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**Implicit and explicit memory in Alzheimer's disease and  
Parkinson's disease**

**Bondi, Mark William, M.A.**

**The University of Arizona, 1989**

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**IMPLICIT AND EXPLICIT MEMORY IN  
ALZHEIMER'S DISEASE AND PARKINSON'S DISEASE**

by

**Mark William Bondi**

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**A Thesis Submitted to the Faculty of the  
DEPARTMENT OF PSYCHOLOGY  
In Partial Fulfillment of the Requirements  
For the Degree of  
MASTER OF ART  
In the Graduate College  
UNIVERSITY OF ARIZONA**

**1989**

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## ACKNOWLEDGMENTS

Works of art are of an infinite loneliness and with nothing to be so little reached as with criticism. Only love can grasp and hold and fairly judge them. --Rainer Maria Rilke

Although I do not consider this project so lofty as to be compared with a work of art, I am nevertheless indebted to the love and thoughtfulness of others, without whom this project would never have been completed.

I would first like to thank my thesis committee, Dr.s' Alfred W. Kaszniak, Ph.D., Daniel L. Schacter, Ph.D., and James R. Allender, Ph.D. for all their guidance and suggestions during the course of this study. I would also like to express my thanks and appreciation to the staff of the Memory Disorders Clinic of the University of Arizona Health Sciences Center, the Parkinson's Disease Support Group of the Geriatric Resource Center, Yavapai Regional Medical Center in Prescott, Arizona, and especially to Mrs. Anne McKinley, M.S.W. for all her help in securing volunteers for the study, coordinating the scheduling of subject appointments, and for sharing herself and her home with us. In addition, I would like to thank Mary Newman and Steven Shepard for their help in collecting data for this study.

Finally, I would like to thank my family and friends for the love and support they have given. It is you who have seen me through the best and the worst, and have stood by me with confidence. I hope this project serves as a testimony to what I have accomplished only through your love. And to Nadia, my wife and best friend, you have given more of yourself in immeasurable ways and made this all possible through your love and commitment. Thank you.

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## ABSTRACT

Several tasks examined explicit and implicit memory in matched samples of Alzheimer's (AD) and Parkinson's disease (PD) patients, and healthy elderly subjects. Lexical priming, pursuit-rotor tracking, and a fragmented pictures test, followed by explicit memory tests, were given. AD patients were impaired on all explicit tests and on lexical priming, but were intact on pursuit-rotor tracking and the procedural learning (PL) component of the fragmented pictures test. PD patients were significantly better than AD patients on all explicit memory tests, but were selectively impaired on the PL component of the fragmented pictures test. Finally, a mirror reading test was given to the PD patients and matched control subjects, with no significant differences in performance between the two groups demonstrated. Results are discussed in terms of hypothetical cognitive processes and brain circuits underlying different explicit and implicit memory domains.

## INTRODUCTION

Neuropsychologic studies of memory have shifted their theoretic assumptions in recent decades. No longer is memory thought of as mediated by a singly located, neuroanatomic center; nor is it thought of as a unitary process. These conclusions were borne out of research on normal subjects and on patients with memory disorders. A number of theoretical accounts of memory function now exist, each having their own explanatory power with a proportion of the data derived from this current research (see Schacter, 1987; Richardson-Klavehn & Bjork, 1988, for review). The predominant theme of the vast majority of theories now pertaining to memory function incorporate a dichotomous distinction. That is, memory is viewed as being composed of two or more hypothetical forms, or put another way, exhibited by two different types of testing procedures (see Squire, 1987, for a summary). On the one hand are tests that require the subject to remember a particular learning episode in order to extract the appropriate information to complete the task, such as tests of free-recall, cued-recall, and recognition. On the other hand are tests that reveal learning through improved performance--without requiring explicit reference to the episode(s) in which the information was encoded.

Instead of being asked to try to remember recently presented information, subjects are simply required to perform a task, such as completing a graphemic fragment of a word, indicating a preference for one of several stimuli, or reading mirror-inverted script; memory is revealed by a facilitation or change in task performance that is attributable to information acquired during a previous study episode. (Schacter, 1987, p. 501)

While there has been a great deal of evidence concerning the existence of these different forms of memory and testing, there has been much debate about how to classify and explain them in a theoretically sound framework. Examples of such classificatory schemes include Graf & Schacter's (1985) *explicit* versus *implicit* memory distinction, memory with and without awareness (Jacoby & Witherspoon, 1982), memories versus habits (Mishkin, Malamut, and Bachevalier, 1984), and *declarative* versus *procedural* memory (Cohen & Squire, 1980) to mention but a few. While a review of each and every one of these distinctions is beyond the

scope of this paper, the explicit/implicit and declarative/procedural memory distinctions are most germane to the current research.

Schacter (1987) describes implicit memory as being revealed by a facilitation or change in task performance that is attributable to information acquired during a previous study episode, and is outside of the subject's phenomenal awareness. Instead of being asked to specifically remember information, subjects are simply required to perform a task. Explicit memory refers to the conscious recollection of recently presented information or experiences. That is, a subject has an awareness of remembering a learning episode. In addition, explicit memory can be either *involuntary* or *intentional*: an intentional explicit memory refers to a conscious and effortful attempt to reconstruct or re-experience the contents of a learning episode, while an involuntary explicit memory is a spontaneous reconstruction or re-experience of that episode.

Cohen and Squire (1980) have described declarative memory as referring to the recall and recognition of facts, dates, ideas or other material acquired through learning. It is directly accessible to conscious recollection, and appears adapted for one-trial learning. In contrast, procedural memory is contained within skills or other modifiable cognitive operations. It is expressed as the ability to gradually acquire a specific motor, perceptual motor, perceptual pattern-analyzing, or cognitive skill through repeated exposure in that specific activity. This type of memory process is considered more automatic, not accessible to conscious awareness, and appears adapted for incremental learning.

### Theoretical Views of Preserved Learning Abilities in Amnesic Populations

Richardson-Klavehn and Bjork (1988) have designated three theoretical approaches taken in efforts to explain these diverse memory phenomena. The first, which they term an *abstractionist* position, views implicit memory as reflecting modifications in the state of abstract lexical, semantic, or procedural knowledge structures, and which views explicit memory as the formation and retrieval of memory traces representing specific experiences. The

second approach is a polar opposite, which is termed a *nonabstractionist* position. Proponents of this approach do not perceive a necessity of identifying various component “systems” or “forms” of memory. Rather, memory is understood by delineating processing operations at the time of encoding and retrieval. Finally, the third theoretical approach to account for implicit and explicit forms of memory is that of a *hybrid* position. This approach assumes that episodic memory traces can be accessed via implicit or explicit tests. As a result, explicit memory may or may not influence performance on implicit memory tests, based on the manner in which the information is accessed (see Richardson-Klavehn & Bjork, 1988, for discussion).

Proponents of abstractionist positions are predominantly neuroscientifically oriented, and utilize neuropsychological populations, such as amnesics, to demonstrate dissociations between implicit and explicit memory phenomena. The deficits exhibited with explicit tests in these populations are taken as evidence supporting impairment in the system responsible for memory of specific episodes. “In neuroscience, modularity of systems is the rule rather than the exception: If one accepts a straightforward relationship between brain systems and cognitive systems, the hypothesis of multiple memory systems is a logical extension of current knowledge” (Richardson-Klavehn, & Bjork, 1988, p. 485). Thus, it becomes obvious that the use of patient populations with organic impairments is crucial to link proposed brain systems with cognitive systems.

The declarative/procedural memory distinction is an example of a multiple memory system that arose from such a perspective. Declarative knowledge is presumed to be dependent upon intact neuronal circuitry in cortico-limbic-diencephalic structures. This hypothesis has been supported by the results of studies in both human and non-human primates where damage to the hippocampus and amygdala, or to the dorsomedial nucleus of the thalamus, interferes with the learning and retention of declarative types of knowledge. Procedural knowledge, on the other hand, does not appear to depend upon the brain structures damaged in amnesia. Further, because of the diversity of preserved learning abilities contained under the rubric of “procedural

memory” phenomena, it would not appear to depend upon any one structure or location. “One therefore should not expect that a single lesion would affect all of procedural memory, in the way that a lesion of, for example, the hippocampus can affect declarative memory” (Squire, 1987, p. 164). Nonetheless, recent proposals have been forwarded to hypothesize possible anatomical substrate(s) involved in procedural learning. Mishkin, Malamut, and Bachevalier (1984) suggested the cortico-striatal neuronal circuitry may play a role in what they termed *habits* (which is much akin to the procedural memory system). One example of the type of study motivated by this hypothesis was that of Martone, Butters, Payne, Becker, and Sax (1984). They compared patients with Huntington’s disease (HD), in which there is relatively circumscribed damage to the striatum, to those with Korsakoff’s syndrome (KS), who suffer damage to the dorso-medial thalamus and mamillary bodies. The HD patients were significantly worse at acquiring the procedural skills necessary to improve at a mirror reading task, while maintaining near-normal performance on the declarative task of word recognition. The KS patients exhibited the opposite results: impaired word recognition, but intact acquisition of the procedural task of mirror reading. Thus they demonstrated a double dissociation between these two hypothetical forms of memory.

Schacter (1987) has argued that the strength of this multiple memory systems view is that it provides a straightforward account of perceptual-motor skill learning in amnesics who lack conscious recollection of previous episodes. He cautions that its utility in explaining other implicit memory phenomenon is limited, however. For example, priming and skill learning, both considered to be procedural types of knowledge, can be dissociated experimentally (Butters, 1987): a double dissociation between Alzheimer’s Disease (AD) and Huntington’s Disease (HD) on verbal stem-completion priming and motor skill learning was observed. Patients with AD were impaired on verbal priming while retaining intact acquisition of motor skills. Patients with HD demonstrated the opposite results: normal verbal priming and severely impaired motor skill learning. Also,

amnesic patients can learn various types of factual information, yet do not explicitly remember having learned any facts . . . It does not seem reasonable to attribute implicit memory phenomena of this kind to a procedural system, since acquisition of factual knowledge is allegedly the responsibility of declarative memory. (Schacter, McAndrews, and Moscovitch, in press, p. 268)

The point is that implicit memory phenomena are too diverse to be attributed to a particular memory system that lacks the capacity for conscious remembering.

Richardson-Klavehn and Bjork (1988) further describe an adjunct to the abstractionist position, which is the process-oriented theoretical distinction between *activation* and *elaboration* (Graf & Mandler, 1984; and Mandler, et al., 1986). While maintaining neutrality with respect to the issue of memory systems, this position views activation as a result of preexisting mental representations being temporarily "activated." Elaboration is presumed to be necessary in order to retain new relationships and relate disparate stimuli to the context in which they were presented. That is, elaboration is predominantly necessary for explicit types of tests, whereas activation accounts for results from implicit tests such as priming.

Proponents of a *nonabstractionist* position (being predominantly cognitive psychologists) do not find it necessary to distinguish abstract representations of memory phenomena. Kolers and Roediger (1984), for example, take issue with the view of cognitive skill acquisition advocated by abstractionists (cf. Anderson, 1987; Cohen & Squire, 1980; Squire, 1987). In their account, abstractionists predominantly seek to represent behavior in a symbol system like that of computer programs. Indeed, the fundamental idea is to reduce knowledge to a set of propositions that can be entered into the appropriate simulation or program. In that way of theorizing a sharp contrast is made between knowledge and its processing, form or expression (i.e., declarative versus procedural knowledge). For Kolers and Roediger (1984), the contrast between declarative and procedural knowledge is not denied; rather the point is to accommodate declarative knowledge in operationalizable terms of actions. That is, procedures are actions that

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characterize a person's acquisition and use of knowledge; *all* of a person's capabilities can be accounted for in terms of skills or procedures. They argue that "knowledge is a matter of skill in operating on symbols, that the latter are of many kinds, that the kinds are not perfectly correlated, and that knowledge is, as a consequence, means dependent" (Kolers and Roediger, 1984, p. 430).

By means-dependent knowledge they are referring to the acquisition and processing of symbols as being part of an operation that is indivisible: acquiring a representation or the means exercised in doing so are part of what one knows about it. Source information regarding the stimulus is not relegated to be a superfluous aspect of the learning episode, but is shown to be a part of what the person knows (Kolers, 1978). Thus, skill learning is considered to be based upon the specific instances and procedures that led to the acquisition of that skill.

