported the unusual construction of this scale. Plots of Kenny scores for 72 rehabilitation patients by staff time required for patient assistance were drawn for several diagnostic categories and again for each of the six scale categories. The resultant graphs demonstrated non-linear learning curves which were either abrupt, symmetrical, or
right-skewed. No left-skewed or linear plots were obtained. Maximal decrease in staff time corresponded to the middle interval in Kenny scores. This study also provided construct validity for the Kenny Self Care Scale. Predictive validity was indicated by a correlation of 0.90 between improvement on the Kenny and length of stay (Schoening & Iverson, 1968). Concurrent validity was indicated in stroke survivors who demonstrated a correlation of .73 between the Kenny Self Care Evaluation and the Barthel Index (Gresham, Phillips, & Labi, 1980.

None of the functional status scales which has been discussed became the nationally regarded standard instrument for the assessment of rehabilitation outcome. Instead, what happened was that various rehabilitation facilities used a scale which they had created and/or one with features which were a better match for a particular patient population. Not only was there no standard instrument for assessment, there also was no common operationally defined terminology used in outcome analyses, and no consistent level of training required for individuals making functional outcome assessments. The last scale which will be discussed was constructed in an attempt to respond to these problems.

**Functional Independence Measure.**

The Functional Independence Measure provided the dependent variable for this study. The development of the
Functional Independence Measure (FIM) was quite different from the development of previously discussed functional status scales which usually were created at one rehabilitation hospital and then adopted by other facilities. The Functional Independence Measure was constructed by a task force called for by the American Congress of Rehabilitation Medicine/American Academy of Physical Medicine and Rehabilitation at the November, 1983 annual meeting (Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987).

The task force's first mandate was the creation of the Uniform National Data System for Medical Rehabilitation. A grant from the National Institute of Handicapped Research (NIHR) provided initial funding. The intention was to improve the effectiveness and efficiency in rehabilitation by the creation and dissemination of a software data system to service providers, educators, and researchers. A common terminology was established, streamlined data forms were created, and standardized directions were provided. The State University of New York at Buffalo assumed the position of project coordinator. Sixteen items for a functional status scale were selected from a broad sample of 36 currently available functional status scales. Items covered mobility (transfers to bed, wheelchair, tub), locomotion (walking, using a wheelchair, climbing stairs), self-care (eating, bathing, dressing, grooming, & perineal care), sphincter
control (bladder and bowel management), and communication (expression and comprehension).

The Functional Independence Measure's underlying theme was the burden of care placed on others in order for the disabled individual to pursue activities of daily life. The burden of care was further assumed to translate into the utilization of economic and social resources. Patients were rated first as dependent or independent. Within these two designations, further gradations of assistance were specified. Levels 1 & 2 refer to dependence on another person in order for an activity to be performed, or the activity will not be performed. In level 1 the individual is totally dependent, requiring more than half of the effort for a task to be provided by an assistant. The individual who is at level 2 requires moderate assistance and an assistant has to provide less than half of the effort required to accomplish a task. Levels 3 & 4 refer to independence when no other person is required for the activity to be performed. In level 3, the individual requires an assistive device, takes more than the usual amount of time to perform a task, or creates some safety concerns. An individual at level 4 is capable of safely performing all tasks without assistive devices within a reasonable amount of time (Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987). The newly created Functional Independence Measure was intended to be used to assess outcome
in various rehabilitation settings. It was anticipated that systematically collected data would help monitor patients from the initiation of contact with rehabilitation facility through service delivery and follow-up. Changes in performance across time could be noted and studied. The resulting data would elucidate levels of disability, outcome of rehabilitation, duration of care, cost of disability, cost-effectiveness of rehabilitation services, resource allocation requirements, program evaluation, and accountability for accrediting agencies.

The Functional Independence Measure can also be used to compile data from many rehabilitation sites in a uniform manner in order to help formulate decisions about prospective payment for rehabilitation services. The establishment of a comprehensive national data base was felt to be one way of improving the quality of medical records by the collection of uniform records among different rehabilitation settings. The multiplicity of functional status outcome scales used in different rehabilitation hospitals was believed to be contributing to the confusion regarding outcome. Furthermore, outcome studies now are required by a federal demand for a prospective payment plan in rehabilitation medicine.

Benefits of the Functional Independence Measure also include the provision of a standardized manner of procuring baseline data before allocation of rehabilitative services,
generation of information on clinical caseloads within a rehabilitation settings, as well as documentation to aid in the determination of appropriateness for patient discharge. The patient information which is collected through administration of the Functional Independence Measure and subsequent entry into the Uniform National Data Service is now necessary at multiple levels of treatment, research, administration, and legislation (Granger, Hamilton, Keith, Zielezny, & Sherwin, 1986; Keith, Granger, Hamilton, & Sherwin, 1987).

The Functional Independence Measure was given a pilot test to evaluate its face validity and ease of administration. Clinicians from a multidisciplinary background, including a few psychologists in 11 rehabilitation facilities evaluated 110 patients. Each center rated two patients, each with brain injury, stroke, or spinal cord injury, plus any of four other diagnoses. The clinicians were asked for specific feedback on the new scale. Feedback ranged from time to administer the scale to an evaluation of the items. The primary recommendation was for the inclusion of more items. After clinician feedback, subscales for Social Adjustment (social interaction) and Cognition (problem solving) were added and a few other items were modified by the task force. The addition of Cognition was more difficult than the other changes (Keith, Granger, Hamilton, & Sherwin, 1987).
The Functional Independence Measure entered a trial phase in July, 1985 with over 50 rehabilitation centers participating. The purpose was to assess inter-rater reliability, validity, time cost to administer, and scale precision. Again ten patients were evaluated at each center. However, this time there were no stipulations regarding the diagnoses of the patients (Granger, Hamilton, Keith, Zielezny, & Sherwin, 1986; Keith, Granger, Hamilton, & Sherwin, 1987). Psychology was not included among the disciplines represented by the raters. Inter-rater reliability between pairs of raters was .86 at admission and .88 at discharge. An interclass kappa correlation, which adjusted for agreement due to chance, was .54 for all 18 Functional Independence Measure items. Validity was determined by asking the raters in the trial phase four questions: were any items hard to understand, were any items unnecessary, did items need to be added, how would you rate the Functional Independence Measure as a measure of disability on a scale of 1-4? This time there was no change in the rating of item difficulty, 2% more raters thought items were unnecessary, 14% thought items needed to be added, and the overall rating went from 2.98 to 3.44 (Hamilton, Granger, Sherwin, Zielezny, & Tashman, 1987).

The next modification of the Functional Independence Measure involved the elaboration of the levels of independent and dependent behavior by enlarging from four levels to seven
different levels. The levels of dependent and independent behavior were expanded due to clinician feedback from the trial phase. An increased number of levels was believed to enable Functional Independence Measure users to identify changes in patient function with increased sensitivity. Individual item scores range from a low of one, where the patient was totally dependent or in danger of getting hurt if they performed the task, to the highest score of 7, indicating complete independence and safe performance. Composite scores based on all 18 items ranged from 18 to 126. The underlying concept remained the burden of care these behaviors required. Burden of care was defined as the time and energy which had to be relegated to address the disabled individual's dependent needs.

Clinician feedback following the trial phase also indicated concern about the social cognition items. There was a lack of agreement on how to quantify the problem solving, memory, and social interaction activities at various levels of disability. Cognition items were refined and the Guide indicated they would continue to be refined (Uniform Data Management Service, 1990b). Currently the items representing cognition are scored as follows. Problem solving: 1. total assistance, can solve less than 25% of routine problems and may need a restraint for safety; 2. maximal assistance, solves 25-49% of routine problems, but needs direction 50% of the
time to initiate, plan or complete simple activities and may need safety restraints; 3. moderate direction, solves 50-74% of routine problems; 4. minimal direction, solves 75-90% of problems; 5. supervision, needs cuing or coaxing for 10% of problems and only under stress or novel situations; 6. modified independence, recognized problems and carries out complex solutions, but experiences mild difficulty or requires an unreasonable amount of time; 7. complete independence, consistent in problem recognition, solution of complex problems and execution with self correction as needed.

The updated memory item is scored in a similar manner:
1. total assistance, recognizes and remembers less than 25% of the time; 2. maximal prompting, recognized and remembers between 25-49% of the time and needs more than 50% prompting; 3. moderate prompting, recognizes and remembers 50-74% of the time; 4. minimal prompting, recognizes and remembers 75-90% of the time; 5. supervision, requires prompting 10% of the time and only when stressed or in novel situations; 6. modified independence, recognizes familiar people and remembers daily routines with mild difficulty, but may use self-initiated or environmental cues; and 7. complete independence, recognizes people frequently encountered and remembers daily routines and requests without need for repetition.
The social interaction items in Version 3.0 are: 1. total assistance, less than 25% of interactions are appropriate, may need restraint, 2. 25-49% of interactions are appropriate and may need restraint, 3. moderate direction, 50-75% of interactions are appropriate, 4. minimal direction, 75-90% of interactions are appropriate, 5. supervision, requires cuing 10% of the time when under stress or in novel situations and may need encouragement to participate, 6. modified independence, does not need supervision and interacts with other patients, staff and family with mild difficulty in most situations, but may need more time to adjust to social situations or may need medication for control, 7. complete independence, interacts appropriately and is aware of their social impact on others (Uniform Data System & Center for Functional Assessment Research, 1990b).

New data collection forms (see Figs. 2-4) and a revised Version 3.0 of the Guide was published and distributed to contributors to the Uniform Data System. This manual clearly defined terms used in data collection, gave scoring directions, and included educational case histories along with sample data coding sheets. As with the Katz Activities of Daily Living, the level of dependence or independence is based on what the client actually performed, not what they are capable of performing. If patients demonstrated poorer performance on the nursing floor than they did in a therapy
session, the lower score was to be recorded (Hamilton & Granger, 1987; Uniform Data System & Center for Functional Assessment Research, 1990b). Inter-rater reliability for the new seven level version of the Functional Independence Measure, using pairs of clinicians and 263 patients from 21 United States rehabilitation hospitals, was .97 for total Functional Independence Measure scores. Subscale score inter-rater reliability correlations were: self-care .96, sphincter control .94, mobility (transfers) .96, locomotion .93, communication .95, and social cognition .94 (Hamilton, Laughlin, Granger, & Kayton, 1991). The modified FIM appears to possess adequate inter-rater reliability for the groups of subscales which were reported. However, it would be more helpful for researchers if Hamilton's group published inter-rater reliability correlations for each of the 18 subscales.

Inter-rater reliability should remain high and perhaps even improve with a new requirement in the 10/11/90 revision of the manual, that Functional Independence Measure raters who contribute to the Uniform Data System be credentialed. Participating hospitals are required to submit credentialing studies every three years for employees who participate in the entire rating process and every year for raters who evaluate only discipline specific items. The stated purpose of credentialing was to maintain the integrity of the aggregated data (Uniform Data System & The Center for Functional
Assessment Research, 1990a). Educational materials to help with the credentialing process including decision trees for levels of independence have been distributed nationally (Uniform Data System & Center for Functional Assessment Research, 1989).

Recently, concurrent validity of Functional Independence Measure was tested in a group of 24 patients with multiple sclerosis. The instruments used were the Functional Independence Measure; the Barthel Index; the Incapacity Status Scale, which assesses disability; the Environmental Status Scale, which assesses handicap; and the Brief Symptom Inventory. In addition, a Help at Home Diary of minutes of assistance required per day was compiled by patients and their caregivers (Granger, Cotter, Hamilton, Fiedler, & Hens, 1990). Concurrent validity of the Functional Independence Measure, Incapacity Status Scale, Environmental Status Scale, and Brief Symptom Index in predicting minutes of assistance needed per day was demonstrated. However, concurrent validity for these measures was not found for predicting general life satisfaction. This is not surprising as general life satisfaction is not the underlying assumption of either Functional Independence Measure or the Brief Symptom Index. It was noteworthy that of the 47 various scale items, eight of the best ten items in predicting help in minutes per day were from the Functional Independence Measure. The Functional
Independence Measure appeared to be the best predictor of minutes of help required per day in patients with multiple sclerosis. However, for patients who also had limitations in vision, the inclusion of the Incapacity Status Scale item, vision, improved the predictive ability of the Functional Independence Measure. There is increased interest in conducting further research on specific patient groups (Granger, Cotter, Hamilton, Fiedler, & Hens, 1990; Linacre, Heinemann, Wright, Granger, & Hamilton, 1992). This study contributed to that interest.

