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Memory Deficit Compensation Among Survivors of Traumatic Brain Injury

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THESIS APPROVAL

The abstract and thesis of Nancy Ann Carney for the Master of Science in Psychology were presented on January 27, 1995, and accepted by the thesis committee and department.

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ABSTRACT

An abstract of the thesis of Nancy Ann Carney for the
Master of Science in Psychology presented January 27,
1995.

Title: Memory Deficit Compensation Among Survivors of
           Traumatic Brain Injury

Memory impairment is an outcome of Traumatic Brain
Injury (TBI), and associated with lower levels of post-
morbid adjustment. This research isolated the memory
impairment of retrieval deficit, and examined the
efficacy of cues and mnemonics in remediating the
impairment.

Thirty-three male and female TBI survivors, 18 to 71
years old, were pre-tested for attention (COPY), short-
term memory (SD), long-term memory (LD) and recognition
memory (RS) employing the Rey Osterrieth Complex Figure
Test (CFT), and Subtest. Sixteen subjects demonstrating
a retrieval deficit were administered the post-test, with
even random assignment into four treatment conditions: a
control group (CONTROL), a group administered cues
(CUES), a group administered mnemonics (MNEM), and a
group administered mnemonics and cues (BOTH) ($\underline{n}$ = 4).

A MANOVA revealed a significant effect of TRIAL

(p≤.05), no significant effect of TREATMENT, and no interaction. A power analysis indicated the lack of TREATMENT effect could be the result of sample size.

Post-hoc t tests revealed a difference across TRIAL for SD and LD in the two experimental conditions which utilized mnemonics. The sample was divided into two groups according to subjects' level of functioning (HIGH and LOW). A MANOVA showed main effects for LEVEL for SD and RS, for TRIAL for SD, LD, and RS, and a LEVEL by TRIAL interaction for COPY (p<.05). HIGH scored higher than LOW across trials on SD and RS. Post-test scores were higher than pre-test scores for both HIGH and LOW for SD, LD, and RS. LOW scored higher than HIGH on post-test copy scores.

Researchers concluded that (1) distraction resulting from the research design may have contributed to the lack of effect of TREATMENT, (2) mnemonics may be a more effective aid for recall than cues, (3) repeated exposure aided recall, (4) high cognitive functioning subjects performed better than low in tasks of short term memory and visual cues, but the groups were equalized in tasks of long term memory and repeated exposure.

Qualitative information such as demographics and observations made during data collection were considered in presenting explanations for results, and suggestions for future research.

MEMORY DEFICIT COMPENSATION AMONG SURVIVORS

OF TRAUMATIC BRAIN INJURY

by

NANCY ANN CARNEY

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Memory Deficit Compensation Among Survivors of

Traumatic Brain Injury

Traumatic Brain Injury (TBI)

Head injury is defined as "a traumatic insult to the
brain capable of producing physical, intellectual,
emotional, social, and vocational changes (National Head
Injury Foundation, 1985)." The incidence of traumatic
brain injury (TBI) in the United States has been
estimated to be 200 per 100,000 population (Klonoff,
Snow, & Costa, 1986; Wehman et al., 1989). Recent
developments in medical technology have increased the TBI
survival rate (Brotherton, Thomas, Wisotzek, & Milan,
1988; Cole, Cope, & Cervelli, 1985; Elsass & Kinsella,
1987; Godfrey, Knight, Marsh, Moroney, & Bishara, 1989;
Klonoff, Snow, & Costa, 1986; Wehman et al., 1989). It
is estimated that 15 years ago, one in ten TBI victims
survived the trauma. Today, one in ten does not survive
(Kraus, 1984). However, while medicine has developed the
ability to save these lives, it cannot yet restore them
all to normal functioning.

Variables such as injury site and size, length of
time in coma, nature of pathology, as well as age,
gender, and psychosocial history, affect the course and
degree of the survivors' postmorbid recovery (Lezak,

1983; Sohlberg & Mateer, 1989).

While some research indicates deficits may be resolved within the first 3 months (Levin et al., 1987), other studies show that even with minor head trauma, deficits persist beyond 6 months (Bohnen, Jolles, & Twijnstra, 1992). Varying degrees of physical, cognitive and behavioral deficits may persist for life (Lezak, 1983; Ridley, 1989).

Over 60% of TBI victims are males under the age of 35 years (Wehman et al., 1989). The majority are adolescents and young adults (Elsass & Kinsella, 1987). Few recover the ability to return to work (Wehman et al., 1989). The consequence of increased TBI survival rate without adequate rehabilitation is a rapidly growing population of people dependent upon family and social systems (Oregon Head Injury Foundation, 1994). Because little is known about restoring TBI survivors to normal functioning, they often are directed to hospitals, group homes, treatment plans and rehabilitation programs designed for populations with very different problems such as mental illness or mental retardation (Oregon Head Injury Foundation, 1994).

TBI and Memory Deficits

Physical and functional disabilities may occur at

the time the brain damage is sustained; however, the most significant negative outcomes are psychosocial and psychological, often resulting in the development of secondary problems in family and behavior (Cole, Cope, & Cervelli, 1985).

Memory impairment is a common outcome of TBI, and is associated with poor adjustment (Glasgow, Zeiss, & Lewinsohn, 1977). Seventy percent of TBI survivors experience memory deficits beyond a year post-trauma (Sohlberg & Mateer, 1989). While some survivors experience retrograde amnesia (loss of memory of events prior to trauma), the more common amnesia is for post-traumatic events (Sohlberg & Mateer, 1989). Without the ability to acquire and refer to new information, survivors are rendered less capable of adapting to new people, restrictions, and environments.

Rehabilitation

Currently, rehabilitation methods fall into two broad categories, reductionist and dynamic (Trexler, 1987). The reductionist approach uses performance scores on neuropsychologic tests to diagnose the deficit(s), and relies on practice or repetition to restore the function(s). The therapeutic focus is on physical, occupational, and speech therapy (Brotherton, Thomas,

Wisotzek, & Milan, 1988). However, the efficacy of traditional, reductionist rehabilitation relies on functional recall (Leland, Lewis, Hinman, & Carrillo, 1988). Without the ability to consolidate new information, practice will not increase the ability to recall (Glisky & Schacter, 1986; Godfrey & Knight, 1985; Prigatano et al., 1984). The circumstances under which practice increases recall are of particular interest in determining if and when practice-based rehabilitation should be used.

The dynamic rehabilitation approach places a low reliance on absolute neuropsychologic test performance, and an emphasis on individual programs which are plastic and respond to the change and growth of the individual.

Before considering the efficacy of treatment approaches in the remediation of memory pathology, the body of knowledge and theory about nonpathological memory will be examined.

Memory Theory

Traditional Model of Memory. The traditional temporally-based model (Squire, 1975) describes memory in three stages. Sensory memory is available immediately after presentation of the stimulus, and fades rapidly over a period of seconds. Short term memory implies

information is maintained, without permanent storage, for recall and use relatively soon after presentation of the stimulus. Long term memory refers to information which is stored and retrieved for use after minutes, days or years. The theory maintains that retention of long term memory is permanent. The model was expanded to include consolidation as a process which transfers information from short to long term memory.

Single vs. Multiple Memory System Models. An outcome of memory research has been the question: Is memory one system with multiple components, or is it several separate systems (Schacter, 1992)? If memory is a function of one system, then injury might affect all memory processes. However, if it is a function of multiple systems, injury may impair some processes and leave others intact. Therefore, the question holds important clinical implications for head injury research. In pursuit of the answer, many useful models have been created or elaborated, and subsequent research has been generated. One distinction holds that one kind of information retention, implicit memory, occurs nonconsciously, while another kind, explicit memory, is a function of active work on information (Bowers & Schacter, 1990; Schacter, 1992). Priming effects, the

phenomenon of stimulating recall without the individual's awareness through presentation of bits of information, is considered evidence for the existence of implicit memory (Tulving & Schacter, 1990; Tulving, Hayman, & Macdonald, 1991; Schacter, 1992). Priming, or cuing, is one strategy used in TBI rehabilitation (Lezak, 1983).

A second model distinguishes between knowledge of word meanings, or semantic memory, and recollection of time- and place-specific experiences, or episodic memory (Sohlberg & Mateer, 1989). A third distinguishes between automatic behavior, or procedural memory, and the ability to explicitly report, or declarative memory (Sohlberg & Mateer, 1989).

From another perspective, information retention is seen to be a function of depth of processing. The greater the depth, the greater the degree of semantic or cognitive analysis and subsequent retention (Craik & Lockhart, 1972). The use of mnemonic strategies, repetition of bits of information, is believed to enhance depth of processing, and is another technique of TBI rehabilitation (Lezak, 1983).

Experimental results demonstrating use of the theorized levels of memory have been used as evidence in the continuing debate about single vs. multiple memory

systems.