They further suggest that the specificity of learning and transfer can account for those findings of studies which concluded that the dissociation of skills is indicative of different memory "systems," such as the episodic, semantic and procedural memory systems, for example, espoused by Tulving (see Tulving, 1983, for discussion). Because the boundaries of tasks are not thought to be clear in differentiating these different memory systems, little is gained conceptually. "[W]e may anticipate the invention of still other dissociations encountered experimentally. . . It is not certain that much is gained by postulating independent 'systems' responsible for each sort of memory or dissociation" (Kolers and Roediger, 1984, p. 437). For example, readers of transformed text acquire particular skills due to the procedures a transformation activates, and transfer those skills to other transformations as particulars-- because the procedures are task-specific (Kolers and Perkins, 1975). The skill of reading transformed text is developed through memory for analyses of particular instances. It should also be emphasized that the memory for these operations do not have to be made available to conscious awareness (Kolers, 1976). In addition, implicit and explicit memory dissociations

are to be expected by the degree of overlap or similarity between processing operations at study and test, and the processing demands posed by each test..

Processing operations have been described by Jacoby (1983), and by Roediger and Blaxton (1987) as being *conceptually-driven* versus *data-driven*. It is thought that explicit tests rely more heavily upon conceptually-driven processes in an effort to reconstruct or organize prior learning episodes, whereas implicit tests presumably rely upon data-driven processes, which are guided by the information or “data” itself. Implicit and explicit dissociations are thus expected by the manner in which information is initially encoded.

The explanatory power of this theoretical account of implicit memory phenomena has its respective strengths and weaknesses also, as does the abstractionist position (see Schacter, 1987, for discussion). The conceptual- versus the data-driven processing view has trouble with the “findings on short-lived activations, dependence of some priming effects on preexisting representations in amnesic patients, and differences between priming of new and old representations in normals (cf. Feustal, et al., 1983; Schacter & Graf, 1986a)” (Schacter, 1987, p. 512).

### Background

Both the explicit/implicit and declarative/procedural memory distinctions have relied heavily upon neuropsychologic patient groups in efforts to demonstrate dissociations between these respective forms of memory. As Schacter (1987) points out, most modern implicit memory studies utilizing neuropsychologic populations can be classified into two broad categories: research on skill learning and repetition priming.

Skill Learning. The declarative/procedural distinction, for instance, originally arose in the literature on artificial intelligence (cf., Winograd, 1975), and was later adopted to describe the dissociable memory processes investigators (e.g., Cohen & Squire, 1980) were observing in human patients with amnesia due to neurological injury or disease; observations predominantly

in the realm of skill learning. Various disorders cause amnesic symptomatology, including Korsakoff's syndrome, postencephalic syndromes, bilateral medial temporal lobe excision, hypoxic ischemia, posterior cerebral artery occlusion and other cerebral vascular accidents, Alzheimer's disease, and bilateral ECT (see Squire & Cohen, 1984, for review). Despite the amnesics' striking inability to retain or remember recent experiences, they nevertheless demonstrated a variety of preserved learning abilities on certain types of memory tests. Namely, amnesics showed a preserved ability to acquire and retain motor, perceptual and problem-solving skills, despite (1) abnormally poor memory for the learning episodes, and (2) impaired memory-test performance for the data-based knowledge or facts normally accumulated in using the skills.

One of the earliest documented historical examples is taken from anecdotal evidence of skill acquisition in organic amnesia reported by Dunn (1845). He described a woman who had learned to make dresses after becoming amnesic due to a near-drowning incident. She made dresses despite having no explicit memories for doing so. "She applied herself closely to her new occupation and abandoned altogether the old one. Still she had no recollection from day to day what she had done, and every morning began something new unless her unfinished work was placed before her (Dunn, 1845, p. 588)" (quoted from Schacter, 1987, p. 503). Another example is taken from the Swiss neurologist Claparede (1911) involving a Korsakoff's syndrome patient. When meeting this individual, Claparede pricked the patient's hand with a hidden pin while shaking her hand. On a subsequent occasion, he put out his hand again for her to shake, and she withdrew it. When asked why she withdrew her hand, she replied "Sometimes pins are hidden in hands" (quoted from Weiskrantz, 1978). Claparede commented that the woman never recognized the idea of pricking as a memory she acquired in association with him.

Brenda Milner (1962) instigated formal neuropsychological research on skill learning in organic amnesia. The noted amnesic patient H.M. exhibited a preserved learning ability,

despite his dense amnesic disorder. The cause of H.M.'s severe amnesia occurred as a consequence of bilateral damage to the medial temporal lobe region following surgical resection in an attempt to alleviate his violent seizures. H.M. demonstrated that he could learn a mirror-tracing task, and improve his performance across three days of testing. He was required to trace a star (which was attached to a board) from reversed and inverted visual cues provided by a mirror. A metal shield prevented him from looking directly at his hand or the pattern, and it did not interfere with his hand and arm movements. He reduced his error score, becoming more accurate with the task, and similarly reduced the time required to complete the task. He did all this without any conscious recollection or awareness of his accumulated experience with the task. Corkin (1965) extended this line of research, again with H.M., demonstrating a preserved ability to improve on a tactual maze. H.M. decreased the time required to complete successive trials of a 10-choice tactual maze, despite his inability to learn the correct sequences of turns in eighty trials. His performance, however, was below that of normal subjects (Corkin, 1968). H.M. also demonstrated a preserved ability to acquire and retain perceptual-motor skills, such as pursuit-rotor tracking and bimanual tracking. On each of these tasks, H.M. increased his time on target across seven days of testing. Again, although he was slower in comparison to normal subjects, he improved his performance from session to session and maintained that level of performance after a one week delay.

Following the preliminary studies of Milner (1962) and Corkin (1965, 1968), additional studies have subsequently demonstrated preserved perceptual-motor skills in a variety of amnesic populations. These preserved perceptual-motor abilities have been observed in alcoholic Korsakoff's syndrome (Brooks & Baddeley, 1976; Cermak, Lewis, Butters, & Goodglass, 1973), postencephalitic patients (Brooks & Baddeley, 1976), bilateral electroconvulsive therapy patients (Cohen, 1981), bilateral frontal ablation (Eslinger & Damasio, 1985), and Alzheimer's disease (Butters, 1987; and Eslinger & Damasio, 1986). Brooks and Baddeley (1976), for example, demonstrated that amnesic patients produced a

reliable reduction in the time required to complete the Porteus visual maze and a 12-piece jigsaw puzzle. When retested on each of these tasks one week later, they exhibited good retention of the previously acquired abilities. Patient populations unable to improve their performance on perceptual-motor skills such as rotary pursuit tracking have included Huntington's disease patients (Butters, 1987), and Parkinson's disease patients with dementia (Heindel, Salmon, Butters, & Shults, 1988).

Amnesics have also exhibited additional types of preserved learning abilities, extending them into the domain of perceptual and cognitive skills, such as the puzzle solving task of Brooks and Baddeley (1976), rule learning (Kinsbourne & Wood, 1975), and learning to identify geometrically transformed script (Cohen & Squire, 1980; Moscovitch, Winocur, & McLachlan, 1986). Kinsbourne and Wood (1975), for example, demonstrated with Korsakoff's syndrome patients the ability to learn a specific cognitive rule. They predicted, through the use of the rule, successive numbers in different examples of a Fibonacci number series. After a 17-week interval they were retested, and demonstrated retention of the rule. Cohen and Squire (1980) demonstrated with a heterogeneous group of amnesics (the patient N.A., five patients with Korsakoff's syndrome, and three patients receiving bilateral ECT) a preserved ability to improve performance across three days of testing in reading mirror-inverted script. Subjects viewed triads of eight- to ten-letter low frequency words presented in mirror-reversed form. Five blocks of 10 word triads were read on each of three consecutive days of testing, and additionally on a fourth day some 13 weeks later. For each of the blocks, half of the triads were repeated, and half were non-repeated (or new) words. "By analyzing separately the time required to read each nonrepeated and repeated word triad, it was possible to evaluate the ability to acquire the operations or procedures necessary for mirror reading, as well as the ability to benefit from frequent repetition of specific words." (Squire & Cohen, 1984, p. 30). They concluded that amnesic patients acquired a general skill of reading mirror-reversed word triplets as quickly as normal subjects. The amnesic subjects, however, failed to demonstrate

the repeated-word advantage that control subjects demonstrated, thus they interpreted that amnesics were poor at remembering which words they had read. However, the amnesic subjects did read the repeated words faster than new words, but these results were not thought to be of significance. They interpreted the results as suggesting a preserved learning capacity within the domain of procedural memory, but an impaired declarative memory in amnesia.

They proposed that the cognitive skills involved in reading inverted script "belong to a class of operations governed by rules or procedures; these operations have information-processing and memory characteristics different from those operations that depend on specific, declarative, data-based material" (Cohen and Squire, 1980, p. 209). The procedural memory system, according to their view, permits the acquisition and expression of knowledge that guides performance without allowing or requiring conscious recollection. Declarative and procedural knowledge are thus thought to differ in their organization biologically. Differences exist in what kind of information is stored, how it is utilized, and what neural systems are required (Squire, 1987).

The point of this perspective is that one wants to know how the brain itself actually stores information. One wants to find a level of analysis for describing brain function that is biologically useful. This is necessarily an empirical question, not a philosophical debate about how to classify knowledge. Experimental work suggests that the nervous system recognizes a distinction between two kinds of memory processes or systems. (Squire, 1987, p. 160)

Thus, these authors interpret the preservation of skill learning and other preserved abilities (i.e., priming) in amnesic patients who exhibit impairments in explicit remembering, as supporting the hypothesis that a fundamental distinction exists between at least two different kinds of knowledge and the memory systems supporting them.

Of relevance to the conclusions drawn by Cohen and Squire (1980) is a recent study conducted by Masson (1986) concerning the nature of skill acquisition in normal subjects through the use of typographically transformed words. The first hypothesis proposed the acquisition of a general skill independent of the specific instances of training (cf., Squire and

Cohen, 1980), while the other posited that skill acquisition is based on memory for the specific instances encountered during the training (cf., Kolers and Roediger, 1984). By exploring the pattern of the transfer of training, he determined the nature of the skill acquired as a result of reading transformed words. That is, if subjects acquired a general skill, they should be able to apply this skill to all words, including those not encountered in the initial training. If, on the other hand, skill was based on memory for the analysis of specific words encountered during training, transfer of word identification skill to new words would depend on the similarity between those two sets of words. Also, no transfer of training should be observed if new words consist of visual patterns (e.g., letters) that were not experienced during training.

The first experiment involved a training phase that consisted of constructing typographically transformed words from only 13 letters of the alphabet, and a test phase in which three kinds of items were presented: (1) words read during training, (2) new words formed from the same 13 letters used during training, and (3) new words based on letters not experienced during training. The main findings of the experiment were that word identification of typographically transformed words exhibited improvement with a high degree of specificity, but that this skill did not transfer to new words consisting of letters that had not previously been seen in the transformed typography. "The specificity of the transfer observed here violates a fundamental aspect of the general skill view of learning to read typographically transformed words: that the skill is not based on memory for the specific examples used during training (cf. Cohen and Squire, 1980)" (Masson, 1986, p. 482). Subjects presumably remembered the visual pattern and conceptual analysis operations applied to training instances. Masson further emphasized that subjects need not be able to consciously remember these operations in order for them to be carried out. Subsequent analyses demonstrated the highly constrained nature of transfer effects with the transformed text. Finally, Masson (1986) emphasized that the instance-based view of skill acquisition provides an interpretive framework for domains other than word identification (e.f., grammar learning, perceptual and motor skill

development). The emphasis of this approach is on memory for specific training episodes and patterns of skill transfer that can be generated from them (cf. Kolers & Roediger, 1984). For example,

with respect to skill learning among amnesics (e.g., Squire and Cohen, 1984), development of fluent identification of mirror image words strongly suggests the existence of memory (apparently not consciously accessible) for analysis of specific training items. According to this view, there is some question about the utility of the procedural/declarative distinction as a characterization of the amnesic syndrome; it does not seem appropriate to argue that skill learning among amnesics is based on the preservation of a form of memory that is independent of specific episodes experienced during training. (Masson, 1986, p. 487)

Recent studies of skill learning in amnesia have similarly focused upon whether amnesics can acquire item-specific information. Evidence was forwarded initially by Brooks and Baddeley (1976). They demonstrated that amnesics improved their time required to solve a jigsaw puzzle on a subsequent trial, but did not do so with new puzzles. Moscovitch, Winocur, and McLachlan (1986) have argued that the presumed inability of some amnesics to acquire item-specific information, such as poorer performance in comparison to normals on repeated items of mirror-inverted script (i.e., Cohen and Squire, 1980), may be due more to the normal person's ability to utilize a recall strategy than a decrement in the amnesic's ability to acquire item-specific information, *per se*. That is, implicit tests of memory, such as reading, may have been contaminated by explicit recollection in normal subjects. Thus, Moscovitch et al. examined whether amnesics could, in fact, acquire item-specific information, using an easier-reading script transformation--thereby reducing time for recollection to occur. Also, they increased the delay interval. By making these changes, they hoped that reading time (the implicit measure of memory) would be far less contaminated by conscious recollection of studied items (cf. Cohen and Squire, 1980). Subjects were required to read each sentence aloud as fast as possible, and also to state if it was a new or old sentence. They reported that subjects acquired a general skill of reading transformed script, indicated by faster reading of new sentences than the average sentence in the initial session. However, they also

demonstrated that amnesic patients acquired and retained item-specific information about the transformed sentences: all groups read repeated, old sentences faster than new ones, while only the amnesics' were severely impaired on recognition.