**New Importance of Functional Independence Measure.**

Current research on the Functional Independence Measure has been directed at determining the feasibility of using this instrument in the development of a functionally based measure which can be utilized in prospective payment for rehabilitative services (Batavia & DeJong, 1988; Wilkerson, Batavia, & DeJong, 1992; Stineman, 1992). Diagnostic related groups seem to have limited use for patient categorization. They do not explain as much of the variance in resource utilization as methods which utilize severity of illness (Horn & Sharkey, 1983). When diagnostic related groups were chosen for acute medical care, it was felt they provided an average of past costs of hospital stay. The data base from which Yale researchers drew their calculations to derive Medicare costs actually underrepresented rehabilitation patients. It was also
recognized that the diagnostic related group system was developed for short term hospital stays and did not take into account the special circumstances of longer rehabilitation stays. Rehabilitation hospitals have been excluded from federal prospective payment plans which were based on diagnostic related groups. Those units that meet federal exclusion criteria currently are paid retrospectively.

McGinnis' research team tried another method of predicting cost of medical rehabilitation in an effort to find a substitute for diagnostic related groups which could be used to classify patients and solve the prospective payment problem (McGinnis, Osberg, DeJong, Seward, & Branch, 1987). The variables of interest were: a measure of functional status constructed especially for the experiment, patient diagnostic related groups, the Severity of Illness Index, and age. In a stepwise multiple regression, age and the Severity of Illness Index together accounted for 36% of the variance in total charges, with 26% contributed by the Severity of Illness Index alone. Diagnostic related groups contributed only 1% (stroke) or 2% (hip fracture) of the variance. An unexpected finding was that functional status at admission did not contribute significant unique variance. This was explained by the fact that the Severity of Illness Index subsumed functional status, as its items contained dependency on staff and response to therapy. Once the Severity of Illness Index entered the
equation, functional status at admission no longer was a significant predictor due to the intercorrelation of .60 between function at admission and the Severity of Illness Index. The authors also stated that the three hour rule of Medicare, which required three hours of therapy be given to all inpatients regardless of functional level, had the effect of raising the cost of rehabilitation more than would be the case if therapy was prescribed on need alone (McGinnis, Osberg, DeJong, Seward, & Branch, 1987). The authors did not discuss any potential effects of using their own functional scale which was constructed for this experiment. Since the actual construction of the scale and its composition are unspecified, the reader can not determine any potential influence it might have had on the findings.

Still a third method of deriving prospective payment for rehabilitation has been conceptualized. Kreitzer, Loebner, & Roveti (1982) created a model to elucidate a means by which the cost of medical care can be accounted for fairly in a prospective payment system. They also hypothesized that diagnostic related groups were inadequate measures for use in the classification of patients receiving medical service reimbursement. Equitable reimbursement of services needed to be based on some type of homogeneous grouping of patient care. Their own study indicated that when used as a means of patient classification, the diagnostic related groups do not produce
homogenous groups. Kreitzer et al., 1982, hypothesized that variance within the diagnostic related groups could be identified. Once this variance was identified, the source of the variance could be utilized in the formulation of a more useful means of patient classification for a prospective payment system. They further hypothesized that one potential variable to study was illness severity, because severity has practical significance in medical treatment. Kreitzer defined illness severity as the level and impact of a change in the health status of a person due to an illness or injury. They believed that the lumping together of patients with varying levels of illness severity in the same diagnostic related group resulted in problematic heterogeneity within diagnostic related group categories. Illness severity was seen as a missing link between DRG's and cost of care. Kreitzer believed that severity of illness caused the variance in length of stay and that length of stay resulted in medical cost. Consequently, Kreitzer et al., 1982 recommended grouping patients by illness severity within diagnostic related groups.

Stineman, 1992, did not acknowledge Kreitzer, Loebner, & Roveti's model in the published abstract of her recent presentation on her own method of prospective payment for rehabilitation services. However, Steinman's proposal could be seen as an operationalization of Kreitzer's model. Stineman used information from the Uniform Data Management
System to begin creation of a prototype prospective payment system for each diagnosis. Stineman's system classified patients into functionally related groups on the basis of the rehabilitation impairment, such as stroke or spinal cord injury; patient age; and the seven Functional Independence Measure levels of dependence/independence. Data from the Uniform Data System appear to have been extracted which indicated the typical length of stay for each of these function related groups. It is the resultant length of stay which is conceptualized as the important variable in determining the prospective payment. It is anticipated that this method will preclude some institutions being rewarded excessively when they care for less complex and less functionally disabled patients. Reimbursement will be more equitable and in line with the severity and costs involved in patient care. As a result of the growing likelihood that the Functional Independence Measure will be used in the assignment of prospective payment for rehabilitation, there has been a resurgence of interest in the statistical nature of the instrument.

The article that precipitated a closer look at the Functional Independence Measure (FIM) challenged its use in prospective payment because of the ordinal scale of the instrument (Merbitz, Morris, & Grip, 1989). Concern was expressed that the distances between classes on an ordinal
scale are unknown as there is no underlying equal interval present within the scale. Consequently Merbitz et al. argued that data obtained from an ordinal scale would not allow mathematical operations which would directly relate to the real world. As a consequence Merbitz contended that results of mathematical manipulations performed on ordinal data was not logically valid and could not be meaningfully interpreted. Compounded errors would occur when ordinal data was aggregated across domains. Merbitz, Morris and Grip recommended the development of interval and ratio scale measurement.

The difference between observations obtained from ordinal scales and measurements obtained from ratio scales has been stressed in recent literature (Wright and Linacre, 1989). Wright and Linacre proposed a Rasch transformation of ordinal ranked functional status scores into a linear ratio scale form so that mathematical operations could be conducted. A Rasch transformation would establish a consistent level of difficulty for scale items, as well as identify possible unidimensional variables which data can support. Silverstein, Fisher, Kilgore, Harley, & Harvey, 1992, described the two requirements for interval measurement which would improve functional assessment scales. They stated functional status scales needed to be unidimensional and possess additivity. In order to be unidimensional they stressed that items must progress in difficulty across a range of performance, define
a common underlying ability, and possess a constant difficulty for patients. When scale items do not fit in a unidimensional continuum the summed scores yield uninterpretable information. Transformation of Functional Independence Measures from ordinal to ratio scale with a Rasch analysis provide linear measures (Wright, 1992).

This controversy in the literature was considered when planning this study. Dr. Wright kindly sent a working draft of a manuscript which described a Rasch analysis of Functional Independence Measure scores that had been provided by the Uniform Data Management Service (Linacre, Heinemann, Wright, & Granger, 1992). The analysis of 14,799 admission and discharge Functional Independence Measures demonstrated that there were two statistically distinct variables included in aggregate FIM measures. Thirteen items fit with motor functions and five items fit with cognitive functions. Linacre et al. stated that the discontinuity between cognition and motor items indicated that the statistical validity and clinical import of the Functional Independence Measure could be improved by dividing the scale into two unidimensional variables. This empirically derived information was used in the current study to justify the creation of an aggregate motor and an aggregate cognition score. The Rasch analysis also demonstrated that the Functional Independence Measure functioned the same way at admission and discharge from
rehabilitation. This empirically derived information about the stability of the Functional Independence Measure was used in the current study as justification for the creation of a score that rated improvement in Functional Independence Measures from admission to discharge from rehabilitation. The comparison between the raw score and Rasch converted Functional Independence Measure scores was considered in the limitations of the current study at the conclusion of the discussion section. The controversy in the literature regarding the appropriateness of the Functional Independence Measure in the derivation of prospective payment for rehabilitation medicine services has assisted in the planning and discussion of the current study.

When it became apparent that Rasch analyses were very difficult for even trained statisticians to conduct, Johnson's 1989 response to Merbitz' article was utilized. Johnson pointed out that Merbitz' position, that all measurement of not at least interval scale is flawed, was unsupported by statistical practice. Johnson contended that non-parametric statistics, such as the Spearman rank correlation, are rigorous and often robust in the face of minor violations of statistical assumptions. Consequently, the current study did employ Spearman correlations.
Effect of Age on Measurement.

The most salient caution obtained by a review of the literature was the possible impact of old age on recovery after brain dysfunction. Most elderly patients with head injury have a concomitant medical disorder that can get masked by the brain injury (Galbraith, 1987). Elderly persons have reduced cranial reserve and are less able to recover from even minor brain injuries. Older patients with severe head injuries have a much poorer outcome. In one study of 65 elderly head injured patients, all five patients with severe head injuries and three out of four with moderate head injuries died. Seventy-two percent of the surviving 54 elderly patients had a decrease in functional status at discharge that necessitated increased family involvement and use of community resources (Wilson, Pentland, Currie, & Miller, 1987). The group that experienced a decrease in functional status was significantly older \( p < .01 \) than those patients whose functional status was unchanged. As a result of these findings, a decision was made to exclude individuals over 70 years of age from the current study in order to reduce age related confounds.

In summation, a review of the literature indicated the Orientation Group Monitoring System was an appropriate choice as an instrument to obtain measures of cognition in individuals who have experienced either non-traumatic or
traumatic brain dysfunction. The OGMS assesses individuals who are clearing post-traumatic amnesia (see Fig. 1) and demonstrates adequate reliability and validity. The Functional Independence Measure is an appropriate choice as an instrument to measure functional status at admission to rehabilitation hospitalization as well as improvement in functional status for individuals who have brain injury. The FIM has adequate reliability and validity and is administered in a standardized manner under the supervision of credentialed professionals. The research literature also guided the choice of statistical analyses and the establishment of subject inclusion criteria. The literature also highlighted the need for research that contributes to knowledge of a possible relationship between cognition and Functional Independence Measure in the recovery of patients with brain injury. This study is a first step in the exploration of the potential relationship between cognition at admission to rehabilitation (as represented by OGMS scores) and admission total FIM scores as well as the two underlying dimensions in the FIM which have been recently identified, self-care/motor skills and communication/social cognition skills. The study also explored the relationship between cognition (OGMS) and improvement in total FIM and the two dimensions self-care/motor and communication/social cognition.
CHAPTER IV

METHOD

This retrospective study included all head injured patients in a large university rehabilitation hospital who met criteria. The purpose of the investigation was to determine the relationship between cognition (as represented by Orientation Group Monitoring System scores) at admission to rehabilitation hospitalization and functional outcome (as represented by Functional Independence Measure scores).

Subjects

The population of interest was adults with brain dysfunction of sufficient severity to require rehabilitation hospitalization. The sample studied in this research project was all consecutive adult patients admitted to the inpatient Traumatic Head Injury Unit at Dodd Hall, The Ohio State University Department of Physical Medicine and Rehabilitation who met all the following criteria: (1) subjects had sustained a brain dysfunction within eight months prior to admission, (2) were admitted for rehabilitation while still in post-traumatic amnesia, (3) participated in the Orientation Group Monitoring System (OGMS) for at least one week with the first
two days score and week one aggregate score <2.75, and (4) had Functional Independence Measure (FIM) scores in their hospital record. Patients over 70 years of age were excluded due to reports in the literature of possible confounding variables influencing cognitive scores in the elderly (Galbraith, 1987; Wilson, Pentland, Currie, & Miller, 1987). Data were collected on all 146 individuals meeting criteria who were admitted for rehabilitation hospitalization between April, 1990 and May 30, 1992.

Materials

Archival medical records and the clinical files of the Division of Rehabilitation Psychology, Department of Physical Medicine and Rehabilitation, The Ohio State University were utilized in order to obtain demographic data, time to rehabilitation admission, Orientation Group Monitoring System (OGMS) scores, and Functional Independence Measure scores.

