PICTORIAL AND VERBAL IMPLICIT AND RECOGNITION MEMORY
IN AGING AND ALZHEIMER'S DISEASE:
A TRANSFER-APPROPRIATE PROCESSING ACCOUNT

by

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ABSTRACT

The indirect influence of prior experience on a subsequent task is termed implicit memory (IM). This study examined the status of pictorial and verbal IM in four groups of 20 subjects each: normal young (M age = 27.2), young-old (M age = 66.7), old-old (M age = 76.6), and Alzheimer's disease (AD) patients (M age = 75.4, M Mini-Mental State Examination score = 17.3). Study conditions involved reading words, naming pictures, and generating best-fit endings for high-cloze sentence frames (e.g., Ron swept the floor with a _____.). Implicit memory was subsequently assessed by word-stem completion (WSC), in which subjects were instructed to complete three-letter stems with the first word that came to mind (e.g., bro___), and picture-fragment identification (PFI), in which subjects attempted to identify perceptually degraded pictures. Among the control groups, WSC priming was greatest following word study, and PFI priming was greatest following picture study, thereby establishing that crossover priming effects recently found among young subjects are fully retained in healthy aging. In contrast to previous studies suggesting that WSC priming may be preserved for deeply encoded material in AD patients, the present results showed that WSC priming was impaired in the AD group regardless of study condition. Nevertheless, AD patients demonstrated normal perceptual priming on the PFI task following picture study. These findings support a dissociation between perceptual and conceptual priming in AD. Explicit yes/no recognition testing revealed standard picture superiority and generation effects among controls. AD patients, in contrast, were impaired on all recognition items. Results are discussed in terms of transfer-appropriate processing theory, which

states that level of retention is a function of the degree to which processes invoked at study are recapitulated at test. Essentially, the similarity between word reading and WSC and between picture naming and PFI is a crucial determinant of priming effects in healthy young and elderly subjects. AD patients' WSC impairment may be due to a lexical-semantic processing deficit, whereas their preserved PFI priming may be supported by intact perceptual processes. Similarly, their uniformly depressed recognition memory may be explained by impaired conceptual processing.

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DEDICATION

This dissertation is dedicated to my mentors:

GREG BROWN, ROGER DIXON, and AL KASZNIAK

gentle spirits, brilliant minds,
witty humorists, and gifted teachers

It's a privilege to learn from any one of these men.
It's an honor to have crossed paths with all three.

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Chapter 1

Introduction

Many cognitive psychologists with an interest in memory processes focus their research on healthy college students. These young individuals constitute a relatively homogeneous population with many desirable traits for memory research, such as accessibility in large numbers, low cost, and the ability to understand and execute task instructions. Life-span developmental psychologists interested in age-related changes in memory frequently focus their research on healthy, elderly individuals in order to control for confounding factors of age-related diseases on cognitive performance. Although subjects in these studies are often more highly educated and in better physical health than age peers, performance differences between them and healthy, young subjects have advanced considerably our ideas of memory and aging. Finally, neuropsychologists interested in memory frequently study brain-damaged populations, who may be hospitalized and often present a heterogeneous sample with regard to several subject variables. Despite many disadvantages of studying patients with brain disease, neuropsychological research does provide an opportunity to learn more about normal memory by better understanding the nature and course of disordered memory as a function of neuropathological processes.

Although each of these fields of psychology has provided unique insights into various aspects of memory functioning, their amalgamation in the field of geriatric, cognitive neuropsychology, by definition, focuses on theories encompassing the broad-based spectrum of peaks and declines across the lifespan as a function of both health and disease, which provides a perspective that ultimately enriches each individual field. This study was motivated by just such a desire, namely to predict and explain the performances of variously aged healthy subjects and Alzheimer's disease (AD) patients on a number of memory tasks with a single, broad-based memory theory.

The literature review chapter begins with a description of three prominent theories of explicit memory. Specifically, levels-of-processing, encoding-specificity, and transfer-appropriate-processing theories are defined, and relevant studies in support of each theory are reviewed. The review continues with the presentation of studies in support of generation and picture-superiority effects, two robust explicit memory phenomena. In each section, theoretical accounts of memory and supportive research findings are presented separately for young normals, elderly normals, and AD patients. The population similarities and differences are then brought together in a summary subsection to conclude each superordinate section. The second half of the literature review focuses on implicit memory and follows a similar organization. Again, experimental findings are presented separately for the various populations of interest and are then summarized in concluding subsections. General findings on standardized implicit memory tasks are reviewed first to highlight differences between young and old and between healthy and demented individuals. Specific implicit memory findings related to levels-of-processing theory and the picture-superiority effect are then reviewed. An overview of the entire literature review is then provided to emphasize the findings that bear most directly on the present study.

