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Domain-specific learning: A neuropsychological rehabilitation investigation of vanishing cues

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The University of Arizona, 1992
DOMAIN-SPECIFIC LEARNING: A NEUROPSYCHOLOGICAL REHABILITATION INVESTIGATION OF VANISHING CUES

by

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1992
As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Ed Cotgageorge entitled Domain-Specific Learning: Neuropsychological Rehabilitation Investigation of Vanishing Cues.

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Ph.D.

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

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TABLE OF CONTENTS

ABSTRACT ................................................................. 8

1. INTRODUCTION ......................................................... 10
   Statement of the Problem .............................................. 13
   Research Questions .................................................. 13
   Rational for This Study .............................................. 14
   Definition of Terms .................................................. 15
   Assumptions Underlying the Study ................................ 17
   Limitations of the Study ............................................. 17

2. REVIEW OF THE LITERATURE .......................................... 19
   Memory Theories ........................................................ 19
      Short Term Memory .................................................. 23
      Long Term Memory: Semantic and Episodic; Declarative
      and Procedural; Implicit and Explicit; Priming ............... 25
   Rehabilitation of Memory ............................................. 31
      Cognitive Rehabilitation .......................................... 31
      Compensatory Techniques ......................................... 34
      Computerized Cognitive Rehabilitation ......................... 36
      Vanishing Cues .................................................... 38
      Other Techniques .................................................. 39
      Efficacy of Cognitive Rehabilitation ............................ 40
   Implications of the Literature ..................................... 43

3. RESEARCH METHODOLOGY ............................................. 45
   Subjects ............................................................... 45
   Instrumentation ...................................................... 46
   Procedure ............................................................. 50
   Data Collection ...................................................... 51
   Hypotheses ............................................................ 51
   Design Methodology .................................................. 52
   Statistical Analysis ................................................ 53
   Supplemental Data ................................................... 54
      Etiology of Memory Loss .......................................... 54
      Medications ....................................................... 54
      Time Since Injury/Onset of Injury ............................... 56
      Education Level ................................................... 56
Table of Contents -- Continued

4. RESULTS .......................................................... 57
   General Results ............................................ 57
   Traumatic Brain Injury and Geriatric Controls ............. 58
       Geriatric Controls .................................... 59
       TBI Subjects .......................................... 60
   Alzheimer’s Disease Subjects ............................. 63
   Testing the Hypotheses ................................. 67
       Hypothesis 1 ........................................ 67
       Hypothesis 2 ........................................ 67
       Hypothesis 3 ........................................ 68
       Hypothesis 4 ........................................ 70
       Hypothesis 5 ........................................ 70
   Factor Analysis ........................................... 71

5. SUMMARY, DISCUSSION, CONCLUSIONS ...................... 74
   Summary .................................................. 74
       Purpose ............................................... 74
       Sample ............................................... 74
       Procedure .......................................... 75
       Statistical Analysis .................................. 75
   Discussion ............................................... 76
   Conclusions ............................................. 79
   Implications for Future Research ......................... 82

REFERENCES ................................................... 83
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Frequency Distribution of Brain Impairment Categories</td>
<td>58</td>
</tr>
<tr>
<td>2.</td>
<td>Demographic Characteristics of Geriatric Control Subjects</td>
<td>60</td>
</tr>
<tr>
<td>3.</td>
<td>Demographic Characteristics, and Mean Verbal IQ, Digit Span, WCM, WAC, and Mean Total Number of Trials Required For TBI Subjects</td>
<td>62</td>
</tr>
<tr>
<td>4.</td>
<td>TBI and Geriatric Control Group Means for Number of Trials for the First Two Lessons</td>
<td>63</td>
</tr>
<tr>
<td>5.</td>
<td>Demographic Characteristics of Alzheimer's Disease Subjects</td>
<td>64</td>
</tr>
<tr>
<td>6.</td>
<td>Rotated Factor Matrix, Sorted By Variables Contributing to the Factors</td>
<td>73</td>
</tr>
</tbody>
</table>

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mean number of trials required by the TBI and GC Subjects</td>
<td>58</td>
</tr>
<tr>
<td>2.</td>
<td>Number of hints required per trial for AD subject #2</td>
<td>66</td>
</tr>
</tbody>
</table>
ABSTRACT

This project represents a descriptive study of 19 neurologically impaired adults. The etiology of the impairment includes traumatic brain injury and progressive neurological disease such as Alzheimer's Disease. Four non-impaired geriatric adults were controls for the Alzheimer's Disease patients in this study. Subjects in the study were taught, through the method of vanishing cues, information about computer operating system commands and computer programming. The primary purpose of this project was to determine whether or not these groups could acquire this information and determine the extent to which memory and attention deficits contribute to learning new information in neurologically impaired individuals. Subjects participated in learning sessions presented by a microcomputer. The sessions lasted for twenty minutes to one hour, depending on the subjects ability to attend to the task. Each subject interacted with the computer by answering the questions or doing the procedures presented. Not all of the subjects reached the criteria of zero or one hints that are required before moving on to the next lesson. None of the subjects with progressive neurological disease completed any of the lessons.

Linear regression and multiple regression were used to determine whether or not the degree of memory loss or the degree of attention deficit a subject demonstrated accounts for a significant amount of variance on the criteria variable of number of trials to complete the
learning lessons. Generally, differences between all of the groups was found and the variance accounted for by degree of memory loss and attention deficit was found to be significant.

A principal components factor analysis determined that there was a memory and general intelligence factor and an attention factor that contributed to a subject's performance on the learning lessons. The factors when entered simultaneously into a multiple regression equation accounted for about .50 percent of the variance in the number of trials required to complete the learning lessons. It was concluded, that the factors were statistically significant in determining performance on the learning lessons.
CHAPTER 1
THE PROBLEM

Introduction

The restoration and rehabilitation of memory functioning in memory impaired humans using a computer has elicited a high degree of interest from many researchers. Empirical evidence has failed to support the claims of many of the researchers involved in computerized memory research and rehabilitation. Conversely, computerized rehabilitation methods that have served to alleviate specific problems associated with memory disorders have provided empirically supported examples of effective use of computers in the rehabilitation of memory impaired individuals. Both the efficacy of computerized rehabilitation and its practical utility make it a promising resource for rehabilitative interventions (O'Connor and Cermak, 1987). The most popular software and computer applications used for computerized rehabilitation include drill and repetition performance tasks that include instructions in the use of a particular mnemonic strategy. Typically, the software is presented in a game format. No reliable published evidence exists that demonstrates game format, repetition drill computer retraining packages have any general effect on memory function. The minimal information that does exist suggests that computer-delivered training does not differ from training administered by some other means (Glisky and Schacter, 1986).

Recent work by Glisky and Schacter (1986, 1988, 1989) has provided reliable and methodologically sound information that demonstrates one
useful method of computerized rehabilitation in assisting with the rehabilitation process of memory impaired individuals. The method used by Glisky and Schacter is called the "method of vanishing cues". The vanishing cues method has shown some initially promising results and may prove to be an integral part of the rehabilitation and training issues facing memory impaired individuals. Application of the method of vanishing cues is, however, limited to a relatively small number of subjects, most of whom are traumatically brain injured. The generalizability of the vanishing cues method with subjects whose memory impairment comes from etiologies other than traumatic brain injury is unknown.

What is known is that memory impaired persons can learn and retain some new skills and knowledge (Brooks and Baddeley, 1976; Warrington and Weiskrantz, 1974,1982) but so far there is not much evidence demonstrating memory impaired patients have the ability to acquire meanings of new words (Glisky, Schacter, Tulving, 1986). The evidence for new learning of words by severely amnestic patients has been demonstrated by both vanishing cues and an anticipation method. The anticipation method is described in conjunction with the vanishing cues method later in this chapter. Compared to anticipation procedures, the vanishing cues method has yielded higher levels of both learning and retention (Glisky and Schacter, 1986). In addition, the vanishing cues method includes a domain-specific component that potentially allows the information acquired to be applied by the learner.
While research pertaining to computerized memory training is in the early stages, vanishing cues method research results provide some evidence that computerized memory training may enable memory impaired individuals to learn domain-specific skills; to apply these skills; and to benefit from having these skills in working, living and social environments. The studies to date that have used the vanishing cues method have been limited to the application of this method to memory impaired persons who have sustained memory loss secondary to Traumatic Brain Injury (TBI) or other neuro-insults such as anoxic events and viral encephalopathy (Glisky and Schacter, 1986, 1987). Results similar to those obtained by Glisky and Schacter have not been demonstrated with persons suffering memory impairment secondary to progressive neurologic disease such as Alzheimer's Disease. In addition, the relatively small number of subjects reported by researchers who were using the vanishing cues method has constrained the ability to predict which amnestic individuals might be able to learn new information from the use of the vanishing cue method. The use of vanishing cues with individuals with progressive neurologic disease and traumatic brain injury and prediction of the number of trials required to learn new information when using the vanishing cues method was the major emphasis of this study.

The effect of attention deficits on performance of the vanishing cues learning lessons was another emphasis in this study. Preliminary data generated by Sohlberg and Mateer (1989) points to the importance of addressing attention as a potential factor underlying memory problems.
Prior to using the vanishing cues method to help teach amnestic individuals, it would be appropriate to determine whether the differences in acquisition rate of learning new information is correlated to a "memory factor" or an "attention factor". It is not currently known whether there is meaningful difference between the acquisition rate of subjects who are memory impaired when compared to subjects who possess attention deficits.

Statement of the Problem

This study was designed to examine the following assumptions: 1) Regardless of memory impairment etiology, memory impaired persons will be able to learn new information when the information is taught with the method of vanishing cues, and 2) Attention deficits will diminish the ability of the memory impaired person to learn new information that is taught with the method of vanishing cues. Specifically, the problem was this: Do factors exist that would determine which memory impaired individuals are most likely to be able to learn new information from the use of the vanishing cues method?

Research Questions

The following general research questions were addressed in this study: 1) Do memory impaired subjects who also have attention deficits (please refer to the Definitions of Terms section of this chapter for a definition of attention deficit) have the same general rates of learning and
retention of new information as memory impaired subjects who do not have attention deficits when using vanishing cues? 2) Will subjects with progressive neurologic disease have the same general rates of learning as subjects for whom memory impairment arises from other etiologies? More precise hypotheses will be found in the third chapter.

Rationale for This Study

A review of the literature revealed that there has not been any reported investigation regarding the use of the vanishing cues training method with people who have progressive neurological disease. The same literature review further revealed a paucity of research regarding who might benefit from the use of vanishing cues. Camp (1989) reported the use of "spaced-retrieval" memory interventions with Alzheimer’s patients to teach these patients name-face relationships. The results of that study indicate that "spaced-retrieval" is an effective way to train Alzheimer’s patients to increase their ability to make face-name associations and further indicates that Alzheimer’s patient’s are capable of learning and retaining new information. Given this, an investigation into whether or not other techniques, such as vanishing cues, produce learning, requires further study.

Since the vanishing cues method has been shown to be effective in a limited group of amnestic patients with varying etiologies (Glisky and Schacter, 1986), prediction of who might best be able to use vanishing
cues methods would serve several purposes. The purposes include identifying factors that contribute to the ability to learn new information, providing a method for assessing a memory impaired individuals ability to learn new information, and contributing to rehabilitation program planning.