Next, they utilized a degraded script to examine whether item-specific information could be acquired at a rate comparable to normals, and if so, could the information be obtained after only a single trial. Also, changing the local verbal context of the words (e.g., changing old items into recombined items) was done to determine if amnesics preserved learning abilities were sensitive to local, contextual manipulations. All the subjects, young and elderly normal, and amnesics read old sentences faster than either new or recombined sentences. The results supported the notion that under the appropriate testing conditions, amnesics memory is sensitive to local verbal context. Recombined items were read significantly more slowly than old items. Further, the advantage of normal over amnesic populations on implicit measures of memory was eliminated when the experimental paradigm restricted the use of conscious recollection. Amnesics also exhibited formation and retention of new associations between randomly paired words, in a single trial--as indexed by improved reading time. Thus, the conclusions of this experiment are:

1. Memory-disordered patients are capable of acquiring item-specific information, not just general rules or procedures.
2. A single trial is often sufficient to acquire new item-specific information that can influence later performance.
3. The memory-disordered patient is capable of forming and retaining new associations between previously unrelated materials and not merely strengthening or reactivating previously formed associations. (Moscovitch, et al., 1986, p. 343)

Amnesics have also recently demonstrated acquisition of other complex cognitive skills, further widening the domain of preserved abilities. Charness, Milberg, and Alexander (1988) reported that a patient with Korsakoff's syndrome acquired the ability to learn an algorithm for squaring two digit numbers mentally over a 7 day period, at a rate comparable to that of age-matched controls. In spite of being able to implement the algorithm successfully, the patient

was unable to articulate how he had learned the skill. These results are, however, in contrast with those of Moscovitch, et al. (1986), as it appears that the Korsakoff's amnesic failed to learn item-specific information in the algorithm: he failed to do better on old problems in comparison to new problems.

Charness, et al. focused upon the use of Anderson's (1987) ACT\* (Adaptive Control of Thought) theory of skill acquisition in formulating an explanation of the preserved and impaired learning abilities of their amnesic patient. Briefly, in the ACT\* theory, knowledge is thought to come in declarative form. It is then used to generate solutions, and knowledge becomes compiled to form new skills. The key step is the knowledge compilation process, which produces the domain-specific skill (Anderson, 1987).

Knowledge compilation involves the gradual process in which knowledge is converted from the declarative to the procedural form. With practice the knowledge is directly applied without the intercession of other interpretive procedures. The building up of procedures to perform specific tasks, thus produces a great deal of efficiency in terms of time and working memory demands. "One feature of this knowledge compilation process is that it predicts a marked improvement from a first to a second problem of the same kind" (Anderson, 1987, p. 195). Knowledge compilation is divided into two distinct subcomponents: proceduralization and composition. Proceduralization builds versions of the productions that no longer require the domain-specific declarative information to be retrieved into working memory. Rather, the essential products of these retrieval operations are built into the new productions. In other words, proceduralization eliminates the reference to certain declarative facts by building into productions the effect of that reference. Composition is a process that takes sequences of productions that follow each other and collapses them into a single production that has the effect of those sequences. That is, composition collapses several productions into one. This new complex production can apply and perform in less time the actions that earlier required more productions.

Charness, et al. (1988) suggest that skill acquisition requires a number of different component processes, and that composition and proceduralization would provide explanatory power in describing the pattern of results obtained from the Korsakoff's syndrome patient. Campbell (cited in Charness, et al., in press) has stated that skill acquisition of the algorithm within their study appears to involve two phases: (1) it must be interpreted in a step by step fashion in working memory, and (2) later the steps appear to become "compiled." The knowledge compilation step is the focus of this experiment, in which composition and proceduralization are both subcomponents.

It is of interest to see whether these two facets, 'composition' and 'proceduralization,' can be dissociated. There is already evidence in the literature that proceduralization occurs abnormally slowly for amnesics. Even when amnesics are able to learn a new task at a normal rate, such as reading inverted print, they fail to show equivalent improved performance on specific repeated words (Cohen & Squire, 1980). (Charness, et al, 1988, p. 7)

Thus, they proceeded to determine if these two subcomponents of the knowledge compilation process could be dissociated with the Korsakoff's syndrome patient. They demonstrated that the amnesic did not show improvement on practiced, specific (OLD) problems, in comparison to unpracticed, transfer (NEW) problems. Normal controls did perform better on the old problems. That is, the control subjects showed an advantage on those specific problems that were practiced. The amnesic, however, failed to show such an advantage.

These results appeared to be at odds with those obtained by Moscovitch, et al., (1986). Charness, et al. commented that the contrast between the two experiments is possibly due to the nature of the tasks involved: preserved or learned abilities in amnesics appears to depend upon task-specific variables (p. 23). However, Charness, et al. do not address the argument put forward by Moscovitch, et al. with regard to the potential contamination of the implicit measures by explicit recollection. "The advantage normal people have over amnesics in reading repeated items may be due to the normal person's ability to use a recall strategy" (Moscovitch, et al., 1986, p. 332), as in the Cohen and Squire (1980) study. The same

strategy is very possible within the Charness, et al. paradigm also. Normal subjects performed these operations over 6 consecutive days of testing, and may have benefited from explicit recollections of practiced problems, in comparison to the amnesic patient, who had no such explicit recall strategy to utilize. Indeed, this possibility is buttressed when examining that the amnesic patient was nominally faster on the transfer set, suggesting that the normal subjects experienced some interference, or negative transfer from the practice set. Finally, the possibility of explicit contamination on the implicit measures by normal subjects may have contributed to the observed differences throughout the operations in response latencies. The amnesic patient was consistently slower than normals in his response latency to problems. When Moscovitch, et al. accommodated for the potential explicit contamination by modifying their paradigm, this observed difference in response latencies between amnesic and normal subjects disappeared.

Another example of complex cognitive skill acquisition involves a preserved ability to acquire the cognitive skills necessary to induce the continuation of a Fibonacci number series as demonstrated in amnesics by Wood, Ebert, and Kinsbourne (1982). Also, Glisky, Schacter, and Tulving (1986) demonstrated the acquisition, in an amnesic patient, of knowledge to operate, program, and interact with a microcomputer. A densely amnesic patient could learn to write programs, edit them, and use disk storage and retrieval mechanisms. Finally, Nissen and Bullemer (1987) reported on the use of a serial learning task in which subjects were exposed to a spatial array of lights and simply had to press a key corresponding to the light when it was activated. They discovered that when the lights were flashed according to a repeated serial pattern, both the amnesic and control subjects responded faster than when a random pattern of lights was flashed. The amnesic patients learned this task at a normal rate, despite being severely impaired on explicit recall of the repeating serial pattern. That is, when asked to remember the sequence of the repeated serial pattern of lights, amnesics could not recall any such pattern.

Schacter, et al. (in press) has argued that implicit memory for newly acquired associations, as in the serial learning (Nissen and Bullemer, 1987) and reading tests (Moscovitch, et al., 1986) could be interpreted as indicating that these patients have implicit access to contextual information, but cannot gain explicit access to it; or that different types of contextual information are required for implicit and explicit memory of new associations. Further studies will be needed to test such hypotheses, in addition to specifying those exact conditions under which implicit memory for new associations will occur.

Priming. In addition to the preserved learning abilities in the domain of perceptual-motor, perceptual and cognitive skills, another type of learning ability preserved in amnesics is that of “priming.” Repetition priming, for example, is one class of general priming tasks that facilitate the current processing of material by prior exposure to the stimulus materials. This processing can occur automatically, outside of conscious or effortful control, and is maintained even when subjects cannot recall or recognize the stimulus materials. Much of this recent priming work has stemmed from paradigms developed within cognitive psychology (Schacter, 1987), and applied to amnesic populations. A plethora of tasks have been developed to demonstrate priming phenomena, including lexical decision, word identification, word stem or fragment completion, reading of transformed script, face identification, free association, and tachistoscopic or perceptual identification (see Schacter, 1987, for review).

Early examples of priming with amnesics were observed by Warrington and Weiskrantz (1968, 1974) when they demonstrated the ability to identify fragmented pictures and words with greater accuracy upon retesting with the same materials, despite having poor memory for previously viewing the stimulus materials. With word stems also, amnesics were more accurate in completions with previously exposed stimulus materials, again, despite poor recognition memory for the stimulus items.

More recent work with amnesic populations has demonstrated robust examples of learning utilizing priming tasks. However, it is also clear that the nature of the instructions of a given

test determine whether or not amnesics exhibit the facilitatory effects provided by the priming. For example, Graf, Squire, and Mandler (1984) showed that amnesics were impaired in comparison to control subjects when three-letter cues were given to help them remember the previously presented study words. When asked to complete the stems with the first word that comes to mind, however, amnesics demonstrated comparable levels of priming to that of the normal subjects. Similar examples have been obtained using common idioms (Schacter, 1985), and highly related word pairs (Shimamura, & Squire, 1984).

Finally, with respect to priming phenomena, studies have demonstrated contrasting results, showing that amnesics both can and cannot form new associations depending on the type of priming task employed. Schacter and Graf (1986), for instance, found that mild amnesics were able to form new associations for unrelated words, but severe amnesics were not. Formation of new associations in amnesics has been demonstrated elsewhere also (e.g., Moscovitch, et al., 1986; and McAndrews, Glisky, & Schacter, 1988). Examples of amnesics inability to retain novel information has been reported by Cermak, Talbot, Chandler, & Wolbarst (1985), who found that amnesics do not show priming of nonwords on a perceptual identification task, and by Diamond and Rozin (1984), who showed similar results with a word-stem task. As Schacter (1987) points out, the theoretical view of activation accounts well for the findings of Diamond and Rozin, and Cermak, et al. Activation accounts well for the priming effects of words with preexisting representations or knowledge structures (i.e., familiar words, idioms or high associates) and the lack of priming effects with nonwords, because of no preexisting representations. It has greater difficulty, however, with the results of Schacter and Graf and Moscovitch, et al., in which there is evidence of some dependence on elaborative processing--at least with mild-to-moderately amnesic patients.

Salmon, Shimamura, Butters, & Smith (1988) demonstrated, with a number of different amnesic populations including Alzheimer's disease (AD), Korsakoff's syndrome, and Huntington's disease, a selective deficit in AD patients on lexical and semantic priming tasks.

They concluded that the memory capacities of AD patients are characterized by a breakdown in the structure of semantic memory. AD involved a deficiency in activating preexisting representations (i.e., word associates) stored in semantic memory. Not only was this impairment evident with the explicit tests of memory, but also with the implicit tests (e.g., lexical and semantic priming). Another study conducted by Nebes, Martin, and Horn (1984) found just the opposite: AD patients demonstrated impairment only on more “effortful” memory tasks, such as tests of recall or recognition. On tasks that require more “automatic” processing (i.e., priming), they found evidence leading them to conclude that AD patients’ semantic memory is normal.

In sum, amnesic populations have demonstrated a variety of preserved learning abilities in the domains of perceptual, perceptual-motor, and cognitive skills, as well as in priming phenomena. Thus, a logical extension from the results obtained with amnesics would be to explore additional clinical populations with relatively selective neuroanatomic damage; such populations provide an additional means to examine potential dissociations both between and within explicit and implicit forms of learning, in addition to addressing some of the inconsistent results, especially with respect to priming phenomena.