Specifically, the following information was obtained from the rehabilitation hospital records and the Division of Rehabilitation Psychology clinical files: date of birth, sex, years of education, date of head trauma, date of admission to rehabilitation, OGMS aggregate and subscale scores, and FIM total and subscale scores (see Fig. 1). Patient age in years was determined by subtracting the date of birth from the date of rehabilitation hospitalization. The following descriptive data also were obtained in order to provide additional
information on the sample: gender, level of education, and type of brain dysfunction. The variables gender and level of education in the obtained sample provided some assurance that the sample was comparable to other samples which had been reported in the literature. It was possible that a particularly high or low level of education in this sample could affect cognitive scores. Initially, it was anticipated that the two groups of brain dysfunction (traumatic and nontraumatic) which are coded in the Functional Independence Measure protocols could contrasted to probe for significant differences in obtained correlations. There might have been theoretical and clinical importance if a significant difference between the two groups was obtained. This comparison was not conducted due to very different sample size of the two groups. The Orientation Group Monitoring System (OGMS) scores that were extracted were the aggregate score and the seven behavioral subscale scores: orientation to time; orientation to place; knowledge of group members and therapists; attention span; associate learning; episodic memory; and use of planning and scheduling aids. When the OGMS criterion scores were extracted, it became apparent that a decision had to be made to specify exactly how the subject criterion of <2.75 on the OGMS would be established. Holidays tended to create work weeks with four rather than five days. The more specific OGMS score criterion was that subjects had to participate in the OGMS with a weekly aggregate score of
<2.75 based on not less than three days of OGMS participation in a five day week, or two days participation in a four day week.

The OGMS was specifically designed for prospective monitoring of post-traumatic amnesia in closed head injured patients. It yields a weekly measure of cognitive function which is based on behavioral observations of attention, orientation, associative learning, episodic recall and the effective utilization of environmental cues during a daily therapeutic orientation group (see Fig.1-3). The OGMS has an inter-rater reliability of .87 (Corrigan, Arnett, Houck, & Jackson, 1985). Construct validity of the OGMS has been supported by findings that reduction in OGMS scores in excess of the standard error of measurement is highly sensitive (98%) and specific (93%) to medical complications (Jackson, Mysiw, & Corrigan, 1989). Further support for construct validity of the OGMS has been obtained by the negative correlation with agitation -.53 and the observation that low OGMS scores improve before agitation diminishes (Corrigan & Mysiw, 1988). The OGMS has high concurrent validity with the Galveston Orientation and Amnesia Test and the Mini-Mental State (Mysiw, Corrigan, Carpenter, & Chock, 1990; Corrigan & Mysiw, 1988). One particular advantage which the Orientation Group Monitoring System has over the Galveston Orientation and Amnesia Test is that it captures the multiple dimensions of impaired consciousness during post-traumatic amnesia. The OGMS
also is an instrument with advantages over the Rancho scale, as it provides a quantitative measure of discrete clinical variability during post-traumatic amnesia, while the Rancho scale provides a qualitative measure which does not capture such discrete clinical variability. Weekly aggregation of daily OGMS scores reduces biases which could be caused by daily variability. While some attenuation is evident at the top of the OGMS scale, it has a range of utility in the assessment of cognitive function in patients who are in the acute phase of recovery from brain dysfunction (Corrigan, Arnett, Houck, & Jackson, 1985). The OGMS fills the gap between the Glasgow Coma Scale and traditional neuropsychological measures of cognitive function (see Fig. 1).

The extracted Functional Independence Measure (FIM) scores were: the total FIM score, and the 18 subscale scores for eating; grooming; bathing; dressing-upper body; dressing-lower body; toileting; bladder management; bowel management; transfer to bed/ chair/ wheelchair; transfer to toilet; transfer to tub & shower; walking/ wheelchair mobility; managing stairs; comprehension; expression; social interaction; problem solving; and memory (see Figs. 3-5).

The FIM is a functional status scale established by the Uniform Data System to assesses severity of patient disability. FIM scores can be used as a rehabilitation outcome measure for program evaluation, quality assurance, and
research. FIM data that was collected by 1,000 clinicians on 413 patients in 33 comprehensive rehabilitation centers in the United States indicated good face validity, a feasible administration time of 32 minutes, and an inter-rater reliability of .88 (Hamilton & Granger, 1987). Concurrent validity for FIM has been demonstrated in patients with multiple sclerosis. When compared with the Barthel Index, the Incapacity Status Scale, the Environmental Status Scale, and the Brief Symptom Index, FIM demonstrated greater ability to predict the minutes per day of assistance which patients required to accomplish functional activities of daily living (Granger, Cotter, Hamilton, Fiedler, & Hens, 1990).

The Ohio State University Department of Physical Medicine and Rehabilitation has been granted the credentialed status which is now required by the Uniform Data System (UDS Data Management System, 1991). Credentialing indicates personnel who entered FIM data on study subjects were trained with UDS educational materials and met or exceeded criterion scores on UDS examinations. Patient data submitted by the Physical Medicine Department met specific UDS standards and Ohio State University data were consistent with data submitted from other medical facilities.

Procedure

The research design was intended to clarify the nature of cognition and functional status in patients who were receiving inpatient rehabilitation for brain dysfunction. Extracted
data from consecutive admissions to the Traumatic Head Injury Unit at the Department of Physical Medicine and Rehabilitation, The Ohio State University Hospitals was used to investigate two research questions.

First Research Question.

The first research question was: What is the relationship between cognition (as represented by the admission OGMS aggregate and seven subscale scores) and functional independence (as represented by the total FIM score at admission) in persons receiving inpatient rehabilitation on the Traumatic Head Injury Unit? Is cognition related to functional independence in a manner that is similar to age (Wilson, Pentland, Currie, & Miller, 1987), and length of time from injury to rehabilitation (Saneda & Corrigan, 1992)? This question was investigated through three analyses.

First a Spearman's coefficient correlation was computed to elucidate the relationship between both the initial aggregate OGMS score and the initial 7 OGMS subscale scores, the interval between injury and admission to rehabilitation, patient age, and the years of formal education; with the admission total FIM score. The independent variables were: aggregate and subscale OGMS scores, time to rehabilitation admission, education, and age. The dependent variable was the admission total FIM score. A Spearman rank order correlation was selected due to the ordinal scale of the data.
The second analysis involved the calculation of two additional Spearman coefficients. Each of these Spearman Correlations was computed between the OGMS items and either a created FIM aggregate variable for motor/self care or a created FIM aggregate variable for communication/social cognition. Statistical justification for the use of these two created dependent variables, FIM motor/self care and FIM communication/social cognition, was provided by Linacre, Heinemann, Wright, Granger, & Hamilton, 1992. Linacre's group performed a Rasch analysis on the FIM scores of 14,799 patients. The resulting statistics indicated that the five FIM communication/social cognition items: comprehension, expression, social interaction, problem solving, and memory did not combine in a homogeneous manner with the rest of the FIM items. Linacre concluded that these 5 FIM items measured cognitive disability and the rest of the FIM subscales measured motoric disability. The creation of the two aggregate dependent variables self-care/motor and communication/social cognition FIM was also justified by the historic construction of the FIM. The five communication/social cognition items were added to the FIM at a later point during construction of the FIM. Clinical feedback during pilot field testing also indicated that the five communication/social cognition items appeared to have a different appearance than the thirteen self-care motor items (Keith, Granger, Hamilton, & Sherwin,
1987). The motor/self care aggregate score was created by the summation of admission FIM scores on the eating, grooming, bathing, dressing-upper body, dressing-lower body, toileting, bladder management, bowel management, transfer to bed/chair/wheelchair, transfer to toilet, transfer to tub, walking, and stair climbing items. The created FIM aggregate communication/social cognition score was created by the summation of admission FIM scores on the comprehension, expression, social interaction, problem solving, and memory items.

The third analysis that was conducted to answer the first research question used a stepwise multiple linear regression. The stepwise regression explored the amount of variance in functional independence that can be accounted for by initial cognition scores, age, education and time to rehabilitation. A stepwise multiple regression analysis was conducted with the following independent variables: age, time from injury to rehabilitation, and initial aggregate OGMS scores. The initial OGMS item scores were not placed in the model along with the aggregate score because the aggregate OGMS score is a linear combination of the OGMS item scores. The aggregate score was likely to be highly correlated with the individual item scores. Inclusion of both aggregate and item scores would have introduced the problem of multicollinearity into the model (Cohen and Cohen, 1983). If
the OGMS item scores were to have had a higher correlation with the admission total FIM score than the aggregate OGMS score, they would have been entered into the model in place of the aggregate OGMS score. However, only the Orientation to Time item had a higher correlation ($r = .50$) than the aggregate Orientation Group Monitoring System score ($r = .48$). Consequently, the aggregate OGMS score was retained and the OGMS item scores were left out of the model.

The hypotheses generated by the first research question were as follows.

**Hypothesis 1.** The aggregate OGMS score at admission to rehabilitation has a significant correlation with the admission Functional Independence Measure total score.

$H_0: \rho_1 - \rho_2 = 0$

$H_1: \rho_1 - \rho_2 \neq 0$

**Hypothesis 2.** The OGMS subscale Associative Learning at admission to rehabilitation has a significant relation with the admission Functional Independence Measure total score.

$H_0: \rho_1 - \rho_2 = 0$

$H_1: \rho_1 - \rho_2 \neq 0$

The justification for this hypothesis regarding the relationship between Associative Learning and functional independence can be found in Saneda and Corrigan, 1992. Associative Learning appeared to perform differently from
other OGMS target behaviors. Initial Associative Learning scores did not predict whether or not an individual would clear post traumatic amnesia. However, improvement in Associative Learning from week one to week two was the best of all OGMS subscales in predicting clearing post-traumatic amnesia. The performance of the Associative Learning subscale indicated that there might be different relationships between the various OGMS subscales and admission FIM scores.

**Hypothesis 3.** The time from trauma to rehabilitation admission has a significant relation to Functional Independence Measure total score.

\[ H_0: \mu_1 - \mu_2 = 0 \]
\[ H_1: \mu_1 - \mu_2 \neq 0 \]

Time from trauma to rehabilitation has accounted for more variance than age or duration of post traumatic amnesia in predicting whether or when PTA would clear in prior research (Saneda & Corrigan, 1992).

**Hypothesis 4.** The initial aggregate OGMS score and time from injury to rehabilitation admission will contribute significant unique variance to functional independence, as represented by admission total FIM scores.

\[ H_0: R^2_{yx} = 0 \]
\[ H_1: R^2_{yx} \neq 0 \]
Second Research Question.

The second research question was: How much variance in the improvement of functional independence can be accounted for by cognition early in rehabilitation? Improvement in functional independence was defined as the change in FIM scores from admission to discharge. Improvement was operationalized by the creation of a variable representing the difference between discharge and admission FIM scores. This second research question also was investigated in three analyses.

In the first analysis, a Spearman's coefficient correlation was computed in order to explore the relationship between the initial aggregate OGMS score, the initial seven OGMS subscale scores, the interval between injury and admission to rehabilitation, age, and education; with the change in total FIM score. The created variable representing the change in FIM score was obtained by subtracting the admission total FIM score from the discharge total FIM score. The independent variables were: aggregate and subscale OGMS scores, time to rehabilitation, years of formal education, and age at time of rehabilitation admission. The created dependent variable was the difference in total FIM score.

There are some problems resulting from the use of change scores. The subtraction of the admission Functional Independence Measure score from the discharge Functional
Independence Measure score runs the risk of false conclusions, as such change scores systematically relate to any random error of measurement (Cronbach & Furby, 1970). In addition, a Rasch transformation of Functional Independence Measure motor items indicated the slope at the extreme ends of the raw untransformed FIM scores was flat, whereas the slope at the extreme ends of the transformed FIM scores was steep. This meant that it is much harder to show improvement at the end of the scale and easier to show improvement at the middle of the scale. A change of 10 score points at the high end of the scale was the equivalent of a four times the change in ten points at the middle of the FIM scale. The net result could be a ceiling effect (Linacre, Heinemann, Wright, & Granger, 1992). A ceiling effect could reduce the range of Functional Independence Measure difference scores. Because of these problems, findings which are obtained through the use of difference scores need to be interpreted with caution.

The second analysis involved the calculation of two additional Spearman's coefficient correlations. Each of these correlations was computed between the OGMS items, time to rehabilitation, age, education, and either a created variable representing the change in motor/self care or a created variable representing the change in communication/social cognition. The motor/self care variable was created by summing the differences between admission to discharge scores on the
following FIM items: eating, grooming, bathing, dressing-upper body, dressing-lower body, toileting, bladder management, bowel management, transfer to bed/chair/wheelchair, transfer to toilet, transfer to tub, walking, and climbing stairs. The communication/social cognition variable was created by summing the difference between admission and discharge scores on the following FIM items: comprehension, expression, social interaction, problem solving, and memory.

