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EFFECTS OF OVERT AND SILENT STUDY ON RECALL OF VISUAL
INFORMATION BY HEAD INJURED PATIENTS

The Ohio State University

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EFFECTS OF OVERT AND SILENT
STUDY ON RECALL OF VISUAL INFORMATION
BY HEAD INJURED PATIENTS

DISSERTATION

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

By

James A. Arnett, B.S., M.A.

* * * * *

The Ohio State University

1984

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Structured group and monitoring program for rehabilitation of early head injury, with R.D. Jackson, J.D. Corrigan, & L.J. Houck. 45th Annual Assembly of the Academy of Physical Medicine and Rehabilitation; Los Angeles, Nov. 6, 1983. Abstract: Archives of Physical Medicine and Rehabilitation, 1983, 64, 10, 518.

FIELDS OF STUDY

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CHAPTER I

INTRODUCTION

Each year an estimated 9.8 million americans suffer some form of head injury. Approximately 14% of these injuries (1.4 million) involve serious brain trauma (Caveness, 1977).

Persons who survive severe brain injury suffer a range of impairments, physical and mental, from the mild to the profound. Problem solving ability, general intellectual capacity, concentration and attention, and memory may be impaired. Of the possible mental deficits the victim can incur, perhaps the most debilitating is the loss of memory function. According to Mauss-Clum and Ryan (1981), 87% of brain injury victims have some degree of memory impairment. This impairment may take different forms including retrograde and anterograde amnesia, various lengths of post traumatic amnesia, and inability to transfer new information into permanent memory stores. The most apparent memory deficit in the severely brain injured person is the extreme difficulty encountered in learning new information. A typical patient may have a large vocabulary and an excellent fund of semantic information acquired premorbidly, but they remain severely handicapped because their inability to remember present personal experience stifles learning and prevents meaningful functioning in any social setting.

Considerable effort is expended in the rehabilitation of persons with all types of serious injuries and illnesses including head trauma. Physical rehabilitation is a well defined practice with clearly structured therapy programs following psychiatric evaluation. The rehabilitation of mental functions is less clearly defined. Head injury victims in rehabilitation participate in elaborate retraining programs

including considerable practice, use of memory aids --schedule cards and diaries-- and other techniques believed to improve memory. Unfortunately these treatments are often lacking in empirical justification.

Most research into the memory function makes use of animals or normal human subjects. Research on the memory processes of the brain injured person is greatly needed in view of the considerable effort and expense of this type of rehabilitation.

Research in learning, understanding, remembering and forgetting is characterized by a diversity of theory. A typical theoretical model of human memory (Atkinson and Shiffrin, 1968) proposes three memory registers: sensory, short-term, and long-term. Information, actually stimulus energy from the environment, enters the sensory register first. This information moves into the short term storage register if it is actively attended to. According to the Atkinson and Shiffrin model, information in short term memory must be actively rehearsed or it will be irretrievably lost. These authors suggest that rehearsal in short term memory is done primarily by repeating the sound of the stimulus. This sound or acoustic coding of information has important implications for the research proposed here. In order to rehearse information and eventually transfer it to long term memory storage, it must be repeated acoustically or verbally. What is repeated verbally is what will be retained. Other forms of coding, including imagery, may be possible. Kosslyn (1981) suggests a theory of how information is represented in the form of visual mental images. It seems likely that normal humans attend to the environment with a combination of encoding strategies.

The research proposed here will examine the effectiveness of attention and short-term memory processes in brain injured human subjects. It is hypothesized that the brain injured person remembers information less well than the normally functioning person for two reasons. The brain injured person does not actively attend to the stimulus to be remembered and the brain injured person does not rehearse the information. If the verbal or acoustic rehearsal

hypothesis is valid then a verbal or language rehearsal would be necessary for the remembrance of visual information. It is also hypothesized that the normal human attends to and analyzes a visual stimulus by means of repetition of ideas in the form of language. Whether the verbal rehearsal is overt or covert will have little effect on the memory performance of normal persons because the verbal rehearsal takes place automatically as part of the attending and remembering process. It is suggested that the verbal rehearsal function is considerably attenuated in the brain injured person. If this is so then the memory of the brain injured person should be improved by directing the injured person to overtly recite information presented in visual form. If a visual stimulus, such as a photograph, is presented to a group of normal subjects and a group of brain injured subjects and they are later asked to recall the visual stimulus, overt verbal rehearsal of the stimulus information may improve the memory performance of the brain injured more than that of the normal subjects.

These hypotheses will be tested by administering two tasks to a group of brain injured subjects and a group of hospitalized control subjects. Each task involves studying and later recalling details of a photograph. One task involves studying the photograph silently. The other task involves studying the photograph while reciting aloud the details noted.

CHAPTER II

LITERATURE REVIEW

This review is divided into three parts: 1. an overview of the memory function with some attention to models of memory and processes of attention and concentration, 2. the effects of serious brain injury, and 3. current practice in cognitive rehabilitation. This review must be selective in view of the great quantity of research on human and animal memory.

The Memory Function

According to Gleitman (1981), "Memory is the way in which we record the past and later refer to it so that it may affect the present." Memory and learning are inextricably linked. As with learning, memory cannot be measured directly. Rather the organism must demonstrate the memory or lack of it in some sort of test.

Prior experience affects present behavior in remarkable ways. because humans and animals so readily demonstrate relatively permanent changes in behavior as a result of prior experience, it is inferred that a mental impression of that prior experience must exist. This mental record, sometimes called a trace, has never been demonstrated physiologically. Current theories of the physiology of memory suggest that the total brain is involved in the storage of a memory. This conclusion results from a considerable body of research which generally shows that the effects of prior experience can never be completely eradicated (Lashley, 1929), (Meyer, 1982). A recent study by McCormic, et al. (1982) is an exception to this rule. This study suggests that the cerebellum is involved in the storage of a

classically conditioned response and removal of the cerebellum, after learning, appears to destroy the memory.

The study of memory and cognition begins very early in human history. The ancient greek philosophers were probably the first to seriously consider the memory function and to record their thoughts on the subject. The first model of memory was probably Plato's conception of memory as being like a wax tablet. Experiences left impressions or traces in this tablet just as a solid object would leave its imprint when pressed into wax. Plato also considered the mind to be something distinctly separate from the body.

Aristotle contributed to the study of memory by creating a list of conditions that he believed were important for the formation of a memory. Among these were the way the material is organized and the frequency of presentation. Aristotle also suggested that memory traces could become associated so that recall of one idea could lead to the recall of another. The concept of association has had great impact on philosophy and psychology and it continues to be important today.

John Locke, the seventeenth century philosopher, continued the concept of the mind as a tabula rasa. Locke added to this model the idea that complex ideas and thoughts were composed of simpler thoughts. For example, Locke suggested that our idea of an apple, a complex idea, is composed of simpler ideas such as roundness, redness, and shineyness. These ideas become associated to produce the idea of an apple through the principle of contiguity: association in time and place.

Following Plato's earlier thoughts on the separation of mind and body, Rene Descartes proposed that the body was governed by the laws of nature and the mind was free of these restrictions. This proposed dualism of mind and body raises the question of how the two interact within the person. Where is the mind located and how does it affect the body? Descartes' dualism allowed the scientific study of the body but added little to our understanding of the mind and its processes.