#### The Suitability of Alzheimer’s Disease and Parkinson’s Disease Patients for Implicit Memory Investigations

Persons suffering from Parkinson’s disease (PD), and those with Alzheimer’s disease (AD), are of particular interest for such investigation. In PD patients, there is a marked degeneration and loss of pigmented dopaminergic cells located in the substantia nigra (and to a lesser extent in the locus ceruleus). These cells send projections to the striatum, which is a structure thought to be functionally dependent upon intact substantia nigral production of dopamine. Also, in PD patients without evidence of dementia, the neocortex and limbic structures are relatively spared (see Marsden, 1982; Passafiume, Boller, & Keefe, 1986, for

review). By contrast, in AD patients without extrapyramidal symptoms, the striatum appears to be undamaged, whereas the neocortex and limbic structures are compromised. In AD patients, microscopic neuritic plaques and neurofibrillary tangles occur in disproportionately greater amounts than in age-matched nondemented individuals. The plaques and tangles are particularly abundant in the neocortex and hippocampal bodies. The pattern of their distribution in the hippocampal bodies suggests isolation from input and output of neuronal activity to and from the cortical regions, and probably contributes to the memory deficits as a result (Hyman, VanHoesen, Damasio, & Barnes, 1984). Primary sensory and motor areas of the neocortex appear to be relatively spared. Other pathologic features include brain atrophy, reduced acetylcholine, and reduced metabolic activity (see Kaszniak, 1986, for review).

Despite these apparent differences in neuropathologic features, it should be noted that there is some controversy over the potential for overlap between AD and PD. This is suggested by the observation of a greater proportion of neuritic plaques and neurofibrillary tangles found in PD than would be expected in a population of similar age (Hakim & Mathieson, 1979). Similarly, there is some evidence of an increased incidence of dementia in PD patients (Boller, 1983; Brown & Marsden, 1984). Careful examination of the cognitive abilities of people affected by these diseases is therefore desired in an effort to establish similarities or differences that exist between AD and PD. For example, to what extent does the dementia in PD overlap with the cognitive profiles of performance in AD patients; are their profiles similar or are there fundamental differences? As Sahakian, et al. (1988) indicate, detailed comparisons of the cognitive profiles of these two disease populations is warranted, but have rarely been performed within the same study (Sagar, 1984; Sagar, et al., 1985; El-Awar, et al., 1987). Further, because of the proposed role of the striatum in procedural learning (Mishkin, et al., 1984), the selective neuropathologic features associated with AD and PD offer unique "experiments of nature" with which to compare performance on implicit memory tests, such as skill learning and priming, to those of explicit memory. Indeed, there are a number of possible

comparisons that could be made between AD and PD: (1) comparing nondemented PD patients with AD patients free of extrapyramidal symptoms for implicit/explicit and implicit/implicit task dissociations, (2) comparing demented PD patients both with AD patients free of extrapyramidal symptoms and with AD patients exhibiting extrapyramidal symptoms.

Previous research utilizing PD patients has demonstrated circumscribed deficits in cognitive functions, often being manifest on those tasks thought to be sensitive to the integrity of the frontal lobes (Lees & Smith, 1983; Taylor, Saint-Cyr, & Lang, 1986). Taylor and colleagues have borrowed proposals from neuroscience and adopted a functional/anatomic hypothesis concerning semi-closed neuronal circuitry loops between basal ganglia and frontal cortical areas to explain such "frontal-like" deficits in PD. DeLong and Georgopoulos (1981) and DeLong, et al. (1983) first proposed the concept of "motor" and "complex" loops existing between basal ganglia and frontal cortex.

The motor loop, as the name implies, controls the parameters of movement. Diverse cortical influences arising from the supplementary motor area, arcuate premotor area, motor and somatosensory cortex send projections to the putamen. The putamen in turn sends topographically organized projections to the ventrolateral two-thirds of both the internal and external segments of the globus pallidus, and to caudolateral portions of the substantia nigra. The pallidum continues by correspondingly sending its projections to the ventrolateral nucleus of the thalamus, which projects back to supplementary motor cortex--thereby creating the closed loop (see DeLong, et al, 1983, for review).

A separate "complex" loop is thought to transmit information through basal ganglia to granular frontal association areas thought to be involved in more purely mental operations. Alexander, et al. (1986) reappraised this proposal, and found that there were at least two distinct basal ganglia-thalamocortical circuits that selectively influence separate prefrontal areas. The first circuit they termed the dorsolateral prefrontal circuit. Corticostriate projections arising from dorsolateral frontal cortex, the posterior parietal cortex and the arcuate premotor area

terminate within the dorsolateral head of the caudate nucleus and throughout a continuous rostrocaudal expanse that extends to the tail of the caudate. Rostral portions of the caudate nucleus in turn project to the dorsomedial globus pallidus and to rostral portions of the substantia nigra. The pallidal segment projects to the ventral anterior nucleus of the thalamus, while the substantia nigra has been shown to project to the dorsomedial nucleus of the thalamus. These in turn project back to dorsolateral prefrontal cortex. While Alexander and colleagues do not attribute any functional characteristics to this circuit, they do state that evidence from lesioning and single-cell recording studies suggest that “this system may participate in processes subserving spatial memory” (Alexander, et al., 1986, p. 371).

The second circuit is termed the lateral orbitofrontal circuit. The ventromedial sector of the caudate nucleus receives projections arising from the lateral orbitofrontal cortex, and the superior and inferior temporal gyri. The caudate then projects to dorsomedial portions of the internal pallidal segment, and to rostromedial substantia nigra. It is the nigral projections that lead to the medial parts of the ventral anterior and to the dorsomedial nuclei of the thalamus, and in turn project back to the lateral orbitofrontal cortex. Again, no functional characterization of this circuit has been established. Alexander, et al. (1986) mention, however, that bilateral lesions in primates restricted to the lateral orbitofrontal cortex or the portion of caudate projecting to it “result in a perseverative interference with an animal’s capacity to make appropriate switches in a behavioral set (Divac, et al., 1967; Mishkin & Manning, 1978)” (Alexander, et al., 1986, p. 371).

Taylor, et al. (1986) were among the first investigators to reference these basal ganglia-thalamocortical circuit loops to hypothesize that cognitive deficits in PD would occur as a consequence of disturbed caudate outflow. These deficits reflected an impairment in the ability to spontaneously generate efficient strategies when relying on self-directed task-specific planning. Since the prefrontal cortex is presumed to play an important role in self-directed behavioral planning, these investigators concluded that the validity of a neostriatal outflow

model in predicting the consequences of caudate nucleus dysfunction was supported. Most recently, Saint-Cyr, Taylor, and Lang (1988) have extended this line of reasoning to the domain of procedural learning. They argue that cognitive procedural learning depends on the establishment of heuristic strategies through the action of a circuit which involves the neostriatum and the prefrontal cortex (e.g., the “complex” loop). Saint-Cyr, et al. (1988) constructed a modified version of the Tower of Hanoi puzzle. Because the cognitively complex puzzle was not considered appropriate to clearly demonstrate differential ability in cognitive procedural learning in pathologically distinct patient groups (i.e., Butters, Wolfe, Granholm, & Martone, 1985), they developed “an experimental strategy which would depend exclusively on practice for mastery without over-reaching the problem-solving resources of the patient groups selected” (Saint-Cyr, et al., 1988, p. 943). Thus, a simplified variant of the Tower of Hanoi puzzle was constructed, which they so named the “Tower of Toronto.” They utilized PD patients in the early stages, deciding they were the best available model of regional basal ganglia dysfunction with which to address the “complex” loop circuit hypothesis. Because the pathophysiology of PD involves both disturbed caudate nucleus outflow and reduced availability of dopamine in the lateral convexity of the prefrontal regions (Scatton, Rouquier, Javoy-Agid, and Agid, 1982), Saint-Cyr, et al. concluded that the prefrontal component of the “complex” loop is placed in double jeopardy in PD. Also, amnesic patients with no prerolandic damage were selected, as well as Huntington’s disease (HD) patients in order to permit comparison with previous studies. The results demonstrated that the PD patients and early HD patients were selectively impaired in procedural learning, whereas the amnesic patients were not. In contrast, the PD patients and some of the HD patients exhibited intact recall and recognition, whereas the amnesics did not, thus illustrating a double dissociation.

Adopting a functional/anatomical hypothesis, findings were interpreted as evidence that transmission of error signals, originating in the caudate and fed back to the dorsolateral cortex by thalamic relay, affect certain frontal-sensitive

functions selectively. In this regard it was notable that PD patients could not perform novel problem-solving tasks efficiently unless provided with cues from the structured familiar knowledge base or explicit guidelines to follow. (Saint-Cyr, et al., 1988, p. 953)

The present investigation combines analyses of the hypothetical “complex” loops (i.e., Alexander, et al., 1986), and their role in frontal lobe dysfunction (Taylor, et al., 1986) with that of the proposed role of the striatum in the acquisition of procedural types of knowledge (i.e., Mishkin, et al., 1984) to examine the possibility of a selective deficit in PD on additional procedural learning tasks. The utilization of AD patients provides comparative data to examine possible double dissociations in explicit versus implicit memory, in addition to offering a neuropathologic comparison with PD.

Also, through the use of more than one implicit test, some of the theoretic points of nonabstractionist positions can be addressed. First, by extending the findings of Masson (1986), with normal subjects demonstrating an instance-based skill acquisition, to that of patient populations such as PD, two complementary issues are addressed: (1) can PD patients acquire the perceptual pattern-analyzing skills necessary to improve at reading mirror-inverted script, or is this type of task sensitive to the disruption of the “complex” loops (i.e., Alexander, et al., 1986; Taylor, et al., 1986), and (2) is this skill general in nature (cf. Cohen & Squire, 1980), or is it instance-based (cf. Masson, 1986)?

Saint-Cyr, et al. have stated that simpler types of procedural learning tasks such as mirror reading and pursuit-rotor tracking involve oculomotor and visuomotor functions. They have further stated that combined destruction of the two major neostriatal efferent pathways, prefrontal cortex and superior colliculus, is necessary for the abolition of voluntary oculomotor control (see Schiller, True, & Conway, 1980). This combined destruction does not appear in PD. That is, the neuropathology in PD does not involve combined destruction of both neostriatal efferent pathways. Therefore, deficits would not be expected to occur in mirror reading because of the relative sparing of at least some of these pathways. By the same token, relative sparing of motor procedural learning tasks such as pursuit-rotor tracking would be

expected in PD patients. Saint-Cyr, et al. further hypothesize that a set of lesions disturbing outflow of both neostriatal efferent pathways might be necessary to completely disrupt other cognitive and motor skill procedural learning tasks as well.

Assessment of implicit and explicit processes can also be assessed in PD and AD through the use of a fragmented pictures test (Snodgrass, Smith, Feenan, & Corwin, 1987), which provides an index of both explicit learning of the physical configuration of stimuli (i.e., perceptual memory) and increased fluency on the tasks themselves, reflected as improved performance on novel items with task practice (i.e., skill learning) (Corwin & Snodgrass, 1987). A double dissociation is predicted in such a paradigm, with PD patients demonstrating intact perceptual memory relative to controls, but impaired skill learning. The AD patients, on the other hand, are predicted to demonstrate intact skill learning relative to controls, but impaired perceptual memory. The critical question of theoretic import depends upon the functional characteristics of the task, however. That is, if the fragmented pictures test is assumed to rely upon frontally-sensitive cognitive procedures similar to those required of the Tower of Toronto puzzle (e.g., Saint-Cyr, et al., 1988) or the Wisconsin Card Sorting Test (e.g., Taylor, et al., 1986) in order to demonstrate increased skill acquisition, then the AD and PD patients should demonstrate this dissociation.

Third, through the use of a stem-completion repetition priming task, the present investigation further addresses the dissociability of different implicit learning tasks themselves (e.g., Butters, 1987), as well as assessing the state of memory structures associated with lexical representations in AD patients (cf., Salmon, Shimamura, Butters, & Smith, 1988), contrasted with PD patients. Because AD causes a disruption of cortico-cortical loops, they are predicted to exhibit impaired performance relative to control subjects and PD patients.

Finally, a motor skill learning task was incorporated as a final procedural learning task, again, in order to determine whether this type of procedural learning is sensitive to disrupted outflow of neostriatal influences in the proposed "complex" loops associated with the

neuropathologic damage in PD. Both the AD and PD patients are not expected to differ in performance from their matched control subjects because of the intactness of at least some portions of the major neostriatal efferent pathways. Also, a direct comparison in pursuit-rotor performance has not been conducted in the same study between AD and PD patients.

## METHOD

### Subjects

Sixteen patients with PD (twelve male, four female), twelve patients with AD (eight male, four female), and sixteen healthy control subjects (seven male, nine female) participated in this experiment. The groups were matched on the basis of age, sex, education level, and estimated premorbid intelligence (Wilson, Rosenbaum, and Brown, 1979) as shown in Table 1.

AD patients were recruited from the University of Arizona Medical Center Memory Disorders Clinic of the Departments of Neurology and Psychiatry. A diagnosis of probable AD was given according to the criteria developed by the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (ADRDA) (McKann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984) after a physical and neurological examination by a staff neurologist, medical history, laboratory tests, and neuropsychological evaluation. All AD patients selected for inclusion were free of extrapyramidal symptoms.