Following the overview, the study design is then laid out, and the primary mission is noted, which is to examine the effects of initial study condition--involving word reading, picture naming, and sentence completion--on subsequent verbal and pictorial implicit memory measures and on explicit recognition memory in healthy young, young-old, and old-old subjects and AD patients. Specific predictions based on previously reviewed studies are then enumerated.

The method chapter presents a description of the study design, the selection criteria for subject inclusion and group assignment, and the development and criteria for all measures used in the experimental study and test tasks. A brief description is provided of a number of neuropsychological measures as well, which were administered in part to ensure appropriate classification of patients and controls. The procedure, which was rigidly adhered to for all subjects, is then presented in sufficient detail to permit exact replication by interested parties. The procedure for each task is presented in the order in which it was administered in the study.

The results chapter begins with a description of group differences on the neuropsychological tests; neuropsychological performance is also discussed in terms of clinical normative data. Results of the experimental study tasks are presented next, with a discussion of methodological concerns involving potential item-selection effects. The results of both implicit memory tests--word-stem completion and picture-fragment identification--are then reported, with initial discussions of scoring and item-exclusion issues, followed by results involving baseline performance and, ultimately, priming performance. In each case, differences in performance related to groups and to study conditions are explored. In the final subsection of the Results section, scoring issues related to the explicit recognition memory test are presented, followed by reports of recognition accuracy and response bias, again as a function of subject group and study format.

Following an initial review of the primary findings, the discussion chapter proceeds with a discussion of the neuropsychological test performance. Findings are related to the clinical neuropsychology of aging and dementia. The results of the healthy and AD subjects' performance on the study tasks are then reviewed and discussed in terms of theoretical implications of imperfect encoding for implicit memory research. Implicit and explicit test performance is then discussed in separate subsections pertaining first to healthy subjects and then to AD patients. In each of these subsections, the primary findings are enumerated and then discussed. Present findings are related to previous research, and possible explanations of differences in results are explored. It is argued that transfer-appropriate processing theory provides the most parsimonious account of the findings for both healthy young and healthy elderly subjects as well as for individuals with AD. The Discussion concludes with a few caveats pointing out the limitations of the present findings and some suggestions for future research.

Chapter 2

Literature Review

The term explicit memory (EM) refers to memory that is measured directly. Essentially, EM is measured by tasks and instructions that require the intentional retrieval of previously studied material. They are the measures usually associated with traditional psychological studies of memory, such as free recall, cued recall, and recognition. EM performance tends to profit from encoding variations involving, for example, semantically rather than shallowly oriented processing, generated rather than passively presented material (termed the generation effect), and pictorial rather than verbal material (termed the picture-superiority effect) among healthy, young adults. Aging appears to attenuate some of these advantages, and Alzheimer's disease (AD) may eliminate some or all of them. These phenomena were described and explained within a levels-of-processing framework, which was the prevailing memory theory throughout the 1970s. More recently, encoding specificity and transfer-appropriate processing (TAP) theories were derived to address certain shortcomings of the levels-of-processing theory.

The term implicit memory (IM) refers to demonstrations of memory based on indirect measures. In contrast to EM, IM measures make no reference to prior events or experiences. Instead, retention of previously exposed material is measured by changes in performance on subsequent exposure(s) to the same or related material. The dependent variable, or measure of change, is usually either speed or accuracy of response. Despite the differences between EM and IM, they share a similar pattern of variable performance between populations, with robust findings among healthy, young adults, slightly attenuated findings among healthy, elderly adults, and generally reduced and sometimes absent findings among AD patients.

Before reviewing literature relevant to the present study, it is worth commenting on the choice of terms that will be used in this paper. Although the EM/IM distinction was first formally introduced less than a decade ago (Graf & Schacter, 1985), a number of other terms have since been used to represent the same phenomena by other authors. For example, because IM is expressed without conscious or deliberate recollection, it has been described as incidental memory (Eysenck, 1974) or memory without awareness (Jacoby & Witherspoon, 1982). Some authors (e.g., Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988) prefer to use the terms direct and indirect to refer to the measures used, rather than EM and IM, because the latter have frequently been used to refer both to tasks and mental structures or processes. In the following, the implicit/explicit taxonomy will be used for convention, but with the same intent as Richardson-Klavehn and Bjork's indirect/direct distinction.