One way to resolve the mind-body problem is to assume that all behavior is reflexive and therefore a response to environmental stimulation. Learning and memory can then be viewed as associations between stimuli and responses rather than mental processes. This approach gave rise to the study of elementary associative learning by Pavlov (1927) and later to the behavioral approach to psychology. The behavioral approach to the explanation of behavior attempts to describe, explain, and predict behavior in terms of analysis of stimulus-response patterns without recourse to the internal state of the organism (Skinner, 1974).

And yet it is apparent that the internal state of the organism does change with learning. Studies of latent learning (Tolman and Honzik, 1930) demonstrate that learning can take place in the absence of reward or active response. In a similar way Bandura and Walters (1963) have demonstrated that new behaviors can be learned simply by observation. It is clear that the retention of a response requires a memory function.

The study of behavior carries with it an air of objectivity which has undoubtedly enhanced its credibility. However, in recent years it has become apparent that the mind can be studied objectively through behavioral responses of the organism. The mind, and mental processes, may be one of the most interesting and fruitful areas of study in psychology. The study of mental processes in the mentally disabled may lead to more effective rehabilitation strategies.

Most research into the memory function suggests that there are separate and distinct types of memory within one mind. William James (1890) made a distinction between Primary Memory, information held in consciousness and easily retrieved, and Secondary Memory which is information not in consciousness. These memories, primary and secondary, correspond to the commonly identified short term and long term memory stores of current research. Early models of memory made use of James' primary-secondary distinction. Waugh and Norman (1965)

suggested the concept of rehearsal of information in order to transfer information from primary to secondary storage.

A more detailed model of memory has been proposed by Atkinson and Shiffrin (1968). This model proposes three memory storage registers: sensory, short-term, and long-term. According to this model, information from the environment first enters the sensory register where it is retained for a very brief time (less than one second). Unless the information is attended to and transferred into the short term register, it will be lost. The capacity of the sensory register is relatively small. Early attempts to measure this capacity involved briefly presenting a stimulus (letters and numbers) and asking the subject to report what was seen. Results suggested that the sensory memory capacity was limited to 4 or 5 items. Sperling (1960) devised a system whereby the subject gives a partial report of what is seen in the brief exposure. Results with this procedure indicate that the sensory register capacity is about 12 items. There appears to be more information in the sensory register at any one time than can be reported before it is lost. A sensory register has been demonstrated for the auditory sense as well (Crowder and Morton, 1969).

If information is actively attended to by the organism, it is transferred from the sensory register to the short term register. The short term register also has a limited capacity. Miller (1956) suggested that the short term memory capacity was limited to seven plus or minus two pieces of information. These pieces or "chunks" of information must be actively rehearsed or they will be lost in a short time. The duration of short term memory, without rehearsal, appears to be about 15 to 20 seconds (Peterson and Peterson, 1959). Further study by Murdock (1961) demonstrated that the duration of short term memory depended on the amount of information that the subject was attempting to retain. Regardless, this type of memory is relatively short lived.

Information which is actively rehearsed tends to be transferred to long term memory. How information is permanently stored is a crucial question because the formation of long-term memory is a way of defining learning (Seamon, 1980). Atkinson and Shiffrin suggest that information is automatically transferred to long-term storage if it is held in short-term storage by rehearsal. Once in long-term storage, memory is believed to be relatively permanent.

The original Atkinson-Shiffrin model has undergone considerable modification by Shiffrin (1975). Shiffrin now suggests that the short-term store is not separate from the long-term store. Instead information goes directly from the sensory register to the long-term store. The activation of the permanent memory trace in long-term memory is the equivalent of placing information in short-term storage. For Shiffrin, the storage of information in memory (short and long-term are unified) is accomplished by establishing a connection between information not previously associated in long-term storage.

There is some question about the permanence of long-term memories. While most researchers seem to agree that once stored in long-term, memories appear to be permanent, an opposing view is taken by Loftus and Palmer (1974). These authors have demonstrated that the wording of questions can change the quality of and, in some cases, the actual details of recalled information. Loftus has proposed a model of updated memory to explain these results. She describes memory as malleable and as being updated or overwritten by new information. Bekerian and Bowers (1983) offer an alternative explanation for the results obtained by Loftus. They suggest that memories may be permanent and that forgetting or error responses may depend on whether the retrieval conditions bias one to use an appropriate strategy for accessing the old memory.

Atkinson and Shiffrin use the term coding to describe the process of storing information. Coding is a process whereby information is somehow compressed, simplified, or otherwise altered so that

some of the information is lost but the result is easier to remember. Forming associations between units of information is one form of coding.

Despite Shiffrin's concept of a unified memory model, there is good evidence that suggests that memory may have short and long term stores. The best evidence comes from the free recall experiments. In these experiments (Murdock, 1962) the subject is given a long serial list of 20 to 40 words and is then asked to recall the words in any order. Consistent results show that the first few words and the last few words are more easily remembered than the words in the middle of the list. It is hypothesized that the first items in the list were rehearsed sufficiently for transfer to long-term storage and the last few items in the list are easily recalled because they are still in short-term storage. The items in the middle of the list are lost because they are inadequately rehearsed.

Tests of immediate recall using auditory and visual modalities yield results pertinent to the proposed research. It is possible to test immediate recall of information using a visual presentation, and auditory presentation, or a combination of the two. The mode of presentation affects the recall results in interesting ways. Corballis (1966) found that items presented early in a serial list were recalled equally well regardless of the mode of presentation. The same is true for items presented in the middle of the list. Effects of the presentation modality were found in recall of items presented at the end of the list, and particularly for the last item presented. Here recall was better for items presented auditorily. This suggests that an echoic trace is created by an auditory presentation just as an iconic trace is created visually and that the echoic trace may be more helpful in recall. The difference in recall ability for auditory and visual presentation is called the modality effect. It is suggested by Crowder (1976) that subjects may rehearse auditorily the last one or two items in a serial list. This prolongs

the echoic trace. At the same time the iconic trace may fade or be masked by successive visual experience.

Perhaps the subject could improve recall of visually presented information by reciting aloud the stimulus information as it is presented and thereby create an echoic trace. Murray (1966) and Conrad and Hull (1968) found that oral rehearsal of a visual stimulus improved recall. This effect appears to be due to auditory stimulation or the subject's ears and it makes no difference whether the source of stimulation is the subject's voice or not. It seems logical that performance would be improved if a subject were to use two sensory channels for a single memory task.

Subjects appear to discriminate among pictures more easily than among verbal labels for those pictures (Levin, Ghatala, and Wilder, 1974). Paivio (1971, 1978) explains this by suggesting that pictures are more likely to be coded both verbally and visually and this dualistically coded information is more easily remembered. Paivio's model of memory contains two separate but interconnected stores: a verbal store for words and a non-verbal store for images. Images have a great probability of being encoded in both stores because transfer from non-verbal to verbal store is more rapid than the converse.