Information-Processing Model of Memory. Memory as
an information-processing system consists of components
of attention, encoding, storage, consolidation, and
retrieval (Walker, 1976). It is conceptualized as a
system of highly integrated and interdependent parts
which process information at different levels (Cermak,
1982; Craik & Lockhart, 1972). Sohlberg & Mateer's
(1989) elaboration of the components is as follows:

> Attention involves alertness and arousal. It is the
> capacity to hold information in a temporary store
> while mental operations are performed. Encoding
> refers to the level of analysis performed on
> material to be remembered. Storage is the transfer
> of information to a form or location in the brain
> for permanent storage or access. Consolidation is
> the process of integrating new memories into an
> existing schema. Retrieval is the search for or
> activation of memories and monitoring of the
> accuracy and appropriateness of memories pulled from
> storage. (p. 139)

Application of Models of Memory in Traumatic Brain Injury
Research

The preceding memory models represent three

approaches to the study of normal memory, and may be considered for their efficacy in providing a framework for memory pathology research.

Traditional. The traditional, linear model provides useful initial diagnostic criteria. A patient presenting low immediate memory, but intact recall after a 30-minute delay, may be experiencing attention or visual deficits rather than memory problems. However, by definition, short and long term memory are distinguished by rate of decay, capacity of storage, and type of encoding, and these distinctions do not always remain consistent under experimentation (Sohlberg & Mateer, 1989). Furthermore, the simplicity of the model does not lend itself to diagnosis of complex cognitive breakdowns typical of TBI.

Dichotomous. The dichotomous models outlined earlier (explicit vs. implicit, semantic vs. episodic, procedural vs. declarative) have been used to generate research with TBI survivors. Individuals presenting below normal explicit memory demonstrated near normal implicit memory on tasks involving priming or cuing (Bowers & Schacter, 1990; Tulving & Schacter, 1990). Other studies demonstrated that individuals with intact semantic memory presented below normal episodic memory, and individuals with impaired declarative memory could

automatically follow procedures they didn't remember
learning (Sohlberg & Mateer, 1989). Schacter and
colleagues have been actively researching the question of
single vs. multiple systems, utilizing both normal and
memory deficit subjects (Bowers & Schacter, 1990;
Schacter, 1992; Tulving & Schacter, 1990). However, as
stated earlier, their research indicates that, without
the fundamental ability to retain new information, the
tool most widely used in rehabilitation, practice and
repetition, will not increase recall (Glisky & Schacter,
1986). So the question remains, how can the dichotomous
models being generated be used to remediate memory
problems?

Information Processing. Using the information
processing model of memory as a guide, Sohlberg and
Mateer (1989) responded to Glisky and Schacter's
assertion that practice does not increase recall in TBI
survivors. They pointed out that treatment conditions in
the cited studies exercised only the retrieval component
of memory. They asserted that cognitive functioning can
be improved with rehabilitation that targets specific
processes defined by the information processing model.
They noted that subsequent research using the model to
distinguish deficits, and using practice to remediate,

has demonstrated restoration (Mateer & Sohlberg, 1988).

Their dynamic (as opposed to reductionist) rehabilitation

method assumes that different cognitive areas can be

treated individually and can be directly retrained or

corrected. The first step is to accurately identify the

impaired process or processes.

Diagnostic Use of the Information Processing Model

A theoretical framework for identifying specific

neurologic impairments in terms of the information

processing model was defined by Sohlberg and Mateer

(1989). They classified four types of deficits

(attention, encoding, storage, and retrieval) and

associated them with expected behaviors and test

performances:

Memory Problems Secondary to Attention Deficits

. . . some individuals do have difficulty with

focused, sustained, selective, alternating, and

divided attention. The problems prohibit the

effective registration of information for further

information processing or subsequent recall.

Memory Problems Secondary to Encoding Deficits

. . . a patient with perceptual deficits may have

difficulty reproducing or even recognizing visually

presented designs but may not have a memory deficit

per se. . . . Their understanding, organization, and categorization of material to be remembered is reduced, and attempts at subsequent recall of information are diminished.

Memory Problems Related to Storage

Patients with storage impairments often have normal immediate and short-term memory. Their long-term memory is seriously impaired.

Memory Problems Secondary to Retrieval Deficits

. . . the information is stored somewhere in the patient's nervous system but cannot be retrieved. Such patients may have intact recognition abilities. (p. 146)

Meyers, Meyers, and Lange (1993, unpublished) hypothesized that the Sohlberg and Mateer taxonomy could be used to identify specific deficits using tests of immediate recall, short term recall, long term recall, and recognition. They suggested that people with attention, encoding, storage, and retrieval deficits would demonstrate different patterns of performance across these four tests. The Benton Visual Retention Test (BVRT) was used to measure immediate memory span and attention deficit (Lezak, 1983). The Rey Osterrieth Complex Figure Test (CFT) was used to measure short-term

recall at the 3-minute drawing, and long-term recall at
the 30-minute drawing (Lezak, 1983). The CFT Recognition
Subtest (RS), a series of drawings which serve as cues to
recall the CFT, was used to measure recognition (Meyers &
Meyers, 1992). Of the 48 head injured subjects tested,
11 demonstrated an attention deficit pattern, 8 an
encoding deficit pattern, 5 a storage deficit pattern,
and 21 a retrieval deficit pattern.

Application of Diagnostic Results

Having established that patterns can be demonstrated
for deficits in areas defined by the information
processing model, Meyers et al. (1993, unpublished)
suggested that different treatment approaches for deficit
remediation could be used with individuals expressing
different patterns. For instance, individuals with
retrieval deficit appear to be aided in recall by cues,
as demonstrated by the increase in their score for the
CFT Recognition Subtest. Cues, then, might be an
effective strategy for rehabilitation of retrieval
deficit individuals.

Cues, partial bits of information (Sohlberg &
Mateer, 1989), are a form of compensatory technique; an
external memory aid. Luria (1963) promoted the use of
cues to restore organized recall. Studies have

demonstrated that normal memory can be enhanced by cuing (Craik & Watkins, 1973).

Another form of compensatory technique, internal memory aids, includes mnemonic strategies such as rehearsing information or using visual imagery. As stated earlier, mnemonic devices are thought to increase depth of processing. Some research has demonstrated increased recall among head trauma patients through use of mnemonic techniques (Lewinsohn, Danaher, & Kikel, 1977). However, strategies did not generalize (Sohlberg & Mateer, 1989), the effect on recall did not persist at 1 week (Lewinsohn, Danaher, & Kikel, 1977), and recall for patients with global amnesia did not improve (Jones, 1974). Other variables yet unidentified may affect the relationship between mnemonics and recall, and should be targeted in TBI research.

Summary

The following questions present themselves as important precursors to TBI research:

1) Multiple Systems of Memory. If memory is a function of multiple systems, what are they? How can they be differentially tested? How are they interdependent? How can impairments in one system be distinguished from those in another?

2)   Practice. It has been demonstrated that without the
capacity to retrieve, practice will not enhance recall.
On the other hand, subjects seem to respond to practice
when it is applied to specific memory processes. When
does practice work, and when is it a waste of time?

3)   Compensation Techniques. Under what circumstances
will cues be most useful; when will mnemonics be most
useful? What is the "survivor profile" most likely to
respond to cues or mnemonics? Assuming memory is
composed of multiple systems, to which system deficits
should cues be applied; should mnemonics be applied?

The Current Research

The purpose of this research project was to
investigate the possible effect of the external aid of
cues and the internal aid of mnemonics on recall for
head-injured individuals who have demonstrated a
retrieval deficit.

Subjects were tested to obtain measures of attention
(COPY), short-term recall (SD), long-term recall (LD),
and recognition (RS). Those who demonstrated a retrieval
deficit pattern (retrieval deficit is operationally
defined in the Method section) were included in the
study, and their scores recorded as pre-test scores.
They then were tested a second time under one of four

conditions: no memory aids, cues, mnemonics, or both cues

and mnemonics. It was expected that, in retrieval

deficit pattern subjects, cuing would increase the scores

for their short- and long-term recall from pre-test to

post-test; that mnemonics would not increase the scores;

and that scores for the group that received both cues and

mnemonics would be the same as scores for the group that

received only cues, further validating that mnemonics

would not enhance recall. Specific hypotheses were:

a) For the CUES group, the SD and LD scores were
   expected to increase significantly from PRE-
   TEST to POST-TEST.

b) For the CUES group, the POST-TEST SD and LD
   scores were expected to be significantly higher
   than the same scores for the CONTROL and MNEM
   groups.

c) None of the test scores for CONTROL was
   expected to change significantly from PRE-TEST
   to POST-TEST.

d) Scores for MNEM were not expected to change
   significantly from PRE-TEST to POST-TEST.

e) POST-TEST SD and LD scores for BOTH were not
   expected to be significantly different from
   those for CUES.

Method

<u>Subjects</u>

The Family Head Injury Support Network in Portland, Oregon sponsors support-group meetings attended by TBI survivors and their families. The Support Group allowed the research team to attend meetings and ask for volunteers. Potential volunteers were told that research was being conducted with respect to memory deficits and head injury. Anyone who had sustained a head injury, and who experienced a problem with memory, qualified for initial testing. No financial reimbursement was offered. Tests would be conducted at a location and time convenient to the volunteer. Volunteers would be involved in a maximum of two separate testing sessions, conducted a week apart. The tests would be simple recognition tests; they would not be invasive or stressful. Each session would last about an hour. All test data would remain confidential, and upon request would be released to the volunteer at the conclusion of the study. All connection between the individuals' identities and their results would be destroyed at the conclusion of the research. It was emphasized that it was highly unlikely that any individual would receive direct personal benefit from participating in the study.