Explicit Memory: A Selective Review of Research Findings and Theory

A number of memory theories advanced in the past 25 years have resulted from studies of normal, young individuals--particularly college sophomores in psychology courses. Although most theorists emphasize the normal rather than the young as a referent for application of their theories, many basic theoretical tenets proffered as generalized theories of normal memory are found eventually to be limited in certain ways to normal young individuals only. Therefore, each theory discussed will first be presented under the heading of "Young normals"; population differences will be discussed under appropriate subject groupings in succeeding sections.

Levels of Processing, Encoding Specificity, and Transfer-Appropriate Processing

Young normals. The levels-of-processing framework (Craik and Lockhart, 1972) posits that the extent to which information is retained is a function of the level of analysis, or depth, to which it was processed at initial presentation. The deep-to-shallow processing continuum is rated along a dimension that can be characterized as richness of meaning or semantic elaboration. In this way, "deeply" processed information is analyzed in terms of meaningful semantic properties and associations. In contrast, "shallowly" processed information is analyzed not for meaning, but for superficial properties--such as acoustic or phonemic features--of the to-be-remembered material.

The levels-of-processing view focuses inherently on the encoding operations engaged during acquisition, as opposed to retrieval. Indeed, the levels-of-processing effect is typically demonstrated by variable levels of retention resulting from manipulations of task orientation, an acquisition variable. Subjects are oriented either to shallow orthographic or phonetic features by instructions to count the number of vowels in a word or indicate whether it rhymes with another word, respectively. Orientation to a deeper level of the stimuli is purportedly achieved by having the subject indicate whether the word is a member of a particular taxonomic category, for example. According to Craik and Lockhart (1972), the semantic orienting task establishes deeper or more elaborate memory traces than do less semantically oriented processing tasks. Such traces are more durable than their shallower counterparts, which ultimately leads to better and longer lasting recall. Empirical support for this prediction comes from studies involving a variety of experimental paradigms in which it has been demonstrated repeatedly that deeply processed information is better learned and subsequently better recalled than information processed in a more shallow manner.

One of the major criticisms of this theory is that it cannot adequately explain experimental findings of better retention, as measured by recognition or cued recall, of words processed on the basis of superficial as opposed to meaningful features, as has sometimes been found (for review, see Tulving, 1979). Instead, counterintuitive findings such as these are readily explained by the encoding specificity principle (Tulving, 1983, chap. 11; Tulving & Thomson, 1973), which relegates as much importance to retrieval operations as to those employed at acquisition. In essence, it is not the level of processing per se at either acquisition or retrieval that determines recall probability, but rather the match or compatibility between encoding and retrieval processes. The importance placed on the relation between trace and cue information predicts that one's level of success in recalling an event depends on the degree to which the conditions at the time of recall recapitulate or mimic the conditions of initial encoding.

In updated revisions of the levels framework (e.g., Jacoby & Craik, 1979), emphasis is placed on the notion that the retrieval context, like the encoding context, is an important determinant of what is remembered. The influence of Tulving and Thomson's (1973) encoding specificity principle is clear. Jacoby and Craik (1979) discuss a feature-overlap model of recognition in which encoding takes place at both acquisition and retrieval; the match, or overlap, between the originally encoded trace and that which is encoded during the retrieval context determines the extent to which material is recognized in a probabilistic manner (i.e., the greater the overlap, the greater the recognition). They further stress that retrieval processes result from both the more-or-less automatic encoding of the stimulus itself as well as the more elaborate and active reconstructive operations that may be induced by task demands.

Further support for the importance of retrieval conditions comes from experiments conducted by Morris, Bransford, and Franks (1977). These researchers, like Tulving and Thomson (1973), recognize the shortcomings of the levels-of-processing framework in its singular focus on processing at input and the arbitrary labeling of analyses as inherently superficial or meaningful. In their theory of transfer-appropriate processing (TAP), they argue instead that the appropriateness of specific acquisition activities is always relative to the particular goals of the learning episode. For example, phonemic analyses of incoming information will lead to superior performance relative to semantic analyses when retention is tested by recognition of rhymes of the target words. More standard retention measures, such as free recall or recognition of the original words presented, demonstrate the superiority of semantic acquisition, because such testing situations bias semantic processing.