According to the memory models described, a memory failure can be explained in several ways. Memory may fail because of coding failure, storage failure, or different forms of retrieval failure. Inadequate coding or a storage failure would mean that the information was never learned. A retrieval failure would mean that the information was learned but for some reason it is inaccessible. Although these concepts are appealing on logical grounds, practical attempts to separate encoding problems from storage and retrieval problems have been difficult (Houston, 1981).

Assuming that information has been properly stored, a memory failure can be explained by the possibility of competing or interfering responses which inhibit or prevent the desired response. The desired

correct information is not recalled but in its place information that is similar comes to mind (Postman, 1961).

Head Trauma and its Effects

Each year in the United States over 1 million persons suffer serious head injuries. These injuries stem from a variety of causes including motor vehicle accident, gunshot wounds, falls, and diving accidents. The form that the brain damage takes varies according to physical laws governing acceleration of movable masses and subsequent deformation and destruction of tissue.

The skull and its muscles weigh about 9 kilograms while the brain itself weighs about 1.8 kilograms. Because of this difference in mass, the brain and skull respond differently to acceleration from external forces. The brain strikes the skull at the site of the external blow and may rebound, striking the skull at a point opposite to the blow. Rotational acceleration of the head may cause twisting and tearing of deep brain structures. Also a rotational acceleration can cause abrasion of the surface of the brain as it rubs against the rough internal surface of the skull. Brain damage can result from swelling of brain tissue, loss of blood supply, or direct destruction of tissue. Damage from a blow to the head is often diffuse; it may involve large areas of one or both hemispheres and shearing of inter-cortical and brain stem neurons. Skull fractures have little prognostic value. Ten percent of patients with skull fracture die, while 3% without skull fracture die (Leech and Shuman, 1982).

Victims of head trauma suffer a variety of mental and physical problems. Physical problems may include loss of function of a part of the body, motor ataxia and loss of coordination and balance, and impairment of sensory function. Mental impairment is more difficult to quantify and may be more debilitating for the victims. Refer to table 1 from Mauss-Clum and Ryan (1981) for an example of deficits reported by victims' families.

TABLE 1

Changes in Head-injured Patients Noted by Family Members
(N = 30)

<u>Change Noted</u>	<u>Percentage Reporting</u>
Decreased Memory	87%
Dependency	73%
Depression	57%
Impatience	57%
Decreased Ambition	53%
Irritability	53%
Temper Outbursts	50%

In a large study of the head injured in England, Lewin, Marshall, and Roberts (1979) report statistics describing long term outcome effects of severe head injury. These patients were examined 10 years after injury. Of 479 patients who had been amnesic or unconscious for one week or longer, 4% were totally disabled and 14% were severely disabled to a degree precluding normal occupational or social life. A greater length of coma correlated with more severe long term disability. The most common severe mental disability reported by these authors is fronto-limbic dementia. This disability occurred almost exclusively in young adults with athetoid pseudobulbar and brain stem cerebellar lesions and is described as severe impairment of day to day memory with the release of irritability and rage reactions. Frontal dysmnesia and frontal personality change without irritability or memory impairment were common results in the less severely injured young victims. Two highly characteristic results of injury after middle age were patterns of anxiety apparently reflecting a neurotic response to memory and other less obvious cognitive deficits. Post traumatic epilepsy occurred in 28% of the cases examined. Epilepsy prevalence varied from 7% among those with uncomplicated injury and

post traumatic amnesia of no more than a week to 61% among those with complex injuries involving brain compression or surgical penetration of the brain.

Levin, Grossman, Rose, and Teasdale (1979) in a small scale follow-up study emphasize the permanence of disability. Of 27 patients studied 1 year after injury, 10 made a good recovery, 12 were moderately disabled, and 5 were severely disabled. These authors report that intellectual level, memory, linguistic deficit, and personal social adjustment correspond to overall outcome. The severely disabled patients exhibited unequivocal cognitive and emotional sequelae at the follow-up interval. About one third of the patients examined exhibited a deficit in long-term memory processes.

The severely head injured also exhibit deficits in reaction time. Miller (1970) studied five head injury patients who were judged to have post traumatic amnesias of over a week and no motor deficits at the time of testing. Results show a general increase in reaction time and the discrepancy between the head injured and the controls increased with task complexity. These results are explained in terms of a central, rather than a sensory or motor disturbance. These results are similar to reaction time studies with the aged. Strich (1961) suggests the aged and the head injured perform similarly because of similar anatomical changes, namely a general fall out of nerve cells.

Sleep and dreaming disturbances in closed head injury patients have been examined by Prigatano, Stahl, Orr, and Zeiner (1982). These researchers examined 10 head injured adults six months after injury and found abnormal sleep patterns and a positive correlation between presence of REM sleep and cognitive functioning. These patients had two to three times more awakenings during the course of the night which may reflect problems with neural disinhibition. The patients also showed a significantly lower arousal level during the waking hours.

Depression is a significant reaction to left hemisphere injury according to Robinson and Szetela (1980). These authors suggest that depression severity correlates with closeness of the lesion to the frontal pole and that depression may be a symptom of injury to specific pathways in the frontal cortex.

Memory deficits accompanying head injury are many and complex. The major memory problems can be categorized as post traumatic amnesia, retrograde and anterograde amnesia, long-term memory failure, and short-term memory failure. Often the terms remote and intermediate memory appear in the the head injury literature to describe areas of memory. Actually in accordance with most memory models, remote and intermediate memory are both parts of long-term memory but the distinction may be useful because certain patients show different recall abilities with the two areas: the distant past and the recent past.

The term "post-traumatic amnesia" (PTA) refers to a period of time following closed head trauma during which the patient is confused, disoriented, suffers from retrograde amnesia and seems to lack the capacity to store and retrieve new information (Schacter and Crovitz, 1977). The assessment of PTA is difficult because it depends on reports from the patient concerning his or her awareness of an ongoing stream of experience. When a patient is no longer experiencing PTA he or she is often able to give a date on which these memories begin. As noted by von Wovern (1966), "The patient often maintains that the duration of unconsciousness was much longer than that initially observed and recorded". A typical patient may report that she has been in three or four hospitals but the present one is where she "woke up". Assessment of PTA is further complicated because patients often appear to drift into and out of the amnesic state. Periods of coherent orientation may be interspersed with periods of confusion.

Because assessment of PTA is difficult, some researchers prefer other terms to describe the patient's condition. Moore and Ruesch (1944) prefer to simply describe the patient as disoriented. Sisler and Penner (1975) consider disorientation, retrograde amnesia, and anterograde amnesia as components of PTA. The duration of PTA appears to correlate with the severity of neurological damage as evidenced by other measures (Russell and Smith, 1961). The duration of PTA may be used as a measure of the severity of trauma. Moore and Ruesch note that length of the post traumatic period of disorientation correlates well with the severity of trauma as determined by other neurological signs.

It is possible for patients to demonstrate some memory function during the period of PTA. Mandleberg (1975) reports that patients tested during PTA are often able to obtain a "borderline" score on the verbal section of the Wechsler Adult Intelligence Scale. Also, the digit span test, a measure of short term memory, may be near normal during PTA.

As noted by Schacter and Crovitz, several questions concerning memory processes during PTA remain unanswered. It is not known what coding processes are available to the patient in PTA nor is it known how temporal parameters or retrieval cues affect memory performance during PTA.