The benefit to the individuals would be the knowledge that they participated in research which may contribute to an understanding of, and ultimately better treatment for, traumatic brain injury. Specifics regarding research hypotheses were not provided.

After several months it was necessary to shift recruitment efforts from the support group population to other sources. Many members of the support group were living in group homes for the severely impaired. The post-test qualification rate with these volunteers was very low (approximately 25%). Subjects were sought who had reintegrated into the mainstream of life. Previous research indicated that TBI survivors who lived independently were more likely to have the kind of retrieval deficit targeted for the study (Meyers, Meyers, & Lange, 1993). To locate such survivors, posters were hung at schools, hospitals, and veterans' organizations. Announcements were made in college classes. Professionals such as physiatrists, neuropsychologists, occupational therapists, and optometrists were contacted and asked to speak to their patients regarding the study, inviting them to participate. The need was communicated into the TBI community "word of mouth."

The various recruitment efforts resulted in a sample

diverse in its functional level and severity of deficit. While all subjects included in the study demonstrated the retrieval deficit, that is, they qualified quantitatively according to the criteria specified, it is important to note that the earlier recruits tended to be lower functioning, while the latter recruits were so high functioning that some were undistinguishable from the general population until tested with instruments designed to uncover their deficits.

A total of 33 volunteers was pre-tested to select persons showing the pattern of scores for retrieval deficit. Test results for 16 met the criterion for inclusion in the study and subsequent post-testing. Reasons for exclusion were as follows: Thirteen demonstrated the wrong pattern of test results: that is, their results defined them as having a storage deficit. One was disqualified due to the inability to perceive the stimulus. One did not keep the post test appointment. One would not consent to being post-tested. One was intoxicated at the time of the post-test appointment.

Characteristics of the 16 men and women who were post-tested, and therefore included in the study, were as follows: All subjects were Caucasian. Their ages ranged from 21 to 71 years ($\underline{M}$ = 41.56, $\underline{SD}$ = 14.44). Seven were

women, nine were men. Three were taking medication

related to their head injury. The measurement for span

of time since the trauma occurred was in months. The

minimum was 4 months; the maximum was 791 months--almost

66 years ($\underline{M}$ = 166.06 months [13.83 years], $\underline{SD}$ = 197.23).

Number of days in coma ranged from 0 (four subjects

reported not experiencing a coma) to 1 full year ($\underline{M}$ =

34.81, $\underline{SD}$ = 91.23). Four people required assisted living

environments. Five, at some point post-morbid, had

engaged in a formal rehabilitation program. Education

ranged from 12 to 20 years ($\underline{M}$ = 15.25, $\underline{SD}$ = 2.54). With

respect to the nature of the trauma, one was a birth

trauma, one was a cerebrovascular accident, 12 were

impact-related, one was chemically induced, and one was

the result of a sustained high fever (see Appendix 1).

<u>Materials</u>

The Rey Osterrieth Complex Figure Test (CFT) (Rey,

1941; Osterrieth, 1944), shown in Appendix 2, was the

stimulus. The direct copy procedure was used to measure

individual ability to reproduce the figure. In this

test, the subjects copy the figure while it is displayed

before them, a behavior requiring complex higher order

functioning (Lezak, 1983). This was the "Copy Test" in

the experiment. Short-term recall was measured from a

drawing of the CFT done from memory 3 minutes after initial exposure to the stimulus (3-minute delay). Long-term recall was measured from a drawing done from memory 30 minutes after initial exposure to the stimulus (30-minute delay). The Recognition Subtest (RS) for the CFT was used to measure recognition (see Appendix 3). Criteria for scoring the four tests were those outlined by Meyers & Meyers (1992). Refer to Table 1 for inter-rater reliability information.

A list of descriptions of what the CFT might look like was used as both cues and mnemonics (see Appendix 4).

Procedure

Subjects were tested individually in the presence of either one or two experimenters. Prior to both testing sessions, they were asked to sign an informed consent form (see Appendix 5). The researcher read the form to the subjects, and answered any questions before requesting signatures.

The first testing session, the pre-test, was identical for all subjects. The Complex Figure was presented, and the subjects copied the figure, while it was displayed, using a #2 pencil. They were allowed to erase. After the copy was completed, the Complex Figure

and the copy were placed out of sight. Interference
tests, taken from a protocol of standard neuropsychologic
tests employed at Pacific Gateway Hospital in Portland,
Oregon, were administered for 3 minutes. The subjects
were then asked to draw the Complex Figure from memory.
After the 3-minute recall drawing was completed, it was
removed from sight. Additional interference tests were
administered for 30 minutes. The subjects were asked to
draw the Complex Figure from memory a second time. This
copy was placed out of sight. The subjects were then
presented with the CFT Recognition Subtest (RS), a series
of drawings, some of which are part of the Complex
Figure, and some of which are not. Those drawings
recognized as being part of the original Complex Figure
were to be circled by the subjects.

The copy score (COPY) was used to verify that the
subjects could see and attend to the stimulus. The score
from the 3-minute delay (SD) was used as a measure of
short-term recall; the score from the 30-minute delay
(LD) was used as a measure of long-term recall; the score
from the Recognition Subtest (RS) was used as a measure
of recognition-memory.

Scores from the pre-test were used to establish the
deficit pattern and subsequent inclusion in, or exclusion

from, the post-test phase of the study. Criteria for
exclusion were as follows:

1)   The subject demonstrated normal memory.

Memory was considered normal if all four scores fell
at or above the 25th percentile of the distribution
for non-head-injured persons. Therefore, pre-test
scores were converted into percentiles, and compared
to age-corrected norms (Meyers & Meyers, 1992) (see
Appendix 6).

2)   The subject did not demonstrate a retrieval deficit
pattern.

Retrieval deficit was defined by the relationship
between the LD score and the RS score. Based on the
research of Meyers, Meyers, & Lange (1993), an RS
score at or greater than 2 percentiles above an LD
score constituted a pattern which was interpreted as
representing a retrieval deficit. Because the
Complex Figure Task and Recognition Subtest are
scored with different scales, 2 percentiles
difference can represent a large gap, dependent upon
the norms used specific to the age, gender, and
education of the subject. In our research, the
smallest change from LD to RS was 2.5 percentiles.
The raw scores for this subject represented 40% of a

possible 100% (raw score 14.5 of a possible 36

total) for LD, and 79% (raw score 19 of a possible

24 total) for RS. An increase from LD to RS of 39%

was considered sufficient to qualify as a retrieval

deficit pattern.

Individuals who did not fit the desired profile were

given an explanation of the outcome, thanked for their

participation, and not tested further. Individuals who

fit the profile were tested a second time 7 days after

the first test. The second testing was the post-test.

Subjects selected to continue were randomly assigned

to one of four groups for the second series of tests, the

post-test. The control group (CONTROL) received no

treatment. The second administration of the CFT to

CONTROL was identical to the first.

A second group (CUES) was read the list of cues (see

Appendix 4) twice during testing; at the onset of both

the 3-minute and 30-minute recall drawings. They were

not read the list at the time of the copy test.

A third group (MNEM) was administered mnemonics at

the time the subjects were looking at the CFT and copying

it (the copy test). The experimenter read from the list

of cues, and had the subject repeat back the descriptions

of what the CFT might look like. For example, "it has a

bowling ball", "a railroad track", "it looks like a rocket", and so forth. No further aids were presented to subjects in this group throughout the remainder of testing.

A fourth group (BOTH) received a combination of the treatment for MNEM and the treatment for CUES.

Scores for the CFT Copy (COPY), 3-minute delay (SD), 30-minute delay (LD), and Recognition Subtest (RS) for each of the 4 groups (TREATMENT) were recorded for the pre-test and post-test (TRIAL).

Results

Means and standard deviations for COPY, SD, LD, and RS scores for the pre- and post-tests for the four experimental conditions are reported in Table 2.

Means of all scores increased from pre- to post-test except the COPY score of the BOTH condition. The greatest increase in scores from pre- to post-test for both SD and LD was observed in the BOTH condition. The smallest increase in scores from pre- to post-test for SD and LD was observed in CUES.

The highest overall variance for the SD and LD scores was observed in the pre- and post-tests for the CUES condition. Variance for those scores was also high in the BOTH condition.

COPY and RS scores remained stable across both trials and treatment conditions, with corresponding minimal variance.

A profile analysis of pre-test data was performed comparing the profile of scores for the four experimental conditions. No significant difference was found between profiles, $F(9,36) = 0.31$, $p = .97$, confirming that variance among subjects was equally distributed across the four groups before administering the treatment.

A multivariate analysis of variance (independent

variables were TREATMENT [4 levels] and TRIAL [2 levels];
dependent variables were scores for COPY, SD, LD, and RS)
was performed (see Table 3). Main effects for TRIAL were
observed for SD, $F(1,12)$ = 18.69, p = .001; LD, $F(1,12)$ =
23.39, p < .001; and RS, $F(1,12)$ = 6.42, p = .03. No
main effects for TREATMENT were observed. There were no
TRIAL by TREATMENT interactions.

A profile analysis of post-test data comparing the
profile of scores for the four experimental conditions
showed no significant difference, $F(9,36)$ = .23, p = .99.
The treatment conditions had no significant effect on the
change between pre-test and post-test scores.