The third analysis conducted in response to the second research question used a stepwise multiple linear regression. This regression analysis determined the amount of variance in the change of functional independence from admission to discharge which could be accounted for by cognition, age, education, and time from injury to rehabilitation. The independent variables were: the initial aggregate OGMS score, time from injury to rehabilitation admission, years of formal education, and age at time of rehabilitation. The OGMS item scores were not placed in the model along with the aggregate OGMS score to prevent the problem of multicollinearity (Cohen & Cohen, 1983). If for some reason the OGMS subscale scores were to have demonstrated a higher correlation with the created difference score, they would have been entered into the model in place of the aggregate OGMS score. Only Orientation to Time \((r = .22)\) and Episodic Recall \((r = .23)\) enjoyed higher correlations than the aggregate OGMS \((r = .18)\)
in the preceding Spearman's correlation which determined the relationship between the independent variables of interest and the dependent variable created by the difference between admission and discharge total FIM scores. Consequently, only the aggregate OGMS score and not the individual OGMS item scores were placed in the model.

Justification for the utilization of a difference score as the dependent variable in all the second research question analyses was provided in an unpublished manuscript (Linacre, Heinemann, Wright, Granger, & Hamilton, 1992). Linacre used Rasch's mathematical model to (1) convert FIM scores, which are on an ordinal scale, into an interval scale, and (2) transform nonlinear measures into linear measures. Conversion of FIM scores to measures needs to be the same at both admission and discharge in order to be valid. Subsequent analyses revealed differences in the standard error for admission and discharge FIM scores of only 0.25 logits in a sample of 14,799 rehabilitation patients. They believed that 0.25 logits was small enough to be ignored in practice. The conclusion reached by Linacre et al. was that FIM scores at admission and discharge have the same meaning. This permits a valid comparison of the admission and discharge FIM scores and the use of a difference score as the dependent variable in this study.
The second research question generated the following hypotheses.

**Hypothesis 5.** The time from injury to rehabilitation admission has a significant relationship with the change in total FIM scores.

\[ H_0: \beta_1 - \beta_2 = 0 \]
\[ H_1: \beta_1 - \beta_2 \neq 0 \]

**Hypothesis 6.** The aggregate OGMS score has a significant relationship with the change in total FIM scores.

\[ H_0: \gamma_1 - \gamma_2 = 0 \]
\[ H_1: \gamma_1 - \gamma_2 \neq 0 \]

**Hypothesis 7.** The aggregate OGMS and the time from injury to rehabilitation admission will contribute significant unique variance to improvement in functional independence as represented by the created total FIM difference score.

\[ H_0: R^2_{yx} = 0 \]
\[ H_1: R^2_{yx} \neq 0 \]

Power analyses were conducted prior to data collection. It was anticipated that the effect size for hypotheses 1, 2, 6 and would be small, \( r = .30 \). Alpha was set at 0.05, power was set at 0.80. According to power tables (Cohen and Cohen, 1983), 84 subjects would be required for the experiment. For hypothesis 3 and 5, it was anticipated that the effect size would be \( r = .40 \). With alpha set at 0.05 and power at .80, the
power tables indicated 46 subjects were required for the experiment. It was further anticipated that the effect for hypotheses 4 and 7 would be $R^2 = .16$. With Alpha set at 0.05 and power at .80 the power analysis for $R^2$ indicated that 84 subjects were required to conduct the experiment. Although the total sample size was 146, the traumatic brain dysfunction group contained 122 subjects and the nontraumatic brain dysfunction group contained only 24 subjects. The sample sizes for both FIM diagnostic categories were too small to allow a cross validation research design.
CHAPTER V

Results

A total of 146 Traumatic Head Injury Unit patients met research criteria. These subjects were assigned to either the traumatic or nontraumatic brain dysfunction groups by their International Classification of Disease Number (ICD-9) in accordance with the guidelines of the Uniform Data Management System (1992). The resultant groups were of very different size. The traumatic brain dysfunction group had 122 subjects, while the nontraumatic brain dysfunction group had 24 subjects. Discrepant sample sizes precluded a statistical comparison of the two groups. Consequently, the traumatic brain dysfunction group became the focus of study. Results achieved by the nontraumatic brain dysfunction group will be summarized at the conclusion of the discussion.

**Traumatic group descriptive statistics.**

The traumatic brain dysfunction group consisted of 122 individuals, 92 (75%) male and 30 (25%) female, a sex ratio that is typical of this population (Rose, 1981). Ninety percent of the subjects were right handed, while 10% were
left handed. The mean time from injury to rehabilitation admission was 36.9 days (s.d. 33.7 days, range 6-228 days). This is comparable to the 37 day mean onset of all first rehabilitation admissions for brain dysfunction reported to the UDS by 108 medical rehabilitation hospitals in 1990 (Granger & Hamilton, 1992). The mean age of subjects was 31.7 years (s.d. 11.6 yrs., range 15-67 yrs.). This group of subjects is younger than the 45 year mean age of all patients with brain dysfunction who were admitted for their first rehabilitation hospitalization in 1990 (Granger & Hamilton, 1992). The difference in age probably reflects the inclusion of older patients with nontraumatic diagnoses such as stroke, in the UDS age figure. The mean length of formal education of subjects was 11.9 years (s.d. 2.3 yrs., range 7-20 yrs.). All 122 subjects in the traumatic brain dysfunction group used verbal rather than nonverbal expression and auditory rather than visual means of comprehension at both admission and discharge. Consequently, the means of expression and comprehension did not constrain results.

Non-traumatic group descriptive statistics.

The nontraumatic brain dysfunction group consisted of 24 individuals, 16 male (67%) and 8 female (33%). The mean time from injury to rehabilitation admission was 52.3 days (s.d. 52.4 days, range 10-244 days). The mean length of formal education was 12.4 years (s.d. 2.8 years, range 7-20).
All subjects in the nontraumatic group used verbal expression and auditory comprehension. Results of the nontraumatic group are reported at the conclusion of this section. Sufficient power was not achieved for many analyses. Results may have heuristic value for those analyses which obtained significance.

Results for traumatic group

Results for the First Research Question.

The first research question was: what is the relation between cognition (as represented by admission OGMS aggregate and seven subscale scores) and functional independence (as represented by total FIM scores)? The Spearman correlation coefficient computed between the Aggregate OGMS, seven OGMS subscales, time to rehabilitation, age, and education with the total FIM score at admission demonstrated that there were significant relationships between selected measures of cognition and functional independence (see Table 1). In response to the first hypothesis, a relationship between the aggregate OGMS and total FIM at admission was obtained ($r = .49$, $p < .0001$). The second hypothesis also was substantiated as Associative Learning had a significant relation to admission FIM ($r = .29$, $p < .003$). The third hypothesis also was substantiated when a significant relationship was demonstrated between time to rehabilitation admission and total FIM at admission ($r = -.42$, $p < .0001$). The longer the time to
rehabilitation admission the lower the patient's functional status. All of these correlations were in the expected direction. The effect size for aggregate OGMS and time to rehabilitation admission was larger than expected. In addition, relationships were obtained between the following OGMS subscales and the total FIM at admission: Orientation to Time (r=.50 p<.0001), Orientation to Place (r=.33 p<.0002), Orientation to Group (r=.26 p<.005), Attention Span (r=.27 p<.003), Episodic Recall (r=.25 p<.03), and Use of Aids (r=.42 p<.0001). Age and education were not significantly related to admission total FIM score. Therefore, age and education were not significantly related to functional independence in a manner similar to cognition.

Table 1. Relationships between cognition and total Functional Independence Measures at admission.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
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<td>.00</td>
<td>31.7</td>
<td>11.6</td>
<td>.9816</td>
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<td>Time to rehabilitation</td>
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<td>36.9</td>
<td>33.7</td>
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</tr>
<tr>
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<td>.8704</td>
</tr>
<tr>
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<td>122</td>
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<td>2.17</td>
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<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Time</td>
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<td>2.16</td>
<td>0.54</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Place</td>
<td>122</td>
<td>.33</td>
<td>2.06</td>
<td>0.44</td>
<td>.0002**</td>
</tr>
<tr>
<td>Orientation to Group</td>
<td>120</td>
<td>.26</td>
<td>2.06</td>
<td>0.51</td>
<td>.0048**</td>
</tr>
<tr>
<td>Attention Span</td>
<td>121</td>
<td>.27</td>
<td>2.46</td>
<td>0.44</td>
<td>.0025**</td>
</tr>
<tr>
<td>Associative Learning</td>
<td>105</td>
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<td>1.77</td>
<td>0.62</td>
<td>.0031**</td>
</tr>
<tr>
<td>Episodic Recall</td>
<td>74</td>
<td>.25</td>
<td>2.04</td>
<td>0.60</td>
<td>.0339*</td>
</tr>
<tr>
<td>Use of Aids</td>
<td>115</td>
<td>.42</td>
<td>2.34</td>
<td>0.57</td>
<td>.0001**</td>
</tr>
</tbody>
</table>

*p<.05

**p<.01
The second analysis conducted in response to the first research question employed two Spearman correlation coefficients. One correlation used a dependent variable which was created by summing admission FIM self care/motor item scores. This analysis indicated somewhat surprisingly that cognition was related to motor impairment. The obtained relationships were: Aggregate OGMS ($r = .40 \ p < .0001$), Orientation to Time ($r = .44 \ p < .0001$), Orientation to Place ($r = .24 \ p < .008$), Orientation to Group ($r = .20 \ p < .03$), Attention Span ($r = .21 \ p < .02$), Associative Learning ($r = .26 \ p < .007$), Use of Memory Aids ($r = .35, \ p < .0001$) (see Table 2).

Table 2. Relationships between cognition and aggregate Functional Independence Measure Self Care/Motor scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
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<tbody>
<tr>
<td>Aggregate Orientation</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Monitoring System</td>
<td>122</td>
<td>.40</td>
<td>2.17</td>
<td>.36</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Time</td>
<td>122</td>
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<td>2.16</td>
<td>.54</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Place</td>
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<td>.0084**</td>
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<tr>
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<td>2.06</td>
<td>.51</td>
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</tr>
<tr>
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<td>.21</td>
<td>2.46</td>
<td>.44</td>
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</tr>
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<td>Associative Learning</td>
<td>105</td>
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<td>1.77</td>
<td>.62</td>
<td>.0072**</td>
</tr>
<tr>
<td>Episodic Recall</td>
<td>74</td>
<td>.18</td>
<td>2.04</td>
<td>.60</td>
<td>.1310</td>
</tr>
<tr>
<td>Use of Aids</td>
<td>115</td>
<td>.35</td>
<td>2.34</td>
<td>.57</td>
<td>.0001**</td>
</tr>
</tbody>
</table>

The dependent variable in the second Spearman correlation was created by summing admission FIM Communication and Social Cognition item scores. As predicted, significant relationships were obtained: Aggregate OGMS ($r = .64 \ p < .0001$), Orientation to Time ($r = .61 \ p < .0001$), Orientation to Place ($r = .47 \ p < .0001$),
Orientation to Group (r=.36 p<.0001), Attention Span (r=.41 p<.0001), Associative Learning (r=.32 p<.001), Episodic Recall (r=.29 p<.01), and Use of Aids (r=.54 p<.0001) (see Table 3).