To date, no investigations have been found which address the use of vanishing cues with persons with progressive neurological disease, the contributing factors of successful utilization of vanishing cues, or the prediction of who might benefit from use of vanishing cues methods. If individuals with progressive neurological disease demonstrate the ability to learn new information which leads to correct performance of a specific task with vanishing cues, perhaps training subjects with progressive neurological disease will increase their ability to perform specific tasks. If not, then training with vanishing cues would be expected to have only a chance relation to change in level of task performance.

It is premature, at this stage, to consider vanishing cues as a memory compensation treatment in and of itself. Investigation of its utility as an adjunct to rehabilitation of the memory impaired is needed. This study was an initial step in formulating a response to such a need.

Definition of Terms

The following definitions are for the purpose of this project.

Vanishing Cues: A term coined by Glisky, Schacter and Tulving (1986) meaning a process of using prompts and hints that produce a desired response and then gradually reducing the stimulus information, until a
response is made in the absence of any external stimuli. For the purposes of this study this term will always relate to the computerized stimuli described in Chapters 2 and 3. In the anticipation method the subject is presented with a definition of a word and then given 10 seconds to verbally produce the entire word. After 10 seconds the subject is told the correct word for a given definition. No letter fragments or "hints" are provided.

**Traumatic Brain Injury (TBI):** A single definitional statement cannot be made that encompasses the complexity of brain injury. Thus, the sufficient and necessary factors that need to be present for the presence of significant brain injury should be in the context of the following: (a) alteration in the level of consciousness sufficient to provide a Glasgow Coma Scale rating of 14 or lower; (b) posttraumatic amnesia of 5 minutes or greater; (c) physiologic evidence (e.g., EEG), radiologic evidence (e.g., CT, MRI), or objective physical findings (e.g., paralysis, aphasia, sensory deficit) (Bigler, 1990).

**Memory Impaired:** This term refers to a subject whose General Memory and/or Verbal Memory Index score(s) on the Wechsler Memory Scale-Revised (WMS-R) is at least 1 standard deviation below the mean score of 100. Subjects with Index scores falling between 1 and 2 standard deviations below the mean are considered mild to moderately memory impaired. Subjects whose Index scores fall below 2 standard deviations below the mean were considered to be severely memory impaired.

**Attention Deficit:** This term refers to a subject whose Attention and
Concentration Index score on the WMS-R is at least 1 standard deviation below the mean score of 100. Subjects with Index scores falling between 1 and 2 standard deviations below the mean were considered to have mild to moderate attention impaired. Subjects whose Index scores fall below 2 standard deviations below the mean were considered to be severely attention impaired.

**Progressive neurologic disease:** Primary Degenerative Dementia of the Alzheimer Type (AD).

**Assumptions Underlying the Study**

The following assumptions are made:

1. The sample of memory impaired subjects in this study was representative of a larger population of individuals with memory impairment. This larger population was limited to those memory impaired individuals who have not had previous exposure to computer use.

2. Lack of familiarization with a computer will not significantly adversely effect a subject's ability to learn.

**Limitations of the Study**

1. Generalizations to larger populations may be limited due to the nonrandom selection process for participants. The study was dependent upon subjects drawn from residential head injury rehabilitation treatment centers in the Denver and Atlanta metropolitan areas, and any characteristics unique to the individuals in these settings may not be generalizable. However, the sample did represent memory impaired persons
from a wide geographic area as the facilities serve most of the Rocky Mountain and southeastern United States respectively.

2. Subjects in this study received extensive rehabilitation services. The results may not be generalizable to subjects with less extensive rehabilitation support services.

3. The sample size may limit the generalizability of the results.

4. Current medications and psychological functioning may influence the subject’s performance on not only the outcome measure but on the neuropsychological tests that determine acceptance for inclusion in the study. Strict controls for medications were beyond the scope of this study. Medications will not be included in the analysis of the relationships among variables.
CHAPTER 2
REVIEW OF THE LITERATURE

This chapter presents a review of the literature pertinent to the current study, including a brief orientation to some of the major sources of influence for the study. First is a review of current, relevant memory theories. Next is a review of cognitive rehabilitation and neuropsychological rehabilitation memory retraining research including a review of research related to computerized memory retraining and noncomputerized memory retraining. Finally, implications of the literature are presented.

**Memory Theories**

Of the higher cortical functions (e.g., perception, language, memory and action), memory is perhaps the most studied (Squire, 1982a). Memory has been defined as "the persistence of learning in a state that can be revealed at a later time" (Squire, 1987, p. 3) and "a system for storing and retrieving information that is acquired through our senses" (Baddeley, 1990. p. 13). However, current memory research does not view memory as a unitary system but rather a complex combination of separate subsystems (Baddeley 1984, p. 9). "The proliferation of interest in studying memory is encouraging, yet it has led to considerable fragmentation in the field. Animal studies are separate from human studies; clinical studies are separate from normal studies. Some researchers are interested in information processing without much regard for the machinery involved;
others are concerned with making macroscopic brain-behavior statements without much interest in the finer points of information processing" (Goldberg, 1984).

As can be seen by the preceding statements, there is no unified or single theory of memory functioning.

The experimental analysis of memory began in the mid-19th century with the work of Herman Ebbinghaus, whose purpose was to study the evolution of memory with respect to time (Van der Linden and Van der Kaa, 1989). Ebbinghaus published his first monograph on the topic of memory in 1885. The neuropsychological study of memory dates to approximately 1915 when Karl Lashly began his attempts to identify the neural locations of learned habits. The emphasis of early investigations into memory was on identifying and localizing the systems, structures, regions and mechanisms within the brain that are critically involved in memory functioning (Thompson, et al., 1984).

Scoville and Milner (1957) demonstrated that severe and long lasting amnesia follows bilateral ablation of the mesial temporal lobes. Since the Scoville and Milner study the psychological study of memory changed significantly from one of localization and structure of memory to an analysis of the process of storing memories (Kolb and Whinshaw, 1985). The last 20 to 25 years of memory research have seen a progressive trend away from theories concerned with structure and mechanism of memory toward theories dealing with memory processes and operations. Thus early models in the information-processing tradition focused on various memory "stores"
(e.g., sensory memory, short-term store or STS, and long-term store or LTS) containing memory traces whose information content varied as a function of the store they occupied (Craik, 1984).

A significant portion of memory research literature is aimed at determining whether or not memory is a single unitary system or several dissociable subsystems, each of which plays a distinct role in memory and learning processes. According to Baddeley (1990), theorists supporting an "interference" hypothesis of memory functioning tend to claim that short term and long term memory experiment results reflect the operation of a single memory system (Baddeley, 1990, p. 50). Baddeley further suggests that theorist supporting "trace" hypotheses of memory functioning tend to claim that short and long term memory experiment results reflect the operations of dichotomous, duplex or multiple memory systems. Some memory theorists have begun to view memory not as a single entity but as separate systems. These systems constitute the major subdivisions of the overall organization of the memory complex (Tulving, 1985). Memory systems have been defined as the minimal neural networks required to record, retain, and retrieve a form of knowledge (Gabrieli, Milberg, Keane and Corkin, 1990) and as "organized structures of more elementary operating components" (Tulving, 1985).

Further, according to Tulving (1985), these organized structures that comprise memory systems represent systems consisting of a neural substrate and its behavioral or cognitive correlates. Some of the components of these memory systems are shared by all systems, other components are
shared by some of the subsystems, and still other components are unique to individual systems. According to Moscovitch (1984), there are at least a dozen candidates existing in the human and animal literature for "duplexity" theories of memory i.e., theories of memory identifying more than one type of memory system. The following paragraphs contain a review of some of the definitions of memory and memory systems proposed by researchers investigating various aspects of memory.

Many types of memory have been identified experimentally. Each of these falls into the broad categories of visual and verbal memory. Visual memory systems include iconic memory (Turvey, 1973); short-term visual memory (Posner, Boies, Eichelman and Taylor, 1969); long term visual memory (Rock and Englestein, 1959); and facial recognition (Davies, Ellis, and Shepherd, 1981). Verbal memory systems include echoic memory (Efron, 1970a; Deatherage and Evans, 1969); short-term auditory memory (Moray, Bates and Barnett, 1965); long-term auditory memory (White, 1960); memory for voices (Meundall, Mayes and Neary, 1980); and semantic and episodic memory (Tulving, 1972).

Atkinson and Shiffrin (1968) proposed what has been referred to as the modal model of memory (Baddeley, 1990). The modal model makes a distinction between short and long term storage processes. This model probably represents the "high water mark of two-component or dichotomous models of memory" (Baddeley, 1990, pp. 61) and as such has received considerable experimental attention. While there have been challenges to the modal model and the constructs of short and long term memory processes
(Craik and Lockhart, 1972; Tulving, 1966; Shallice and Warrington, 1970), short and long term memory process functions and identification continues to provide a direction for memory research. Another approach to the study of memory is proposed by Graf and Schacter (1985). These authors propose a view of memory based on conscious and unconscious recollection of information as opposed to duration of the retention of information. This dichotomous memory process is defined as explicit or conscious and implicit or unconscious memory. Graf and Schacter (1985) do not identify explicit and implicit memory as separate memory systems. Rather these are descriptive labels that distinguish between memory tasks that require subjects to make an explicit reference to a particular study episode to express learning, and those that do not.

The following section provides a more detailed description of some of the memory systems and distinctions identified above. These memory distinctions are those that are most pertinent to this study.

**Short Term Memory**

Short term memory has been defined in the following ways: a limited capacity, temporary store that holds information for a few seconds (Wilson, 1987); and memory with a limited capacity, exclusive reliance on acoustic codes, and extremely rapid decay (Schacter, Kaszniak and Kihststrom, in press). Other terms that are used synonymously with short term memory include "primary memory", "immediate memory", and "working memory". Craik and Rabinowitz (1984) indicate that there is a useful distinction between "primary memory" and "working memory". "Primary
memory" refers to situations in which small amounts of material are held briefly in memory and are then retrieved in a relatively untransformed fashion. Examples of primary memory tasks are digit span forward, recalling the last few words from free-recall list (recency effect), and the Brown-Peterson Paradigm (Craik, 1984). Working memory refers to the memory required in situations in which the individual must hold, manipulate, and transform the material before responding (Baddeley, 1986). Working memory is divided into three main components; the central executive, the articulatory loop and the visuo-spatial scratchpad (Baddeley, 1986). The central executive is involved in selection and control functions; the articulatory loop is a "slave subsystem" of the central executive that allows for temporary storage and manipulation of up to three items of speech-based information; and the visuo-spatial scratchpad provides temporary storage of non-verbal information. Digit span backwards, and dual task paradigms are examples of situations where individuals must actively manipulate material. The active manipulation of information during the performance of a range of cognitive tasks such as comprehension, learning, and reasoning task is a defining feature of "working" memory.

There is no doubt that it is useful to use a term such as short term memory to refer to a class of memory tasks in which the amount of material to be remembered is relatively small, and the delay between the presentation and test is on the order of seconds rather than minutes (Baddeley, 1986).