The severely head injured person usually has no memory of a period of time surrounding the actual time of the trauma. The term "retrograde amnesia" (RA) refers to the patient's inability to recall events experienced prior to the trauma and the term "anterograde amnesia" refers to inability to recall events experienced after the trauma. As with PTA, assessment of retrograde and anterograde amnesia is difficult because it depends on reports from the patient about details of past experience which may not be verifiable.

Retrograde amnesia appears to have two distinct forms: a permanent RA of short duration (seconds, hours, or days) prior to the trauma and a much larger but temporary RA that may cover days, weeks, or longer. The temporary form of RA gradually shrinks with the passage of time. Russell (1932) determined that RA tends to be longer with increasing duration of PTA. Sisler and Penner (1975) suggest that the RA period continues to shrink after the patient has emerged from PTA.

The recovery of memory function after head injury appears to be prolonged and gradual. For patients with relatively short comas and short periods of PTA, the recovery may often appear to be nearly complete. However, Symonds (1962) suggests that recovery from the effects of closed head injury may never be total. Brooks (1972) tested closed head injured patients on a variety of memory functions and found no significant relationship between memory performance and length of time since injury. This result led Brooks to conclude that recovery had stopped for the patients examined. In a later study, Brooks (1975) measured short-term memory (STM) and long term-memory (LTM) of two groups of patients, an early group tested on an average 2.4 months after injury and a late group tested on an average 16.6 months after injury. The two groups did not differ on long term memory performance but the late group showed significantly better performance on STM. Brooks suggests that either LTM had stopped improving or it was improving at a much slower rate than STM for these patients. Researchers have explored memory performance of head injured patients in an attempt to understand what part of the memory system is failing. As noted earlier, in the discussion of models of memory, it is difficult to separate the functions of coding, storage, and retrieval. The study by Brooks (1975) is illustrative of problems in this area of research.

Brooks tested 30 closed head trauma patients with free recall of word lists and with the digit span test. In general the head injured patients appeared to have LTM rather than STM problems. Head injured

patients performed less well but not significantly less well than controls on the digit span test. Brooks notes, however, that the statement that a patient has a defect in LTM merely describes rather than explains the patient's problem. LTM probably involves processes of encoding and consolidation, and retrieval and a failure of any of these processes could result in a memory failure.

Brooks next examined the responses of head injured and normal subjects for intrusion errors on the free recall test. An intrusion error is the recall of a word from a list used prior to the list presently being tested. A large number of intrusion errors is hypothesized to indicate a retrieval failure because words have been stored but are being recalled at the wrong time. A small number of intrusion errors would suggest a storage problem. Head injured patients in the Brooks study did make significantly fewer intrusion errors than the controls. As Brooks notes, "A finding of a significantly smaller number of intrusion errors could suggest that the deficit lies not (Primarily) in retrieval but rather in storage in LTM, although retrieval defects would not be excluded".

Brooks also compared memory performance to length of PTA, presence of skull fracture, presence of neurological signs, and time of testing. The presence of neurological signs and the length of PTA showed only a weak relationship to the severity of memory deficit. The presence of skull fracture was of minor importance in determining the severity of the LTM defect. Finally, as noted earlier, patients tested early after injury were significantly poorer on STM but not on LTM.

A few studies have attempted to examine the memory function using visual information. Courville (1942) compared visual and verbal memory functions in patients with closed head injuries. As might be expected, patients with right side impact performed less well than those with left side impact on verbal tasks. (As noted at the beginning of this review, if the head is moving and strikes a solid massive object, the rebound of the brain often causes damage at a site opposite the point of impact. This type of contre-coup damage would

account for Courville's results if major damage would be to the left hemisphere language areas.) The unexpected result of this study was that patients with right side impact also performed less well than those with left side impact on tests of visual memory. A possible explanation for this result, which has implications for the current research, is that verbal skills may play a role in spatial and visual memory tasks. Another explanation is that the tasks were not of equal difficulty, if indeed they can ever be. Brooks (1972) suggests the need for equal difficulty of verbal and visual tasks after finding that head injured patients performed less well than controls on verbal memory tasks but equal to controls on visual tasks. These findings may also indicate that conceptual models of the brain that stress discrete functions for each hemisphere may not be accurate (Sperry, 1982). Sperry notes that patients with commissurotomies (split brains) are able to comprehend language while using their right hemisphere alone. Sperry's conclusion is that the brain functions as a unit in comprehending stimulus information. A brain with interconnected hemispheres and a left side lesion functions less effectively than a brain with disconnected hemispheres.

Rehabilitation of the Head Injured

The survival rate of accident victims has increased as a result of recent advances in medical science. Injury victims, who in the past may have died, now live on with varying degrees of disability and resultant reduced quality of life (Levin, Benton, and Grossman, 1982). This increased survival rate has created an ethical responsibility to help with long term restoration --rehabilitation and retraining-- of these victims. Until very recently rehabilitation of the head injury victim was concerned only with physical problems. The victim's mental condition was largely ignored, often in the belief that nothing could be done. It is likely that the head injury victim will regain the ability to walk and take care of his or her basic daily personal needs. However, it is not possible to predict the

victim's future in terms of quality of life or employment (Malkmus, Booth, and Kodimer, 1980). The head injury victim often experiences a reduced quality of life because of loss of higher cognitive functions. These deficits result in reduced ability to manipulate and interact with the environment. Recently, rehabilitation efforts have been directed toward improvement, restoration, and compensation of these reduced mental functions.

The rehabilitation programs at El Rancho Los Amigos Hospital, The New York University Medical Center, and The Ohio State University Hospitals Rehabilitation Center represent typical approaches to the rehabilitation of head injured persons. This review will concentrate on cognitive rehabilitation; it is understood that physical rehabilitation takes place concurrently.

The Rancho Los Amigos rehabilitation program (Malkmus, et al., 1980) appears to be the most clearly and completely described. The Rancho treatment approach for the adult head injured is based on three factors.

"First, the approach assumes diffuse neurophysiological disruption followed by signs of spontaneous recovery. This means neurological potential for recovery is evidenced and spontaneous recovery can be channeled into functional cognitive skills. Second, recovery of cognitive structures follows a pattern that is definable and predictable. Third, the approach is based upon the premise that all disciplines interacting with the head injury patient have the potential to facilitate increased cognition."

The Rancho Los Amigos Hospital has developed a behavioral rating scale which describes the stages of recovery of the head injury patient and serves as a guide for planning treatment. The Rancho "Levels of Cognitive Functioning Scale" categorizes patients into eight levels as follows (abbreviated form):

- I. No Response. The patient appears to be in deep sleep and is completely unresponsive.
- II. Generalized Response. The patient reacts inconsistently and non-purposefully to stimuli. Responses are likely to be delayed. The earliest response is to deep pain.
- III. Localized Response. The patient reacts specifically but inconsistently to stimuli by turning the head or focusing on an object presented. The patient may respond to some persons --family and friends-- but not to others.
- IV. Confused Agitated. The patient is in a heightened state of activity with severely decreased ability to process information. The patient, if not physically disabled, may perform automatic motor activities such as sitting, reaching, and ambulating as part of his or her agitated state but not as a purposeful act.
- V. Confused Inappropriate. The patient appears to be alert and is able to respond to simple commands fairly consistently. However, with increased complexity of commands or lack of external structure, responses are nonpurposeful, random, or fragmented. Memory is severely impaired, with confusion of past and present in reaction to ongoing activity. The patient can usually perform self care activities with supervision.
- VI. Confused Appropriate. The patient shows goal directed behavior, but is dependent on external input for direction. Past memories show more depth and detail than recent memory. The patient may show beginning awareness of his or her situation by realizing he does not know an answer.