Although TAP theory is reminiscent of the encoding specificity principle outlined above, it differs slightly in its emphasis on optimal retrieval situations and the insistence that subjects be tested with appropriate tests. This emphasis contrasts with Tulving's (1979) position that remembering is always relative, which precludes any statements about an experimenter's ability to develop an absolute, such as the optimal retrieval condition for a particular study. It would appear that the difference between these two theories is more semantic than real. In this paper, the two terms--encoding specificity and TAP--will be used in accordance with their use by the authors of the studies being reviewed.

Nevertheless, they are considered equally representative of the basic idea that memory performance can be best understood and even predicted by an understanding of the relation between processes invoked at acquisition and test.

Although both encoding specificity and TAP improve on the original levels-of-processing framework, they nevertheless both suffer from a lack of specificity. As noted, the general claim that memory performance is determined by the degree of overlap between study and test accounts for many experimental findings that are difficult to explain by a strict levels-of-processing view. At the same time, however, TAP in a broad sense can account for any finding on a post-hoc basis, without providing a means to make specific, a priori predictions of experimental outcomes. Specific predictions require a method for identifying and scaling component processes of various study and test tasks. Recently, proponents of TAP accounts for dissociations between implicit and explicit memory test performance have ordered underlying processes along data-driven versus conceptually driven (Roediger, Weldon, & Challis, 1989) or integrative versus elaborative (Graf & Gallie, 1993) dimensions. The assumptions underlying these two approaches are open to validation by empirical testing of the specific predictions they generate.

Elderly normals. In an extensive review of research on memory in aging, Craik (1977) concluded that age-related memory decline is due to the nature of the processing required for the successful completion of a task. In subsequent work, Craik and his colleagues (Craik, 1984; Craik & Byrd, 1982) found that age differences become more substantial with increasing demand for attentional resources in carrying out effortful processing operations. For example, age differences are great when tasks call for spontaneously initiated, deep, elaborate, or inferential processing (Craik & Byrd, 1982; Craik, Byrd, & Swanson, 1987). Similarly, larger age differences are found on free recall as opposed to recognition tests (Craik, 1977). Again, the results are consistent with the view that the greater the requirements for self-initiated processing (as in unstructured free recall), the worse older people will do relative to young people.

More recently, the contextual hypothesis (Craik et al., 1987; Poon, 1985), which states that memory performance is a function of complex interactions between the subject and the learning context, has accounted for a number of diverse and sometimes seemingly contradictory experimental findings. In general, it has been found that just as age differences are exacerbated when tasks require self-initiated, reconstructive processing operations for success, they are attenuated or eliminated when large degrees of environmental support are provided. The support may be provided by acquisition variables (e.g., explicit encoding strategies as opposed to a neutral study condition), the material (e.g., rich to-be-remembered material with inherent organization as opposed to unrelated word lists), the task (e.g., recognition or cued recall as opposed to unstructured free recall), or by subject variables (e.g., verbal ability, level of activities of daily living). Further, the interactions between these variables determine memory performance to an even greater extent than any individual variable (Craik et al., 1987).

It should be emphasized that the review here is necessarily selective and restricted to findings and theories that pertain in some way to the present study. The interested reader is referred to more broad-based and extensive reviews of aging and memory (e.g., Bäckman, Mantyla, & Herlitz, 1990; Bayles & Kaszniak, 1987; Burke & Light, 1981; Craik, 1977; Hultsch & Dixon, 1984, 1990; Poon, 1985; Salthouse, 1985).

Alzheimer's disease. Before proceeding to a review of the nature of encoding and an analysis of levels of processing in Alzheimer's disease, important diagnostic issues will be discussed briefly. Alzheimer's disease (AD) is a chronic, progressively degenerative, organic brain disorder of undetermined etiology (U.S. Department of Health and Human Services Task Force on Alzheimer's Disease, 1984) that currently affects approximately 2.5 million American adults (Alzheimer's Disease and Related Disorders Association, 1987). AD is the most common of the more than 50 disorders that cause dementia, a cluster of symptoms marked by substantial impairments in memory and at least one other area of cognitive functioning sufficient to interfere with social or occupational abilities in the absence of delirium (American Psychiatric Association, 1987).