Long term memory is a durable store, retaining information for varying periods of time, ranging from minutes to decades, has large and potentially unlimited capacity and encodes information principally by meaning, rather than by speech characteristics (Wilson and Moffat, 1984). Like short term memory, long term memory can be subdivided in to several distinct subsystems. Also like short-term memory there is a distinction made between visual and verbal forms of long-term memory. Vanishing Cues is primarily concerned with verbal memory and as such verbal memory subsystems will be described in this section.

The Semantic and Episodic memory distinction was initially proposed by Tulving (1972) "for the possible heuristic usefulness of a taxonomic distinction" (Tulving, 1972, p. 401). The distinction between Episodic and Semantic memory occurs in earlier writings but its influence on recent psychological research comes primarily from the work of Tulving (Squire, 1987). The following review of Episodic and Semantic memory is based upon the work of Tulving (1972). Tulving argued for an Episodic/Semantic memory distinction as a means to address some of the experimental and theoretical problems found in research of memory. Episodic memory refers to memory for personal experiences and their temporal and spatial relations. A perceptual event can be stored in the episodic memory system but must always have temporal and spatial context attached and it is always stored in terms of its autobiographical reference to the already
existing contents of the episodic memory store. The episodic memory system is susceptible to loss and transformation of information and it can function independently from the semantic memory system. Examples of expressions of episodic memory include statements such as "I remember seeing a flash of light a short while ago." This statement refers to a personal experience that is remembered in temporal-spatial relation to other such experiences.

The Semantic memory system is described as the memory necessary for the use of language. It is a mental thesaurus, organized knowledge a person possesses about words and other verbal symbols, their meaning and referents, about relations among them and about rules, formulas, and algorithms for the manipulation of these symbols, concepts and relations. Some features of semantic memory include the registration of cognitive referents of input signals and less susceptibility to involuntary transformation or loss of information (when compared to episodic memory). An example of semantic memory would be a statement such as "I remember the chemical formula for common table salt is NaCl." A statement such as this can be regarded as memory in that it is content depends upon information entered in to semantic memory at an earlier time. This statement is a linguistic translation of information received about a general concept and its interrelations with other concepts. Tulving (1983, 1985) later expands on the concept of verbal memory by adding Procedural memory to the concepts of semantic and episodic memory. Tulving (1985) indicates that procedural memory represents the lowest
level of a "monohierarchial" arrangement that includes semantic and episodic memory in an ascending and inclusive order. According to Tulving semantic memory is a subset of procedural memory and episodic memory is the single specialized subset of semantic memory.

The concept of procedural memory however has been described by Cohen (1984) and Squire (1982a) as part of a different memory distinction system. The distinction suggested is the Declarative/Procedural memory distinction. According to Squire (1987), Declarative memory is memory that is directly accessible to conscious recollection. It can be declared. It deals with facts and data that are acquired through learning. It is impaired in amnesia. In contrast, Procedural memory is memory that is contained within learned skills or modifiable cognitive operations. It is spared in amnesia. The Declarative/Procedural memory distinction influences the conceptualization of vanishing cues in that the distinction helps identify the processes being affected in vanishing cues learning. Vanishing cues learning is, in part, targeted at utilizing the procedural memory system. The procedural memory designation has been applied to the kind of memory that is embedded in procedures, or occurs as changes in how preexisting cognitive operations are carried out.

A third memory distinction relevant to this review is the Explicit/Implicit memory distinction proposed by Graf and Schacter (1985, 1987). Explicit memory is the term used by Graf and Schacter (1985, 1987) and Schacter (1987) to refer to conscious recollection of recently presented information, such as that expressed on traditional memory tests
of free recall, cued recall and recognition. According to Schacter (1987) most psychological studies of memory have traditionally relied on tests requiring explicit reference to and conscious recollection of a specific learning episode. It is memory requiring deliberate recollection.

Implicit memory refers to that memory in which facilitation of performance on completion, identification, and other such tests does not require conscious or intentional recollection of a specific prior episode. Instead of instructing subjects to try to remember previously studied information, they are simply required to perform a task, such as completing a word fragment or identifying a word from a brief perceptual performance; memory is inferred when task performance is facilitated by prior study of target materials (Schacter, Kaszniak and Kihlstrom, in press).

Graf and Schacter have emphasized that the implicit/explicit dichotomy is a descriptive distinction that does not imply the existence of two separate memory systems. In addition, the major reason for advancing an implicit/explicit distinction stems from empirical observations of dissociations between performance on recall and recognition tests on the one hand and completion, identification and similar tasks on the other. These dissociations have been demonstrated in both normal subjects (Jacoby & Dallas, 1981) and amnestic subjects (Brooks & Baddeley, 1976; Cohen & Squire, 1980 and Shimamura, 1986).

Closely related to the memory distinctions presented so far is the concept of "Priming". Priming is the facilitation of performance by prior
exposure to words or other material (Shimamura, 1986). Priming has also been defined as a type of implicit memory that its function is to improve identification of perceptual objects (Tulving and Schacter, 1990). Tulving and Schacter (1990) hypothesize that priming is a distinct memory system from procedural, episodic and semantic memory systems although priming has "affinities" (Tulving and Schacter, 1990 pg. 246) with procedural and semantic memory. Priming resembles procedural memory by enhancing perceptual skills and it resembles semantic memory in that it involves cognitive representations of the world. Two features of priming that contribute to its distinction from other memory systems are (1) it is nonconscious and (2) a person that is perceiving a familiar object is not aware that the perception of the object is as much an expression of memory as it is of perception. While the contribution of priming as a component of vanishing cues has not been addressed directly in the literature priming does appear to be involved in the type of learning that occurs in vanishing cues. A feature of the information learned in vanishing cues lessons that is also a feature of the information learned in priming experiments is that the information is "hyperspecific" i.e., it does not generalize and success or failure of gaining access to a representation through one cue has no implication for success or failure of access of the same representation through a different cue (Glisky and Schacter, 1988; Tulving and Schacter, 1990).

Tulving and Schacter (1990) identify priming as a nonconscious form of memory which is concerned with perceptual identification of words and
objects and is distinct from other forms of memory. Priming is a type of implicit memory whose function is to improve identification of perceptual objects. From a review of memory research Tulving and Schacter (1990) hypothesize that a "perceptual representation system (PRS)" is responsible for priming effects. The PRS interacts closely with other memory systems but remains a distinct system. Five categories of evidence for the existence of priming are identified. These include 1) intact priming in amnestic patients; 2) developmental dissociations between priming and explicit memory; 3) drug-induced dissociations between priming effects and explicit memory performance; 4) functional independence of priming and explicit memory in normal subjects and 5) stochastic independence between successive tests on the same items. Tulving and Schacter (1990) report that the empirical facts drawn from these categories support a view that suggest the PRS works in the following manner: when a normal person (not memory impaired) is faced with ambiguous stimuli, the individual is capable of adopting either a perceptual or memory mode of cognitive operation. In the perceptual mode, the operations involve relating the stimuli to the information stored in the PRS. This operation, they indicate represents priming. Perception is facilitated independently of any recollection of the learning episode. The memory mode in contrast, consists of matching the cue information to the information stored in episodic memory. They hypothesize that the cognitive operations in the perceptual mode involve the PRS without any obligatory engagement of other memory systems, whereas operations in the memory mode depend on the
resources of semantic and episodic memory.

Rehabilitation of Memory

The following is a review of Cognitive Rehabilitation and of some of the primary treatment approaches used in the rehabilitation or retraining of memory.

Cognitive Rehabilitation

Cognitive rehabilitation, cognitive therapy, neurotraining, cognitive remediation, and mediation of brain-behavior relationship are used interchangeably by some professional, but to others, they denote very different things (Sohlberg and Mateer, 1989). Cognitive rehabilitation has been defined as "the therapeutic process of increasing or improving an individual's capacity to process and use incoming information so as to allow increased functioning in everyday life." (Sohlberg and Mateer, 1989, p. 3); "a new body of interventive strategies which serve to augment the rehabilitation professional's armamentarium designed to assault the consequences of brain dysfunction" (Trexler, 1982, p. 3); "a service designed to remediate disorders of perception, memory and language in brain-injured persons" (Gianutsos, 1980, p. 37); and training or specific exercises which are systematically administered to patients with brain injuries to improve their cognitive functioning (Sohlberg and Mateer, 1989). Cognitive rehabilitation has been a fashionable label used to describe many different things, where as at other times it is simply used to mean rehabilitation of cognitive disturbances without further qualifying what is meant by rehabilitation (Basso, 1989).
Comparative psychology, learning theory, and neurophysiological research have all contributed to the development of cognitive rehabilitation models. The theoretical underpinnings of cognitive rehabilitation however, seem to be provided by two main sources. (Moehle, Rasmussen and Fitzhugh-Bell, 1987). The first of the sources is the neuropsychological theory of Luria's functional systems approach (Luria, 1973) and the second source is cognitive psychology's information-processing approach. Luria distinguished three functional units of the brain that are hierarchically organized and functionally integrated. These include (1) the arousal unit (responsible for regulating cortical tone), (2) the sensory-input unit (responsible for receiving, analyzing, and storing information; and (3) the organizational and planning unit (responsible for the programming, regulation and verification of activity). Luria indicates that the functional units are present in cortical zones. The cortical zones are: (1) primary areas, which receive and send impulses to and from the periphery; (2) secondary areas, which perform information processing; and (3) tertiary areas, which receive input from two or more of the secondary areas and serve to integrate the information. (Luria, 1973; Sholberg and Mateer, 1989; Moehle, et.al., 1987).

Cognitive psychology's information processing theory has played a particularly important role in cognitive rehabilitation (Moehle, et.al., 1987). Information processing can be roughly defined as the "analysis and synthesis of information in sequential steps" (Adamovitch, Henderson and
Auerbach, 1985, p. 38). Information processing theory states that humans process information in two broad modes: verbal and nonverbal or spatial-visuoconstructive. Information processing theorists suggest various levels of information processing follows the initial analytical processing of verbal and nonverbal information. The levels of processing are necessary for information to be learned or to become meaningful. Information processing theorists regard humans as analogous to complex machines, such as computers, with elaborate programs that enable individuals to deal with information (Flavell and Wellman, 1977).

Cognitive rehabilitation, as can been seen from the above definitions is not a particular method or model but rather a compendium of theory, methods and models that are applied to the rehabilitation efforts of individuals who have cognitive impairment. In addition to the formal models identified above Ehrlich and Sipes (1985) have identified "pragmatic" models of cognitive rehabilitation. Pragmatic models are models developed from refinement and experimentation with treatment techniques or programs and are not necessarily theory-based. Pragmatic models are represented by approaches found in treatment facilities and are often represented by "compensation techniques." Compensation techniques are detailed later in this section.

Cognitive psychologist's investigations into memory functioning has provided theories about the nature of human memory, theoretical interpretations of amnesia, and information about the learning abilities of amnestic individuals (Wilson, 1987). A new class of models of memory
came about in the 1960's and was inspired by information processing theory (Van der Linden and Van Der Kaa, 1989). The new class of models proposed that memory research should distinguish among several storage units that are elicited depending on the temporal constraints of the encoding condition. The models identify a precategorical storage system (iconic and echoic memory), short-term memory and long-term memory as the basic storage units for memory. A result of this categorization has been that the majority of memory rehabilitation efforts have been directed toward improving either short-term or long-term memory capacity.