Power Analysis coefficients for TREATMENT for COPY,
SD, LD, and RS were .35, .09, .08, and .15, respectively.
Coefficients for TRIAL for the four scores were .21, .98,
.99, and .64, respectively (see Table 5). Results
indicate the lack of TREATMENT effect could be the result
of sample size.

Post-Hoc Analyses

The presence of the strong effect of TRIAL provided
rationale for post hoc investigation.

While no TREATMENT effect was observed, and no
interaction, follow-up t tests were performed to
determine in what treatment groups, if any, were there

differences in scores across trials. Differences were found between pre- and post-test SD scores for MNEM, $t(3)$ = -3.16, p = .05, and for BOTH, $t(3)$ = -4.89, p = .016; and between pre- and post-test LD scores for MNEM, $t(3)$ = -3.37, p = .043, and for BOTH, $t(3)$ = -5.70, p = .011 (see Table 4). The SD and LD scores for the MNEM and BOTH groups increased significantly from pre-test to post-test. The SD and LD scores for CONTROL and CUES did not change significantly from pre- to post-test. No RS scores changed significantly between trials.

A profile analysis which collapsed treatment conditions and compared the profile of all pre-test scores to that of all post-test scores revealed a main effect for TRIAL (change in scores from pre- to post-test), $F(1,30)$ = 6.97, p = .01; a main effect for SCORE (differences between COPY, SD, LD, and RS scores), $F(3,90)$ = 105.07, p < .001; and a TRIAL by SCORE interaction, $F(3,90)$ = 4.66, p < .01. The difference is significant in the profile of scores between the pre-test and post-test.

A multivariate analysis of variance was used to examine the relationship between LEVEL of function (HIGH and LOW) and TRIAL (change in scores from pre- to post-test) (see Table 7). Using the pre-test COPY score as

the criterion for level of function (see Table 6 for Means and Standard Deviations), main effects for LEVEL were observed for SD, $F(1,14) = 5.01$, $p = .04$; and RS, $F(1,14) = 8.08$, $p = .01$. Main effects for TRIAL were observed for SD, $F(1,14) = 18.55$, $p = .001$; LD, $F(1,14) = 24.49$, $p < .001$; and RS, $F(1,14) = 6.61$, $p = .02$. A LEVEL by TRIAL interaction occurred for COPY, $F(1,14) = 31.18$, $p < .001$.

High functioning subjects scored higher than low functioning subjects across trials on SD and RS. Post-test scores were higher than pre-test scores for both HIGH and LOW functioning groups for SD, LD, and RS. Low functioning subjects scored lower than high functioning subjects on pre-test COPY scores, and higher than high functioning subjects on post-test copy scores.

Follow-up t tests were performed. For the LEVEL effect, high functioning subjects scored significantly higher than low functioning subjects for the pre-test SD and RS scores, $t(14) = -2.83$, $p = .013$, and $t(14) = -2.41$, $p = .03$, respectively. No significant difference was found in post-test scores (see Table 8).

For the TRIAL effect, post-test scores were significantly higher than pre-test scores for high functioning subjects for SD, $t(7) = -2.74$, $p = .029$; LD,

$t(7) = -2.40$, $p = .048$; and RS, $t(7) = -2.50$, $p = .043$. For low functioning subjects, post-test scores were significantly higher than pre-test scores for SD, $t(7) = -3.32$, $p = .013$; and LD, $t(7) = -4.65$, $p = .002$. No significant difference occurred for RS for low functioning subjects (see Table 8).

Discussion

Overview

The outcome of the power analysis suggests that the small sample size may be responsible for the lack of hypothesized results. A number of factors influenced the decision to terminate the project before obtaining more subjects: (1) Ethical parameters limited the ability of professionals to provide access to potential participants. (2) One full year of recruiting and testing yielded what is reported here. (3) The community of head injury survivors, upon whom this research depended, expressed their desire to support more qualitative research which does not use neuropsychological instruments. We offer the following interpretation of results recognizing the limitations imposed by the sample size.

The profile analysis of pre-test data showed no significant difference among groups, indicating our random assignment efforts worked and allowing us to proceed with our analysis.

The TRIAL by TREATMENT analysis of variance indicated that scores increased from pre- to post-test, but that the treatments had no significant effect on that increase. The profile analysis of post-test data

confirmed there was no effect of TREATMENT.

As stated, a greater number of subjects may have allowed differences in the treatment groups to be expressed at a significant level. The power analysis indicates the inadequacy of the small sample size in all results except in the effect of TRIAL for tests involving recall (SD and LD). That is, the increase in SD and LD scores from pre- to post-test is a robust result which would not be expected to be reversed were the sample larger.

Testing of the Hypotheses

1) For the CUES group, the SD and LD scores were expected to increase significantly from pre- to post-test. This result did not occur.

2) For the CUES group, the post-test SD and LD scores were expected to be significantly higher than the same scores for the CONTROL and MNEM groups. This result did not occur. In fact, the post-test SD and LD scores for CUES were the lowest of the four treatment groups.

3) None of the test scores for CONTROL was expected to change significantly from pre-test to post-test. This result did occur. However, there was no effect of TREATMENT for CUES, MNEM, or BOTH in the CONTROL group either. Without a larger sample, it is not possible to

know whether CONTROL did not increase due to lack of treatment, or due to lack of power.

4) Scores for MNEM were not expected to change significantly from pre-test to post-test. Scores for treatment groups did not change significantly across trials.

5) Because mnemonics were not expected to increase recall, post-test SD and LD scores for BOTH (BOTH includes mnemonics and cues) were not expected to be significantly different from those for CUES. Although, as predicted, no TREATMENT effect occurred, and therefore post-test SD and LD scores for BOTH were not significantly different from those for CUES, it must be noted that the difference in post-test means for SD and LD was the greatest between CUES and BOTH. The power analysis implies that with a larger sample, this difference might have been significant.

Two Questions

In this experiment the sample size was not large enough to allow for strong inferences about treatments. The lack of effect may be a result of sample size, of no effect of treatment, or of the effects of extraneous variables. However, although hypothesized results did not occur, a review of the results shows unexpected strong effects which warrant consideration.

1) What happened in CUES? Contrary to prediction, scores did not increase significantly from pre- to post-test. Of more interest, the mean post-test CUES scores were not only lower than those for MNEM and BOTH, they were also lower than those for CONTROL, the group that received no treatment.

2) What happened in MNEM? The only significant increase in SD and LD scores from pre- to post-test was noted when mnemonics were used--in the MNEM and BOTH conditions.

To provide a basis for investigating these questions, the descriptive statistics will be considered.

Means for all scores increased from pre- to post-test except the COPY score of the BOTH condition, which decreased slightly. This increase was expected. Although the subjects have memory deficits, they possess capacity for recall which varies between subjects and situations.

The relative stability of the COPY and RS scores was also anticipated. The COPY task does not specifically exercise recall. The RS task involves visual cues, and the subjects' near-normal scores on the RS pre-test (the mean fell at the 25th percentile) is what qualified them for inclusion in the study.

Cues. The greatest increase in SD and LD means from pre- to post-test was observed in BOTH. The smallest was observed in CUES. Also, CUES had the highest variance of the treatment groups. Variance for BOTH, which includes the treatment of cues, was also high.

The combination of (1) the increase in SD and LD means for pre- to post-test in CUES being smaller than that in CONTROL, and (2) the high variance in CUES, suggests the presence of something actively suppressing recall. In the CUES and BOTH conditions, cues were read to the subjects as they drew the CFT from recall at the 3-minute and 30-minute delays. It is possible that this verbal exchange acted as interference to recall, and became a distraction.

Distractibility is often observed among survivors of TBI; it accounts for adjustment problems and may be mistaken for other, more profound deficits (Lezak, 1983). Distraction becomes an "environmental hazard" to the head injured person. Coping and compensation often include active management of distraction.

During one testing session for this research project, the subject interrupted his task to replace the researcher's pencil with a felt-tipped pen. The noise of the pencil as the researcher took notes was so

distracting to the subject it affected his ability to perform the task. The volunteers selected for the study were those who responded positively to the cues presented in the Recognition Subtest during the pre-test. Their high RS score in relation to their low LD score was what qualified them for the study--what defined them as "retrieval deficit." However, the RS cues were visual, and silently presented.

Because these people responded to the RS cues, they were expected also to respond to the cues presented during the treatment. But the treatment cues were verbal, and may have been distracting. It is possible that presentation of verbal cues at the time when subjects were trying to recall the stimulus served to decrease, not increase, performance.

Mnemonics. Subjects were not expected to respond to mnemonics, because use of mnemonics is assumed to require retrieval capacity, and these subjects were selected for their lack of unaided retrieval capacity. Why, then, were their scores highest when mnemonics were used to enhance recall?

As noted in the discussion about subject selection, the overall group tended to be higher functioning, some having successfully reintegrated into normal life. While

they presented a retrieval deficit, it may not have been
as severe or clearly defined as may have been found with
a lower functioning sample. Perhaps higher functioning
TBI's are capable of making use of both mnemonics and
cues.