Table 3. Relationships between cognition and aggregate Functional Independence Measure Communication/Social Cognition scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Orientation</td>
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<td>.64</td>
<td>2.17</td>
<td>.36</td>
<td>.0001**</td>
</tr>
<tr>
<td>Group Monitoring System</td>
<td>122</td>
<td>.61</td>
<td>2.16</td>
<td>.54</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Time</td>
<td>122</td>
<td>.47</td>
<td>2.26</td>
<td>.44</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Place</td>
<td>120</td>
<td>.36</td>
<td>2.06</td>
<td>.51</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Group</td>
<td>121</td>
<td>.41</td>
<td>2.46</td>
<td>.44</td>
<td>.0001**</td>
</tr>
<tr>
<td>Attention Span</td>
<td>121</td>
<td>.41</td>
<td>2.46</td>
<td>.44</td>
<td>.0001**</td>
</tr>
<tr>
<td>Associative Learning</td>
<td>121</td>
<td>.36</td>
<td>2.06</td>
<td>.51</td>
<td>.0001**</td>
</tr>
<tr>
<td>Episodic Recall</td>
<td>121</td>
<td>.36</td>
<td>2.06</td>
<td>.51</td>
<td>.0001**</td>
</tr>
<tr>
<td>Use of Aids</td>
<td>121</td>
<td>.36</td>
<td>2.06</td>
<td>.51</td>
<td>.0001**</td>
</tr>
</tbody>
</table>

*p<.05,  **p<.01

The third analysis which was conducted in response to the first research question used a stepwise multiple linear regression (see Table 4).

Table 4. Change in R² for the stepwise regression on admission Total Functional Independence Measures.

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Model R²</th>
<th>F</th>
<th>d.f.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Aggregate Orientation</td>
<td>0.2401</td>
<td>37.60</td>
<td>1, 119</td>
<td>.0001**</td>
</tr>
<tr>
<td></td>
<td>Group Monitoring System Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Time to rehabilitation</td>
<td>0.0530</td>
<td>8.84</td>
<td>2, 118</td>
<td>.0036**</td>
</tr>
</tbody>
</table>

*p<.05  **p<.01

In the first step the aggregate OGMS contributed 24% of unique variance to Admission FIM scores (p<.0001). This was a larger effect size than the (R²=.16) which had been predicted.
in the fourth hypothesis. In the second step, time to rehabilitation admission uniquely contributed another 5% to the variance in admission total FIM scores (p<.004). The total model $R^2$ was 0.29. The direction of the obtained relationships was of interest. As admission aggregate OGMS scores increased, admission FIM scores increased. However, as time to rehabilitation admission increased, total FIM scores decreased.

Results for the Second Research Question.

The second research question was how much variance in the improvement of functional independence can be accounted for by cognition early in rehabilitation? The Spearman correlation coefficient computed between the aggregate OGMS, seven OGMS subscale scores, time to rehabilitation, age, and education with the difference in total FIM score demonstrated that there were some significant, although weaker, relationships between a few of the selected measures and functional independence (see Table 5). The relationship between time to rehabilitation and change in FIM predicted in hypothesis 5 was not obtained. The relationship between the aggregate OGMS and change in FIM predicted in hypothesis 6 was significant ($r=-.18$ p<.04), however the effect size was smaller than the ($r=.30$) which had been hypothesized. In addition two of the OGMS subscales demonstrated significant relationships with FIM: Orientation to Time ($r=-.21$ p<.02) and Episodic Recall
(r = -.23 p<.04). All the other variables were nonsignificant.

Table 5. Relationships between cognition and improvement in Functional Independence Measures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>122</td>
<td>-.16</td>
<td>31.7</td>
<td>11.6</td>
<td>.0791</td>
</tr>
<tr>
<td>Time to rehabilitation</td>
<td>122</td>
<td>-.05</td>
<td>36.9</td>
<td>33.7</td>
<td>.5902</td>
</tr>
<tr>
<td>Education</td>
<td>121</td>
<td>.12</td>
<td>11.9</td>
<td>2.34</td>
<td>.1850</td>
</tr>
<tr>
<td>Aggregate Orientation</td>
<td>122</td>
<td>-.18</td>
<td>2.17</td>
<td>.36</td>
<td>.0434*</td>
</tr>
<tr>
<td>Monitoring System</td>
<td>122</td>
<td>-.21</td>
<td>2.16</td>
<td>.54</td>
<td>.0180*</td>
</tr>
<tr>
<td>Orientation to Time</td>
<td>122</td>
<td>-.15</td>
<td>2.26</td>
<td>.44</td>
<td>.1058</td>
</tr>
<tr>
<td>Orientation to Place</td>
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<td>-.08</td>
<td>2.06</td>
<td>.51</td>
<td>.3709</td>
</tr>
<tr>
<td>Orientation to Group</td>
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<td>-.07</td>
<td>2.46</td>
<td>.44</td>
<td>.4745</td>
</tr>
<tr>
<td>Attention Span</td>
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<td>-.07</td>
<td>2.46</td>
<td>.44</td>
<td>.4745</td>
</tr>
<tr>
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<td>.08</td>
<td>1.77</td>
<td>.62</td>
<td>.3929</td>
</tr>
<tr>
<td>Episodic Recall</td>
<td>74</td>
<td>-.23</td>
<td>2.04</td>
<td>.60</td>
<td>.0444*</td>
</tr>
<tr>
<td>Use of Aids</td>
<td>115</td>
<td>-.07</td>
<td>2.34</td>
<td>.57</td>
<td>.4425</td>
</tr>
</tbody>
</table>
* p<.05

The second analysis conducted in response to the second research question also employed two Spearman correlation coefficients. One correlation utilized a dependent variable which was created by summing the differences between admission and discharge scores on FIM self care/motor items. The small but significant relationship was surprising and of theoretical and clinical interest (see Table 6). Orientation to Time (r = -.20 p<.03) was the only variable that demonstrated significance.
Table 6. Relationships between cognition and improvement in aggregate Functional Independence Measures for self care/motor items.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
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<td>122</td>
<td>-.16</td>
<td>2.17</td>
<td>.36</td>
<td>.0698</td>
</tr>
<tr>
<td>Orientation to Time</td>
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<td>2.16</td>
<td>.54</td>
<td>.0272*</td>
</tr>
<tr>
<td>Orientation to Place</td>
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<td>.44</td>
<td>.1625</td>
</tr>
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</tr>
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<td>-.06</td>
<td>2.34</td>
<td>.57</td>
<td>.5047</td>
</tr>
</tbody>
</table>

*p<.05

The second Spearman correlation used a dependent variable which was created by summing the difference between admission and discharge FIM communication social/cognition items. The relationships which were obtained were: Aggregate OGMS (r = -.22 p<.02), Orientation to Time (r = -.23 p<.01), Orientation to Place (r = -.18 p<.04), and Episodic Recall (r = -.23 p<.05) (see Table 7).


<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>.0170*</td>
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<td>2.16</td>
<td>.54</td>
<td>.0120*</td>
</tr>
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<td>-.18</td>
<td>2.26</td>
<td>.44</td>
<td>.0432*</td>
</tr>
<tr>
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<td>.51</td>
<td>.2114</td>
</tr>
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<td>-.08</td>
<td>2.46</td>
<td>.44</td>
<td>.3939</td>
</tr>
<tr>
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<td>.02</td>
<td>1.77</td>
<td>.62</td>
<td>.8311</td>
</tr>
<tr>
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<td>2.04</td>
<td>.60</td>
<td>.0456*</td>
</tr>
<tr>
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<td>-.08</td>
<td>2.34</td>
<td>.57</td>
<td>.3743</td>
</tr>
</tbody>
</table>

*p<.05
The third analysis which was conducted in response to the second research question employed a stepwise multiple linear regression (see Table 8). In the first step, Time to Rehabilitation contributed 7% unique variance to change in functional independence. In the second step the aggregate OGMS contributed 5% additional unique variance. In the third step age was nonsignificant, and in the fourth step education contributed 4% unique variance to the model. In total, 19% of the variance in the change in FIM between admission to discharge from rehabilitation hospitalization was explained by the model. The observed contribution of significant unique variance by Time to Rehabilitation Admission and the aggregate OGMS score in the first two steps of the regression model supported the seventh hypothesis. However, the predicted effect size ($R^2 = .07$) and ($R^2 = .05$), for time to rehabilitation and aggregate OGMS respectively, fell short of the predicted ($R^2 = .16$). The direction of the obtained relationships is of interest. As time to rehabilitation admission, aggregate OGMS scores increased; the amount of change in total FIM scores decreased. As the years of education increased, the amount of change in total FIM scores increased.
Table 8. Change in $R^2$ for the stepwise regression predicting improvement in Functional Independence Measures from admission to discharge.

<table>
<thead>
<tr>
<th>Step</th>
<th>Variable</th>
<th>Partial Model $R^2$</th>
<th>Model $R^2$</th>
<th>F</th>
<th>d.f.</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>.0695</td>
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</tr>
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<td>.0506</td>
<td>.1201</td>
<td>6.78</td>
<td>2, 118</td>
<td>.0104**</td>
</tr>
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<td>3.36</td>
<td>3, 117</td>
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</tr>
<tr>
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<td>.0446</td>
<td>.1893</td>
<td>6.38</td>
<td>4, 116</td>
<td>.0129**</td>
</tr>
</tbody>
</table>

*p<.05
**p<.01

Taken as a whole, the three analyses conducted in response to the second research question demonstrated equivocal support for the relationship between cognition and improvement in functional status in this sample.

Results in the Nontraumatic Group

Results for the first research question.

The Use of Aids had a significant relationship with the total admission FIM score ($r=.58$ $p<.006$) (see Table 9). In addition the Use of Planning and Scheduling Aids had a significant relationship with the created aggregate FIM Motor score ($r=.47$ $p<.03$). In a subsequent Spearman Correlation the following significant relationships with the created aggregate FIM Communication/Social Cognition variable were obtained:
Aggregate OGMS (r=.53 p<.008); Orientation to Time (r=.38 p<.07); Orientation to Group (r=.45 p<.03); and Use of Planning and Scheduling Aids (r=.68 p<.007) (see Table 10). The stepwise multiple regression predicting admission total FIM score was not significant.

Taken as a whole, the analyses conducted in response to the first research question indicated that as the ability of patients in the nontraumatic group to utilize planning and scheduling aids was greater at admission; their total FIM, self-care/motor FIM, and communication/social cognition FIM scores at admission were also greater. Furthermore, as the aggregate OGMS score, Orientation to Time and the Orientation to Group scores were higher at admission; patients in the nontraumatic group experienced higher scores on Communication/Social Cognition FIM items. This preliminary analysis indicates that future studies which employ equivalent traumatic and nontraumatic brain dysfunction groups may find there are differential relationships between cognition and functional independence in these two patient populations. The ability to adequately use planning and scheduling aids may be particularly salient in those individuals with nontraumatic brain dysfunction.

Results for the second research question.

In response to the second research question, the nontraumatic brain dysfunction group indicated only one
significant relationship with the change in total FIM score between admission and discharge; Orientation to Group (r = .63 p < .001). Additionally Orientation to Group had the only significant relationship with the created change in FIM Self Care/Motor variable (r = .54 p < .008) and the created FIM Communication/Social Cognition variable (r = .66 p < .0006).

Table 9 Relationships between cognition and total Functional Independence Measures at admission in the nontraumatic group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
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<td>.14</td>
<td>2.14</td>
<td>0.38</td>
<td>.5086</td>
</tr>
<tr>
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<td>24</td>
<td>.13</td>
<td>2.10</td>
<td>0.52</td>
<td>.5406</td>
</tr>
<tr>
<td>Orientation to Place</td>
<td>24</td>
<td>-.12</td>
<td>2.20</td>
<td>0.52</td>
<td>.5645</td>
</tr>
<tr>
<td>Orientation to Group</td>
<td>23</td>
<td>.10</td>
<td>2.02</td>
<td>0.55</td>
<td>.6352</td>
</tr>
<tr>
<td>Attention Span</td>
<td>24</td>
<td>.24</td>
<td>2.48</td>
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<td>.2578</td>
</tr>
<tr>
<td>Associative Learning</td>
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<td>-.13</td>
<td>1.86</td>
<td>0.61</td>
<td>.5799</td>
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<tr>
<td>Episodic Recall</td>
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<td>-.38</td>
<td>1.96</td>
<td>0.78</td>
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</tr>
<tr>
<td>Use of Aids</td>
<td>21</td>
<td>.58</td>
<td>2.21</td>
<td>0.66</td>
<td>.0062*</td>
</tr>
<tr>
<td>*p &lt; .05</td>
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Table 10 Relationships between cognition and the created aggregate variable FIM Communication/Social Cognition.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>r</th>
<th>M</th>
<th>SD</th>
<th>p</th>
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<tbody>
<tr>
<td>Aggregate Orientation</td>
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<tr>
<td>Group Monitoring System</td>
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<td>2.14</td>
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</tr>
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<tr>
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<td>2.48</td>
<td>.46</td>
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<td>.61</td>
<td>.4741</td>
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<td>.6964</td>
</tr>
<tr>
<td>Use of Aids</td>
<td>21</td>
<td>.68</td>
<td>2.21</td>
<td>.66</td>
<td>.0007**</td>
</tr>
<tr>
<td>*p &lt; .05</td>
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<td>**p &lt; .01</td>
<td></td>
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</table>
Perhaps future research will demonstrate a particular salience of orientation to group members for improvement in functional independence in patients who have sustained nontraumatic brain dysfunction. The stepwise multiple linear regression predicting change in total FIM score was nonsignificant.