**Compensation Techniques**

Compensation refers to the process of circumventing difficulties that arise as a result of memory impairment without necessarily producing an improvement in memory capacity (Sohlberg and Mateer, 1989). These techniques comprise the majority of memory rehabilitation approaches currently practiced, and include many variations on the theme of providing assistive devices, and methods that when applied in the environment have the effect of neutralizing memory deficits. External memory aids and methods (Glisky and Schacter, 1989; Sohlberg and Mateer, 1989; Wilson and Moffat, 1984; Adamovich, Henderson and Auerbach, 1985) include the use of devices such as electronic memories, memory notebook systems, alarms, calendars, buzzers, watches and methods such as environmental modifications e.g., posted reminders, labeled shelves, alphabetized cupboards, and specially structured work environments.

Other variations of compensatory techniques are the internal memory
aids (Sohlberg and Mateer, 1989; Wilson, 1987; Wilson and Moffat, 1984). Internal memory aids are mnemonic strategies that can be used to compensate for memory deficits. Such strategies include rehearsing information to be remembered, using mnemonic devices such as the "peg" method (Moffat, 1984) and visual imagery (Wilson, 1987). The various peg-type mnemonics all involve the learning of a set of standard peg words to which are associated further items which are to be remembered. Moffat (1984) describes the rhyming peg method in which a peg list is formed by choosing words that possess a rhyming relationship to the respective number, this is then paired with a particular procedure such as combing ones' hair.

Visual imagery techniques are the most thoroughly researched and most commonly used mnemonic technique (Glisky and Schacter, 1989). Visual imagery can be defined as remembering by pictures (Wilson, 1987). In this procedure, the to-be-remembered information e.g., names, are paired with an image. Upon need for recall the individual pairs the image with the to be remembered information and recall is to ensue.

The PQRST or Preview, Question, Read, State and Test method is another type of internal memory compensatory technique that has been used by several authors (Glasgow, Zeiss, Barrera, Lewishon 1977; Grafman, 1984; Wilson 1984) in various attempts to provide a structured approach to memory rehabilitation. The method consists of five stages, each stage is identified by the first letter of the activity that the learner is supposed to do at that stage. The stages of PQRST are as follows.
Preview of materials in order to acknowledge the general content of the text; Question the key content of the text; Read the text in order to formulate more questions; State or repeat the information that was read; and Test or answer the questions that have been developed, the answers constituting a summary of the text (Van der Linden and Van der Kaa, 1989).

Computerized Cognitive Rehabilitation

Incorporating the information processing models of memory functioning, cognitive psychology has been a proponent of the notion that repeated drill and practice facilitates memory. As a result of this view, cognitive rehabilitation has relied on repeated exposure to stimuli as the primary method of memory rehabilitation and retraining. The advent of inexpensive computers used to administer materials to be remembered has led to the proliferation of software used by clinicians providing cognitive rehabilitation in memory retraining. However, to the extent that such programs involve meaningless materials such as letters, digits, words and shapes they have no therapeutic value (O’Connor and Cermack, 1987; Sohlberg and Mateer, 1989; Glisky and Schacter, 1989).

Computer technology has recently been used to meet the needs of brain-injury victims. Both the efficacy of this approach and its practical utility make it a promising resource for rehabilitative interventions (O’Connor and Cremak, 1987). Bracy (1985) conducted a study demonstrating that 73% of the rehabilitation centers surveyed that reported providing
cognitive rehabilitation services used microcomputers in their clinical work with the head injured. Computer applications in cognitive rehabilitation have usually taken the form of using the computer to assist clinicians in doing whatever they are already doing (Fisher, 1989) such as word processing and data manipulation.

Clinical applications of computer use in cognitive rehabilitation generally reflect computerized methods of well known and often used noncomputerized memory rehabilitation methods. Several authors report the production of software for use in computerized cognitive rehabilitation. The software addresses a broad range of neuropsychological deficits including memory, attention and concentration, and problem solving. Use of a computerized "PEG" procedure versus a recall procedure and a patient orientation procedure were reported by Skilbeck (Skilbeck, 1984). Bracy (1985) has produced software that addresses training in the areas of attention, maze learning, number and word concepts, spatial memory, auditory memory and problem solving skills e.g., chess games; Gianutsos' (Fisher, 1989, chap.11) software includes pattern recognition, visual field reaction time, free recall, sequence recall, memory span, visual scanning and imperception remediation. Sbordone's (Bracy, 1985) software includes rehabilitation of complex-attention, visual spatial tracking, and task planning. Meyerink and Pendleton (Fisher, 1989, chap. 11) produce software that provides for rehabilitation of orientation, concentration, memory (immediate and delayed, verbal and visual), visuospatial deficits, and overcoming left neglect. Ben-Yishay and Diller (1983) have produced
the Orientation Remedial Module (ORM) to assist in the amelioration of attention deficits. Lynch (1983) while not producing software himself, describes and advocates the use of commercially available computer games for use in cognitive rehabilitation.

Computers have proven most useful for working on attention, visual processing, and reasoning/problem solving. To date, computers have not been an effective means for rehabilitation of memory (Sohlberg and Mateer, 1989). Most memory retraining computer programs involve practice drills that attempt to increase the amount of information a memory impaired person is able to remember. Studies have not shown such exercises to enhance memory (Glisky and Schacter, 1986).

**Vanishing Cues**

The method of vanishing cues is a computerized method of rehabilitation for the memory impaired person which has been identified by Sohlberg and Mateer (1989) as a compensatory method of memory rehabilitation. Van Der Linden and Van Der Kaa (1989) identify vanishing cues as an alternative approach of learning mnemonic strategies. Glisky, Schacter and Tulving (1986) identify the method of vanishing cues as a "Skinnerian procedure" that systematically reduces cued information across learning trials. Regardless of how the method is defined or viewed, vanishing cues is a method that takes advantage of preserved (Glisky and Schacter, 1989) or residual (Parkin, 1982) learning abilities in persons with memory impairment. The method of vanishing cues, developed by Glisky and Schacter (1986), also takes advantage of priming effects to teach amnestic
individuals domain specific information that is limited to a particular procedure or subject. There is no expectation that there will be an increase in memory function for any knowledge domain other than the one targeted. The vanishing cues method also combines knowledge of memory theory and functioning with rehabilitation procedures. Further research of this method of implicit memory learning is necessary to extend the learning and rehabilitation options of the memory impaired, regardless of the etiology of that impairment.

**Other Techniques**

Several other memory rehabilitation techniques have been researched. These include verbal cuing techniques on paired-associate learning tasks (Cermak, 1975); story mnemonics or chain linking procedures (Gianutsos, 1979); embedding the to be remembered information in the lyrics of a song (Gardner, 1977) and a combination of cuing and rehearsal of words linked in a story format (Mattis and Kovner, 1984).

Spaced-retrieval, initially described by Landauer and Bjork (1978), is another compensatory technique which is a relatively simple rehearsal strategy that requires subjects to rehearse items at ever-increasing delays following an initial presentation. The spaced-retrieval technique was used with success to teach name-face associations (Landauer and Bjork, 1978). Schacter, Rich and Stampp (1985) used the spaced-retrieval method with amnestic patients to teach them name-face associations. Results of that study indicated that amnestic individuals were able to learn name-face associations but that retention of the learned associations was
limited. Retention of the associations over more than a few weeks was negligible (Camp, 1989). Camp (1989) modified the previously used procedures by reducing the number of name-face association stimuli to one. By doing so, Camp (1989) was able to demonstrate name-face associate learning with Alzheimer's disease patients.

Efficacy of Cognitive Rehabilitation

Cognitive rehabilitation of memory, especially computerized cognitive rehabilitation has come under scrutiny by various authors (Schacter and Glisky, 1986; Glisky and Schacter 1989; Berrol, 1990; Volpe and Fletcher 1990; Levin, 1990; and Caramazza, 1989). The consensus held by these authors is that cognitive rehabilitation, as it is currently practiced, is of limited value and has not empirically demonstrated an ability to produce meaningful results. According to Glisky and Schacter (1986) one reason for this is that most of the research concerning memory rehabilitation has attempted to restore memory function through the use of repetitive drills and exercises, or to teach patients how to use mnemonic strategies and then expect the strategies to be broadly applied in everyday life. These methods they argue are ineffectual in that the methods 1) try to make general improvements in overall memory functioning, 2) are not generalizable i.e., can't use the strategy in any other environment outside of the training environment, and 3) are not maintained, i.e., the strategy is not used on a regular basis. Schacter and Glisky (1986) state that there is a lack of evidence of maintenance and generalization of mnemonic strategies in amnestic patients and because
of the absence of positive results, "the goal of using mnemonic strategies to produce a general improvement in memory is unlikely to be attained" (Schacter and Glisky, 1986, p. 263).

Studies arguing both for and against cognitive rehabilitation interventions indicate that the majority of the studies presented to date suffer from many methodological deficiencies. These deficiencies constrain the ability to make claims in support of a particular memory rehabilitation technique. The reports of these interventions have generally suffered from great variability in levels of severity of injury (neurobehavioral deficit), absence of uniform data defining success or failure, lack of adequate or consistent verification of performance, and an absence of reliable follow-up over long periods (Berrol, 1990). In addition most of the studies that have been concerned with memory remediation and rehabilitation have, in general, lacked ecological validity and a resultant demonstration of transfer from the laboratory to the real world (Glisky and Schacter, 1986).

The issue of efficacy in cognitive rehabilitation is targeted largely at the techniques that are used in cognitive rehabilitation and the results the techniques purport to produce. The specific techniques have been describe earlier in this chapter. The following section will review the results of some studies that have reported the use of various compensation techniques.

Peg mnemonics were used by Wilson and Moffat (1984). Peg mnemonics have not proven to be of any use as an aid for remembering new information.
for individuals with moderate to severe memory impairment. Peg mnemonics have only helped some individuals with mild memory impairment (Wilson and Moffat, 1984). The conclusion for these studies support the idea that peg mnemonics is not a particularly useful rehabilitation intervention.

Visual imagery techniques were used by Wilson (1987) to teach memory impaired individuals the names of some of the staff in a rehabilitation setting. The results of this application across four single case studies and one small group (four subjects) study produced mixed results. The results of the five studies were that one of the subjects learned a few names, one subject didn't learn any, some learned a few names and one learned some names but was unable to recognize the faces that matched the names. While these studies generated some interesting information, Wilson comments that the results reported cannot be considered an improvement in memory functioning nor can it be said that name learning was improved in patients that have used visual imagery as treatment.

Research reporting the application of external memory aids (memory note books, etc.) has shown some preliminary evidence that these aids may be useful for memory impaired individuals (Sohlberg and Mateer, 1989). However, the studies upon which these reports are based suffer from the same problems as those identified for the use of visual imagery and peg techniques. These problems include methodological issues within the study design and no evidence for generalization and maintenance of the intervention.