The mnemonic device is thought to exercise depth of
processing. The memory cue is repeated at some point
prior to recall. The act of repetition is thought to
"deepen the imprint" of the target stimulus into memory.
Because the target stimulus is "processed deeply" it is
expected to be more available for recall at some time in
the future. This research assumed a clear distinction
between usefulness of mnemonics and usefulness of cues;
it assumed that the retrieval process must be intact in
order for mnemonics to be useful. However, the pattern
of results obtained here suggest that rather than needing
retrieval to be able to use mnemonics, perhaps the use of
mnemonics is an exercise which specifically acts on and
renovates retrieval processes. This may be particularly
true with higher functioning TBI's whose retrieval
process is not utterly destroyed.

The overall improvement from pre- to post-test could
be considered evidence of the positive effect of
mnemonics with this group of retrieval deficit TBI's. It

may be that the pre-test served as a mnemonic exercise for the post-test, accounting for the robust effect of TRIAL.

Given the small sample size and lack of significant effect of TREATMENT, consideration of the effect of mnemonics must remain speculation. What can be asserted with certainty, however, is that when treatment groups were combined and the overall pre-test profile was compared to that of the post-test, the difference in profiles was significant. The entire sample improved in performance with repeated exposure to the stimulus. A practice effect occurred.

Post-Hoc Analyses Discussion

T tests were used to investigate the significant main effect of TRIAL in SD, LD, and RS. They indicated that there was a significant increase in SD and LD scores from pre- to post-test in MNEM and BOTH. SD and LD were the target scores. Of the four scores collected (COPY, SD, LD, and RS), SD and LD were the scores which involved active recall. The internal aid of mnemonics was used in the MNEM condition, and also in the BOTH condition. In the tests involving recall, then, mnemonics were used in both situations where a significant difference was found between pre- and post-test scores. In addition, the

largest gap between post-test treatment score means existed between MNEM and BOTH in the SD and LD scores. This suggests that the combination of cues and mnemonics may be more useful in remediating memory deficits than either used alone.

High vs. Low Function: Sohlberg and Mateer (1989) maintained that practice can increase recall when applied in the "process-specific" mode. What specific process, then, did this experiment isolate and exercise, that such a strong practice effect was observed?

To investigate that question, the sample was divided into two groups - high and low functioning. The criterion for the division was the pre-test COPY score. Because copying requires complex higher order functioning (Lezak, 1983), it was considered an appropriate measure of overall level of function. The group was divided evenly at the median; eight subjects with lower scores in the low functioning group (LOW); higher scores in the high functioning group (HIGH). The expectation was that scores for HIGH would be higher than those for LOW in all categories. In addition, we were interested to know if the HIGH and LOW groups would show different degrees of improvement across trials, indicating that either HIGH or LOW might respond more strongly to practice. From there

the question could be asked, what are the characteristics of the group that responded more strongly to practice? Answers to these questions might lay the groundwork for consideration of the post-hoc question: What specific processes were exercised, that practice, with this group, served to increase recall?

A multivariate analysis of variance was performed to examine the relationship between level of function and the change in scores from pre- to post-test. A main effect of LEVEL occurred. HIGH scored higher than LOW in SD and RS. Higher functioning TBI's performed better than low on the test requiring short-term recall, but when using long-term recall, the two groups were equal. For long-term recall, the high vs. low distinction disappeared. Also, the higher functioning subjects performed better with the visual cues presented in RS.

Follow-up t tests showed that HIGH scored higher on the pre-test SD and RS scores only; not on post-test scores. Repeated exposure (i.e., practice) appears to be another factor which equalizes the two functional groups.

A main effect of TRIAL was observed for SD, LD and RS, providing more evidence for an overall practice effect. Follow-up t tests showed post-test scores were higher than pre-test scores only for the tests involving

recall: SD and LD.

Post-test scores for RS were higher than pre-test scores for the HIGH group, but not for the LOW. Again, performance on the visual cue task presented itself as a distinguishing feature between high and low functioning TBI's.

A LEVEL by TRIAL interaction occurred for COPY. LOW performed lower than HIGH on the pre-test COPY, but higher than HIGH on the post-test COPY. Of course, the former is a function of how the sample was divided. It is interesting, though, that the HIGH copy score decreased slightly across trials, while the LOW copy score increased to be greater than that of HIGH by the post-test. The maximum score for the CFT is 36. While the mean for the entire sample fell below the 25th percentile, it was relatively close to the maximum score for the present sample, indicating a ceiling effect may account for the leveling off of scores. Still, why the significant interaction?

COPY is not specifically a test of recall, although features of recall come into play. For instance, at the onset of the post-test, many subjects would see the CFT and remark, "Oh, this again!" They recalled the stimulus from the pre-test. Perhaps motivation became a factor.

Higher functioning subjects may have lost interest by the post-test, while lower functioning subjects felt the need to prove that this time, they could do better.

In discussions held after completing data collection, participants shared their subjective experience of the protocol. Based on these discussions, the following speculations are offered: The pre-test protocol tends to strip subjects of any opportunity to use their private compensation methods. The CFT is shown to them, they draw it, then all evidence of the stimulus is removed. At that point, they are not aware they will be asked to recall the stimulus from memory. The request is a surprise. Had they known, they probably would have prepared mentally, possibly by using their own compensation methods developed over months and years of learning how to negotiate in everyday conditions of living (a "normal" world). So, particularly for the lower functioning group (people who must work harder at appearing normal) perhaps at the post-test they remembered the surprise from the pre-test; they were prepared, and they tried harder. This effort could then have paid off during COPY, when the stimulus was present, improving their performance. However, after the visual aid of the CFT was removed, although they knew they were

going to have to recall the stimulus, their high motivation could not compensate for the lost cues of the CFT and the LOW performance again fell below that of HIGH.

Summary of the Post-Hoc Analyses: HIGH was expected to perform higher than LOW across tasks, and a TRIAL by LEVEL interaction was sought. The performance of HIGH was expected to increase with practice more than that of LOW. What occurred was:

1) High functioning subjects performed better than low in tasks involving short-term memory.

2) High functioning subjects performed better than low in tasks involving visual cues.

3) Tasks requiring recall after 30 minutes equalized the two functional groups.

4) Practice, i.e., repeated exposure, equalized the two functional groups.

5) The combination of cues and mnemonics appears to be more effective in aiding recall than either when used alone.

The purpose of the post-hoc analysis was to see if practice helped one functional group more than the other. If differences were found, we could then turn to group demographics and associate characteristics with

susceptibility to practice. But practice helped both
groups equally.

As noted earlier, our sample was highly
heterogenous. One strong common characteristic, that
which qualified subjects for the study, was presence of
the retrieval deficit. The results of the post-hoc
analysis suggest that for the retrieval deficit,
practice--perhaps mediated by mnemonic aids--may be
useful in aiding recall. The next step in research would
be to gather a subject pool composed of the various
deficits defined by Mateer and Sohlberg (attention,
encoding, storage, and retrieval) and test them to search
for differential response to practice.

Post-hoc results showed high functioning subjects
performed higher than low functioning subjects on tasks
involving short term memory and visual cues. One
possible explanation is a more intact capacity for
attention among higher functioning subjects. What
characteristics affecting the capacity for attention
differentiate HIGH from LOW?

Demographics of the Functional Groups: Information
was collected regarding gender, age, medications, number
of months since trauma, number of days in coma, assisted-
living requirements, education, formal rehabilitation,

and nature of trauma. Of these demographic data, three categories clearly divide the two functional groups.

1)   No subjects in the HIGH functioning group were receiving medications related to their head injury. Three of the eight in the LOW functioning group were receiving such medications.

2)   Average time in coma was six days for HIGH, 63 days for LOW.

3)   All subjects in HIGH lived independently. Four of the eight in LOW required assisted-living environments.

Conclusion

The success of community re-entry for survivors of TBI relies on appropriate diagnosis and rehabilitation efforts. Restoration of, or assistance to, functional memory is a key component of rehabilitation, and a common problem with TBI. The current task for TBI research is to make useful distinctions about memory systems and the compensation methods those systems, when damaged, might employ.

The intention of this project was to isolate people with the specific impairment of the retrieval process, and test them to find what might help them recall. Cues were expected to be a more powerful aid to memory than

mnemonics. The opposite was demonstrated. In addition, practice was discovered to be the most potent influence in aiding recall with this sample and this design.

The five hypotheses have been discussed. Though inferences have been made based on trends in the data, the significant result remains the strong practice effect.

In the process and outcome of the experiment, highly qualitative influences have surfaced.

1)   Combining information from the literature with our subjects' reports, we feel distraction affected the results.

2)   Attention may account for differential performance on tasks involving short term memory and visual cues.

3)   For lower functioning subjects, motivation for may account for their performing better than higher functioning subjects on the post-test COPY tasks.

4)   There appears to be an association between the demographics of this group and the strong susceptibility to practice.

5)   The characteristics associated with higher functioning subjects (and higher performance on short term memory tasks and visual cues) were (a) no medications, (b) shorter time in coma, and (c)

independent living.

In considering future research, one alternative is to remain with the original quantitative model and pursue stronger experimental evidence about our hypotheses.

1)   A greater number of subjects could be sought and tested with the current design, in order to know whether the results were a function of treatment or power of the applied statistical tests.

2)   The design could be altered to incorporate presentation of visual, non-distracting cues in the CUES condition.