PD patients were recruited from ongoing studies at the University of Arizona Department of Psychology, and from the Parkinson's Disease Support Group of the Yavapai Regional Medical Center. All PD patients have undergone a stringent selection process, including complete neurologic examination and a thorough medical history, and were given a diagnosis of idiopathic PD. Also, because PD is not a homogeneous disorder (Marsden, 1982), additional information was obtained in order to characterize this particular sample of PD patients: the Wechsler Memory Scale (WMS) and Mattis Dementia Rating Scale (DRS) were administered to document the absence of dementia, and disease severity was rated according to the Hoehn and Yahr Clinical Disability Scale (Hoehn & Yahr, 1967). Finally, an estimation of disease duration was established from history.

The dementia rating scale assesses a wide spectrum of cognitive abilities including attention and concentration, memory, conceptualization, construction, initiation and perseveration, and

verbal fluency (Mattis, 1976). Table 1 shows the mean age, sex, years of education, handedness, estimated premorbid intelligence, DRS and WMS-MQ scores of all three subject groups, and Mini-mental State Examination scores for the AD patients. An analysis of variance indicated no significant differences between control subjects and PD patients on the DRS,  $F(1,23) = 3.29, p > .08$ , but were significantly different on their WMS-MQ scores,  $F(1,23) = 5.98, p < .05$ . Inclusion of the AD patients revealed significant differences across groups (see Table 1) when the AD patients were included into the analysis of variance, indicating the AD patients were significantly impaired on the DRS and WMS. The PD patients exhibited symptom duration ranging from 1 to 16 years, with a median of 8 years. The severity ratings of parkinsonian features were limited to early to middle stages (I, II, and III, Hoehn and Yahr, 1967). Four patients were in Stage I, three patients in Stage II, and nine patients in Stage III. At the time of testing, all PD patients were receiving medications. Ten patients were receiving levodopa medication alone, and six a combination of levodopa and anticholinergic medications.

All subjects completed the stem-completion repetition priming, pursuit-rotor tracking procedure, and the fragmented pictures test. Only the control subjects and the PD patients completed the mirror reading task, however, as it proved to be too difficult a task for the AD patients to complete. The paradigm was attempted on two initial AD patients, and they demonstrated an inability to retain any information regarding specific typographical transformations. For instance, the letter "a" when reversed often could be mistaken for the letter "e". When given appropriate feedback, the subject subsequently continued to make the same mistakes throughout the entire test phase, thus causing floor effects with response latencies.

#### Apparatus

An Apple Macintosh Plus microcomputer was utilized throughout the study as the major tool for stimulus presentation, and timing of responses. The stimulus words for the stem-

Table 1

Demographic and Psychometric Characteristics  
of Matched Samples of Alzheimer's Disease (AD) and  
Parkinson's Disease (PD) Patients, and Healthy Control Subjects  
(Standard deviations are presented in parentheses.)

	AD	PD	Control	<i>F</i> (2, 41)	Significance
Subjects	12	16	16		
Sex				$\chi^2 = 3.49$	N.S.
Males	8	12	7		
Females	4	4	9		
Age	70.67 (7.17)	69.63 (5.86)	69.56 (6.11)	0.17	N.S.
Education	13.58 (3.99)	15.19 (2.07)	15.19 (2.14)	1.50	N.S.
Handedness				$\chi^2 = 0.06$	N.S.
Right	11	15	15		
Left	1	1	1		
Estimated Premorbid I.Q.	119.4 (11.4)	123.0 (7.7)	123.3 (7.2)	0.54	N.S.
Mattis Dementia Rating Scale	103.8 (8.3) [n = 6]	138.4 (3.6) [n = 16]	140.7 (1.6) [n = 9]	<i>F</i> (2, 28)=153.6	<i>p</i> < .001
Wechsler Memory Scale (Memory Quotient)	69.0 (6.1) [n = 9]	119.5 (13.5) [n = 16]	134.0 (15.6) [n = 9]	<i>F</i> (2, 31)=68.0	<i>p</i> < .001
Mini-Mental State Exam	18.0 (2.9) [n = 10]				
Hoehn & Yahr Clinical Disability Scale		Stage I = 4 Stage II = 3 Stage III = 9			
Note: Length of illness estimate		1-16 years (Median = 8 years)			

completion study lists, the mirror reading stimuli, the pursuit-rotor tracking disk, and the fragmented pictures were all displayed via the 16.5 cm x 11.5 cm monochromatic monitor of the Macintosh Plus microcomputer. The stem-completion repetition priming task, free- and cued-recall tasks were presented on separate sheets of paper.

### Materials and Procedures

Mirror Reading. The mirror reading paradigm was constructed from the set of stimuli developed by Masson (1986), Experiment 1: *Materials*. The 26 letters of the alphabet were arbitrarily divided into two sets of 13 letters, with the constraint that each set contain equal numbers of vowels (where *y* was considered a vowel), and that the letters *q* and *u* be assigned to the same set. The letters in one set were *a, b, d, g, i, j, l, n, q, s, u, v,* and *x*, and the remaining letters were in the other set. Two lists of 144 words were constructed, one from each letter set. Word length in both lists ranged from 3 to 8 letters and averaged 4.4 letters in the first list and 4.7 letters in the other. The mean word-frequency value (Kucera & Francis, 1967) in the first set was 270 per million with a range of 0 to 28,852, a result of the word *and* being included in the analysis (Excluding *and* produced a maximum value of 3,001 and a mean of 70). The range of frequency values in the second set was 0 to 3,618, with a mean of 194.

Procedure. The experiment consisted of a training phase and a test phase. In the training phase, subjects read a randomly ordered series of 24 word triplets. All words presented to a subject in the training phase were randomly drawn from one of the two lists so that the subject was exposed to only 13 letters of the alphabet during this phase. The letter set used in the training phase was counterbalanced across subjects. Word triplets were displayed by using lowercase mirror image letters, printed left to right as with normal typography, but each letter was a mirror image of its normal counterpart. Adjacent words in a triplet were separated by a blank space, two hyphens, and a second blank space.

Presentation of each word triplet was preceded by a visual prompt consisting of the

word READY printed in normal typography in the center of the screen. The subject pressed a button to erase the prompt. After a 500-ms pause, a word triplet appeared at the center of the screen with individual letters in mirror image form and the subject began reading. [A sheet of paper containing the word triplets in normal typography was used so the the subject's accuracy could be checked easily]. Subjects were instructed to read aloud each word in a triplet as quickly as possible and were required to reread any word on which an error was made. When the last syllable of the third word in a triplet had been vocalized, the experimenter pressed the space bar on the computer keyboard. This caused the triplet to disappear and the ready signal for the next trial to appear. The computer recorded reading time, which was defined as the time between onset of the word triplet and the experimenter's key process to end the trial. The reading time for a triplet included any time needed to reread words due to errors, and errors were not recorded.

The test phase began [after one block of trials of pursuit-rotor tracking] and consisted of 72 trials involving the same procedure as that used in the training phase. One set of 24 triplets was exactly the same as the one that had been read in the training phase. A second set of 24 was based on the 72 words taken from the same list as that sampled in the training phase but which had not been read previously, and the third set of 24 triplets was based on words randomly drawn from the list not sampled during the training phase. The three types of triplets (old, new with old letters, and new with new letters) were presented in a random order during the test phase. (Masson, 1986, p. 481)

After the end of the testing session, a yes/no recognition test was administered. The recognition test consisted of 40 words presented in lowercase and normal typography, one at a time, in the center of the screen. The subject was asked to indicate whether or not that word was previously presented on the screen in mirror-inverted form. Twenty of the words were previously presented, and the remaining 20 words were foils.

Stem-Completion Repetition Priming. *Materials.* Forty words were selected for the stem-

completion task. Each word was four to seven letters in length, and the mean word frequency of occurrence value (Kucera & Francis, 1967) was 62 per million. The composition of this list was constructed carefully so that no words were repeated with those of the mirror reading lists, so that three-letter cues could not be completed to make words from the mirror reading list. For the stem-completion study lists, approximately 10 possible words could be used to complete each target stem, only one of which was presented for study. This was done to insure that baseline guessing rates would be at a low frequency of occurrence. The 40 words were then randomly divided into four study lists. Ten additional words were selected to serve as fillers, five at the beginning and five at the end of the list, to prevent primacy and recency effects. Thus, a study list contained 30 words: 10 target words, 10 distractor words, and 10 fillers.

*Procedure.* Before the study list was presented, the subject was instructed to rate whether the word presented on the screen was pleasant or not, on to a five-point scale (1 = “very unpleasant” and 5 = “very pleasant”). The pleasantness rating was done to ensure elaborative processing of the study list word. Following the instructions, the 30 word study list was presented, self-paced, in a random fashion (with the exception of the filler words) one at a time in the center of the computer screen, in uppercase typography.

After completion of the study list, subjects proceeded to complete a famous names distractor task. The task contained three-letter cues of famous persons’ first and last names. This task was given for two reasons: (1) to provide a short delay interval between study and test, and (2) to acclimate the subject to completing three-letter stems.

Following the distractor task, the stem-completion repetition priming task was completed. It consisted of 20 randomly ordered three-letter cues, 10 stems that could be completed using the target words from the study list, and 10 stems from one the lists the subject never viewed. The probability of generating a target word from the latter list was used to provide a measure of baseline or chance probability. The words used to assess baseline guessing rates for some

subjects were used as target items for the others, thus counterbalancing the word lists across subjects. Subjects were instructed that each three-letter cue was the beginning of an English word, and were told to write a few letters to make each into a word. They were further instructed that they could write any English word, but simply to write the first word that came to mind.

After finishing the stem-completion task, a cued-recall test of the 20 words from the study list was conducted. Subjects were instructed to use each three-letter cue to help them remember the list of words they saw on the computer with the same beginning letters.

**Pursuit-Rotor Tracking.** *Materials.* The pursuit-rotor tracking task was conducted on the Apple Macintosh Plus microcomputer via a software program. The rotating target disk appeared upon the screen and the “stylus” was controlled by the computer “mouse” attached to the microcomputer. There were two speeds at which the target disk rotated, and this was adjusted according to the time on target during the practice trial(s). That is, if subjects maintained contact between the target and “mouse” for 1 to 3 seconds at the high speed (14 rpm), then the learning blocks remained at that speed. If, however, contact was not maintained for at least one second, then the speed was dropped (7 rpm) for the learning trials. Butters, et al., (1987) used a similar adjustment scheme to equate initial performance across subject groups. All sixteen control subjects, four of the PD patients and three of the AD patients were run on the 14 rpm speed for the learning trials. The remaining AD and PD patients were dropped to the 7 rpm speed for the learning trials.

*Procedure.* All trials were completed by the preferred hand. There were 6 blocks of trials throughout the testing procedure, with an interblock interval of 10 to 30 minutes during which time other tasks were conducted. Each block contained five 20 second learning trials, with a 10 second intertrial interval. The measure of motor skill acquisition was the number of seconds of contact between the “mouse” (as it appears on the computer screen) and the rotating target disk. Time on target was measured by the computer.

**Fragmented Pictures Test.** *Materials.* The fragmented pictures test (Snodgrass, et al., 1987) was conducted on the Apple Macintosh Plus microcomputer. Pictures of common objects or animals were displayed with eight levels of fragmentation upon the computer screen, beginning with the most fragmented form. Identification thresholds and subject responses were recorded by the microcomputer.