VII. Automatic Appropriate. The patient appears appropriate and oriented within hospital and home setting, goes through daily routine automatically with minimal confusion and has shallow recall of activities.

VIII. Purposeful Appropriate. The patient is alert and oriented, is able to recall and integrate past and recent events and is aware of and responsive to his or her culture. The patient shows carry-over of new learning and needs no supervision once activities are learned.

The Rancho Los Amigos Hospital offers treatment to the head injured who are functioning at all levels of the above scale. The focus of treatment varies according to the scale level. The treatment approach is based on stimulation for levels II and III, providing structure and structured training for levels IV, V, and VI, and community integration for levels VII and VIII. The patient with decreased response --levels II and III-- will receive a variety of stimulation aimed at all sensory systems. These include television, recorded music and familial sounds and voices, pictures of relatives, tactile stimulation with a variety of temperatures and textures, etc.

As the patient progresses to levels IV, V, and VI, structured training is provided. Patients participate in structured activities and begin to practice structured routines. An example of such a structure might be a detailed list of morning activities: go to bathroom, wash with soap and water, brush teeth, etc. Structured activities include any regularly occurring organized activity such as occupational, physical, or speech therapy, recreation, and group activities. The patient will also begin keeping a diary or log of daily activities.

Patients who achieve levels VII and VIII are given counseling and practice at integration into family and community. Structure is gradually reduced while assistance is provided in helping the patient take responsibility for personal needs and use of time.

The Institute of Rehabilitation Medicine of the New York University Medical Center uses a variety of electronic and electro-mechanical devices designed to improve the patient's concentration, reaction time, and scanning of the environment. This center also makes use of group experiences for intermediate and advanced head trauma patients (NYUMC Monograph 60, 1979). The objectives of the group experience include practice of interpersonal skills, establishing a sense of worth in spite of disability, and to provide a sense of belonging for the normally isolated patient.

The Ohio State University Rehabilitation Center makes use of structured group experiences for patients at all but the lowest levels of the Rancho Scale. Patients at the lower functional levels participate in a daily orientation group, the purpose of which is to drill members on orientation to time, place, and names, to practice episodic recall, simple associative learning, and the use of schedule aids. Patients at the higher functional levels participate in a group, four meetings per week, which is designed to treat memory problems commonly found in the head injured. A common practice in the "memory group" is the elaboration of information contained in a photograph or short story. Information is organized into a structure of who, what, when, where, and why. It was in this group that the experimental paradigm using overt and covert study --the basis of the current research-- was developed.

Summary

There is a great need for effective rehabilitation strategies for the treatment of the head injured. This need can only increase as medical science contributes to an increased accident survival rate. In response to this perceived need there has been considerable growth in the field of rehabilitation medicine. Unfortunately, according to Levin, et al. (1982), few studies have attempted to assess the effects of rehabilitation on neuropsychological recovery from severe head injury.

Memory problems are one of the most common sequela of head injury. These memory deficits generally have two characteristics: first, old memories seem to be more easily recalled than new memories, and second, semantic or general knowledge often is more easily recalled than personal experience. These problems indicate a need for strategies for learning new information (creating new memories or better retrieval of memories).

The scientific study of memory is difficult. At present, attempts to separate encoding, storage, and retrieval (components of current memory models) have been equivocal. Research into the memory function of the head injured is further complicated by the heterogeneous nature of traumatic brain damage and the difficulty of observing matched treatment and control populations. In spite of the lack of empirical validation, considerable effort is expended in rehabilitation in attempts to help patients improve their memory performance.

This study attempts to contribute to the theory of memory and expects to contribute to the treatment strategy for memory deficits. It is hypothesized that reciting out loud while studying visual information will help in the later recall of that information by the head injured patient. This hypothesized gain in performance may be explained in four ways: First, reciting out loud may help the subject maintain attention and concentration. Second, these activities may aid in remembering because they make use of different sensory channels simultaneously. Third, overt recitation of the stimulus information may help in remembering because it allows better encoding through elaboration. Finally overt recitation of the stimulus may help in later recall by giving the subject practice in retrieval of stored information.

CHAPTER III

METHODOLOGY

Subjects

Two groups of subjects were used in this study: a group of 9 head trauma patients and a group of 9 patients with spinal cord injuries who were hospitalized for rehabilitation.

The head trauma subjects were patients of the head trauma rehabilitation unit of Dodd Hall, The Ohio State University Hospitals. Six of these patients were hospitalized in the head trauma rehabilitation unit and three were outpatients attending the head trauma clinic. This group consisted of three females and six males with ages from 17 to 52 (mean age = 31.5 years). These patients were rated as class V or higher on the Rancho Levels of Cognitive Functioning Scale. Patients who could not respond verbally or were unable to readily identify common objects in pictorial form were excluded. All head trauma subjects were known to have memory problems as measured by the Russell Modification of the Wechsler Memory Scale (30 minute recall less than 75% for either semantic or figural information) or by observation of the rehabilitation staff. Because of the difficulty of finding suitable subjects, this group was highly mixed. All head injured patients exhibited severe mental performance deficits including impaired memory. Head injured subjects are described as follows:

- #1. A 26 year old, male, injured in a motorcycle accident. He was tested 76 days after his accident and was rated at level 7 on the Rancho Scale. He exhibited memory and mild speech problems as noted by hospital staff.

#2. A 48 year old, male, injured during an assault. He was tested while an outpatient, approximately one year after he was injured. He was rated at level 7 on the Rancho Scale. He was living at home and was independent with self care but was able to perform only the simplest activities without supervision because of intermittent "Blackouts" and lapses of memory and concentration.

#3. A 37 year old female, injured in an automobile accident. She was rated at level 5 on the Rancho Scale and was tested in the hospital, 88 days after she became injured. In neuropsychological testing she could give no evidence of long-term verbal memory. She was intermittently oriented to time, place, and important names.

#4. A 35 year old, female, injured in an automobile accident. She was rated at level 8 on the Rancho Scale and was tested as an outpatient, approximately three years after her date of injury. This patient exhibited serious problems with spatial orientation and processing of non-verbal information. Her performance on the Wechsler Memory Scale indicated a severe short-term figural (non-verbal) memory problem. Although she had a good work history, she has been unemployed since her injury.

#5. An 18 year old female, injured in an automobile accident. She was rated at level 7 on the Rancho Scale. She was tested approximately three years after her injury. At the time of this study, she had been readmitted to the rehabilitation hospital because of improved mental status and the possibility of learning functional skills. Neuropsychological testing indicated poor long-term memory. Thirty minute recall was 33% for semantic information and 40% for figural information.