3)   Subjects presenting the four patterns from the Sohlberg and Mateer taxonomy (attention, encoding, storage, retrieval) could be tested for differential response to practice.

4)   Methods of analysis could be employed which are designed to construct a model associating performance with other factors.

A second and perhaps more appropriate alternative is to ask questions such as: What compensation methods do TBI survivors develop on their own? Do those methods generalize? How can they be enhanced? Can they be taught to others? If so, what is the best method of instruction? Then a research design could be constructed

which examines compensation as opposed to deficits. The current design effectively strips subjects of any opportunity to use their private, perhaps unconscious, methods of compensation. It then measures their performance against normal data and reveals what is already obvious: they are not normal. Perhaps a more meaningful research project would be to gather qualitative data and develop an instrument which tests capacities that are meaningful in the lives of TBI survivors.

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Table 1

Rey-Osterrieth Complex Figure Test

Inter-rater Reliability (Pearson's Correlation

Coefficient)

	Rater 1	Rater 2	Rater 3
Rater 1	1	.938	.99
Rater 2	.938	1	.94
Rater 3	.99	.94	1

Table 2

Means and Standard Deviations for Four Scores, Four

Treatment Conditions, and Two Trials

			COPY	SD	LD	RS
Pre-Test	M	=	29.63	15.13	15.94	20.25
CONTROL	SD	=	2.63	4.97	4.60	.50
Post-Test	M	=	31.38	20.13	20.69	21.00
CONTROL	SD	=	2.93	6.91	7.96	1.63
Pre-Test	M	=	30.44	16.69	16.31	20.25
CUES	SD	=	2.98	9.24	10.31	.96
Post-Test	M	=	31.75	19.19	20.19	20.75
CUES	SD	=	1.50	9.17	7.36	.96
Pre-Test	M	=	29.69	15.81	15.50	20.00
MNEMONICS	SD	=	2.27	2.86	1.31	1.41
Post-Test	M	=	31.88	20.75	20.38	20.50
MNEMONICS	SD	=	1.11	1.40	1.80	1.00
Pre-Test	M	=	32.88	15.81	14.56	20.25
BOTH	SD	=	2.55	6.97	6.86	.50
Post-Test	M	=	32.56	24.06	24.13	21.75
BOTH	SD	=	2.94	8.12	7.75	.96

Table 2 (Continued)

Means and Standard Deviations for Four Scores and Two

Trials (Treatment Conditions Combined)

			PRE-TEST	POST-TEST
COPY	$\underline{M}$	=	30.66	31.89
	$\underline{SD}$	=	2.71	2.08
SD	$\underline{M}$	=	15.86	21.03
	$\underline{SD}$	=	5.81	6.60
LD	$\underline{M}$	=	15.58	21.34
	$\underline{SD}$	=	5.97	6.24
RS	$\underline{M}$	=	20.19	21.00
	$\underline{SD}$	=	0.83	1.16

Table 3

Multivariate Analysis of Variance

		TREATMENT	TRIAL	TRIAL x TREATMENT
COPY	$F(1,12) =$	1.83	1.60	.31
	$p =$	.20	.23	.82
SD	$F(1,12) =$	.28	18.69	.97
	$p =$	.84	.001	.44
LD	$F(1,12) =$	.20	23.39	1.16
	$p =$	.90	.000	.37
RS	$F(1,12) =$	.66	6.42	.54
	$p =$	.60	.03	.66

Table 4

$\underline{T}$ tests for Main Effect of Trial

Pre- and Post-Test SD Scores

CONTROL	$\underline{t}(3) = -1.44$, $\underline{p} = .245$
CUES	$\underline{t}(3) = -1.06$, $\underline{p} = .367$
MNEM	$\underline{t}(3) = -3.16$, $\underline{p} = .051$
BOTH	$\underline{t}(3) = -4.89$, $\underline{p} = .016$

Pre- and Post-Test LD Scores

CONTROL	$\underline{t}(3) = -1.54$, $\underline{p} = .221$
CUES	$\underline{t}(3) = -1.34$, $\underline{p} = .272$
MNEM	$\underline{t}(3) = -3.37$, $\underline{p} = .043$
BOTH	$\underline{t}(3) = -5.70$, $\underline{p} = .011$

Pre- and Post-Test RS Scores

CONTROL	$\underline{t}(3) = -0.73$, $\underline{p} = .519$
CUES	$\underline{t}(3) = -1.73$, $\underline{p} = .182$
MNEM	$\underline{t}(3) = -1.73$, $\underline{p} = .182$
BOTH	$\underline{t}(3) = -2.32$, $\underline{p} = .103$

Table 5

Power Analysis

		Noncentrality	Power
COPY	Treatment	5.49	.35
	Trial	1.59	.21
	Interaction	.93	.09
SD	Treatment	.84	.09
	Trial	18.69	.98
	Interaction	2.92	.20
LD	Treatment	.59	.08
	Trial	23.39	.99
	Interaction	3.49	.24
RS	Treatment	1.97	.15
	Trial	6.42	.64
	Interaction	1.63	.13

Table 6

Means and Standard Deviations

Level of Function Specified by Pre-Test Copy Score

		High Functioning		Low Functioning	
		Pre-Test	Post-Test	Pre-Test	Post-Test
COPY	M =	32.88	31.19	28.44	32.59
	SD =	1.36	2.53	1.62	1.32
SD	M =	19.25	23.34	12.47	18.72
	SD =	5.82	5.99	3.48	6.72
LD	M =	18.75	22.78	12.41	19.91
	SD =	6.38	5.98	3.56	6.55
RS	M =	20.63	21.50	19.75	20.50
	SD =	.74	.76	.71	1.31

Table 7

Multivariate Analysis of Variance

Level of Function Specified by Pre-Test COPY Score

		LEVEL	TRIAL	LEVEL x TRIAL
COPY	$F(1,14)$ =	4.44	5.56	31.18
	p =	.05	.03	.000
SD	$F(1,14)$ =	5.01	18.55	.81
	p =	.04	.001	.38
LD	$F(1,14)$ =	3.08	24.49	2.22
	p =	.10	.000	.16
RS	$F(1,14)$ =	8.08	6.61	.04
	p =	.01	.02	.85

Table 8

<u>T</u> tests for Effect of Trial and Effect of Level of
Function (Level of Function Specified by Pre-Test COPY
Score)

<u>Trial Effect</u>

		<u>High Functioning</u>	<u>Low Functioning</u>
SD	<u>t</u>(7) =	-2.74	-3.32
	<u>p</u> =	.029	.013
LD	<u>t</u>(7) =	-2.40	-4.65
	<u>p</u> =	.048	.002
RS	<u>t</u>(7) =	-2.50	-1.45
	<u>p</u> =	.043	.197

<u>Level Effect</u>

		<u>Pre-Test</u>	<u>Post-Test</u>
SD	<u>t</u>(14) =	-2.83	-1.45
	<u>p</u> =	.013	.168
RS	<u>t</u>(14) =	-2.41	-1.87
	<u>p</u> =	.03	.082

Appendix 1.

HEAD INJURY RESEARCH PROJECT

DEMOGRAPHIC INFORMATION AND TEST PERFORMANCE DATA

Name: _____

Age: _____   Gender: _____

Date of Birth: _____   Race: _____

Education Level: _____

Occupation Prior to Injury: _____

Current Occupation: _____

Date of Injury: _____

Nature of Injury: _____

_____

_____

Hemisphere Damage: _____

Handedness: _____   Length of Coma: _____
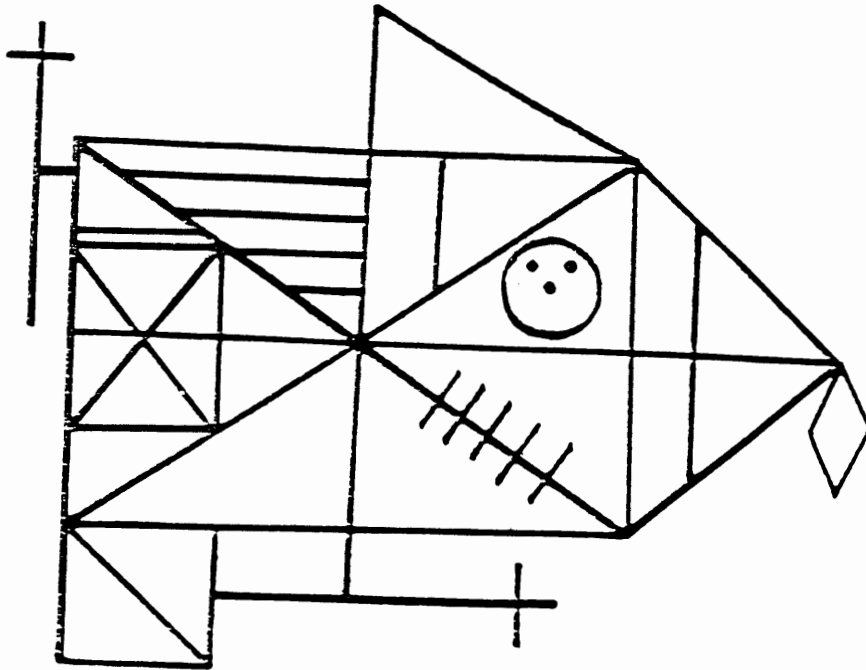
Current Medications: _____

Rancho Level: _____

Rehabilitation Programs: _____

_____

_____

Current Living Situation: _____

CFT SCORES:	Raw	Percentile	Time
Copy	_____	_____	_____
3-Minute Delay	_____	_____	_____
30-Minute Delay	_____	_____	_____
Recognition	_____	_____	

Interference Tests: _____

Rey Osterrieth Complex Figure

Complex Figure: Recognition Subtest
© John E. Meyers, Phv D.