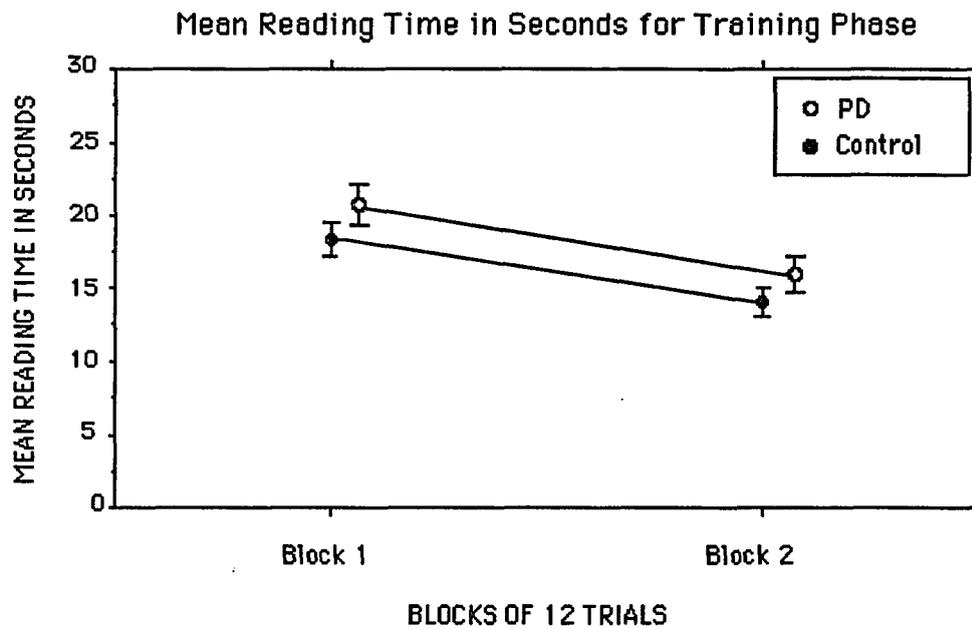
*Procedure.* The fragmented pictures test contained two phases. In the first or training phase, a set of fifteen pictures were presented to the subject, who then attempted to identify the picture at the most degraded level possible. Guessing was allowed. Once the subject identified the correct name of the picture, the computer recorded the identification threshold for that picture. The average level of fragmentation required for correct naming was termed the training threshold (TRAIN); unnamed items were discarded. Following a 5 to 10 minute break and some short questions regarding the subject's demographic status and history, the procedure was repeated with (1) a representation of the training pictures mixed randomly with (2) an equal number of novel pictures. Thus, the test phase consisted of what were termed 15 OLD pictures and 15 NEW pictures.

The data obtained by this experiment were the identification thresholds for the training stimuli during the first phase, and the identification thresholds for the old and new stimuli during the test phase. Two separate measures were obtainable, given this data. First, a measure of skill learning was indexed by a decrease in thresholds between the training and new pictures (TRAIN - NEW). Second, a measure of perceptual memory was indexed by a decrease in thresholds between the new and old pictures in the test phase (NEW - OLD). Obtaining the perceptual memory measure by this method excluded improvement in performance due to skill learning. In other words, the measure of perceptual memory was corrected for task practice. In addition to the identification thresholds obtained, a free recall test for the pictures presented on the computer screen was conducted approximately 5 to 10 minutes following the fragmented pictures test.

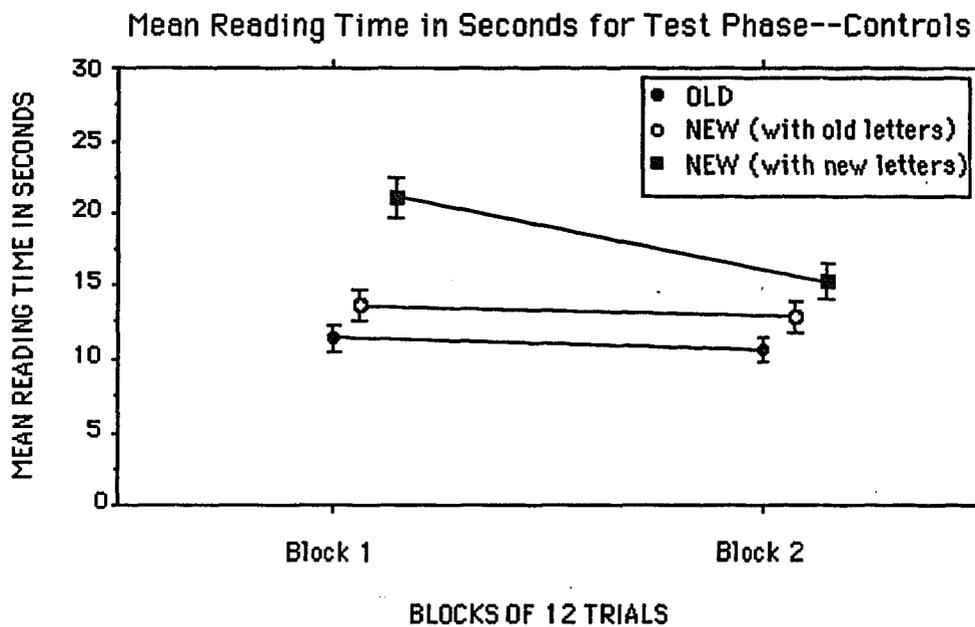
## RESULTS

**Mirror Reading.** The data were analyzed in manner similar to that of Masson (1986). The mean reading times for the training phase are shown in Figure 1. The data are plotted as blocks of 12 trials, and each mean is based on 192 reading times for each group (control subjects and PD patients). An mixed model analysis of variance (ANOVA) of training phase reading times with block (1 vs. 2) as a within-subjects factor, and group (Control vs. PD) as a between-subjects factor indicated that subjects significantly improved their reading skill over the 24 trials of the training phase. The second block of trials for each group were read more quickly than the first block of trials (Controls: 14.2 vs. 18.4 s; PD: 16.0 vs. 20.8 s),  $F(1, 30) = 27.61$ ,  $p < .001$ . There was no significant difference, however, between groups ( $F < 1$ ). Also, the group by trial block interaction was not significant ( $F < 1$ ).

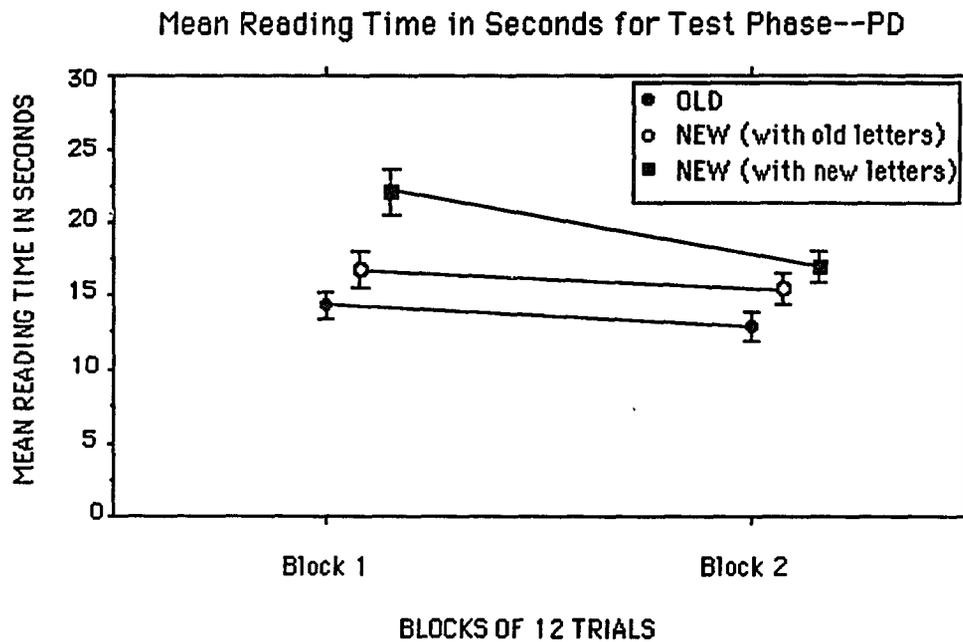
Figures 2 and 3 show the mean reading times for each group during the test phase. Transfer of skill was assessed by analyzing reading times for the three different types of triplets presented in the test phase of the experiment. The within-subjects factors in this repeated measure ANOVA were type of triplet and trial block, while the between-subjects factor was group. As in the training phase, reading time improved from the first to the second block of 12 trials as indicated by a main effect of block,  $F(1, 30) = 18.47$ ,  $p < .001$ . Also, a main effect of type of triplet showed that the skill learned in the training phase transferred with varying degrees of success,  $F(2, 60) = 18.55$ ,  $p < .001$ . As can be seen in Figure 1, identification time was shortest for the training words and somewhat longer for new words based on the same letter set as training words. Reading time was especially long for words based on the unfamiliar letter set. The interaction between triplet and block was reliable,  $F(2, 60) = 18.64$ ,  $p < .001$ , indicating that the rate of improvement across blocks of trials decreased as similarity to the training words increased. As in the training phase, there was no significant difference between groups  $F(1, 30) = 1.35$ ,  $p = 0.254$ . Finally, the group by trial block interaction was not significant ( $F < 1$ ).



**Figure 1.** Mean reading times (in milliseconds) of the control subjects and Parkinson's disease (PD) patients during the training phase of the mirror reading experiment.



**Figure 2.** Mean reading times (in milliseconds) of the control subjects during the test phase of the mirror reading experiment. Circles indicate the mean reading times for the first triplet type, comprised of the same words presented during the training phase (OLD words based upon OLD letters); open circles indicate the mean reading times for the second triplet type, comprised of new words made from the same 13 letters used to make the training phase words (NEW words made from OLD letters); squares indicate the mean reading times for the third triplet type, comprised of words made from the 13 letters of the alphabet not used to make the training phase words (NEW words made from NEW letters). Vertical bars indicate one standard error of the mean.

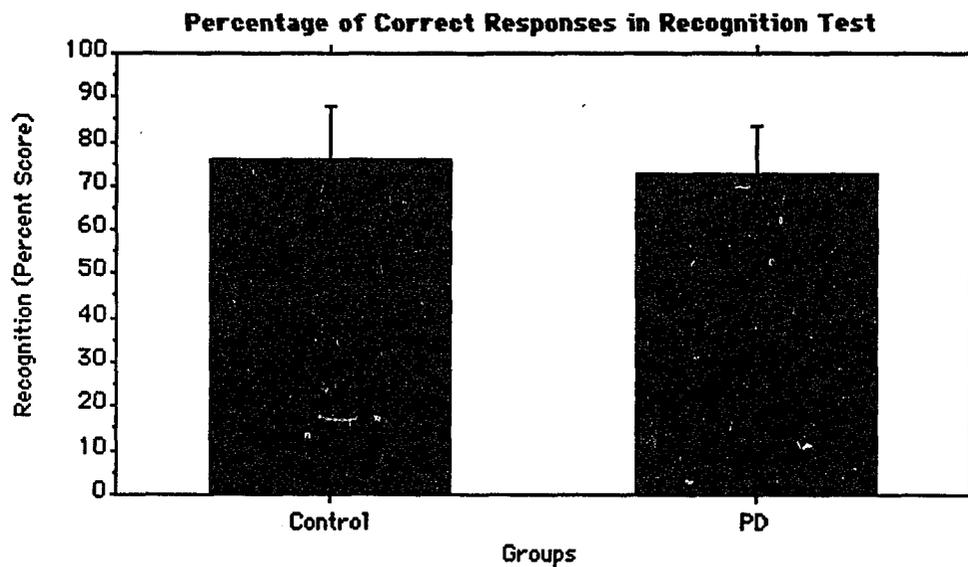


**Figure 3.** Mean reading times (in milliseconds) of the Parkinson's disease (PD) patients during the test phase of the experiment. Circles indicate the mean reading times for the first triplet type, comprised of the same words presented during the training phase (OLD words based upon OLD letters); open circles indicate the mean reading times for the second triplet type, comprised of new words made from the same 13 letters used to make the training phase words (NEW words made from OLD letters); squares indicate the mean reading times for the third triplet type, comprised of words made from the 13 letters of the alphabet not used to make the training phase words (NEW words made from NEW letters). Vertical bars indicate one standard error of the mean.

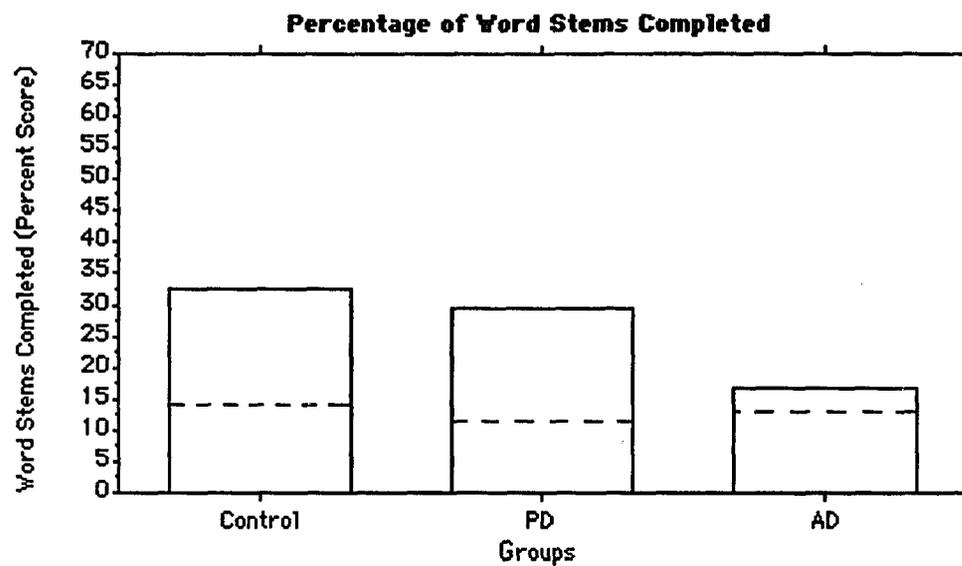
According to Masson (1986), a critical question to be answered from this analysis was whether any transfer to words based on the unfamiliar letters could be observed. This was tested by comparing performance during the training phase with performance on new words formed from unfamiliar letters during the transfer phase. If there is no transfer, then there should be no reliable difference between the reading times in these two cases and the improvement shown across blocks of 12 trials should be the same. A repeated measures ANOVA confirmed both of these expectations, finding a significant effect of block,  $F(1, 30) = 40.61, p < .001$ , but no reliable difference between the two sets of triplets ( $F < 1$ ), and no interaction between triplet and block,  $F(1, 30) = 1.06, p > .31$ . Also, there was no significant difference between groups ( $F < 1$ ). Finally, neither the group by trial block interaction nor the group by triplet type were significant ( $F$ 's  $< 1$ ).