Summary Research Question One.

In summary, analyses were conducted in response to the first research question regarding the relationship between cognition (as represented by admission aggregate OGMS and seven OGMS subscale scores) and functional independence (as represented by admission Functional Independence Measure total scores). The following results were obtained for the traumatic brain dysfunction group. Analyses with Spearman correlation found a significant relationships between the following admission OGMS scores and admission total FIM scores. The aggregate OGMS was significantly related to the total FIM \( r = .49 \) \( p < .0001 \). Consequently, the first hypothesis that there was a significant relationship between admission aggregate OGMS scores and admission total FIM scores was not rejected. A significant relationship was found between the admission OGMS subscale Associate Learning and total FIM \( r = .29 \) \( p < .003 \). Therefore, the second hypothesis that there was a significant relationship between Associate Learning and admission total FIM scores was not rejected. A significant relationship was found between the time from trauma and
rehabilitation admission \( r = -0.42 \ p < 0.001 \). The third hypothesis that there was a significant relationship between time to rehabilitation and admission total FIM scores was not rejected. This study was unique in that it found a significant relationship between cognition (represented by the admission aggregate and seven subscale OGMS scores) and functional independence in motor tasks (as represented by a variable created by summing scores on admission FIM self-care and motor subscales, see Table 2.). A significant relationship also was found between cognition (as represented again by admission aggregate OGMS scores) and functional independence in cognitive tasks (as represented by a variable created by summing admission FIM Communication and Social Cognition subscale scores see Table 3.). A stepwise multiple regression analysis indicated that cognition (represented by the admission OGMS aggregate score) and time from trauma to rehabilitation admission contributed significant unique variance to functional independence (as represented by admission total FIM scores, see Table 4.). The aggregate OGMS scores contributed 24 percent unique variance \( p < 0.001 \) while time to admission contributed \( 0.05 \) percent unique variance \( p < 0.004 \). This finding resulted in not rejecting the fourth hypothesis that admission aggregate OGMS scores and time to rehabilitation admission would contribute significant unique variance to admission total FIM scores. The non-traumatic
brain dysfunction group was too small (n=24) to have sufficient power to detect significant relationships. Only a few of the OGMS subtests (such as Use of Scheduling Aids, r=.58 p<.006) did demonstrate a significant relationship with admission total FIM scores and the created FIM self-care/motor score (Use of Scheduling Aids, r=.47 p<.03). Due to the small sample size and resulting low power, no general conclusions were drawn for the non-traumatic brain dysfunction group for the first research question. Answering the first question would require a larger sample.

Summary for Research Question Two.

In summary, analyses were conducted in response to the second research question regarding how much variance in the improvement in functional independence (represented by a created variable which was the difference between admission and discharge total FIM scores), and could be accounted for by cognition (represented by aggregate and subscale OGMS scores) and selected demographic variables such as time to rehabilitation. A Spearman correlation did not find a significant relationship between time to rehabilitation and improvement in total FIM scores in the traumatic brain dysfunction group. Consequently, the fifth hypothesis which predicted such a relationship was rejected. A significant relationship was found between aggregate OGMS scores and improvement in total FIM scores (r=-.18, p<.04, see Table 5.).
However, the effect size was smaller than was anticipated \((r=.30)\). Consequently, the sixth hypothesis that the aggregate OGMS would have a significant relationship with change in FIM scores was not rejected. A subsequent Spearman analysis was conducted between both OGMS aggregate and OGMS subscale scores and a variable created by summing the improvement in FIM self-care and motor subscales. Orientation to Time was the only variable to demonstrate significance \((r=-.20 \ p<.03\) see Table 6.). Another Spearman correlation was computed between both aggregate and subscale OGMS scores and a variable created by summing the improvement on FIM Communication and Social Cognition subscales. The following significant relationships were obtained: aggregate OGMS \((r=-.22 \ p<.02)\), Orientation to Time \((r=-.23 \ p<.01)\), Orientation to Place \((r=-.18 \ p<.04)\), and Episodic Recall \((r=-.23 \ p<.05,\) see Table 7.). A stepwise multiple linear regression found in the first step that Time to Rehabilitation contributed 7 percent unique variance to change in admission to discharge total FIM scores, aggregate OGMS provided five percent unique variance in the second step, age was nonsignificant in the third step, and that education contributed four percent unique variance in the fourth step. Consequently the seventh hypothesis that the aggregate OGMS and time from trauma to rehabilitation admission would contribute significant unique variance to the improvement in the total FIM score was not rejected. As expected, the \(n=23\)
non-traumatic brain dysfunction group that had less statistical power, had fewer significant effects in analyses conducted in response to the second research question. The only significant relationship obtained in the Spearman correlation between cognition (represented by admission aggregate and subscale OGMS scores) and improvement in FIM scores was with Orientation to Group ($r=.63 \ p<.001$). Orientation to Group also had the only significant relationship with the created variables improvement in Self-Care/Motor FIM ($r=.54 \ p<.008$) and improvement in Communication/Social Cognition FIM ($r=.66 \ p<.0006$). A stepwise multiple regression analyses prediction improvement in total FIM scores was not significant.
To our knowledge, no prior research has looked at the relationship between OGMS scores (as a measure of impaired cognition) and the Functional Independence Measure (as a measure of disability) at admission to rehabilitation hospitalization in persons who have experienced either traumatic or non-traumatic brain dysfunction. Likewise, to our knowledge no prior research has investigated the relationship of cognition (as represented by OGMS scores) to just the FIM Self-Care and Motor subscale scores or to just the FIM Communication and Social Cognition subscale scores at admission to rehabilitation. No prior research has analyzed the increments in unique variance in the prediction of admission FIM scores which are contributed by OGMS scores, time to rehabilitation, age and education. Similarly, no prior research has investigated the relationship of cognition (as represented by OGMS scores) with improvement in FIM scores during rehabilitation hospitalization. Nor has prior research investigated the relationship of cognition (as represented by OGMS scores) to either improvement in FIM Self-Care Motor
subscales scores or to improvement in FIM Communication and Social Cognition subscale scores. Likewise, a search of the literature does not show research which has investigated the contribution of unique variance by measures of cognition to the prediction of improvement in Functional Independence Measure scores, time to rehabilitation, age, or education.

This deficiency in the literature is particularly salient because the stated goal of rehabilitation is to move disabled patients from a dependent state to a more independent and self-sufficient state (Granger & Greer, 1976). We know that accidents are the fourth largest cause of death in persons over 35 years of age and that the prevalence of head injury is high enough to account for 40% of all accident fatalities (Cooper, 1982). Clearly head injuries affect a large number of individuals with serious sequelae. Since advances in neurotrauma result in increasing numbers of individuals who survive head injury and then require expensive rehabilitation (Johnson, 1984), it is very important that research be conducted on the process and efficacy of rehabilitation in head injury survivors. This topic is important and timely. The current study does indicate public policy regarding payment and provision of rehabilitation services needs to be
formulated with the awareness that it can not be determined at the time of admission to rehabilitation which patients will have maximal improvement in functional independence scores.

The existing research literature is deficient in outcome studies which investigate cognition as it relates to the admission Functional Independence Measure status as well as to the improvement in Functional Independence Measure scores in persons with brain dysfunction. The two research questions which were investigated in this study are one contribution to this needed research.

The three analyses conducted in response to both research questions did demonstrate a significant positive relationship at admission to rehabilitation between measures of cognition (OGMS) and measures of functional status (FIM) in the traumatic brain dysfunction group. Initial aggregate Orientation Group Monitoring Scale scores had a significant correlation with admission total Functional Independence Measure \( r = .49 \ p < .0001 \). Initial aggregate OGMS scores also contributed 24% unique variance to the variance in Admission FIM scores in this sample. Twenty-four percent of variance was an unexpectedly large contribution. Prior research had indicated that other factors: location and severity of brain dysfunction, presence of medical and multiple trauma complications, premorbid personality characteristics, and age might reasonably be expected to contribute substantially to
functional independence scores (Jennett & Teasdale, 1981). The unexpectedly large contribution of cognition to admission FIM was particularly surprising because 13 of the 18 subscales which contribute to the aggregate admission FIM assess patients' motor skills and self-care status rather than their cognitive status.

The presence of differential relationships between various OGMS items and admission total FIM was explored. It had been anticipated that Associative Learning would have a significant correlation with admission FIM due to the apparent differential performance of Associative Learning in the literature (Saneda & Corrigan, 1992). It also appeared that the task of learning paired associates in the OGMS was novel and not duplicated by other components of the rehabilitative team effort. Those patients who were able to meet the OGMS criterion of 100% performance on five paired associates over a two week period (Corrigan, Arnett, Houck, & Jackson, 1985) at rehabilitation admission also would be likely to demonstrate higher levels of functional independence at admission. They might also be expected to demonstrate greater progress in rehabilitation from brain dysfunction than those who failed to meet the OGMS criterion.

However, this study did not find a differential performance for the OGMS subscale Associative Learning. Associative Learning did have positive significant
relationships with total admission FIM, the created motor/self care aggregate FIM, and the created communication/social cognition aggregate FIM in a manner which was similar to the other OGMS aggregate and subscale scores (see Tables 1, 2, & 3). When the absolute value of the obtained relationships between the OGMS subscales and admission total FIM were compared, the admission Orientation to Time had a higher correlation with admission total FIM ($r = .50 p < .0001$) than Associative Learning ($r = .29 p < .003$, see Table 1). In order to explore the possible relevance of the performance of Associative Learning and Orientation to Time, a test of the significance of the difference in correlations between two dependent samples was undertaken (Cohen & Cohen, 1983, pp. 56-57). Scores on Associative Learning were missing for 17 subjects. Consequently, all 105 subjects who had Associative Learning scores were identified. An additional Spearman's correlation coefficient was computed for these 105 selected subjects (see Table 11). The new correlations between OGMS subscales and total admission FIM scores were: (Orientation to Time $r = .47 p < .0001$) and Associative Learning ($r = .29 p < .003$). The correlation between Orientation to Time and Associative Learning was ($r = .45 p < .0001$). The resultant $t$ value was nonsignificant ($t (102) = .167, p = .05$). The intercorrelation between Orientation to Time and Associative Learning, together with a small decrease in effect size for Orientation to Time
contributed to this finding. The relationship between admission Associative Learning and admission total Functional Independence Measure scores can not be said to be significantly different than other OGMS subscores and total FIM. In addition, no support can be found for a differential relationship between Associative Learning and improvement in FIM scores, as no significant relationships were obtained (see Tables 5, 6, & 7).

Table 11 Relationships between cognition and total Functional Independence Measures for 105 Selected Subjects with Associative Learning Scores.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>R</th>
<th>M</th>
<th>SD</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Age</td>
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<td>-.04</td>
<td>32.4</td>
<td>12.0</td>
<td>.6495</td>
</tr>
<tr>
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<td>35.8</td>
<td>34.7</td>
<td>.0001**</td>
</tr>
<tr>
<td>Aggregate Orientation</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring System</td>
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<td>.47</td>
<td>2.18</td>
<td>0.36</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Time</td>
<td>105</td>
<td>.47</td>
<td>2.18</td>
<td>0.54</td>
<td>.0001**</td>
</tr>
<tr>
<td>Orientation to Place</td>
<td>105</td>
<td>.32</td>
<td>2.26</td>
<td>0.45</td>
<td>.0008**</td>
</tr>
<tr>
<td>Associative Learning</td>
<td>105</td>
<td>.20</td>
<td>1.77</td>
<td>0.62</td>
<td>.0031**</td>
</tr>
</tbody>
</table>

*p<.05
**p<.01

While Orientation to Time did not have a significantly larger relationship with admission total FIM scores, the large effect size for Orientation to Time is intriguing. Orientation to time is a component of general mental competence (Benton, Hamsher, Varney, & Spreen, 1983). Benton, Van Allen, & Fogel (1964) found 57% of patients with dementia also experienced impaired orientation to time. Joslyn and Hutzell (1979) found that patients with brain damage in a Veterans' Administration neuropsychiatric hospital demonstrated greater impairment in
temporal orientation than did patients with schizophrenia, while alcoholics who were not brain damaged demonstrated normal temporal orientation.