#6. A 52 year old, male, injured in an aircraft accident. He was tested while an outpatient approximately 14 months after his accident. He was rated at level 5 to 6 on the Rancho Scale. Neuropsychological testing indicated poor long-term memory. Thirty minute recall was 78% for semantic information and 66% for figural information. This patient was experiencing double vision and was given to labile outbursts.

#7. An 18 year old, female, injured in an automobile accident. She was tested 42 days after her accident and was rated at level 6 on the Rancho Scale. Neuropsychological testing indicated good long-term figural memory but impaired long-term semantic memory. Thirty minute recall was 20% for semantic information and 100% for figural information.

#8. A 25 year old, male, injured by a falling object while at work. He was tested 40 days after his accident and was rated at level 7 on the Rancho Scale. Neuropsychological testing indicated a serious non-verbal memory problem. Thirty minute recall was 83% for semantic information and 0% for figural information.

#9. A 39 year old, male, injured in an automobile accident. He was tested approximately 5 years after his accident and was rated at level 5 on the Rancho Scale. At the time of this study, he had been readmitted to rehabilitation because of improved mental status and the possibility of learning adaptive skills. Short-term memory problems were noted by the hospital personnel. This patient was highly distractible and exhibited confabulation and confusion.

Subjects in the control group were selected from the rehabilitation patient population and were free of head injuries. These patients were selected in an attempt to control for effects of reaction to severe injury and lengthy hospitalization. This group was composed

of nine patients with spinal cord injuries. One female and eight males comprised this group; their ages ranged from 17 to 47 years with a mean age of 30.8 years.

All subjects received a brief description of the study and were advised that their participation was voluntary. They were also informed that all test data would be held in strict confidence. All subjects were asked if they agreed to participate in the experiment; they were also asked to sign a simplified consent form (Appendix A). After completion of the experimental tasks, both groups were given an explanation of the study and all questions were answered. The only element of deception in this study involved not telling the subjects that the principal objective was the comparison of the trial results; this was explained after completion of the tasks.

Stimuli:

Two photographs, 8" x 10" and 10" x 14" were selected as the stimuli to be studied. These photographs were selected so as to contain a large amount of detail consisting of common objects and people in ordinary clothing and settings. The photographs contain a wealth of detail so that subjects would not easily exhaust the available details during the study intervals.

Instructions:

The tasks were presented as follows:

WE ARE GOING TO DO TWO SIMPLE TESTS OF YOUR MEMORY. IN EACH TEST I WILL GIVE YOU A PICTURE TO STUDY FOR A SHORT TIME, THEN A LITTLE WHILE LATER I WILL ASK YOU TO ANSWER SOME QUESTIONS ABOUT THE PICTURE.

The tasks were presented in alternating order and the photographs were alternated so that each photograph was used with both tasks.

Silent Study: IN THIS TASK I WOULD LIKE YOU TO STUDY THE PICTURE SILENTLY UNTIL I TAKE IT AWAY. DON'T SAY ANYTHING OUT LOUD. DO YOU UNDERSTAND? ARE YOU READY?

If the subject did not understand the task, additional explanation was given by essentially repeating the above instructions.

Overt Study: IN THIS TASK I WOULD LIKE YOU TO STUDY THE PICTURE AND WHILE YOU ARE STUDYING IT, SAY OUT LOUD EVERYTHING THAT YOU SEE, AS IF YOU WERE TELLING ME WHAT YOU SEE. DO YOU UNDERSTAND? ARE YOU READY?

Again, additional explanation is given so that the subject understands the task.

Each photograph was presented for 1 minute. After the 1 minute presentation the subjects waited 2 minutes before recall of the information. To inhibit possible rehearsal of the stimulus information during the waiting period, the subjects were asked a series of questions. Subjects were asked for age, today's date, their date of injury, how long they have been hospitalized, and what hospital they had been in before the present one. Questioning was stopped at the end of the two minute period and the subjects were asked to recall all possible information about the photograph that they had studied, as follows:

NOW, TELL ME ALL THAT YOU CAN REMEMBER ABOUT THAT PICTURE.

The subjects were allowed to freely recall information in any way that they wished. When it appeared that a subject had recalled all that they could remember, he or she was given one extra opportunity, as follows:

NOW, THINK FOR A MOMENT AND TELL ME IF THERE IS ANYTHING ELSE YOU CAN REMEMBER.

All subject responses were tape recorded for later analysis.

Analysis of Subject Responses:

In order to objectively score the subjects' responses, the following procedure was used: Responses of five normal adults were recorded for both photographs and lists of all commonly cited details were created from these responses. These "detail lists" appear in appendix A. Only concrete descriptive statements were accepted as details: inferences about the subjects of the photographs were not counted.

Two judges, using the detail lists, independently listened to the subjects' responses and checked off details on the lists. These judges were ignorant as to the task being performed (silent or overt study). By using the detail check lists, the judges were able to obtain high agreement as to the subject responses (Inter-rater correlation = .96).

Design and Data Analysis:

Analysis of results was by repeated measures analysis of variance. Each group responds twice: once for each task. The independent variables are the task format (silent or overt study) and the group make-up (head injured or non-head injured). The dependent variable is the total number of details recalled by a subject. This is a mixed between subject-within subject design. Refer to Appendix B. for a description of the statistical procedures used (Myers, 1979. pp. 201-210).

Hypothesis 1: Recall performance of the control group will be superior to recall performance of the head injured group on both tasks.

Hypothesis 2: Recall performance of the head injured group will be greater with overt study than with silent study.

Hypothesis 3: Recall performance of the control group will not differ between the two tasks.

CHAPTER IV

RESULTS

Refer to table 2 for a listing of data collected with group means and standard deviations. The relative distribution of means is displayed graphically in Figure 1.

As expected --hypothesis 1-- the control group performed much better than the head injured group in both conditions ($p < .001$). The control group recalled an average of 14.4 details with silent study and an average of 12.5 details with overt study. In contrast, the head injured group recalled an average of 6.3 details with silent study and an average of 8.5 details with overt study. The much reduced memory performance of the head injured group is evident in both treatment conditions.

Table 3 shows analysis of variance of the data collected in the study. The analysis of variance does not show a significant study method effect but does show a significant interaction ($p < .05$) between group (Head Injured or Control) and study method (Silent or Overt). This result indicates that the study method affected the two groups in different ways. The recall performance of the head injured group was greater with overt study than with silent study --hypothesis 2. Hypothesis 3 --that study method would have no effect on recall performance for the control group was not supported. Overall performance of the control group declined with overt study.

TABLE 2

Details Recalled by Subjects

<u>Head Injured</u>		<u>Controls</u>	
<u>Silent</u>	<u>Overt</u>	<u>Silent</u>	<u>Overt</u>
6.5	9	17.5	11.5
9	11	16.5	18
5.5	7	14.5	14.5
8.5	12.5	17.5	11
3	8	6	7
8	5	11	6
8.5	9	15	16
3	6	18	10
5	9	13.5	18.5
M = 6.3	M = 8.5	M = 14.39	M = 12.5
SD = 2.35	SD = 2.35	SD = 3.87	SD = 4.53

FIGURE 1

Average Details Recalled Using Two Study Methods

Although performance of the control group appears to suffer with overt study, a visual inspection of the data suggests that individual performance was highly varied. Using overt study, four members of the control group gave improved performance, one was unaffected, and four gave decreased performance. If individual performance is classified simply as improved or unimproved then analysis of each group's performance by a Sign Test (Hays, 1973) illustrates the study effects in a possible more meaningful was.