The mean percentage of correct responses for the recognition test are shown in Figure 4. An ANOVA was performed on the recognition data, indicating no significant difference between groups on recognition performance ( $F < 1$ ).

Stem-Completion Repetition Priming. The data were analyzed similar to Salmon, et al. (1988). Stem-completion performance and baseline guessing rates of the three groups are shown in Figure 5. An ANOVA was performed on baseline guessing rates across the three groups, which revealed no significant differences ( $F < 1$ ). Thus, there were no reliable differences in the ability of any subject group (particularly the AD patients) to perform the basic task of completing three-letter stems with words. Control subjects and PD patients exhibited priming scores significantly greater than baseline guessing rates, whereas the AD patients did not (Control:  $t(15) = 3.39, p < .01$ ; PD:  $t(15) = 3.95, p < .01$ ; AD:  $t(11) = 1.30, p = .22$ ). As in Salmon, et al. (1988), a stem-completion score for a subject was calculated by subtracting the baseline guessing rate from the percentage of target words completed for each subject. An ANOVA was performed on these stem-completion priming scores with



**Figure 4.** The percentage of correct responses on the recognition test of the mirror reading stimuli for Parkinson's disease (PD) patients and control subjects. Vertical bars indicate one standard deviation.



**Figure 5.** The percentage of word stems completed with previously presented words (i.e., target stems) by Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. The baseline guessing rates of each group are indicated by the broken line.

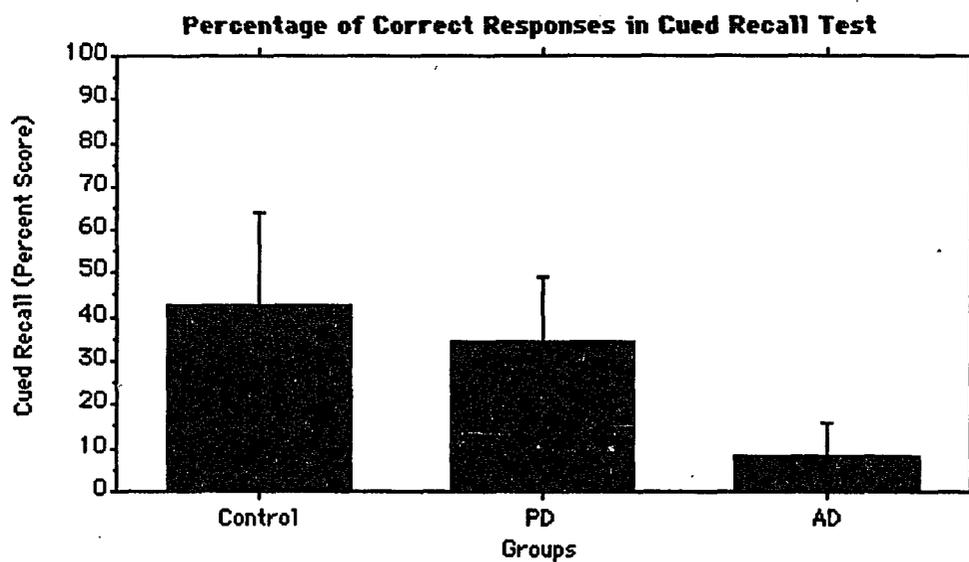
groups as the between-subjects factor. There was a marginally significant difference in priming performance across the subject groups,  $F(2, 41) = 3.07, p = .057$ .

Pairwise comparisons revealed that the AD patients were significantly impaired in stem-completion performance relative to the control subjects and PD patients (AD vs. Control:  $t(26) = 2.25, p < .04$ ; AD vs. PD:  $t(26) = 2.57, p < .02$ ), but that the control subjects and PD patients did not differ in their performance ( $t < 0.1$ ).

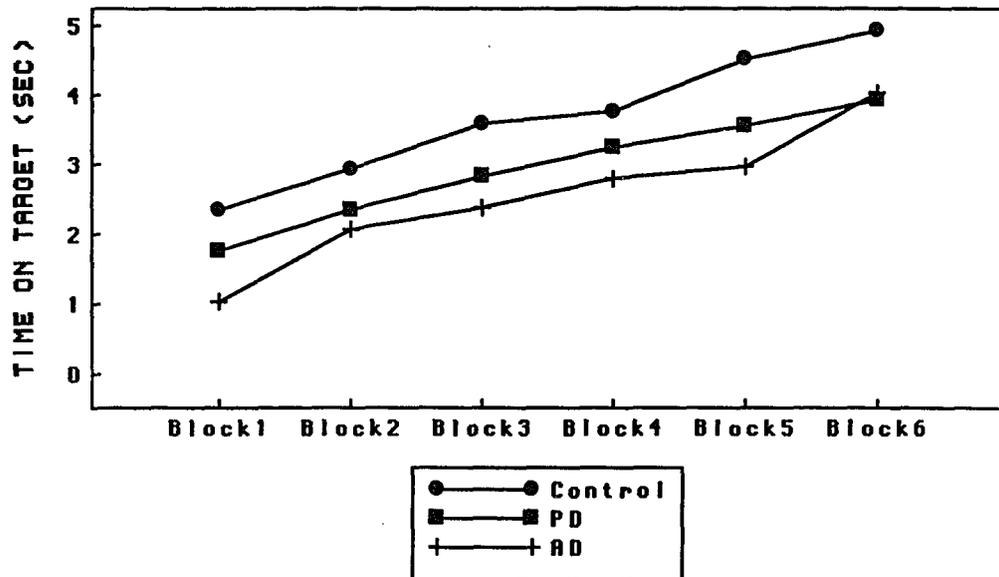
The mean percentage of correct responses for the cued-recall test are shown in Figure 6. An ANOVA was conducted on subjects' performance on the cued-recall test, indicating a significant difference across groups,  $F(2, 41) = 16.34, p < .001$ . Pairwise comparisons revealed that the AD patients were significantly impaired in cued-recall performance relative to the control subjects and PD patients (AD vs. Control:  $t(26) = 5.28, p < .001$ ; AD vs. PD:  $t(26) = 5.72, p < .001$ ), but that the control subjects and PD patients did not differ in their performance,  $t(30) = 1.21, p > .24$ .

Pursuit-Rotor Tracking. The mean scores for time on target (in seconds) within each of the six blocks of trials for the three subject groups are shown in Figure 7. A repeated measures ANOVA was performed to determine if there were any significant differences across the groups in the acquisition of the motor skill. There was a main effect of block,  $F(5, 205) = 33.72, p < .001$ , but no significant difference across subject groups,  $F(2, 41) = 2.02, p > .14$ , and no significant group by trial block interaction ( $F < 1$ ). Thus, the results indicate that all three groups significantly improved at pursuit-rotor tracking over the six blocks of trials, and that the rate of improvement was commensurate across the groups.

Fragmented Pictures Test. The mean identification threshold scores for each subject group on the TRAIN, NEW, and OLD pictures are shown in Table 2. An ANOVA was performed on the TRAIN scores, with groups as the between-subjects factor, revealing a significant difference across groups on the training identification thresholds,  $F(2, 41) = 25.41, p < .001$ . Pairwise comparisons, using the Scheffe method, demonstrated that the AD



**Figure 6.** The percentage of correct responses on the cued-recall of study list words for the stem-completion repetition priming test for Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. Vertical bars indicate one standard deviation.



**Figure 7.** The mean time on target (in seconds) for each of six blocks of trials during the pursuit-rotor experiment for Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. Crosses denote AD patients, squares denote PD patients, and circles denote control subjects.

Table 2

**Mean Identification Thresholds of  
Alzheimer's Disease (AD) and Parkinson's Disease (PD) Patients,  
and Matched Healthy Control Subjects for the  
Training and Test Phases of the Fragmented Pictures Test  
(Standard deviations are presented in parentheses.)**

Subject Group	TRAIN	NEW	OLD
AD	6.582 (0.513)	6.006 (0.546)	6.300 (0.651)
PD	5.472 (0.484)	5.425 (0.483)	4.108 (0.862)
CONTROL	5.359 (0.466)	5.013 (0.554)	3.704 (0.539)

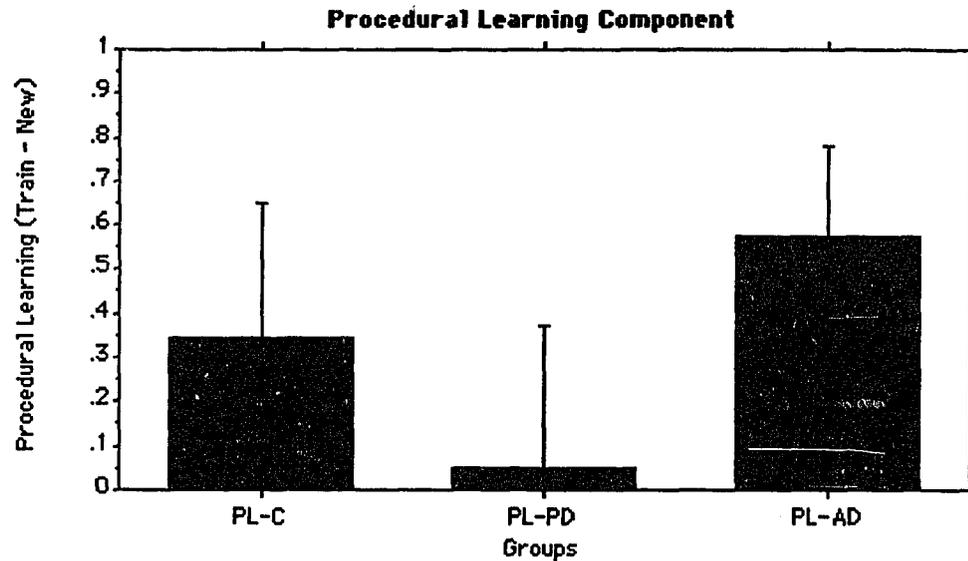
patients' mean TRAIN score was significantly greater than both the PD patients,  $F(1, 26) = 17.93, p < .05$ , and control subjects,  $F(1, 26) = 21.75, p < .05$ , indicating that the AD patients required more fragmentation levels than the other groups for successful completion.

The mean scores for each subject group on the procedural learning (PL) and the perceptual memory (PM) scores are shown in Figures 8 and 9. An ANOVA was performed on each of these composite measures, with groups as the between-subjects factor, revealing a significant difference across subject groups on both PL,  $F(2, 41) = 11.69, p < .001$ , and PM,  $F(2, 41) = 53.87, p < .001$ .