Second, orientation to time has particular importance in the recovery of patients with head injury. High, Levin, & Gary (1990) serially studied the pattern of recovery of orientation to person, place, and time in 84 patients who were hospitalized with head injuries. For 70% of the patients the sequence was recovery of orientation to: person, place, and then time. An additional 13% experienced the recovery sequence: person, time, & then place. The obtained sequence was not found to be related to either the locus of brain injury or to injury severity. The test instrument which High used was the Galveston Orientation and Amnesia Test (GOAT) (Levin, O'Donnell, & Grossman, 1979). High's use of the GOAT is particularly relevant as the GOAT has demonstrated concurrent validity with the OGMS in patients who were hospitalized on the Head Injury Unit at Ohio State University (Mysiw, Corrigan, Carpenter, & Chock, 1990).

The finding that the absolute value of the correlation between Orientation to Time and admission FIM was larger than Associative Learning and FIM supported High's finding that Orientation to Time is particularly salient in the majority of severely head injured patients. Apparently, Orientation to Time is indicative of progress in recovery from brain injury.
Inpatients who achieve higher scores on Orientation to Time apparently have higher scores on their admission total FIM, yet also demonstrate less improvement in total FIM scores from rehabilitation admission to discharge. This may indicate a ceiling effect in the FIM (Linacre, Heinemann, Wright, Granger, & Hamilton, 1992).

The importance of the Orientation to Time OGMS subscale was highlighted by the significant relationships it also shared with: the created aggregate communication/social cognition variable ($r = .61 \ p < .0001$), the created aggregate self care/motor variable ($r = .44 \ p < .0001$), the change in admission to discharge total FIM score ($r = -.21 \ p < .02$), the change in created aggregate cognition score ($r = -.23 \ p < .01$), and the change in the created aggregate motor score ($r = -.20 \ p < .03$). Associative Learning, rather than Orientation to Time, had salience in predicting improvement in functional status. It is possible that Orientation to Time is related to injury severity as it appears to be indicative of progress in recovery from traumatic brain injury. It would be beneficial if future research probed the relationship between Orientation to Time at rehabilitation admission and a measure of severity of traumatic brain injury such as post traumatic amnesia. Duration of PTA is a measure which traditionally has been used as a marker for injury severity in acute brain trauma (Jennett, 1976). Duration of PTA also has practical
significance. The clinician can use a severity index to assist in the determination and timing of treatments for optimal patient benefit (Saneda and Corrigan, 1992).

A cognitive component of functional status in motor skills was observed. This discovery can be further explored in terms of potential cognitive-behavioral based interventions such as self-instructional training (SIT) for increased independence in functional status in self care and motor skills. (Meichenbaum & Goodman, 1971). The rationale for this concept comes from the finding that SIT is effective with impulsive children as well as those learning skills (Meichenbaum & Goodman, 1971; Kendall & Finch, 1976; Meichenbaum, 1976). Many individuals with brain dysfunction are impulsive, lacking both social restraint and judgement (Jennett & Teasdale, 1981). Individuals who have experienced traumatic brain dysfunction also often need to relearn skills. Cognitive recovery precedes performance recovery in patients with traumatic brain dysfunction (Mandleberg, 1976). Consequently, a stronger cognitive skill can be used to facilitate recovery of those motor self care skills which are more difficult to regain.

A review of the literature did not identify other research which demonstrated that the cognitive ability to be oriented to time at admission to rehabilitation had a significant relationship with functional status in self
care/motor skills. The importance of this finding might lie in a new appreciation the influence of thought in executing the complex sequential motor acts which are assessed on self-care/motor FIM items. The common dimension which is probably tapped by both orientation to time and self-care motor skills is the ability to conceptually sequence behavior in time. Transfer activities, such as transfer into the bathtub, walking, and stair climbing necessitate planned integration of complex motor activity. Apparently, cognitive skill is more important for the reacquisition of functional independence in these skills than has been appreciated in the past.

Orientation to Time is important because of its repeated demonstration of statistical significance in this study and its role in the sequential recovery of orientation in patients with brain dysfunction. Not only is there a sequence of recovery in orientation, there is additionally a sequence of recovery within the dimension of time. Disoriented patients experience a backward displacement of dates. As recovery of orientation ensues, this backward displacement of dates decreases. The backward displacement of dates is sensitive to injury severity. Those patients with the greatest backward displacement have the longest PTA and were older (High, Levin, & Gary, 1990).

Further research should investigate the possibility of using scores on Orientation to Time for treatment and clinical
prognosis. Such future research would be in consistent with Wylie & White's observation (1964) that new measuring instruments often result in new observations from which new hypotheses are derived. The importance of explaining the level of disability and of patient independence to both the patient, the family, and the employer was emphasized by Richardson (1973). Jennett and Teasdale (1981) also alluded to the importance of functional outcome as a means of anticipating recovery. They considered that the ability to learn subsequent to a head injury correlated with the capacity to recover function and was important information for professionals responsible for planning rehabilitation.

Although this study did not find support for the suggestion of a possible differential relation between OGMS subscales and patient outcome, it did provide support for Saneda and Corrigan's (1992) findings regarding the importance of the interval between time of brain trauma and admission to rehabilitation hospitalization. In this study, time to rehabilitation had a significant negative relationship with admission total FIM ($r=-.42$, $p<.0001$). This can be interpreted to mean that patients who had a shorter time to rehabilitation admission had higher functional status at admission. Longer time to rehabilitation might be influenced by physical factors such as greater severity of brain dysfunction, medical complications, and/or multiple trauma injuries. Longer time to
rehabilitation also could result in problematic motivation for rehabilitation if inappropriate expectations for recovery were encouraged by professionals in the acute hospital. These interpretations are supported by the finding that time to rehabilitation provided 5% unique variance to admission total FIM, \( F = 8.84 \) (2,118) \( p < .0036 \).

Whereas the influence of time to rehabilitation on admission functional status was straightforward, the influence on time to rehabilitation and change in functional status was not as straightforward. Conflicting findings indicate the need for further research to clarify the nature of the impact of time to rehabilitation on change in FIM scores from admission to discharge. When analyzed by itself in a Spearman correlation, time to rehabilitation had no significant relationship with improvement in total FIM scores (see Table 5). This finding could be interpreted to mean that time to rehabilitation had no significant effect on improvement in functional status, or that a ceiling effect related to the psychometric properties of the FIM scale precluded demonstration of significant relationship between time to rehabilitation and improvement in FIM scores. It was notable that Time to rehabilitation admission did contribute significant unique variance in a stepwise multiple regression model predicting the improvement in total FIM from admission to discharge. Time to rehabilitation was significant in the
first step of the model, \((F=8.89\ (1,119),\ P<.0035)\). When combined with the aggregate OGMS score in step two, the effect of time to rehabilitation was greater, \((F=12.14\ (2,\ 118)\ p<.0007)\). When age was added in the third step, the effect of time to rehabilitation remained significant \((F=11.03\ (3,\ 117)\ p<.0012)\). When education was entered into the model in the fourth step, the result of time to rehabilitation became \((F=9.85\ (4,\ 116)\ p<.0021)\). The summary of the model indicated time to rehabilitation had a significant effect on improvement in functional status when cognitive status, age, and education were considered together. When the direction of the obtained relationships with improvement in FIM scores are considered, it appears that longer time to rehabilitation, higher aggregate OGMS scores, and less education are contributing and perhaps mutually influencing factors that lead to significantly less improvement in functional status from rehabilitation admission to discharge.

The relevant literature was searched for support or refutation of this interpretation. Cope & Hall's 1982 retrospective study found that 16 patients with head injuries who had early admission to rehabilitation hospitalization (defined arbitrarily as less than 35 days post trauma) had one half the total days of hospitalization compared to 20 patients with late rehabilitation admissions. Cope & Hall's findings appear to conflict with the finding of a nonsignificant
relationship in a Spearman correlation coefficient computed between time to rehabilitation and improvement in functional independence. The explanation for the contrasting findings between this study and Cope and Hall's study may rest with two factors. First the dependent variables were different. Cope and Hall's dependent variable, total days of hospitalization, may be related to improvement in Functional Independence Measure scores, but the two dependent variables are not identical. Second, Cope and Hall's two experimental groups were not equivalent. The early and late rehabilitation admission groups were not equivalent on two important variables affecting length of hospitalization: bowel and bladder continence and mental/emotional characteristics. The early admission group was significantly less impaired on these factors. Their claim that early rehabilitation reduced total length of hospitalization as a consequence of an earlier introduction of orientation apparently was not supported in their study, despite their claim to the contrary. Rather, the significant differences between early and late groups supports a basic difference in injury severity between the two groups. Others have attributed early admission to rehabilitation hospitalization as an indicator of decreased injury severity (Saneda & Corrigan, 1992).

The stepwise multiple regression conducted in response to the second research question in the current study does support
the findings of Spettell, Ellis, Ross, Sandel, O'Malley, Stein, Spivack, & Hurley, 1991. Spettell et al. found that although length of acute hospitalization was affected by injury severity, the length of acute hospitalization added significantly more to the prediction of length of rehabilitation hospitalization. The understanding of the influence of time to rehabilitation admission on functional status appears to rely on the unique as well as the interactive effects of time to rehabilitation. Perhaps there are unknown multiple interacting influences at work. Further research could clarify the complex nature of the influence of time to rehabilitation admission on functional outcome, as well as on the length of stay in the rehabilitation hospital.

The importance of this study in guiding future research also extends to the exploration of the influence of cognitive measures on the improvement in functional independence. The relationship between the selected cognitive measures of interest could have attenuated relationships with improvement in Functional Independence Measures (see Tables 5 & 6). Not only were there fewer significant relationships, but the effect size was smaller when compared with the relationships between admission OGMS scores and admission FIM scores (see Tables 1, 2, & 3). There are several likely explanations for this difference in effect.
First, the scores which were entered into the analyses summarized on Tables 5 & 6 may have been influenced by natural brain recovery. Physical recovery results in an improvement in cognitive and functional status which is not linear. Rather, the shape of plotted recovery functions approximates the shape of a learning curve (Kaplan, 1990; Mandleberg, 1976; Newcombe, Marshall, Carrivick, & Hiorns, 1974; and Vigouroux et al., 1971). The greatest amount and fastest rate of recovery occurs during the first 6 months after brain injury and slows noticeably thereafter (Bond & Brooks, 1976). Additional recovery is occasionally seen with severe head injuries beyond this 6 month window of maximal recovery (Kaplan, 1990; Tuel, Presty, Meythaler, Heinemann, & Katz, 1992). The implication from the recovery literature is that different functions do recover at different rates, with the recovery process slowing over time, and varying with injury severity (Katz, 1992). The natural plateau in the rate of physical brain recovery could have attenuated the effect size for the relationship between cognition and improvement in functional status. Additionally, individual differences in the type, location, and severity of head injuries have an unknown influence on improvement in FIM scores. Likewise, the presence of multiple system injuries, medical complications, and drug reactions also has an unknown impact of improvement in FIM scores.
Still another explanation for the observed attenuation in relationship between measures of cognition and improvement in functional independence measures lies in the psychometric properties of the FIM. The FIM shares psychometric difficulties with other functional outcome scales. It is an ordinal scale and lacks the properties of an interval scale (Silverstein, Fisher, Kilgore, Harley, & Harvey, 1992). There is no constant order of difficulty among the items (Silverstein, Kilgore & Fisher, 1991). This results in lack of consistency in the continuum of functional outcome which the scale is supposed to assess. Equal total FIM scores can have different meanings for the achieved level of functional outcome represented by the FIM total score. The highest scores in Eating are less difficult to attain for many patients than the highest scores on Stair Climbing (Wright, 1992). Violations of equal difficulty and equal intervals on FIM have an unknown impact on the validity of the scale and could result in attenuation of scores. Attenuation in improvement in FIM scores could also represent a ceiling effect whereby it takes greater improvement for an increase a FIM score at the top of the scale than at the middle of the scale. Linacre, Heinemann, Wright, Granger, & Hamilton, 1992, found that when the bounded range of FIM raw scores was mapped to the conceptually infinite range of FIM patient performance there was a departure in slope at the extremes of the ogive. A
change of 10 total FIM raw score points at the extreme of a range was almost 4 times the size of a change in 10 raw scale points in the middle of the range. The attenuation noted in relationships between cognition and functional status perhaps can be partly explained by these psychometric problems.