Name: _____   Date: _____

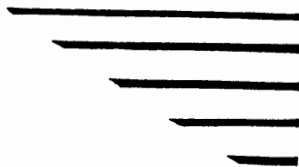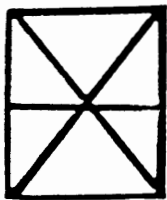Age: _____   Sex: M   F   Handedness: R   L   Education: _____

Directions:

Circle the figures that were part of the larger whole design you copied and then drew.
Each figure is facing the same direction as in the original design. There are four pages.
Turn the page and begin.

(Do not write below this line)
_____

Notes and Observations:

_____

False Positive: _____   False Negative: _____   Correct: _____
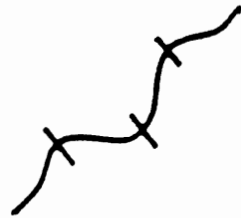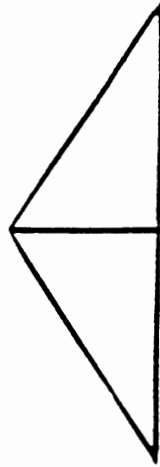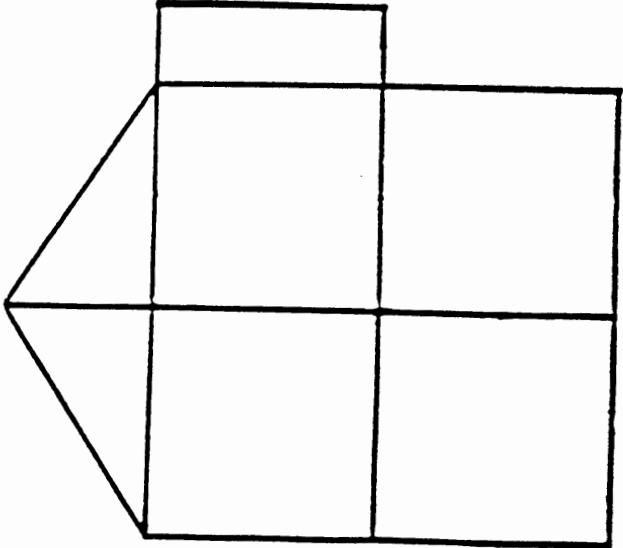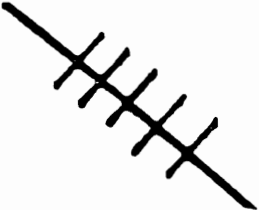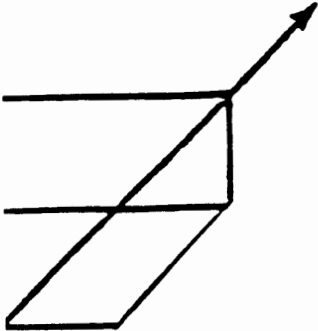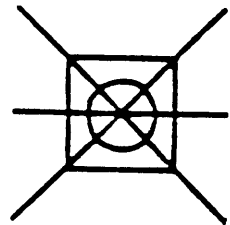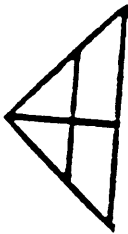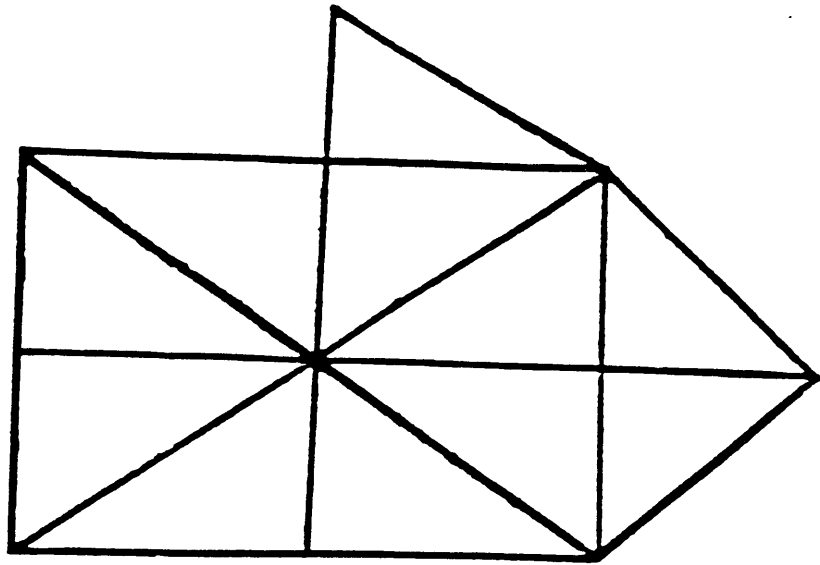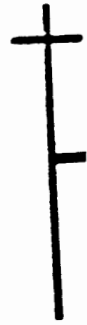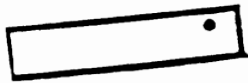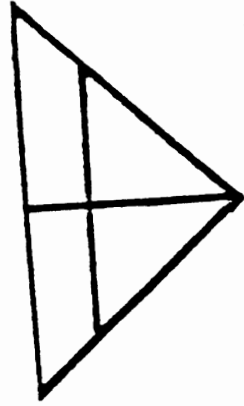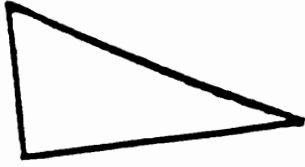
APPENDIX 4.

Description of Complex Figure for Cue and Mnemonic Aids

1.   It's a rectangle with a triangle at the right end, and a triangle on top.

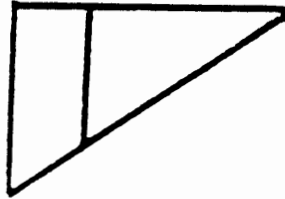2.   At the tip of the triangle on the right is a little diamond-shaped figure.

3.   It has two crosses; one on the left side, and one on the bottom.

4.   It has a bowling ball in it.

5.   It has something that looks like railroad tracks in it.

6.   It has a box with an X on the left side.

APPENDIX 5.

INFORMED CONSENT

I, _____, agree to take part
in this research project on the study of memory loss among people
with brain injury.

I understand that I will spend about an hour taking tests
that will measure my ability to recall things.

I understand that I may become fatigued during the tests,
and that I may not be able to do all of the tests accurately or
completely.

_____ has told me that the purpose of
the study is to learn more about memory loss with head injured
people, so that better rehabilitation can be designed for people
with this problem.

I may not receive any direct benefit from taking part in
this study. But the study may help to increase knowledge that
may help others in the future.

_____ has offered to answer any
questions I have about the study and what I am expected to do.

_____ has promised that all information
I give will be kept confidential to the extent permitted by law,
and that the names of all people in the study will be kept
confidential.

I understand that I do not have to take part in this study,
that I can withdraw from this study at any time, and that neither
action will result in any effect or harm to me or my relationship
with _____.
(Name of home, institution, etc.)

I have read and understand the above information and agree
to take part in this study.

Date: _____ Signature: _____

Date: _____ Signature: _____
                                              (Guardian)

If you have concerns or questions about this study, please
contact the Chair of the Human Subjects Research Review
Committee, Office of Grants and Contracts, 105 Neuberger Hall.

CFT and Recognition Subtest
Females Age 16-39 years with 8-15 years Education
(N= 93)

Copy Time (minutes)		Three Minute Recall		Thirty Minute Recall		False Positive	
<0-1.9	95	<19	.5	18	.5	0	78
2-2.9	91	19	1	18.5	1	1	12
3-3.9	56	19.5	3	19	2	2	7
4-4.9	24	20	6	19.5	4	3	1
5-5.9	9	20.5	8	20	7	>3	.5
6-6.9	4	21	10	20.5	9		
7-7.9	3	21.5	11	21	11	**False Negative**	
>8	.5	22	13	21.5	13		
		22.5	16	22	15	0	80
Copy Raw		23	19	22.5	16	1	58
<28	.5	23.5	22	23	18	2	36
28	1	24	26	23.5	20	3	20
28.5	1	24.5	31	24	23	4	6
29	1	25	36	24.5	26	5	1
29.5	1	25.5	41	25	30	>5	.5
30	1	26	46	25.5	35		
30.5	1	26.5	50	26	41	**Correct**	
31	1	27	55	26.5	46	<18	.5
31.5	1	27.5	58	27	52	18	1
32	3	28	61	27.5	53	19	10
32.5	4	28.5	65	28	55	20	24
33	9	29	69	28.5	60	21	43
33.5	9	29.5	74	29	65	22	67
34	16	30	80	29.5	70	23	86
34.5	16	30.5	81	30	75	24	99
35	37	31	82	30.5	78		
35.5	49	31.5	85	31	81		
36	62	32	87	31.5	82		
		32.5	88	32	83		
		33	90	32.5	85		
		33.5	92	33	88		
		34	95	33.5	91		
		34.5	95	34	95		
		35	96	34.5	96		
		35.5	97	35	97		
		36	99	35.5	98		
				36	99		