AD is the prototypical cortical dementia. As such, it may be differentiated from subcortical dementias (e.g., Cummings & Benson, 1983, 1984) as well as from axial and mixed dementias (e.g, Joynt & Shoulson, 1985). Only clinicopathologic diagnoses of AD are definitive, requiring both documentation of dementia during life and characteristic neuropathology upon biopsy or autopsy. To improve diagnostic accuracy during life, a joint task force of the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (ADRDA) outlined a set of criteria for the clinical diagnosis of probable AD (McKhann et al., 1984). The criteria include the establishment of a clinical diagnosis of dementia documented by impaired mental status, neuropsychological deficits in at least two areas of cognition, progressive memory decline, undisturbed consciousness, onset between the ages of 40 and

90, and the absence of other systemic disorders that could account for the progressive deficits. For further discussion of the epidemiology, diagnosis, pathophysiology, and clinical presentation of AD patients, see also Blessed, Tomlinson, and Roth (1968), Brumback, Leech, Carella, and Miner (1990), Evans et al. (1989), Kaszniak (1986), Katzman et al. (1988), Kemper (1984), Moss and Albert (1988), Schneck, Reisberg, and Ferris (1982), Strub and Black (1988), and Terry and Katzman (1983)

Memory is characteristically the prominent deficit in AD. Even casual observers can detect a striking impairment in the ability of AD patients to acquire new information, as patients will typically ask the same question repeatedly in the span of an hour or two, seemingly unable to recall that the question had been asked and answered numerous times. In an extensive review of neuropsychological studies of dementia, Kaszniak (1986) reported that AD patients are impaired in all areas of memory functioning, although evidence suggests that secondary, or long-term, memory is more deficient than primary, or short-term, memory (e.g., Ober, Koss, Friedland, & Delis, 1985; Wilson, Bacon, Fox, & Kaszniak, 1983). Remote memory, or the ability to remember significant events from one's childhood and adolescence, is typically preserved early on, but it too becomes impaired in advanced stages of the illness.

Some investigators maintain that AD patients' impairments may cut across theoretical distinctions of memory, such as Tulving's (1972) episodic/semantic distinction, as deficient memory has been revealed for both personal events and factual information (Kaszniak, 1986). In contrast, it has been argued that controlled, or effortful, processing declines in dementia, while automatic processing, or that which does not require attentional resources

(Hasher & Zacks, 1979), is preserved until the end stages of the disease (Jorm, 1986).

The study of levels-of-processing effects in AD patients indicates that they suffer from a pervasive encoding deficit that includes, but is not limited to, the semantic attributes of stimuli (Martin, Brouwers, Cox, & Fedio, 1985; Martin & Fedio, 1983). In other words, when left to their own devices, they appear unable to encode a sufficient number of stimulus features or attributes to result in successful recall. This finding is consistent with Weingartner et al.'s (1982) finding that AD patients do not benefit from the inherent organization provided by categorized word lists. In both cases, there is a deficit in the spontaneous adoption of semantic encoding processes that would benefit patients' memory performance.

Deficient use of semantic encoding processes is reminiscent of the problems in active, elaborative encoding displayed by normal elderly individuals. However, for the elderly, the provision of contextual support and/or the requirement for such processing by task instructions ameliorates and, in some cases, normalizes their performance to the level of normal young individuals. Results of similar studies with AD patients are mixed (see Kaszniak, 1986, and Nebes, 1989, for reviews). Martin et al. (1985) found that the provision of semantic orienting tasks did improve memory performance in AD. In contrast, others have found that AD patients fail to benefit from semantic orienting on recognition memory tests (Corkin, 1982; Wilson, Kaszniak, Bacon, Fox, & Kelly, 1982).

The preceding discussion represents a very small sampling of the extensive literature on the nature of semantic memory in AD and the contribution of naming and fluency deficits to their memory problems.

Unfortunately, a more thorough review of that literature is outside the scope of this paper. However, several excellent primary and review papers are available (e.g., Appell & Kertesz, 1982; Bayles, 1982; Bayles & Kaszniak, 1987; Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Emery, 1988; Huff, 1988; Morris & Kopelman, 1986; Nebes, 1992a, 1992b; Ober, Dronkers, Koss, Delis, & Friedland, 1986; Rosen, 1980; Schacter, Kaszniak, & Kihlstrom, 1991).

Summary. In line with levels-of-processing theory, attention to the semantic attributes of incoming stimuli benefits recall of that material for normal, young individuals relative to recall following attention to superficial stimulus features. Both encoding specificity and TAP theories account for findings demonstrating that level of retention is best predicted by the match between processes or tasks at study and test. Normal elderly individuals also retain more deeply than shallowly processed information, but they show age-related decrements on effortful processing tasks. Although they tend not to adopt elaborative processing strategies spontaneously, their performance improves with contextual support. Level of retention is best predicted by interactions between subject, task, material, and test variables. Alzheimer's patients show striking memory impairments marked by deficient semantic encoding, with limited benefits from semantic orienting tasks. Level of explicit retention is usually poor irrespective of the nature of the task or instructions.