A Rasch analysis of this study's data might tease apart the relative contribution of measurement error due to the ordinal scale of the FIM and the attenuation which is due to the natural physical slowing of the recovery rate. The inability to perform a Rasch analysis is a limitation of this study. Findings should be considered with appropriate caution. The sample, while large enough for statistical power was not large enough for replication in a cross validation experimental design. Subjects were limited to those who survived brain dysfunction and recovered sufficiently to be admitted to both rehabilitation hospitalization and to the Orientation Group Monitoring System. Patients with traumatic brain dysfunction who died, remained in a persistent vegetative state, did not reach criterion for entry into the OGMS, or who received only mild head injuries were not included. The specific nature and severity of brain dysfunction was not controlled and had an unknown effect on findings. Likewise the impact of motivation, social support, medical history including prior head injury and multiple trauma injury was not assessed. In addition, the comparison of
the FIM categories Traumatic and Nontraumatic Brain Dysfunction was not possible due to the small size of the obtained nontraumatic group.

In summary, as hypothesized in the first research question, this study did find significant positive relationships between measures of cognition and functional status at admission. The aggregate OGMS and the OGMS Associative Learning subscale had a significant positive relation with total FIM scores. A significant contribution of cognition to self care and motor function was demonstrated for the first time. This newly observed relationship stimulated exploration of the potential use of cognitive skills in the rehabilitation of motor skills. Additionally, time to rehabilitation admission also had a significant relationship with total FIM scores. Both the aggregate OGMS score and time to rehabilitation made a significant unique contribution to the variance in functional independence as represented by total FIM scores. Consequently the first 4 hypotheses were not rejected.

In response to the second research question, time from injury to rehabilitation did not have a significant relation to improvement in functional independence. Consequently, the 5th hypothesis was not accepted. The aggregate OGMS did have a significant negative relationship with improvement in total FIM. Although the effect size was smaller than expected, the
6th hypothesis was tentatively not rejected. Time to rehabilitation and the aggregate OGMS score did contribute significant unique variance to improvement in FIM. In addition, education also contributed unique variance to improvement in FIM. Prior research was replicated by the finding of a significant unique and additive contribution of time to rehabilitation to the prediction of improvement in functional status. Time to rehabilitation was significant in predicting gain in functional status when entered into a regression model that included the aggregate OGMS scores, age, and education. Future research could explore more fully the complex interacting relationships involved in predicting improvement in functional independence following brain dysfunction. This finding allowed non-rejection of the 7th hypothesis. In addition, the possible differential performance of Associative Learning and functional independence was studied. While Associative Learning had a significant positive relationship with admission total FIM (r=.29 p.003) it was not significantly different from the relationship of Orientation to Time (r=.46 p<.0001) with admission total FIM scores. A further post hoc analysis was conducted due to interest in a possible differential performance for Associative Learning. The t test of significance for a correlation between dependent samples was conducted between Orientation to Time and Associative Learning was
nonsignificant. No significant relationship was obtained for a Spearman correlation conducted between admission Associative Learning and improvement in FIM scores from admission to discharge. Consequently a differential performance for the Associative Learning OGMS subscale was not demonstrated in this study.

Additional research also should be focused on teasing apart the relative effect of spontaneous brain recovery and error in measurement on the attenuation observed in performance at the top of the FIM scale as well as in the amount of change in functional status accounted for by measures of cognition. Replication is encouraged.

One important specific research question which needs to be asked is what relationship would be demonstrated between OGMS scores and Functional Independence Measures if the scores which were used in this study were converted from ordinal scale into a ratio scale via a Rasch transformation. Would admission OGMS scores still have significant relationships with the admission total FIM score or with the created variables Self-Care/Motor FIM and Communication/Social Cognition FIM? Would cognition (as represented by OGMS scores) continue to demonstrate a different relationship than age and education with admission total FIM scores? Would a greater number of OGMS subscales have significant relationships with improvement in FIM following
transformation? If the same results were obtained, it would support the findings of this study and facilitate interpretation of FIM scores obtained by traumatic brain dysfunction patients. We would have a better idea that it was appropriate to utilize the Functional Independence Measure for tracking clinical improvement, program evaluation, peer review, and perhaps as part of a method of prepayment for rehabilitation services. However, if this study was replicated with the addition of a Rasch transformation of FIM scores and different findings were obtained, it also might be of clinical and theoretical importance. If a transformation of FIM scores reduced an attenuating ceiling effect, a replication study might find that more OGMS subscales had significant relationships with improvement in FIM scores. It appears that a replication study would be a worthwhile contribution to the field. This is a study that is waiting to happen. It would be both theoretically and clinically interesting to know if the results obtained in the current study were altered by the Rasch transformation of FIM scores.

Another interesting future research project would be to explore the relationship between OGMS scores and Functional Independence Measure scores after discharge from rehabilitation hospitalization. The dependent variables could be discharge placement and follow-up FIM scores that are obtained after discharge from rehabilitation. Do OGMS scores
at admission predict discharge placement and follow-up Functional Independence Measure scores?

The current study only begins to explore the possible important information which lies in the relationship between cognition and functional independence in persons who have experienced brain dysfunction. Perhaps it will stimulate others to continue this line of investigation.
LIST OF REFERENCES


Eisenberg, H.M. & Weiner, R.L. (1987). Input variables: How information from the acute injury can be used to characterize groups of patients for studies of outcome. In H.S. Levin, J. Grafman, & H. M. Eisenberg (Eds.), Neurobehavioral Recovery from head injury (pp.13-29). NY: Oxford University Press.


Appendix A

Figure Providing Information on the Independent Variable Orientation Group Monitoring System
Range of Utility for Measures of Cognitive Function in
the Acute Phase of Recovery following Traumatic Head Injury

End
Injury
of Coma
Volition
PTA Clears

Ranchos Level of Cognitive Function

Glasgow Coma Scale

Disability Rating Scale

Western Neuro Sensory Stimulation Profile

Galveston Orientation and Amnesia Test

Orientation Group Monitoring System

Fig. 1

Appendix B

Functional Independence Measure Coding Sheets
Fig. 2. Uniform Data System For Medical Rehabilitation Inpatient Coding Sheet, Side 1.
Fig. 3. Uniform Data System For Medical Rehabilitation Inpatient Coding Sheet, Side 2.
UNIFORM DATA SYSTEM FOR MEDICAL REHABILITATION
REHABILITATION FOLLOWUP CODING SHEET

1. Rehab Facility Code [ ] [ ] [ ]
2. Patient Number [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
3. Admission Date [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
4. Discharge Date [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]

13. Living Arrangement
   a. Setting FOLLOWUP [ ]
      01- Home 02-Board and Care 03-Transitional Living 04- Intermediate Care 05-Skilled Nursing 06-Acute Unit-your own facility 07 - Acute Unit-Another facility 08-Chronic Hospital 09-Rehab Facility 10-Other 11-Deaf
   b. Living with FOLLOWUP [ ]
      1-Alone 2-Family/Relatives 3-Friends
      4-Attendant 5-Other

14. Vocational Status
   a. Category FOLLOWUP [ ]
      1-Employed 2-Sheltered 3-Student 4-Homemaker 5-Not working 6-Retired-age 7-Retired-disability
   b. Effort FOLLOWUP [ ]
      1-Full-time 2-Part-time 3-Adjusted workload

15. Followup
   a. Date [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ] [ ]
   b. Information source [ ]
      1-Patient 2-Family 3-Other
   c. Method [ ]
      1-In-person 2-Telephone 3-Mail
   d. Health Maintenance [ ]
      primary secondary
      1-Own care 2-Unpaid helper 3-Paid attendant 4-Paid professional
   e. Therapy [ ]
      1- None 2-Outpatient Therapy 3-Home Based Paid Therapy 4- Both 2 & 3 5-Transient Hospital

19. Other Diagnoses: (since discharge) ICD Code for new impairments, co-morbidity and complications

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<th>Description</th>
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</tr>
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<td>7</td>
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22. Functional Independence Measure (FIM)

<table>
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<tr>
<th>Levels</th>
<th>Modified Independence (Device)</th>
<th>Complete Independence (Timely, Safely)</th>
<th>HELPEF</th>
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<td>2</td>
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<td>HELPEF</td>
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<td>3</td>
<td>Complete Independence</td>
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<td>HELPEF</td>
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<td>HELPEF</td>
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<th>Self Care FOLLOWUP</th>
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<tbody>
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<td>A. Eating</td>
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<tr>
<td>B. Grooming</td>
<td></td>
</tr>
<tr>
<td>C. Bathing</td>
<td></td>
</tr>
<tr>
<td>D. Dressing-Upper Body</td>
<td></td>
</tr>
<tr>
<td>E. Dressing-Lower Body</td>
<td></td>
</tr>
<tr>
<td>F. Toiletting</td>
<td></td>
</tr>
<tr>
<td>Rainster Control</td>
<td></td>
</tr>
<tr>
<td>G. Bladder Management</td>
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</tr>
<tr>
<td>H. Bowel Management</td>
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<table>
<thead>
<tr>
<th>Mobility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer:</td>
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</tr>
<tr>
<td>I. Bed, Chair, Wheelchair</td>
<td></td>
</tr>
<tr>
<td>J. Toilet</td>
<td></td>
</tr>
<tr>
<td>K. Tub, Shower</td>
<td></td>
</tr>
<tr>
<td>Locomotion</td>
<td></td>
</tr>
<tr>
<td>L. Walk/wheel Chair</td>
<td></td>
</tr>
<tr>
<td>M. Stairs</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communication</th>
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</tr>
</thead>
<tbody>
<tr>
<td>N. Comprehension</td>
<td></td>
</tr>
<tr>
<td>O. Expression</td>
<td></td>
</tr>
<tr>
<td>Social Cognition</td>
<td></td>
</tr>
<tr>
<td>P. Social Interaction</td>
<td></td>
</tr>
<tr>
<td>Q. Problem Solving</td>
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</tr>
<tr>
<td>R. Memory</td>
<td></td>
</tr>
<tr>
<td>Total FIM</td>
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</tbody>
</table>

NOTE: Leave no blanks; enter 1 if patient not testable due to risk.

COPY FREELY: DO NOT CHANGE

Fig. 4. Uniform Data System For Medical Rehabilitation Followup Coding Sheet.
Appendix C

Sample Data Form Used in The Study
<table>
<thead>
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<th>Subject Data Form</th>
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<td><strong>Date of Trauma</strong>:</td>
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<td><strong>Admit. Dodd</strong>:</td>
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<tr>
<td><strong>Birthdate</strong>:</td>
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<tr>
<td><strong>Ed. Level</strong>:</td>
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<tr>
<td><strong>CHI</strong>:</td>
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</table>

**ADMIT. OGMS**

<table>
<thead>
<tr>
<th><strong>Aggregate</strong>:</th>
<th><strong>Attn. Span</strong>:</th>
</tr>
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<tbody>
<tr>
<td><strong>Orientation to Time</strong>:</td>
<td><strong>Assoc. Learning</strong>:</td>
</tr>
<tr>
<td><strong>Orientation to Place</strong>:</td>
<td><strong>Episodic Recall</strong>:</td>
</tr>
<tr>
<td><strong>Know. Group</strong>:</td>
<td><strong>Use of Aids</strong>:</td>
</tr>
</tbody>
</table>

**Discharge Total FIM**

**Admission Total FIM**

**Admit Self-care/Motor FIM**

**Discharge Self-care/Motor FIM**

**Admit Communication/Social Cognition**

**Discharge Communication/Social Cognition**

**Multiple Trauma**

---

Fig. 5. Sample Data Form Used in The Study.