CFT and Recognition Subtest
Females Age 16-39 years with 16+ years Education
(N= 32)

Copy Time (minutes)

<0-1.9	95
2-2.9	43
3-3.9	21
4-4.9	12
5-5.9	7
6-6.9	4
7-7.9	2
>8	.5

Copy Raw

<28	.5
28	1
28.5	1
29	1
29.5	1
30	1
30.5	1
31	1
31.5	1
32	3
32.5	4
33	9
33.5	9
34	21
34.5	16
35	25
35.5	49
36	62

Three Minute Recall

<19	.5
19	1
19.5	2
20	2
20.5	3
21	3
21.5	31
22	3
22.5	6
23	9
23.5	15
24	21
24.5	26
25	31
25.5	37
26	43
26.5	50
27	56
27.5	60
28	65
28.5	70
29	75
29.5	76
30	78
30.5	82
31	87
31.5	91
32	96
32.5	96
33	96
33.5	96
34	97
34.5	98
35	99
35.5	99
36	99

Thirty Minute Recall

18	.5
18.5	1
19	2
19.5	4
20	7
20.5	9
21	3
21.5	6
22	9
22.5	16
23	18
23.5	26
24	34
24.5	43
25	53
25.5	55
26	57
26.5	59
27	62
27.5	66
28	70
28.5	74
29	78
29.5	82
30	87
30.5	78
31	90
31.5	92
32	93
32.5	93
33	96
33.5	96
34	96
34.5	96
35	97
35.5	98
36	99

False Positive

0	71
1	15
2	5
3	1
>3	.5

False Negative

0	87
1	68
2	34
3	12
4	4
5	1
>5	.5

Correct

<18	.5
18	1
19	6
20	18
21	43
22	81
23	93
24	99

CFT and Recognition Subtest
Males Age 16-39 years with 8-15 years Education
(N=89)

| Copy Time (minutes)		Three Minute Recall		Thirty Minute Recall		False Positive	
<0-1.9	95	<20	.5	<19	.5	0	59
2-2.9	81	20	1	19	1	1	7
3-3.9	50	20.5	2	19.5	1	2	4
4-4.9	18	21	3	20	1	3	1
5-5.9	3	21.5	6	20.5	1.5	>3	.5
6-6.9	1	22	8	21	2		
>6	.5	22.5	11	21.5	4	**False Negative**	
		23	15	22	7		
Copy Raw		23.5	18	22.5	9	0	83
<28	.5	24	22	23	12	1	62
28	1	24.5	23	23.5	15	2	31
28.5	1	25	25	24	19	3	13
29	2	25.5	29	24.5	23	4	2
29.5	3	26	33	25	28	5	2
30	3	26.5	37	25.5	31	6	1
30.5	3	27	42	26	34	7	.5
31	4	27.5	48	26.5	41		
31.5	4	28	55	27	48	**Correct**	
32	5	28.5	62	27.5	52	<18	.5
32.5	5.5	29	69	28	57	18	1
33	7	29.5	72	28.5	63	19	3
33.5	8	30	75	29	70	20	24
34	13	30.5	79	29.5	73	21	41
34.5	13	31	83	30	76	22	75
35	29	31.5	86	30.5	79	23	94
35.5	29	32	89	31	82	24	99
36	70	32.5	91	31.5	83		
		33	94	32	84		
		33.5	95	32.5	88		
		34	96	33	92		
		34.5	96	33.5	93		
		35	97	34	94		
		35.5	98	34.5	95		
		36	99	35	96		
				35.5	98		
				36	99		

CFT and Recognition Subtest
Males Age 16-39 years with 16+ years Education
(N= 30)

Copy Time (minutes)		Three Minute Recall		Thirty Minute Recall		False Positive	
<0-1.9	97	<19	.5	<19	.5	0	89
2-2.9	42	19	1	19	1	1	4
3-3.9	14	19.5	3	19.5	2	2	2
4-4.9	10	20	7	20	3	3	1
5-5.9	4	20.5	7	20.5	3	>3	.5
6-6.9	4	21	7	21	3		
7-7.9	2	21.5	10	21.5	3	**False Negative**	
>8	.5	22	14	22	7		
		22.5	15	22.5	10	0	92
Copy Raw		23	17	23	14	1	67
<28	.5	23.5	21	23.5	15	2	46
28	1	24	25	24	17	3	10
28.5	1	24.5	25	24.5	19	4	4
29	1	25	25	25	21	5	1
29.5	1	25.5	32	25.5	24	>5	.5
30	1	26	39	26	28		
30.5	1	26.5	42	26.5	31	**Correct**	
31	3	27	46	27	35	<17	.5
31.5	5	27.5	48	27.5	42	17	1
32	7	28	50	28	50	18	3
32.5	7	28.5	55	28.5	51	19	3
33	7	29	60	29	53	20	10
33.5	8	29.5	62	29.5	58	21	46
34	10	30	64	30	64	22	75
34.5	19	30.5	69	30.5	67	23	96
35	28	31	75	31	71	24	99
35.5	50	31.5	80	31.5	80		
36	71	32	85	32	89		
		32.5	90	32.5	90		
		33	96	33	92		
		33.5	96	33.5	92		
		34	96	34	92		
		34.5	96	34.5	96		
		35	97	35	97		
		35.5	97	35.5	98		
		36	99	36	99		

APPENDIX 7
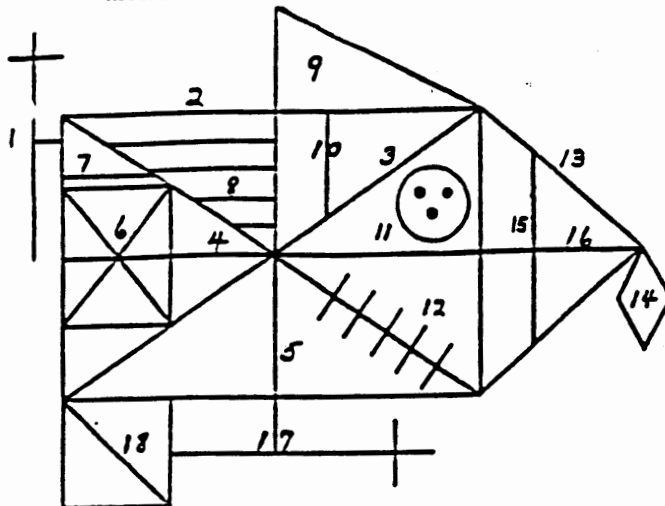
Scoring system for the Rey-Osterrieth Complex Figure (Maximum Score - 36)

	Placed Properly	Placed Poorly
Correct	2	1
Distorted or incomplete, but recognizable	1	.5
Absent, not recognizable	0	0

Copy				Descriptors	3' Recall				30' Recall				Recognition Subtest
2	1	.5	0	1. Cross upper left corner, outside rectangle	2	1	.5	0	2	1	.5	0	False Positive ____
2	1	.5	0	2. Large rectangle	2	1	.5	0	2	1	.5	0	
2	1	.5	0	3. Diagonal cross	2	1	.5	0	2	1	.5	0	False Negative ____
2	1	.5	0	4. Horizontal midline of 2	2	1	.5	0	2	1	.5	0	
2	1	.5	0	5. Vertical midline of 2	2	1	.5	0	2	1	.5	0	Correct ____
2	1	.5	0	6. Small rectangle in 2 to left	2	1	.5	0	2	1	.5	0	
2	1	.5	0	7. Small line above 6	2	1	.5	0	2	1	.5	0	— — —
2	1	.5	0	8. Four parallel lines in 2, upper left	2	1	.5	0	2	1	.5	0	— — —
2	1	.5	0	9. Triangle above 2, upper right	2	1	.5	0	2	1	.5	0	— — —
2	1	.5	0	10. Small vertical line in 2, below 9	2	1	.5	0	2	1	.5	0	— — —
2	1	.5	0	11. Circle with 3 dots in 2	2	1	.5	0	2	1	.5	0	— —
2	1	.5	0	12. Five parallel lines in 2, crossing 3,lower right	2	1	.5	0	2	1	.5	0	—
2	1	.5	0	13. Sides of triangle attached to 2 on right	2	1	.5	0	2	1	.5	0	— —
2	1	.5	0	14. Diamond attached to 13	2	1	.5	0	2	1	.5	0	— —
2	1	.5	0	15. Vertical lines in triangle 13, parallel to right vertical	2	1	.5	0	2	1	.5	0	— —
2	1	.5	0	16. Horizontal line in 13, continuing 4	2	1	.5	0	2	1	.5	0	
2	1	.5	0	17. Cross attached to lower center	2	1	.5	0	2	1	.5	0	
2	1	.5	0	18. Square attached to 2, lower left	2	1	.5	0	2	1	.5	0	

__ __ Total   Total _____   _____ Total
_____ Percentile   Percentile _____   Percentile