The Generation Effect

Young normals. Normal individuals remember material better when they generate it themselves than when it is externally presented, a phenomenon known as the generation effect (Slamecka & Graf, 1978). In a series of experiments, subjects were required either to generate a word from its initial letter preceded by a related stimulus word (e.g., rapid-f) or to simply read the presented word pair (e.g., rapid-fast). Under a variety of retention measures, including cued and uncued recognition, free and cued recall, and a measure of subjective confidence ratings, the self-generated material was better remembered (Slamecka & Graf, 1978). The authors tentatively explained the results as generation-induced, enriched memory traces leading to greater accessibility than the less enriched traces established by reading. However, it is particularly noteworthy that words generated to a rhyme (e.g., save-c for save-cave) provide as much memorial benefit as words generated to a semantic associate (e.g., ruby-d for ruby-diamond). This indicates that the magnitude of the generation effect is not related to the depth of encoding (at least along a semantic dimension) as would be expected from levels-of-processing theory.

Despite the finding that the generation effect is highly robust across a variety of circumstances, it too can be viewed as a function of the relation between study and test as dictated by the encoding specificity principle. For example, Glisky and Rabinowitz (1985) found a generation specificity effect in which generation at test was ineffectual in benefitting memory when the items were not also generated at encoding. Instead, the repetition, or match, of generation operations from study to test yielded the best recognition. This finding is in complete accordance with TAP theory, which Glisky and Rabinowitz referred to as a "goodness of encoding" construct. Similarly, in a study in which test manipulations involved the use of related distractors in recognition and the generative context as a cue in cued recall, certain study-test interactions led to the interpretation of the generation effect as a reflection of context-sensitive item distinctiveness (Begg, Snider, Foley & Goddard, 1989). Again, the idea is not so much that generating renders items more distinctive than does passive reading of the same items--which it undoubtedly does--but that, with regard to probability of subsequent recall, a much greater determinant of recallability is the extent to which the discriminations performed at study are reinstated at test. Although this argument appears to minimize the role of generation in the generation effect, it furthers the applicability of TAP theory.

Elderly normals. The generation effect appears to be preserved in normal aging (Mitchell, Hunt, & Schmitt, 1986). This finding supports the view that despite older adults' tendency to not engage in elaborative processing spontaneously, they can and do engage in such processing when mandated by task instructions (e.g., generating words from incomplete sentence frames). More importantly, they enjoy the memorial benefits that have come to be associated with internally generated stimuli in young people (Slamecka & Graf, 1978). It should be noted, however, that the generate condition does not lead to equivalent retention levels for young and old subjects in absolute terms. Instead, it is the improvement in retention, as measured by cued recall, from the passive "read" study condition to the active "generate" condition that is parallel across age groups.

Alzheimer's disease. As with so many other aspects of memory, the generation effect appears to be deficient in AD. Mitchell et al. (1986) found that not only did the generate condition fail to normalize the memory of the AD group, but those patients failed to demonstrate a memorial advantage of generated over read words even among themselves. This result is qualitatively different from the normal old subjects who were at least able to improve from the read to the generate task within group.

Their impoverished performance notwithstanding, it should be noted that the AD patients were able to successfully complete the generate task. That is, they did manage to come up with appropriate endings for incomplete sentences having two high-frequency object alternatives. This is consistent with a recent review (Nebes & Madden, 1988) suggesting that AD patients are not impaired when required to choose best-fit sentence endings, so long as the sentence context is highly constrained and directed. When required to make a self-directed search of their lexicon, however, as in confrontational naming, fluency, and unconstrained sentence completion tasks, the same patients are impaired disproportionately.

Summary. In an application of levels-of-processing theory, subject-generated material is presumed to be more deeply encoded than externally presented material, and, indeed, such material is better remembered by normal young subjects. Elderly subjects also show better recall for self-generated as opposed to externally provided words, but their absolute level of retention is lower overall relative to young subjects. AD patients are able to generate items appropriately in highly constrained generate conditions, but their memory is no better for actively generated than for passively read words.