Landau (1988) argues that measured neuropsychological change is first
step in cognitive rehabilitation but that investigators should have as an ultimate goal some "real world" effect. The environmental/ecological validity argument appears to be a central feature of some recent investigations of cognitive rehabilitation. Some current memory rehabilitation efforts appear to be directed toward addressing the environmental/ecological validity argument. Glisky and Schacter (1986) introduced the term "domain-specific" training and include domain-specific training as part of their model for memory rehabilitation. Another way in which the environmental validity argument is being addressed is by identifying rehabilitation methods to increase or capitalize on functioning memory systems rather than attempting to improve upon impaired memory subsystem. While it remains unclear as to whether loss of either short-term or long-term memory can be remediated, it is clear that the efficiency of the memory systems can be measurably enhanced in a brain damaged population (Berrol, 1990).

Implications of the Literature

There is a paucity of research studying the effects of computerized and noncomputerized cognitive rehabilitation of memory. The majority of research that does exist is characterized by studies that are all too often described in vague terms (Schacter and Glisky, 1986), have significant methodological problems e.g., no control groups or are poorly controlled, utilize neuropsychological test scores as outcome measures, and seldom demonstrate significant improvement in memory functioning (cf. Prigatano, et. al., 1984).
Currently, it is not known what neuropsychological factors contribute to the memory impaired individual's ability to learn. Glisky and Schacter (1987) suggest that jobs or tasks requiring invariant procedures and a learning context that simulates the real-world environment as closely as possible are factors, although not neuropsychological, that seem to contribute to the memory impaired persons ability to learn. It remains to be demonstrated whether patients who have other cognitive deficits in conjunction with their memory disorders will be able to benefit from the vanishing cues method. In addition, the issue of transfer and generalizability of newly learned information to other environments has been addressed but not resolved.

The present study attempts to combine elements of neuropsychological assessment and a new approach to cognitive rehabilitation of memory disorders in a residential treatment setting where the emphasis for rehabilitation includes a broad array of treatment modalities but does not address memory rehabilitation in other than an external compensatory manner.
 CHAPTER 3
RESEARCH METHODOLOGY

Subjects

The subjects in this study were 19 memory impaired adults who have experienced memory impairment as a result of either a progressive neurological disease such as Alzheimer's Disease or Traumatic Brain Injury (TBI). Seventeen of the subjects were TBI and two of the subjects were AD. The subjects were volunteers who have heard about the study from clinicians at the Swedish Hospitals Gerontology Center and Learning Services - Bear Creek and Peachtree facilities. Swedish Hospitals Gerontology Center is a day program for elderly Alzheimers patients and the Learning Services' facilities are post-acute rehabilitation programs for persons with acquired brain injury. In addition to the 19 memory impaired subjects were four normal geriatric subjects who were to be used as a control group for the AD subjects.

Inclusion criteria for this study were as follows: (1) No history of developmental or previous learning disabilities; (2) No history of computer use or training; (3) Mild to severe memory impairment as determined by the results of the neuropsychological test battery administered to each subject; (5) Sufficient English language skills to ensure valid neuropsychological testing. (6) At least 12 months post diagnosis; and (7) At least 18 years old.

Subjects were excluded from this study for any of the following (1) Receptive or expressive aphasia of sufficient severity to significantly
interfere with the cognitive assessment required by this study; (2) Genetic or congenital disorder resulting in cognitive disturbances; (3) Significantly subnormal intelligence prior to the TBI; (4) Acquired cognitive impairment from any cause other than the brain injury or dementing condition for which the subject would be enrolled in this study; (5) Presence of Schizophrenia, Paranoid Disorder, other Psychotic disorder, Major Depression, or Bipolar Disorder as defined by the DSM-III-R; and (6) History of or current Psychoactive Substance Use or Alcohol Abuse Disorder.

Subjects were asked to make a nine week commitment to the learning sessions.

Instrumentation

Following is a brief description of the tests and equipment comprising the neuropsychological test battery and software used for this project. These neuropsychological tests were chosen to identify subjects who are memory impaired and attention impaired, and possess intellectual and language functioning that would allow for the completion of the lessons. Some of the subjects had participated in neuropsychological testing prior to the beginning of this project. When the subject had participated in a recent neuropsychological test battery only the neuropsychological tests required by this study were administered if they had not been administered previously. The test battery given was as follows:

1. The Weschler Memory Scale-Revised (WMS-R) yields Verbal, Visual, General Memory and Delayed Recall memory scores and an
Attention/Concentration subscale score. The WMS-R was used in this study to determine the degree of memory impairment and/or attention impairment of the subjects. The WSM-R has a mean of 100 and a S.D. of 15. Degree of memory and/or attention impairment in the study was related to the standard deviation from the mean that the subjects score on a subscale fell. Subjects whose subscale scores fell within one standard deviation from the mean (scores of 85 and above) were not considered to be impaired on that subscale. Subjects whose subscale score fell into the two standard deviations below the mean range (scores between 70 and 84) were considered mild to moderately impaired on that subscale. Subjects whose subscale score fell three standard deviations below the mean (scores of 69 or lower) were considered severely impaired on that subscale.

2. The Weschler Adult Intelligence Scale (WAIS-R) is the most commonly used test of intellectual ability for research purposes (Lezak, 1983). The Weschler Adult Intelligence Scale - Revised was used in this study. Lezak (1983) indicates that how well the WAIS-R measures the cognitive functions of interest to neuropsychologist is not well know. However, since the format of each subtest is essentially unchanged from the predecessor Weschler Adult Intelligence Scale (WAIS), it is not likely that WAIS-R factor analysis and performance patterns of discrete groups of brain impaired patients will differ much from those of the WAIS. For the current study, the WAIS-R was used to identify those individuals whose intellectual functioning was significantly impaired.

3. The Controlled Oral Word Association Test (FAS) is a measure of
verbal fluency and has proven to be a sensitive indicator of brain dysfunction, in particular frontal functioning (Lezak, 1983).

4. The Recognition Memory Test (RMT) (Warrington and James, 1967) is a test of memory for words and faces. Facial recognition is particularly sensitive to memory deficit and memory span. For this study facial recognition provided additional evidence for the presence or absence of memory deficit. For some subjects the Facial recognition portion of the Multilingual Aphasia Examination (Benton and Hamsher, 1976) was used because the RMT was not available.

5. The Wisconsin Card Sorting Test (WCST) is a test widely used to study "abstract behavior" and "shift of set" (Lezak, 1983). The abilities to shift mental set and to think in an abstract manner are related measures of conceptual functions. It is assumed that individuals with severely impaired conceptual functioning would not be able to make the abstract associations required in learning the information presented in the learning lessons in this study. Subjects with more than 50 perseverative errors were not included in the sample. Individuals with greater than 50 perseverative errors are considered to possess severe conceptual and abstration abilities.

6. The Dementia Rating Scale (DRS) (Mattis, 1985) provides a measure of cognitive status in persons with known cortical impairment, particularly of the degenerative type. The five subscales of specific abilities include Attention, Initiation/Perseveration, Construction, Conceptualization and Memory. The DRS was used in this study, along with
the other measures described, to determine the presence of Alzheimer's Type Dementia and/or other progressive dementing disorders.

7. Attention measures are found in the subtests of WAIS-R, WMS-R and DMS. These subtests were used as the attention measures for assessment of attention deficits.

8. The software used in this study was the first three lessons of the computer command and programming system developed by Glisky (1986). Modifications have been made by the author to enable the software to run independently from a clock card and to run on Apple GS hardware. The following is a brief description of how the software operates. The description is provided here in an attempt to describe the vanishing cues method. For a detailed description of the software, please refer to Glisky (1986, 1987).

The program disk is "booted" and the first lesson is begun. The computer instructs the subjects to type their responses to all queries on the keyboard, to guess if they are uncertain of how to respond, and to press the RETURN key for a hint if they are unable to respond at all. Step-by-step instructions concerning a particular computer operation or concept are then displayed on the computer screen. Explanations of concepts entail a few simple sentences, which are presented one sentence at a time. Rather than simply passively reading these instructions, subjects are required to complete some of the sentences by typing appropriate words on the keyboard. They then perform several tasks using the computer command that is being taught.
Instructions concerning the meaning or use of various computer terms or commands are presented as incomplete sentences, and subjects must generate the missing words. For example, when explaining the definition of alphanumeric variables the computer presents the incomplete sentence, "A sequence of characters enclosed in quotation marks is called a _________." Subjects are required to type the word STRING to complete this sentence correctly. If subjects did not know what to type, they could ask for a hint by pressing the RETURN key on the computer keyboard. The initial letter of the target word then appears on the screen. Additional cues in the form of successive target letters could be requested if necessary, and after each letter addition an opportunity is provided for the subject to type the correct word on the keyboard. Incorrect responses always result in the provision of an additional letter cue.

Procedure

Subjects used either an Apple II+, IIE, or GS microcomputer for the three vanishing cues learning lessons. They were told to follow the instructions that appeared on the computer screen in front of them. A test administrator sat with the subjects during the session(s) to direct the subject towards the screen and encourage the subject to continue when necessary. Subjects proceeded through the lessons at their own pace. Subjects worked on the lessons from 20 to 60 minutes per session at least one time per week.

Because the subject works at his or her own pace, not all subjects reached the same place in the learning lesson after a set amount of time.
The number of stimuli presented and the number of responses made varied between subjects and across trials. All subjects, however, were instructed in the same concepts and the concepts were presented in the same order. Subjects progressed from one lesson to another as the criterion of either zero or one hint per lesson was achieved.

**Data Collection**

As indicated previously, the neuropsychological test battery was administered as a regular part of the intake and evaluation process for new clients in the various data collection sites. This project included subjects who began rehabilitation or day treatment programing during the year from June 1990 through June 1991. The neuropsychological battery was administered either by the author or by a neuropsychologist.

Measures of learning and retention are compiled by the microcomputer during the subjects' session with the learning lessons. At the end of each lesson, the subjects' responses to a particular lesson were recorded on a separate data disk. The data was retrieved at a later time for the purpose of statistical analysis.

The Informed Consent Form used in this study was approved by the Internal Review Committees of the Craig\Spalding\Swedish Hospital and the Colorado Neurological Institute.

**Hypotheses**

Based on the problem statement found in Chapter one, and within the limits of the data generated, the following hypotheses were investigated:
1. Degree of memory loss accounts for a significant (p<.05) portion of the variance in the number of trials required to complete the lessons.

2. Degree of attention deficit accounts for a significant (p<.05) portion of the variance in the number of trials required to complete the lessons.

3. The number of trials required for subjects with both attention deficits and memory deficits will be significantly (p<.05) lower than for those with memory impairment alone. According to several authors (Luria, 1973; Sohlberg and Mateer, 1989) intact attention is a prerequisite for memory processes to occur. Luria (1973, p. 287) states "... selective recall requires optimal cortical tone or a state of total vigilance, without which any selective mental processes would be impossible."

4. Significant (p<.05) differences in the number of trials required to complete the lessons exists between subjects with progressive neurological disease and the subjects whose memory and attention deficit etiology is Traumatic Brain Injury.

5. Neither duration since injury, or duration since diagnosis of neurological disease, nor sex account for a significant (p <.05) portion of the variance in the number of trials required to complete the lessons.