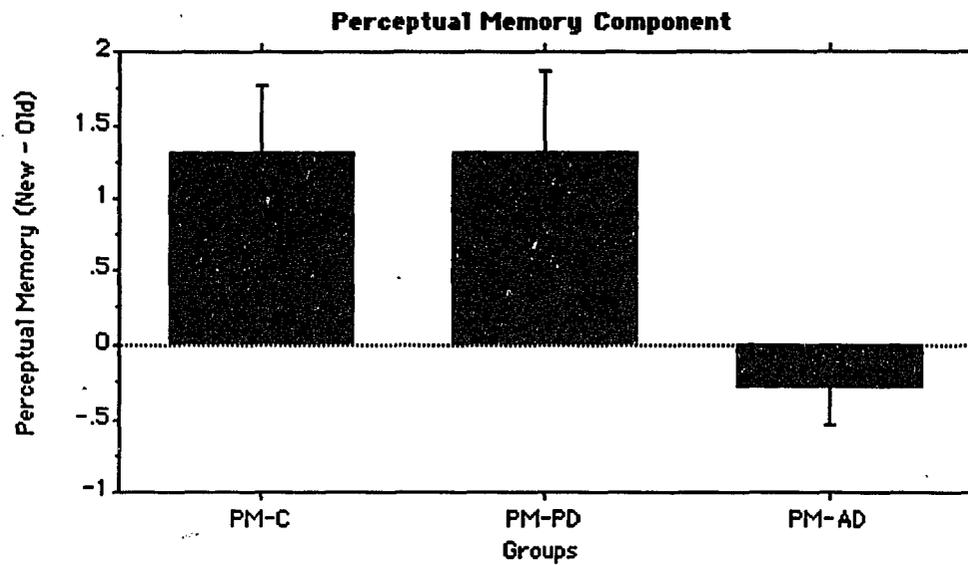
Pairwise comparisons were conducted by using the Scheffe method. The PL component of the fragmented pictures test demonstrated that PD patients were significantly impaired relative to the control subjects and AD patients (PD vs. Control:  $F(1, 30) = 4.26, p < .05$ ; PD vs. AD:  $F(1, 26) = 11.37, p < .05$ ), whereas the control subjects and the AD patients did not differ significantly,  $F(1, 26) = 2.13, p > .05$ . The PM component demonstrated exactly the opposite result, revealing that AD patients were significantly impaired relative to the control subjects and PD patients (AD vs. Control:  $F(1, 26) = 42.10, p < .05$ ; AD vs. PD:  $F(1, 26) = 42.54, p < .05$ , whereas the control subjects and the PD patients did not differ significantly,  $F(1, 30) = .0013, p > .05$ . Thus, the fragmented pictures test revealed a double dissociation in performance between AD and PD patients. Relative to control subjects, PD patients exhibited impaired PL, but intact PM. AD patients, on the other hand, exhibited impaired PM, but intact PL, relative to controls.

Figure 10 shows the mean percentage of correct responses on the free recall test. An ANOVA was conducted on subjects' performance on the free-recall test, revealing a significant difference across subject groups,  $F(2, 41) = 50.89, p < .001$ . Pairwise comparisons, again using the Scheffe method, revealed that significant differences existed across all three groups. AD patients were significantly impaired in comparison with control subjects,  $F(1, 26) = 48.70, p < .05$ , and PD patients,  $F(1, 26) = 27.05, p < .05$ . PD patients demonstrated

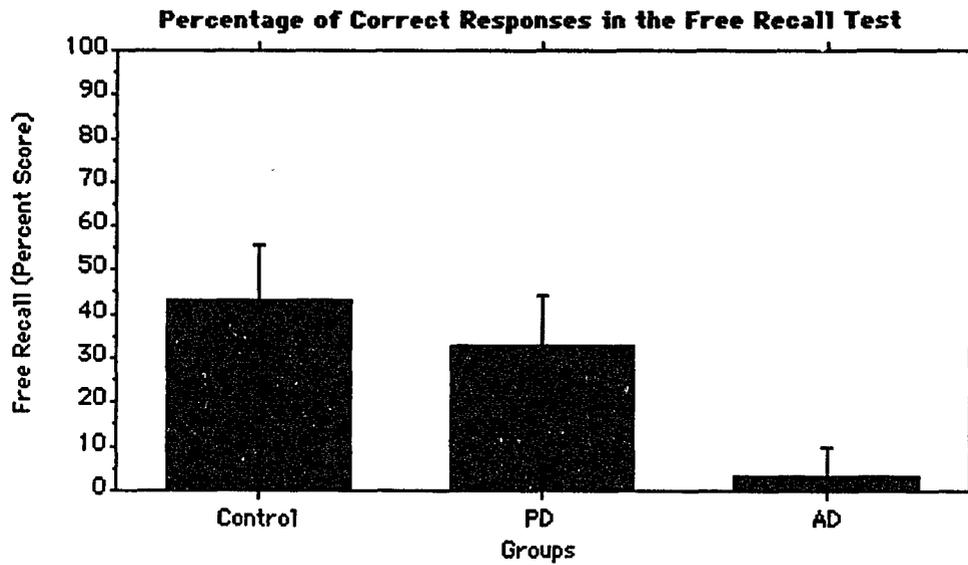
intermediate performance between that of AD patients and control subjects, being significantly better than AD patients but significantly impaired in comparison with control subjects,  $F(1, 30) = 3.69, p < .05$ .



**Figure 8.** The mean procedural learning score from the fragmented pictures test, based upon the difference in mean identification thresholds for the training phase pictures and new pictures presented during the test phase, for Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. Vertical bars indicate one standard deviation.



**Figure 9.** The mean perceptual memory score from the fragmented pictures test, based upon the difference in mean identification thresholds for the new pictures presented during the test phase and the old pictures presented during the test phase, for Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. Vertical bars indicate one standard deviation.



**Figure 10.** The percentage of correct responses on the free recall of stimuli presented in the Fragmented Pictures test for Alzheimer's disease (AD) patients, Parkinson's disease (PD) patients, and control subjects. Vertical bars indicate one standard deviation.

## DISCUSSION

The results demonstrated selective deficits in particular implicit memory domains in both AD and PD. The PD patients' impairments in the procedural learning component of the fragmented pictures test supported the hypothesis that the neostriatum, vis a vis the "complex" loop (Alexander, et al., 1986), is essential to certain types of skill acquisition, particularly those operations necessarily involved in more purely mental operations such as cognitive procedural learning. This conclusion is bolstered by comparison with the AD patients' normal acquisition of the cognitive procedures necessary to profit from continued practice with the task, thus demonstrating a double dissociation.

Because the fragmented pictures test is a novel task, it does not have explicit or familiar guidelines to follow in order to improve at it. This type of task is not as predictable as, for instance, the mirror reading task, in which subjects maintain a sequential reading pattern (i.e., right to left or left to right), where predictable information is contained in the words themselves (i.e., letters), and where the stimulus parameters, locations, or configurations do not differ significantly. The fragmented pictures test, by contrast, is thought to be a more strategy-driven test that the subject has to arrive at internally in order to demonstrate improvement across trials, rather than through a set of familiar or explicit guidelines. Thus, it is not as predictable. Stimulus configurations change, degraded images conjure up any multitude of potential answers, and semantic categories may change with each new stimulus. In short, there are more degrees of freedom in responding, and more chances for error.

Continuing with the functional/anatomic hypothesis adopted by Taylor, et al. (1986) and Saint-Cyr, et al. (1988), the PD patients studied in this experiment demonstrated selective deficits in cognitive functions thought to be primarily dependent upon the integrity of the prefrontal cortex. Other procedural learning tasks, such as mirror reading and pursuit-rotor tracking, are not thought to be primarily dependent upon the "complex" prefrontal loop, and are thought to utilize other oculomotor and visuomotor loops in order to perform these operations

successfully. Thus, the PD patients were not expected to be significantly impaired on these tasks, and indeed were not. Although the PD patients were marginally slower than their matched controls, they nevertheless demonstrated comparable accuracy and improvement with the mirror reading task. The same can be said for their performance on pursuit-rotor tracking: the PD patients demonstrated comparable levels of improvement in acquiring the motor skill. But because these were timed tasks, and rapid visual-scanning was needed, known to be abnormal in PD (White, Saint-Cyr, Tomlinson, and Sharpe, 1983), these difficulties may have contributed to the longer latencies in the mirror reading task, and decreased time on target for the pursuit-rotor tracking. The marginally slower times for the AD patients, however, are not explicable on the basis of abnormal visual-scanning operations, as in PD. They may be accounted for by their deficits in maintaining directions in memory, and frequent need for re-explanation of those directions. Nonetheless, they were found to exhibit rates of improvement comparable to their matched control subjects.

The AD patients' deficits in lexical priming are consistent with previous reports of lexical and semantic priming deficits in AD (Shimamura, et al., 1988; Salmon, et al., 1988), in addition to confirming the dissociability of implicit memory phenomena within and between patient populations (i.e., Butters, 1987). These investigators have concluded that the deficits observed in AD are indicative of impaired activation of preexisting lexical representations, thought to result from a disruption of the organization of semantic memory. They further posit that the dysfunction of temporo-parietal cortex of the dominant hemisphere may be responsible for the priming deficits in AD, because of damage to cortico-cortical loops (Terry and Katzman, 1983), in AD. While the present results do not speak directly to the controversy in AD over the status of semantic memory in AD (cf. Nebes, et al., 1984), they are consistent with those of Salmon et al., and offer replication of a lexical priming deficit in AD.

Further studies are needed to examine these inconsistencies in the status of semantic memory in AD. Careful attention to task requirements may help to elucidate the current

discrepancies. For instance, while both the Salmon, et al. and Nebes, et al. studies utilized “automatic” information processing tasks, they nevertheless were different tasks. Salmon, et al. (1988) used both a stem-completion lexical priming task and a free-associate semantic priming of word pairs. Nebes, et al. (1984), however, used a different method: naming latency of words preceded by either a semantically related (primed trial) or by an unrelated word (unprimed trial) was the measure used to assess semantic memory. Presumably, because of an intact structure in the AD patients’ semantic memory, this allowed for increased facilitation in naming latency when a word was preceded by a semantic associate. Priming was thus measured by calculating the difference in naming latencies between the semantically related and unrelated trials.

What becomes apparent from the studies with contrasting results in the preserved or impaired ability to elicit priming is the task method employed to assess the priming. Careful description of exactly what type of task constitutes a “priming” procedure is essential. Schacter (1987) defines the term as a “facilitation in the processing of a stimulus as a function of a recent encounter with the same stimulus” (Schacter, 1987, p. 506). When considering this definition, the Nebes, et al. (1984) use of the term “priming” to describe their task may not be accurate. There is no prior presentation of the words, simply a semantically or unrelated word preceding the stimulus word. In this sense, the task may be better considered similar to priming, but somehow different. How this difference manifests itself in the processing strategies employed by AD patients may help to explain the contradictory results thus far obtained in the literature.

Another important consideration from this study not explicated by Salmon, et al. is that even though amnesia is apparent in a variety of neuropathologic populations, there are differences in performance of the same implicit task between these differing populations. Thus the use of “amnesics” as a unitary classification, without taking into account the neuropathologic conditions and differences causing the amnesia fails to account for inter-subject differences on implicit tests. For instance, if the HD and AD patients in the Salmon, et

al. study had been grouped into a homogeneous classification of “amnesics with dementia,” examination of the differences between the two groups may not have been considered, or the AD patients’ particular deficits in semantic priming might have been lost in the analyses. Indeed, studies that have utilized a multitude of differing neuropathologic populations as a single “amnesic” group may account for some of the discrepancies in the current literature, especially with respect to priming phenomena. The Salmon, et al. study demonstrates that “amnesics” such as AD and HD patients may exhibit differential deficits to the same priming tasks, because of differences in the neuropathology in each disease.

Finally, the ability of the PD patients to demonstrate comparable skill acquisition in the mirror reading task buttressed the conclusion of the dissociability of implicit learning phenomena, and also demonstrated that the skill of reading typographically transformed words is not a general (i.e., Cohen and Squire, 1980) but an instance-based acquisition (i.e., Masson, 1986). Skill at identifying the mirror-inverted words depended upon the analysis of the particular instances encountered during training. Transfer of the pattern-analyzing skill depended upon the presence of shared features (i.e., letters) between training and test instances (Masson, 1986).

Because the conclusions of an instance-based skill acquisition derived from Masson (1986) were from young normal subjects, and the Cohen and Squire (1980) subjects were amnesics, direct comparisons between the two studies may not be well-founded. The present results, however, begin to bridge the findings of Masson (1986) to patient populations similar to that of Cohen and Squire (1980), but further studies similar to the paradigm used by Masson (1986) with amnesic groups is needed for more direct comparisons.

Explicit memory was observed via free recall, cued-recall, and recognition tests. The AD patients were impaired on the tests of free-, and cued-recall, in addition to the perceptual memory component of the fragmented pictures test, while the PD patients only demonstrated impairment with the more effort-demanding free recall test. These results are consistent with

previous research showing “automatic” versus “effortful” processing differences in PD (Lees and Smith, 1983; Weingartner, Burns, Diebel, and LeWitt, 1984).

In summary, deficits in particular implicit memory domains were demonstrated in both the AD patients and PD patients. A lexical priming deficit was observed in the AD patients, while the PD patients demonstrated a deficit in the procedural learning component of the fragmented pictures test. Equivalent acquisition of a motor skill was exhibited both in the AD and PD patient groups, relative to matched control subjects. Finally, PD patients demonstrated comparable levels of skill acquisition in a mirror reading test, again, relative to matched controls. The AD patients demonstrated deficits in all explicit memory tests given, while the PD patients demonstrated deficits only in the more effort-demanding explicit tests, such as free recall.

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