The Picture Superiority Effect

Young normals. As Jenkins (1979) pointed out in a tetrahedral model of memory, the materials variable can be as important a determinant of memory performance as orienting or retrieval variables. Nowhere is this more apparent than in the differential recall produced by two different types of materials, namely pictures and words. In brief, pictures are nearly always remembered better than words (Paivio, 1971; Shepard, 1967), a phenomenon known as the picture superiority effect (PSE). The effect is not limited to free recall; even with recognition measures in which the test format is verbal, items presented as pictures or drawings at study are recognized with greater success than items presented as words (Madigan, 1983).

At first glance, this finding appears to be at odds with TAP theory. One would logically assume that there could be no better match between study and test than when the identical stimulus is present on both occasions, a situation that occurs in a word-word condition wherein a word presented at study is re-presented as one of the response choices in a recognition test. In this instance, the verbal test format reinstates completely the study format. Nevertheless, pictures of the studied words are recognized better than the words themselves.

Two theories dominate the picture memory literature: the dual-coding theory of Paivio (1971, 1983) and the sensory-semantic model of Nelson and colleagues (Nelson, 1979; Nelson, Reed, & McEvoy, 1977). The former holds that two separate symbolic systems, one involving a verbal code and one involving nonverbal images, subserve memory and cognition. Different stimuli invoke the activation of one or the other system to a greater or lesser extent. For example, words, especially abstract ones, generally invoke verbal processes, whereas pictures are encoded primarily as images.

The two systems are partially interconnected, in that pictures can be named, and words, especially concrete ones, can be imaged. Still, they are functionally independent in their modes of processing. The fact that pictures are easier to recall than words is explained by the claim that when pictures are recalled or recognized, both their imaginal and verbal codes are activated. In contrast, word recall typically activates the verbal code only. The dual activation in the picture recall condition, compared to the single activation in the word recall condition, is what accounts for the picture superiority effect. Empirical support for Paivio's (1971, 1983) dual-code theory comes from the well-established finding that pictures are remembered no better than words when subjects are instructed to create images of presented words. In this case, words as well as pictures enjoy dual activation of both verbal and imaginal codes, thereby eliminating the normal pictorial advantage.

The sensory-semantic model (Nelson et al., 1977) holds that both word and picture stimuli can be represented in memory in terms of visual, phonemic, and semantic features which correspond to the material's physical appearance, name code or label, and significance or conceptual meaning, respectively. Although all three attributes can be processed for a given stimulus, they are not all activated in tandem. The order in which the various features are processed differs depending on the task or material. In line with the levels-of-processing approach, this model maintains that orienting tasks may be manipulated to direct encoding efforts toward a particular type of feature. Instructions to subjects may therefore focus attention primarily toward the meaning, phonemic, or sensory features of presented material.

Processing is also directed by the materials themselves, which may supplement or even supercede the processing directed by orienting instructions (Nelson, 1979). According to the model (Nelson et al., 1977), visual features are always processed first for both pictures and words. Picture processing then proceeds with activation of meaning features. Although most pictures can be named readily, the model emphasizes that the phonemic access required for naming is indirect in the case of pictures, necessarily occurring subsequent to conceptual processing. Naming words, on the other hand, does not necessitate the prior processing of meaning. Phonemic access can proceed directly from the visual identification of a stimulus. Empirical support for this claim of differential ordering of feature access comes from the finding that words are named faster than pictures, but pictures are categorized faster than words (Potter & Faulconer, 1975).

Nelson (1979) has argued that the PSE lies in the greater distinctiveness of the visual representation of pictures compared to those of their written labels. When distinctiveness is reduced, as by repeating the same physically orienting question across presented items (Intraub & Nicklos, 1985), the PSE is eliminated or even reversed. Updated formulations of the original levels-of-processing framework (Craik, 1979; Jacoby & Craik, 1979) have also emphasized the role of discriminability during encoding and its relation to subsequent item retention. Essentially, deep encodings increase discriminability from other encodings, which supports discrimination from distracting alternatives at the time of test. Thus, distinctiveness, or uniqueness of discrimination, appears to play an important role in explaining levels of processing effects, the generation effect, and the PSE (see also Eysenck, 1979).