**Design Methodology**

The design methodology to be used in this study is most similar to a Repeated-Treatment or Repeated Measures within-subjects design. In this study design, the subjects are given a particular treatment, in this case
the vanishing cues lessons. The treatment is then withdrawn in the sense that at the end of a learning lesson the treatment is discontinued. The treatment is then reintroduced. There are no control groups for the TBI subjects in this study as it has been demonstrated previously (Glisky, Schacter, and Tulving, 1986) that the learning rates, for the information contained in the lessons, of memory impaired individuals are not normal as compared to controls who do not have memory impairment. The subjects act as their own controls in the sense that they are being compared only to their own performance.

The dependent variable for this study was the number of trials required to reach the criteria of zero or one hint per lesson.

**Statistical Analysis**

Statistical analysis includes descriptive analysis, simple regression analysis, multiple regression analysis and factor analysis. Multiple regression analysis is used for prediction and explanation of relationships (Pedhauzer, 1982) between predictor and criterion variables. Predictive multiple regression analysis was used in this study to determine which subjects are most likely to be able to effectively utilize the vanishing cues for learning the information contained in the learning lessons. The predictor variables include the test scores of the test battery, while the criterion variable was number of trials for the lessons completed required to reach the criterion of zero hints per lesson.

Factor analysis is a variety of statistical techniques whose common objective is to represent a set of variables in terms of a smaller number
of hypothetical variables (Kim and Mueller, 1978). In this study exploratory factor analysis was used to determine the number of hypothetical factors that can account for the observed covariations between the variables. In this study the variables were the scores on the various tests in the test battery. The scores used in the factor analysis include Verbal and Performance IQ scores determined by the WAIS-R; Verbal, Visual, Delayed Recall and General Memory scores and the Attention/Concentration scores from the WMS-R; Wisconsin Card Sort Test, and Controlled Oral Word Associates Test.

Supplemental Data

In addition to the performance data i.e., trials to criteria, the following information will be collected.

Etiology of Memory Loss

For the purpose of this study, etiology of memory loss has been identified as the event which lead up to the diagnosis of memory loss. Not all subjects meet the criteria of Amnestic Syndrome nor did all of the subjects report TBI as the etiology of their memory loss. All subjects did however demonstrate memory loss sufficient to interfere with their learning abilities and a need for memory compensation strategies.

Medications

Most, but not all subjects were prescribed some sort of medication prior to thier inclusion in the study. The types of medications include
but are not limited to prophylactic antiseizure medications, carbamazepine, and benzodiazepines. Although these medications were prescribed and generally available to the subjects, adherence with prescriptions is unknown. While a limitation of this study is the lack of control for medications, some problems associated with this issue deserve to be addressed.

Researchers in neuropsychopharmacology seem to agree that the state of drug treatment for brain injured and dementia patients is in the formative stages of development. Boyeson (1991) concludes that more basic research is needed to define an appropriate and timely pharmacological regimen and tailor it to a particular type of injury and that an understanding of the drug mechanisms would be desirable. Auerbach and Jann (1991) indicate that pharmacotherapy in neurorehabilitation is complicated by a limited body of knowledge concerning medication side effects, and interactions in neurological populations. Further, Auerbach and Jann (1991) report that consistent with rehabilitation philosophy, education of these issues and a structured review with clients and/or guardians of the purposes, risks, benefits and alternatives to medications is crucial for the ethicolegal constraints of informed consent.

If this is indeed the state of the art in the neuropsychopharmacology of brain injury and disease, then simply controlling for medications in a study such as this would not necessarily address medication control issues. In addition, medication regime matching was problematic for this study in that it could not be accomplished.
Time Since Injury/Onset of Injury

This variable was included as a control variable so as to reduce the arguments associated with "spontaneous recovery". It is generally reported that most neuropsychological recovery occurs within the first year after the onset of the brain injury and that spontaneous recovery accounts for much of the TBI individuals' ability to acquire new information. Subjects in this study were generally at least 12 months post injury.

Educational Level

This variable is included as a control variable. Educational level as a premorbid factor, is often identified as a variable that contributes to better rehabilitation outcomes and recovery of function. Higher premorbid education levels are often correlated with higher levels of recovery.
CHAPTER 4
RESULTS

This chapter reports the results of the study. First general results are presented. The general results of the study are divided into two separate analyses. The first analysis examines the results of the AD group separate from the results of the TBI and Geriatric control group. The second general analysis relates the results of the TBI and Geriatric control groups. Next, the hypotheses are restated and the findings related to each are analyzed. Finally, the results of a factor analysis and multiple regression application are presented.

General Results

Brain impairment categories were reduced to two, Traumatic Brain Injury (TBI) and Alzheimer Disease (AD). Etiology of the brain injury in the TBI category included falls, motor vehicle accidents, gunshot, being struck by other moving objects, viral encephalitis, and cerebral vascular accidents. A non-impaired category, geriatric controls, was comprised of normal geriatric subjects who demonstrated average skills on the neuropsychological test battery used in the study. The purpose of the geriatric control group was to provide a control group for the AD patients. Table 1 shows the frequency distribution within these categories for the 23 subjects in the sample. There were 17 TBI subjects, 4 GC subjects and 2 AD subjects for which useable data were generated.
Table 1
Frequency Distribution of Brain Impairment Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic Brain Injury (TBI)</td>
<td>17</td>
<td>75.0</td>
</tr>
<tr>
<td>Alzheimer's Disease (AD)</td>
<td>2</td>
<td>8.3</td>
</tr>
<tr>
<td>Geriatric Controls (GC)</td>
<td>23</td>
<td>100.0</td>
</tr>
</tbody>
</table>

All of the TBI and GC subjects were able to learn the information contained in the learning lessons by use of the vanishing cues method. The data generated by the AD group were insufficient for use as part of the overall statistical analysis between the groups in the study. Neither of the AD subjects completed any of the lessons and all of the AD subjects required significantly more time to finish a trial than the other groups. However, the AD subjects did demonstrate learning on the first learning lesson. The results for the AD subjects are reported in the following section.

**Traumatic Brain Injury and Geriatric Control Results**

The following section presents the results of the TBI and GC subjects that participated in this study. Figure 1 shows the mean number of trials required for the TBI and GC subjects to complete the first two lessons. The TBI subjects required a mean of 20.6 trials to complete the two lessons. The GC subjects required an average of 15.00 trials to complete the two trials.

Figure 1. Mean number of trials required by the TBI and GC Subjects.
Geriatric Controls

The non-impaired geriatric subjects were included in the study as controls for the AD subjects. All of the geriatric controls completed all three of the lessons. Table 2 shows the demographic characteristics, Wechsler Memory Scale-Revised Index scores, Controlled Oral Word Associates Test (FAS) scores and number of trials required on lesson one and lesson two for the geriatric control subjects. All of the GC subjects completed high school, with one of the subjects completing a four years of college. The mean age of the GC subjects was 63 years. Overall the GC subjects demonstrated average functioning on all of the neuropsychological measures used in this study.

The geriatric control subjects demonstrated that they were capable of learning the information contained in the lessons. The geriatric controls required an average of 4.25 trials to complete lesson one. The control who required seven trails over two sessions was answering the telephone at the senior center in which the data was collected at the same time she was participating in the learning lessons. The geriatric controls required a mean of 10.75 trials to complete lesson two. The geriatric controls required less time per trial than the AD subjects. The data generated by the geriatric controls were included in the factor analysis and multiple regression procedures that were part of this study. The normal geriatric controls in this study were the first such group to complete any of the learning lessons presented with vanishing cues.
Table 2. Demographic Characteristics of Geriatric Control Subjects.

<table>
<thead>
<tr>
<th>Subject</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>62</td>
<td>62</td>
<td>63</td>
<td>65</td>
</tr>
<tr>
<td>Sex</td>
<td>Female</td>
<td>Female</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Education</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Wechsler Memory Scale-Revised</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Memory</td>
<td>98</td>
<td>90</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>116</td>
<td>100</td>
<td>109</td>
<td>100</td>
</tr>
<tr>
<td>General Memory</td>
<td>97</td>
<td>93</td>
<td>100</td>
<td>97</td>
</tr>
<tr>
<td>Attention/Concentration</td>
<td>96</td>
<td>904</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td>Delayed Recall</td>
<td>97</td>
<td>94</td>
<td>96</td>
<td>97</td>
</tr>
<tr>
<td>FAS</td>
<td>38</td>
<td>34</td>
<td>44</td>
<td>40</td>
</tr>
<tr>
<td>Number of Trials for Lesson 1</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Number of Trials for Lesson 2</td>
<td>13</td>
<td>8</td>
<td>9</td>
<td>13</td>
</tr>
</tbody>
</table>

TBI Subjects

The results obtained from the TBI subjects indicated that the TBI subjects were able to acquire and retain the information contained in the computer learning lessons. The rate at which they learned the information varied across the subjects and was related to the degree of memory impairment the subjects possess. Generally, subjects with greater memory impairment required more trials to learn the information. All seventeen of the subjects completed at least two of the computer learning lessons.

Table 3 shows the demographic characteristics, results of the neuropsychological measures and the mean number of trials required to complete the first two lessons for the subjects. The majority of subjects...
in the study acquired brain injuries as the result of closed head injuries occurring in automobile and bicycle accidents and falls. One subject’s brain injury was due to brain cancer. Two subject’s brain injuries were the result of viral encephalitis (Vir.Enc.). One sustained a brain injury as the result of a gunshot wound. Two of the subjects ad cerebral vascular accidents (CVA). Overall, the subjects demonstrated intact intellectual functions with IQ scores falling in the average to low average range of functioning for all of the TBI subjects. All of the subject’s IQ’s were reported to be in the average range prior to their brain injuries. Digit Span average was 7.5 with a S.D. of 2.3 Average Wechsler General Memory (WGM) and Attention and Concentration (WAC) scores fell within the moderately impaired range of functioning. Six of the subjects WGM scores were above 85, four of the subjects WGM scores were between 70 and 84 and seven subjects had WGM scores of 69 or below. Fifteen of the TBI subjects Wechsler Delayed Recall (WDR) scores were below 85 while two of the subjects WDR scores were above 85. Average Wechsler Attention and Concentration (WAC) Scores fell within the below average range of functioning. Seven subjects had WAC scores above 85, four subjects scores fell within the moderately impaired range (70-84) and six of the subjects scores fell below 69.
Table 3.
Demographic Characteristics, and mean Verbal I.Q., Digit Span, Wechsler General Memory, Wechsler Attention and Concentration Scores and mean total number of trials required for the TBI Subjects.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No.</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHI</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Vir.Enc.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Gunshot</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CVA</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Educ.</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>WAIS-R</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Digit Span</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>Wechsler</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Memory</td>
<td>74.82</td>
<td></td>
</tr>
<tr>
<td>Attention/</td>
<td>77.94</td>
<td></td>
</tr>
<tr>
<td>concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean No.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Trials</td>
<td>17.2</td>
<td></td>
</tr>
</tbody>
</table>

The TBI subjects required more trials per lesson than the Geriatric Control subjects. An analysis of variance indicated that the geriatric subjects mean number of trials per lesson was not significantly different from those of the TBI subjects. The TBI subjects required a mean of 6.5 trials to complete lessons one and a mean of 14.12 trials to complete lesson two. The TBI subjects required a mean of 20.6 trials to complete two lessons. The geriatric subject required a mean of 4.25 trials to complete lesson one and a mean of 10.75 trials to complete lesson two. The geriatric subjects required a mean of 15.0 trials to complete two lessons. Table 4 summarizes the mean performance between the two groups.
Table 4.
TBI and Geriatric Control Group means for number of trials for the first two lessons.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>TBI</th>
<th>GC</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Lesson One</td>
<td>6.47</td>
<td>4.25</td>
<td>.13</td>
</tr>
<tr>
<td>Mean Lesson Two</td>
<td>14.12</td>
<td>10.75</td>
<td>.18</td>
</tr>
<tr>
<td>Mean Both Lessons</td>
<td>20.19</td>
<td>15.00</td>
<td>.09</td>
</tr>
</tbody>
</table>

Alzheimer's Disease Subjects

The number of AD subjects who began the study was seven. However, for various reasons, the number of AD subjects for whom usable data were generated was reduced to two. Of the two remaining AD subjects, neither completed any of the lessons and neither reached the criteria of one or zero hints required for the subject to begin lesson 2. Five of the original seven AD subjects did not generate sufficient data for any sort of analysis. Of these five subjects, three withdrew from the study within the first two trials and did not generate data that were sufficiently complete enough to consider for use with this study. One of the subjects was disabled to the point that he was unable to participate in the required testing. One of the subjects data were lost. Table 5 shows the age, years of education, sex, Wechsler Memory Scale-Revised Index Scores, Dementia Rating Scale Scores, and approximate time since diagnosis of AD. Dementia Rating Scale scores fell within the impaired range of functioning. The diagnosis of Alzheimer disease was made prior to the subjects admission into the adult day treatment program from which the subjects were recruited for participation in the study. The estimation of disease duration was established from patient history.
Table 5.
Demographic Characteristics of Alzheimer’s Disease Subjects.