Using the dichotomous classification, eight head injured patients improved with overt study while one remained unimproved. In contrast, four control patients improved with overt study and five were unimproved. Assuming that the probability of improvement equals the probability of no improvement then the probability of a binomial distribution of 8 and 1 occurring by chance alone is .0176. The probability of a result of 4 and 5 occurring by chance alone is .246. This analysis would suggest that overt study has a significant effect on performance of the head injured group but no predictable effect on the performance of the control group.

TABLE 3

Analysis of Variance

Source	df	SS	MS	F
Total	35	737		
Between S	17	595		
A	1	328	328	19.7 *
S/A	16	267	16.68	
Within S	18	142		
B	1	1	1	.152
AB	1	36	36	5.49 **
SB/A	16	105	6.56	

* $\alpha = .001$, $F(1,16) = 16.12$

** $\alpha = .05$, $F(1,16) = 4.49$

CHAPTER V

DISCUSSION

As expected, the control group demonstrated better recall than the head injured group in both test conditions. This result is consistent with the finding, noted earlier, that memory problems are very common among head injury victims. This reduced performance may be due to one or more of several differences in the head injured person. First, the head injured subject is probably less highly aroused and therefore works at a slower pace in processing stimulus information. Likewise, the head injured subject may have difficulty directing attention to the information to be studied. Concomitantly, the head injured subject may have greater difficulty filtering out extraneous stimuli during the study process.

The results of this study suggest that overt rehearsal may be an effective way of helping head injured patients improve their memory for new information. Although the head injured group did less well at recall than the control group (under either condition) they did significantly better at recall after overt rehearsal was used in the study process.

In view of the different theories of memory, it is difficult to explain these results. Likely explanations include effects of overt rehearsal on arousal level, the value of a forced rehearsal, and the effects of a trial retrieval on head injured subjects.

Head injured patients are generally less alert, slower to respond, and less active than the non-head injured patient population. It is possible that speaking out loud causes more general brain arousal which allows a better focus of attention. It seems logical to

assume that overt speech does not add significantly to the arousal level of the control subject.

Popular theories of memory emphasize the role of rehearsal in the formation of a memory. If rehearsal is necessary then it is possible that the head injured subjects did not rehearse, or did not rehearse as well, with silent study. Asking these subjects to speak aloud about the stimulus may have been, in effect, causing them to rehearse.

The hypothesis that overt study actually represents a practice retrieval is based on the work of Meyer and Meyer (1982). Their research with animals may have important implications for treatment of human memory problems. These authors argue that the formation of a memory (engram) takes place very quickly and after encoding, the memory is very durable and stable. If this is the case then what appears to be rehearsal of information may actually be retrieval of the memory which has already been formed. Using this theory, the results obtained with head injured patients might be explained as follows. When the stimulus is presented, a permanent mental impression is formed very quickly --in a few milliseconds. In overt study the subject is actually retrieving memories and translating them into language. When asked to recall the information, the recall is a duplicate of the initial practice retrieval. The head injured patient may be helped by the maintenance of contextual cues formed during the first retrieval.

The effect of overt rehearsal on the control group was not expected; this group recalled somewhat fewer details under the overt study condition than with silent study. There are at least three possible explanations for this result. Transferring the visual information into language seemed to present problems for some of the control subjects. These subjects would sometimes become confused about what to call certain details of the images. When this happened, they then lost study time and hence recalled fewer details of the stimulus.

Secondly, it is possible that even while speaking smoothly and efficiently, this speech is at a slower rate than the sub-vocal speech presumed to be used by the control subject. It appears from these results that the functional brain can process more information than it can speak about --or describe overtly-- in a given time period. Finally, it is possible that the control subjects, being more competent mentally, became alert to the purpose of the study and gave their best performance on the second trial regardless of the study method used. Inspection of the control group performance data gives some support for this hypothesis. Six of the control subjects gave their best performance on the second trial, two gave best performance on the first trial, and one gave equal performance over trials. Note that the post-hoc analysis of results, as improved or unimproved, suggests that the performance of the control group may not be significantly different from chance.

Overt speech is sometimes used as a memory aid by normal persons and these results do not necessarily contradict this practice. Overt speech may actually help the normal person with memory of specific details but at a cost of efficiency. The slower rehearsal, or practice retrieval, then causes reduced performance when only a brief study period is available.

CHAPTER VI

SUMMARY

The purpose of this study was to test the utility of overt rehearsal as a means of helping improve the memory function of persons with severe head injuries.

Patients who were victims of severe head injuries were given pictorial stimuli to study under two conditions: one minute silent study and one minute study with speaking out loud about the stimuli. After a retention interval of two minutes, the subjects were asked to recall all they could remember of the stimulus information. Two groups of subjects were tested: a group of head injured patients and a group of rehabilitation patients who did not have head injuries.

Results

The control group performed significantly better at recall under both conditions than the head injured group ($p < .001$). The head injured group performed better at recall when using overt study than when using silent study ($p < .02$ for result of 8 improved, 1 unimproved). Group data suggests that overt study had a detrimental effect on performance of the control group but this result may not be significant.

Conclusions

Overt rehearsal or study of information may be effective in improving memory performance of head injured patients. Overt rehearsal probably does not improve later recall by subjects who do not have

severe brain injuries. Overt rehearsal may improve recall of specific information in normal persons but at a reduction in learning efficiency.

Limitations of the Study

This study is limited by a small sample size. The head injured group is highly mixed as to location and severity of injury, and overall cognitive performance at time of testing. A larger study might allow for selection of subjects by type and location of injury.

Spinal cord injured patients in rehabilitation were selected as a control for possible effects of long term hospitalization and psychological reaction to serious illness. It must be recognized, however, that spinal cord injury may produce subtle physiological effects in the brain. Specifically, a spinal cord injury may produce changes in the brain stem and thalamus due to dying axons of upper motor neurons. These changes result in loss of a major source of afferent input to the brain (Bresnahan, 1976). For this reason the control subjects used in this study may not have brain function that can be considered normal.

The possible effects of the distractor task on memory performance should be considered further. From research with animals (Bartus and Levere, 1977) it is noted that irrelevant stimuli presented before a choice discrimination task significantly reduced performance of frontally decorticated monkeys. Normal control subjects were unaffected by such stimuli.

Although the use of photographs and a rating system worked well, objective performance scores might be obtained more easily by using specially prepared line drawings as stimuli. This would probably greatly reduce the problem of evaluation of responses.

Implications For Future Research:

The following suggestions are offered for research on the memory function in head injured persons.

If the test procedure used in this study could be simplified and standardized, it might be possible to test large numbers of subjects. This would allow analysis of results with respect to important factors such as location and extent of brain damage, use of medication, length of coma, and time since injury.

A more long term recall test, such as a 24 hour follow-up check would be helpful. This might provide additional support for use of overt study as a treatment method. A 24 hour recall task might also reduce the possible differential effects of the distractor task.