<table>
<thead>
<tr>
<th>Subject</th>
<th>#1</th>
<th>#2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>56</td>
<td>62</td>
</tr>
<tr>
<td>Education</td>
<td>Female</td>
<td>Female</td>
</tr>
<tr>
<td>Education</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Wechsler Memory Scale-Revised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal Memory</td>
<td>72</td>
<td>60</td>
</tr>
<tr>
<td>Visual Memory</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>General Memory</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>Attention/Concentration</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>Delayed Recall</td>
<td>62</td>
<td>51</td>
</tr>
<tr>
<td>Mattis Dementia Rating Scale</td>
<td>102</td>
<td>96</td>
</tr>
<tr>
<td>Time since Diagnosis</td>
<td>1 year</td>
<td>1.5 years</td>
</tr>
</tbody>
</table>

Results of the study indicated that the AD subjects were capable of learning the information contained in the learning lessons. Of the two AD subjects for whom data were generated, the second subject, #2 above, participated in the greatest number of trials. The pattern of learning demonstrated by subject #2 can be seen in Figure 2. The subject required approximately three times as many trials as TBI subjects with similar memory and attention scores on the Wechsler Memory Scale-Revised. The six TBI subjects with General Memory scores and Attention/Concentration scores in the severely impaired range (Attention and Concentration Index score of 69 or less) required an average of 7.5 trials to reach the criteria of zero hints on lesson one. Subject #2 did not complete lesson one over the course of 21 trials, and required 20 hints on trial 21.
There were nine separate words or operations presented in lesson number one. Over the 21 trials, subject #2 demonstrated the greatest difficulty with learning the words and operations of 1) clearing the screen; 2) performing the operation to display the word "something" on the screen; and 3) the operation requiring her to display five dollar signs on the screen. The subject required the least number of hints with the 1) the PRINT command; 2) the name of the programming language; and 3) asking the computer to print her last name on the screen. The subject was able to perform all of the other operations in the lessons with only first letter hints at the end of the 21 trials. She learned the PRINT command the soonest and did not require any hints to identify the function of this command after trial twelve. Figure 2 shows the number of hints required per trial by the subjects.
Figure 2. Number of hints required per trial for AD subject #2.

Typically, the subject completed only one trial per session. On the first two sessions the subject did not complete the entire session. The number of hints shown for the first two sessions represent incomplete trials. On trial number one the subject completed six of the nine possible words and operations in lesson one. On trial number two the subject completed eight of the nine possible words or operations in lesson one. Trials three through 21 were trials in which the subject completed the entire lesson. Figure 2 shows there is clearly learning across sessions and trials. The learning that occurred indicated a continuous reduction of number of hints required across trials. The largest
decreases in number of hints required per trial are seen in sessions 10, 11, 12, and 14. On session 10 (trials 10 and 11), session 11 (trials 12 and 13), session 12 (trials 14 and 15) and session 14 (trials 17 and 18) the subject completed two trials per session. The relatively large reductions in the number of hints required reflects large reductions in the number of hints required reflects intersession learning.

The other AD subject completed five trials in five sessions and also demonstrated a reduced number of hints per trial. As with subject #2, the only lesson-specific information generated in the first few sessions were the total number of hints required per trial. As with the other AD subject, the first two sessions represented incomplete trials, with the subject completing 6 of 9 words and operations on the first trial and 7 of 9 words and operations on the second trial.

Testing the Hypotheses

Regression and multiple regression were applied to the data generated in this study. The results of these analyses were used in testing the hypotheses.

**Hypothesis 1**

Degree of memory loss accounts for a significant (p<.05) proportion of the variance for the number of trials required to complete the lessons. Data in this study supports this hypothesis.

**Hypothesis 2**

Degree of attention deficit accounts for a significant (p<.05) proportion of the variance on the number of trials required to complete
the lessons. Data in this study supports this hypothesis.

**Hypothesis 3**

Subjects with both attention and memory deficits will require significantly (p<.05) more trials to complete the lessons than will subjects with only memory impairment. Data generated in this study support this hypothesis.

Regression analysis showed that all three of these hypothesis were supported. Memory accounted for about .50 of the variance (R² = .49532, Adjusted R² = .46876, p<.05) in the number of trials required to complete the first two lessons. Regression analysis with attention as the independent variable demonstrated that attention accounted for about .32 of the variance (R² = .31709, Adjusted R² = .28115, p<.05) in the number of trials required to complete the first two lessons. Similar results were obtained when memory and attention were used as the independent variables in a multiple regression analysis. Beginning with memory it was determined that memory accounted for about .50 of the variance in trials to criteria on the two learning lessons. When attention was added there was not a significant increase in the amount of variance (R² = .49591, Adjusted R² = .43990) accounted for in the number of trials to criteria for the two learning lessons. The change in R² when attention was added was .00059. This change was not significant (p<.05).

The results of these analyses show that the memory variable which provides the most information in explaining the number of trials to reach criteria for the two lessons. The greater the subjects memory impairment,
then generally the subject will require more trials to reach the criteria for the two lessons. Attention was also shown to provide information in explaining the number of trials to reach criteria for the two lessons. Attention explained less than memory but still provided significant information about a subject's performance.

When memory and attention were considered together in a multiple regression analysis, memory was demonstrated to explain most of the variance in trials to criteria. Memory and attention were shown to be significantly correlated (Pearson $r = .778$). This amount of correlation has the effect of reducing the magnitude of the regression coefficients when the variables are considered together. It further has the effect of appearing to provide contradictory information as to the contribution of the correlated variables. In this study, the memory and attention variables clearly contribute individual and separate information when each is considered alone. In the multiple regression analysis the contribution of attention appears to be significantly less. According to Pedhazur (1982), this is not contradictory. Pedhazur (1982) indicates that the test of $R^2$ in the regression analysis refers to the question of whether one or more regression coefficients are significantly different from zero against the hypothesis that all of them are equal to zero. The test of a single regression variable in the case of multiple regression refers to the question of whether it differs from zero, while partialing out all the other variables. Since the variables memory and attention are significantly correlated, partialing out their effects when they are
considered together is not possible. The results here reflect the correlation between memory and attention and indicate that memory as well as attention contribute to the criteria for number of trials. Attention in this case does not significantly contribute to information about the number of trials needed when information about memory is known. Attention did contribute to the subjects performance in much the same manner as memory. As attention decreases the number of trials required to reach criteria increases.

**Hypothesis 4**

Significant (p<.05) differences in the number of trials required to complete the lessons exists between subjects with progressive neurological disease and subjects whose attention and memory deficit etiology is traumatic brain injury. A statistical analysis between the AD and TBI groups was not possible in this study. Qualitatively it appeared that this hypothesis was supported in this study. In general, the TBI subjects were able to complete the lessons and progressed through each lesson with learning and retention demonstrated. The AD subjects also demonstrated learning and retention but required so many more trials that they were unable to complete the first lesson in the amount of time that the TBI subjects took to complete two lessons.

**Hypothesis 5**

Neither duration since injury nor sex account for a significant (p<.05) portion of the variance on the number of trials required to complete the lessons. The data in this support this hypothesis. The mean
duration since injury for the TBI subjects was 16 months. Duration since injury did not significantly correlate with trials to criteria ($r = .2380$, $p > .05$). Regression analysis showed that duration since injury accounted for less than .06 of the variance in trials to criteria for the two lessons ($R^2 = .05665$, Adjusted $R^2 = .00624$, $p > .05$).

Subject sex was not significantly correlated with trials to criteria for the lessons in this study ($r = -.2178$, $p > .05$). Regression analysis showed that subject sex accounted for less than .05 of the variance in trials to criteria for the two lessons ($R^2 = .04744$, Adjusted $R^2 = .00269$, $p > .05$). There was no significant difference between male and females in the number of trials required.

**Factor Analysis**

In addition to analyzing the data related to the hypothesis of this study a factor analysis, was performed to determine whether or not the independent variables would combine so as to identify memory and/or attention factors that could be used in predicting a subject's performance on the learning lessons. A principal components analysis with Varimax rotation was conducted with the independent variables. The factors generated were then used as the independent variables in regression and multiple regression procedures to determine the relative contribution of the factors in predicting subjects performance.

Two factors were extracted from the factor analysis. Table 6 shows the rotated factor matrix, sorted by the variables contributing to the factor. The variables that comprised the first factor included the WAIS-R
Performance IQ (PIQ) subscale which loaded the highest of any of the variables in the first factor. The next variable that had a high factor loading on the first factor was the WMS-R Delayed Recall subscale (WDR). The next variable, the Wisconsin Card Sorting Test (WCST) also had a high factor loading. The remaining variables of the first factor, WMS-R General Memory (WGM) and the WAIS-R Verbal IQ (VIQ) had factor loadings of a lesser magnitude than the first three mentioned. These factors also loaded on the second factor. As such these last two variables do not appear to be the contributing greatly to the distinction between the factors. The first factor appears to represent a general intelligence and memory factor as the variables contributing to the factor are most closely associated with memory and intelligence measures that were part of the neuropsychological test battery used in this study.

The variable that had the highest factor loading on the second factor was the Controlled Oral Word Associates Test (FAS). The variable with the next highest loading on the second factor was Digit Span (DS). The WMS-R Verbal Memory (WVM) subscale and the WSM-R Attention and Concentration (WAC) subscale also loaded on the second factor. The second factor appears to represent an attention factor as the variables contributing to the factor are most closely associated with attention measures that were part of the neuropsychological test battery used in this study.
Table 6. Rotated factor matrix, sorted by variables contributing to the factors.

<table>
<thead>
<tr>
<th>Variable</th>
<th>FACTOR 1</th>
<th>FACTOR 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance IQ</td>
<td>.90452</td>
<td>.16546</td>
</tr>
<tr>
<td>Wechsler Delayed Recall</td>
<td>.86642</td>
<td>.14914</td>
</tr>
<tr>
<td>Wisconsin Card Sort Test</td>
<td>-.76330</td>
<td>-.29803</td>
</tr>
<tr>
<td>Wechsler General Memory</td>
<td>.76132</td>
<td>.60051</td>
</tr>
<tr>
<td>Verbal IQ</td>
<td>.6725</td>
<td>.50302</td>
</tr>
<tr>
<td>Controlled Oral Word</td>
<td>.00163</td>
<td>.91872</td>
</tr>
<tr>
<td>Associates Test</td>
<td>.42436</td>
<td>.85725</td>
</tr>
<tr>
<td>Digit Span</td>
<td>.48577</td>
<td>.61816</td>
</tr>
<tr>
<td>Wechsler Verbal Memory</td>
<td>.51898</td>
<td>.58748</td>
</tr>
<tr>
<td>Wechsler Attention/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Regression analysis performed with the first factor showed that the first factor accounted for about .31 of the variance in number of trials required for completing the two lessons ($R^2 = .35812$, Adjusted $R^2 = .31277$, $p<.05$). Regression analysis performed with the second factor showed that the second factor accounted for about .13 of the variance in number of trials required for completing the two lessons ($R^2 = .19230$, Adjusted $R^2 = .13461$, $p>.05$).

Of the two factors, the first factor contributed a significant ($p<.05$) amount of the variance in the number of trials required to complete the lessons. The second factor did not contribute a significant amount of the variance in the number of trials required to complete the two lessons.
CHAPTER 5

SUMMARY, DISCUSSION AND CONCLUSIONS

This chapter presents a summary of the development and implementation of the study. The results presented in Chapter 4 are presented in relationship to the hypothesis postulated. Major findings of the study are reviewed and recommendations for future research are suggested.

Summary

Purpose

The purpose of this project was to determine whether degree of memory and/or attention impairment contributed to the subjects ability to learn and if it was possible to identify factors that assist in determining how many trials a subject might require to learn new information when the information is presented with the vanishing cues method. It was also the purpose of this project to determine whether or not individuals with Alzheimer's Disease who demonstrated memory impairment were able to demonstrate learning of new information with the method of vanishing cues.

Sample

The project represents a study of 19 adults who are memory impaired as a result of traumatic brain injury and Alzheimer's Disease. There were also four geriatric subjects who were not memory impaired used as controls.
for the AD subjects. The TBI subjects were all residents of a residential treatment program for brain injured adults. The subjects with AD were participants in a day-treatment program for the neurologically impaired elderly. The GC were all participants in a parks and recreation program for senior citizens. The involvement of all subjects was strictly voluntary.

**Procedure**

Subjects participated in learning sessions lasting from approximately 20 minutes to 90 minutes. Duration of each session was dependent upon the subjects desire and ability to remain in the lesson. The first session consisted of explaining the purpose of the study and asking the subjects about their background with computers. Subjects who demonstrated that they already knew any amount of the information contained in the learning lessons were disqualified from participation.

The subjects selected sat in front of an Apple IIE or Apple GS computer and responded to the vanishing cues learning lessons. The subjects continued the learning lessons until they achieved the criteria of requiring 1 or 0 hints for each of the learning lessons. The AD subjects did not complete any of the lessons. The TBI and GC subjects completed at least two of the lessons.

**Statistical Analysis**

Simple linear regression, multiple regression and factor analysis were applied to the data collected from the subjects. The simple regression was used to determine the relative effect of individual memory
and attention variables in accounting for variance in the number of trials required to complete the lessons. Multiple regression analysis was used to determine the combined effects of memory and attention variables in accounting for the variance in the number of trials required to complete the lessons. A factor analysis was performed to determine whether or not the various subtests of the neuropsychological test battery used in the test contained factors that may be useful in identifying subjects that are most likely to benefit from the use of the vanishing cue method.

Discussion

Only the TBI and GC subjects were included in any statistical analysis for reasons discussed previously. The data generated in the study support the hypothesis that degree of memory and attention deficit account for significant variance in the number of trials required to reach criteria on the learning lessons. Memory deficit was demonstrated to be the neuropsychological variable that contributed the greatest amount of variance in trials to criteria. Attention was also shown to contribute. When memory and attention variables were considered together, memory remained the variable that explained the greatest amount of variance. This was largely due to the fact that memory and attention as measured by WGM and WAC were found to be highly correlated in this study. The correlation between these two variables was significant and supported memory as the variable that contributes the most to performance within the learning lessons.

The GC subjects did not differ significantly from the TBI subjects
in the number of trials required to complete the two lessons. This result may be attributable to memory loss associated with normal ageing and its effect on learning. However, the sample size of the GC subjects (N=4) may have also contributed to this finding. Since there are no other examples of normal geriatric subjects with which to compare the GC subjects in this sample, the learning for this group is considered normal. Given the small number of subjects in the GC sample, it is difficult to accurately interpret this result and any comment as to the factors contributing to this result should be considered with caution.

The two AD subjects, who generated usable data, did not generate enough usable data with which to perform a meaningful statistical analysis. Therefore, the AD subjects results are interpreted in a qualitative rather than a quantitative manner. Results of the study support the hypothesis that significant differences in learning and retention exist between AD subjects and subjects with memory and attention deficits due to TBI. AD subjects were able to learn the information in the learning lessons but required far more trials to acquire the information. AD subjects were less able to remain on task for a given trial and also expressed a need to be close to the group. AD subjects required more encouragement regarding their performance and feedback regarding their performance was necessary for almost every concept introduced in a given lesson. AD subjects did not appear to possess nor did they express any apprehension regarding working with a computer.

Two features of AD subject #2's learning were of particular
interest. AD subject #2, whom completed the most trials, demonstrated a overgeneralization component to the information she had learned. Once she had learned the need for quotation marks for her name, she put quotation marks on every command. Directly telling her that the quotation marks were not necessary did not change her behavior. The other feature was her response when the computer would ask her to "PRINT WHAT?". "PRINT WHAT?" is a question used when the subject types a "PRINT" statement without a string variable. The subject would generally responded by typing "PRINT WHAT". She did not appear to understand that this was a question. Dealing with the consequences of these two features of her learning represented the majority of the hints she required in the latter trials.

The study supported the hypothesis that neither duration since injury nor sex of the subject account for a significant portion of the variance in trials required to criteria. All TBI subjects were at least 12 months post injury with one exception. The exception was 10 months post injury. One subject was approximately 5 years post injury and had had a second brain injury. In this study there was no significant correlations between the duration since a subject was first brain injured and their performance on the lessons. Sex of subject did not significantly contribute to their performance on the lessons. The sample was about equally distributed between males and females. The results of this hypotheses further support the hypothesis that neuropsychological deficits such as memory and attention determine performance on the learning lessons as opposed to demographic variables such as duration
since injury and sex of subject.

The factor analysis extracted two factors. The first factor appeared to be a memory and general intelligence factor, while the second factor could be interpreted as an attention factor. The factors extracted by the factor analysis did not appear to contribute information related to predicting a subject's performance that was more useful than the results of the regression analysis that used single memory and attention variables. In fact, the multiple regression analysis performed with individual memory and attention variables provided more information about a subject's performance than either of the factors. The factor analysis did support the other findings in this study that identify memory as the primary contributor to performance on the lessons, with attention appearing to have a somewhat less significant contribution. The multiple regression analysis that used the two factors showed that memory was the primary predictor variable for predicting performance on the lessons.

Conclusions

The conclusions drawn from this study are generally based on the results of the statistical analysis of the data. These statistical analyses were performed to test the specific hypotheses and were presented in Chapter 3. Some conclusions presented related to the AD subjects are based upon observation rather than statistical analysis. The following are some of the major conclusions and findings of the study:

1. All of the groups were capable of learning the information
presented in the lessons, including the AD subjects. The TBI group,
appeared to learn the information in spite of the particular combination
of memory and attention deficits present and in the presence of other
neuropsychological deficits. The AD subjects learned the information at
a significantly slower rate than the TBI group.

The geriatric control group in this study represents the first known
group of non-impaired elderly individuals to use the vanishing cues
method. It is not clear from the results of this study if the results
generated by the GC represents normal learning with elderly individuals.

2. AD subjects demonstrated the ability to acquire new information
of a novel nature with the method of vanishing cues. The amount of
information acquired by the AD was significantly less over a given amount
of time when compared to the other subjects in this study. However, there
is no reason to believe that given additional time the AD subjects would
not complete the lessons. This finding is consistent with other studies
(Camp, 1989) that have reported that AD subjects are capable of learning
new information. The methods of spaced retrieval and vanishing cues
however appear to be quite different. It appears from this study that
there is more than one way in which AD subjects learn.

3. Attention was demonstrated to be a factor in the acquisition of
the new information but remains less of a factor than memory and
intelligence. In this study, the definition of attention was limited to
the Digit Span results and the composite attention variable derived from
the Weschler Memory Scale-Revised. Digit Span has been shown to be intact
with memory impaired individuals. The type of attention measured by the Weschler Memory Scale-Revised may or may not be of the same nature as the theoretical attention types suggested by other authors (Sohlberg and Mateer, 1989). Therefore results of the attention deficits contributed in this study should be interpreted with caution.

4. The findings supported previous findings (Glisky and Schacter, 1988, 1989) in that for memory impaired groups the method of vanishing cues has been demonstrated to be effective in laboratory settings and in domain-specific vocational settings. Prior to this study, the method of vanishing cues had not been used in the context of an overall rehabilitation program where other therapies were occurring simultaneously that addressed other emotional and cognitive deficits. As such, this study contributes to the potential usefulness of the vanishing cues method with memory impaired individuals in a rehabilitation setting.

5. Duration since injury, and sex did not emerge as significant variables in accounting for performance on the learning lessons.

6. Results of the factor analysis performed in this study should be interpreted with caution. While the factor analysis tended to support the presence of memory and attention factors, the same results may not be generated by another sample. This is possibly a function of the sample size and or the configuration of the subjects within the sample. At this time that the most that can be said about the factor analysis results is that they are suggestive a general intelligence and memory factor and an attention factor. These factors do not, however, add predictive
information about a subject's performance over and above the information available when a subject's WGM and WAC scores are known.

**Implications for Future Research**

The first chapter of this study indicated that a primary purpose of the study was to identify the relative contribution of attention deficits and memory deficits in the learning of new, novel information regardless of etiology of the deficits and in the presence of other cognitive deficits. In an effort to further identify these contributions some recommendations for future research are summarized below.

1. In order to attempt build a predictive model, further research utilizing an increased sample size should be considered.

2. Further research is recommended with the AD individuals to determine if the finding of learning on the part of the AD subjects was unique to this study.

3. There is a need to generate domain-specific information to be taught to the subjects in both the day treatment and transitional living environments with related research efforts designed to evaluate the acquisition of new information of a domain-specific nature.

4. Use of a different configuration of independent variables for the factor analysis may add to the ability to interpret the pattern of factor loadings. Use of variables that are less correlated is suggested.
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