In consideration of the possibility of brain function impairment due to spinal cord injury, a second control group of normal functional subjects would be necessary to assess the effects of the study methods on the normal brain.

Controlled tests of overt rehearsal need to be conducted with patients as they practice important behavior patterns during rehabilitation. Learning and relearning skills of daily living is a major goal of most head injured patients in rehabilitation. It is in this area that effective memory aids would be most useful.

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APPENDIX A

Consent Form

Detail Lists

CONSENT FORM

I have talked with James A. Arnett about the research study:

Effects of Covert and Overt Study on Recall of
Visual Information by Head Injured Patients. 83B0095.

which is being done by W. Bruce Walsh and James A. Arnett.

The study has been explained to me.

I have had a chance to ask questions about the study.

I understand what will happen during the study.

I understand that I may withdraw from the study if I want to.

I agree to participate in the study.

Signature of Subject

Date

Signature of Witness

Date

PHOTOGRAPH A

47

____ Photograph is in black and white
____ A man in left center (by himself)
____ Shovels on shoulder, shovels
____ Cigarette in mouth, smoking
____ A hat on his head
____ Sleeves rolled up
____ White shirt
____ Trousers
____ Plank, board he is standing on
____ A group of men to right center
____ Two are wearing hats (one is not)
____ Wheelbarrows
____ Dirt in wheelbarrows (like dirt)
____ Plank, board, they are pushing on, walking on
____ Sandy, dusty ground
____ Tracks in dirt or sand
____ Group of men in background (right)
____ Hills in back
____ A wagon or car (in back)
____ Tree leaves in upper right
____ Shadows and bright sunlight

____ Total Rater _____ Date _____

PHOTOGRAPH B

48

- ☐ Photograph is in color
- ☐ A dog
- ☐ A second dog
- ☐ One dog is brown or brown and white
- ☐ One dog is black or black and white
- ☐ One dog has a collar (one does not)
- ☐ A man
- ☐ A second man
- ☐ One man has his arm on the other's shoulder
- ☐ Hats
- ☐ Shorts, Denim shorts, cutoffs
- ☐ Sleeveless shirt
- ☐ Short sleeve shirt
- ☐ Socks
- ☐ Old shoes or boots
- ☐ Red, brown, arid, dry, etc., dirt
- ☐ Telephone (utility) poles
- ☐ Telephone (power) lines
- ☐ A hill in back
- ☐ A large tree
- ☐ A small tree or bush
- ☐ Grass or weeds
- ☐ Clouds in sky

☐ Total

Rater ☐

Date ☐

APPENDIX B

Statistical Analysis

Data Table

	B1 (Silent)	B2 (Overt)	
A1 (Control)	17.5	11.5	29
	16.5	18	34.5
	14.5	14.5	29
	17.5	11	28.5
	6	7	13
	11	6	17
	15	16	31
	18	10	28
	13.5	18.5	32
	129.5	112.5	242
A2 (Head Injured)	6.5	9	15.5
	9	11	20
	5.5	7	12.5
	8.5	12.5	21
	3	8	11
	8	5	13
	8.5	9	17.5
	3	6	9
	5	9	14
	57	76.5	133.5
	186.5	189	375.5

Analysis of variance with one between-subjects and one within-subject variable:

- (1) Correction factor, C = squared total of all scores divided by total number of scores.

$$C = \frac{(375.5)^2}{36} = 3916$$

(2)

$$\begin{aligned} SS_{\text{total}} &= \sum_i^n \sum_j^a \sum_k^b Y_{ijk}^2 - C \\ &= (17.5)^2 + (16.5)^2 + \dots + (6)^2 + (9)^2 - C \\ &= 4653 - 3916 = 737 \end{aligned}$$

(3)

$$\begin{aligned} SS_{B.S} &= \frac{\sum_i^n \sum_j^a T_{ij}^2}{b} - C \\ &= \frac{(29)^2 + (34.5)^2 + \dots + (9)^2 + (14)^2}{2} - C \\ &= \frac{9022}{2} - 3916 = 595 \end{aligned}$$

(4)

$$\begin{aligned} SS_A &= \frac{\sum_j^a T_j^2}{nb} - C \\ &= \frac{(242)^2 + (133.5)^2}{(2)(9)} - C \\ &= 4244 - 3916 = 328 \end{aligned}$$

(5)

$$\begin{aligned} SS_{S/A} &= SS_{B.S} - SS_A \\ &= 595 - 328 = 267 \end{aligned}$$

$$\begin{aligned}
 (6) \quad SS_{W.S} &= SS_{\text{total}} - SS_{B.S} \\
 &= 737 - 595 = 142
 \end{aligned}$$

$$\begin{aligned}
 (7) \quad SS_B &= \frac{\sum_k^b T_{..k}^2}{na} - C \\
 &= \frac{(186.5)^2 + (189)^2}{(9)(2)} \\
 &= \frac{70503}{18} - 3916 = .847
 \end{aligned}$$

$$\begin{aligned}
 (8) \quad SS_{AB} &= \frac{\sum_j^a \sum_k^b T_{jk}^2}{n} - C - SS_A - SS_B \\
 &= \frac{(129.5)^2 + (112.5)^2 + (57)^2 + (76.5)^2}{9} \\
 &\quad - 3916 - 328 - .847 \\
 &= \frac{38528}{9} - 3916 - 328 - .847 = 36
 \end{aligned}$$

$$\begin{aligned}
 (9) \quad SS_{SB/A} &= SS_{W.S} - SS_B - SS_{AB} \\
 &= 142 - .847 - 36 \\
 &= 105
 \end{aligned}$$

Analysis of Variance

Source of Variance	df	SS	MS	F
Total	(abn -1) 35	737		
Between S	(an-1) 17	595		
A	(a-1) 1	328	328	19.7
S/A	a(n-1) 16	267	16.68	
Within S	an(b-1) 18	142		
B	(b-1) 1	.847	.847	.129
AB	(a-1)(b-1) 1	36	36	5.48
SB/A	a(n-1)(b-1) 16	105	6.56	

$$a = .001, F_{(1,16)} = 16.12$$

$$a = .05, F_{(1,16)} = 4.49$$

The Sign Test:

$$p(r \text{ successes}; N, p) = \binom{N}{r} p^r q^{N-r}$$

p = probability of a success.

q = probability of a failure.

N = total trials.

r = number of successes.

$$\binom{N}{r} = \begin{array}{l} \text{possible combinations of } N \text{ units} \\ \text{taken } r \text{ at a time.} \end{array}$$

Results of recall task with overt study were classified as improved (+) or unimproved (-) for both groups. If chance alone determines results of the individual trials, then

$$p(+) = p(-) = .5$$

Results using overt study with the head injured group:

Improved (+) = 8

Unimproved (-) = 1

$$\begin{aligned} p(8) &= \binom{9}{8} (.5)^8 (.5)^1 \\ &= (9) (.5)^8 (.5)^1 \\ &= .0176 \end{aligned}$$

Results using overt study with the control group:

Improved (+) = 4

Unimproved (-) = 5

$$\begin{aligned} p(4) &= \binom{9}{4} (.5)^4 (.5)^5 \\ &= (126) (.0625) (.0313) \\ &= .246 \end{aligned}$$