Elderly normals. Before proceeding to a discussion of the PSE in aging, it is worth noting that verbal memory is considered to be relatively well-preserved in aging in comparison to nonverbal memory (for reviews see Albert & Heaton, 1988; Dixon, Kramer, & Baltes, 1985; Hochanadel & Kaplan, 1984). Yet, perhaps because iconic (i.e., visual sensory) memory is presumed to be intact in aging (Poon, 1985), age-related sensory declines are rarely, if ever, implicated as the cause of nonverbal memory declines in aged adults. However, age differences in certain perceptual abilities emerge when stimuli are degraded. For example, older adults perform poorly relative to younger adults when required to identify Gollin-type (1960) incomplete figures (Danziger & Salthouse, 1978; Read, 1988). Gollin figures are line-drawing depictions of common objects in which some of the contour lines and internal details are missing. The task of identifying the object represented by the incomplete stimulus material is known as visual closure.

If the locus of older adults' poor performance in the identification of incomplete figures is in the inference process and is not due to inefficient visuoperceptual processing per se (as suggested by Danziger & Salthouse, 1978), then when (a) complete stimuli are available for visual inspection; (b) generous presentation times are provided; and (c) drawings of highly familiar, concrete objects are used, one would expect to find the standard PSE in which pictures are recalled better than words. In effect, despite typical findings of a verbal-nonverbal discrepancy in older adults, the above constraints should serve to maximize contextual support, which, in turn, should attenuate or eliminate age differences in the retention of pictorial stimuli. This prediction is also consistent with Paivio's (1971) dual-coding theory. The extra information purportedly provided by the activation of both verbal and visual memory codes should disproportionately benefit older adults, just as instructions requiring elaborative encoding do. In both cases, demands on the spontaneous adoption of elaborative encoding operations are reduced because they are incorporated into the materials or instructions.

The results of several studies looking at the PSE in aging are mixed. Craik (1977) noted that age decrements have been found in the recognition of both words and pictures in many circumstances. However, certain age by material interactions indicate that older adults are not at all or only slightly impaired in the recognition of familiar and meaningful pictures. A similar finding was reported by Park, Puglisi, and Sovacool (1983). They too noted that the overall recognition of both words and pictures is lower in old relative to young adults. However, the important finding from their study is that the PSE itself is retained with age. Specifically, older adults' recognition scores were enhanced as much as younger adults' when pictures rather than words served as the to-be-remembered material. Thus, the prediction that the use of pictorial stimuli would eradicate age differences on subsequent recognition testing was not realized. Nevertheless, these data suggest that older adults can and do profit from the additional visual activation induced by pictures as opposed to words in the same manner and to an equivalent degree as young individuals.

An extension of these findings comes from a series of studies conducted by Winograd, Smith, and Simon (1982), in which it was found that the PSE maintains in aging even when oral or written free recall--rather than recognition--serve as the criterial tasks. The authors note, however, that the effect may not be seen when experimental sensitivity is low. This conclusion highlights the need to caution against ceiling effects in the young group when designing studies intended to explore aging effects.

Finally, the work of Rissenberg and Glanzer (1986) provides another example of how age differences in the PSE may be apparent or absent depending on variations in the experimental design. In one of their experiments, results indicated that the additional or extensive encoding enjoyed by the silent viewing of pictures in young adults diminishes with age (as measured by a free recall retention test). Although pictures were recalled better than words for both age groups, the effect was greatly attenuated in the older subjects. The authors did not discuss the fact that their verbal free recall retention measure included lexical access and retrieval components as well as memory. It is therefore not as pure a measure of pictorial retention as the recognition measure used by Park et al. (1983). However, in a second experiment, the PSE was reinstated in the elderly when overt verbalizations were required at study. This finding led to the conclusion that the forced verbalization condition produces more extensive activation than does the passive, silent viewing condition. The difference between the two conditions disproportionately benefits the older adults, because young adults tend to activate spontaneously both verbal and visual codes, even in the silent condition. It should be noted that this result is also consistent with the notion of TAP. In the overt verbalization condition, the lexical retrieval required at study approximates the processes invoked during verbal free recall to a greater extent than does silent viewing.

Alzheimer's disease. The nature of nonverbal memory in AD is a matter of some dispute, although there is no question that it is impaired. Some would argue that AD patients' nonverbal memory deficits are as profound as their verbal memory deficits (Moss & Albert, 1988). Performance on immediate and delayed figural reproduction tasks, typically used as measures of nonverbal memory, is deficient. What is not so clear is whether the deficit is one of perception, construction, or nonverbal memory per se, as these are all confounded in many tasks. In fact, there are those who claim that the confrontational naming disorder in AD is due to a perceptual deficit (Kirshner, Webb, & Kelly, 1984), although the perceptual hypothesis is discounted today in favor of a semantic breakdown hypothesis (e.g., Bayles & Tomoeda, 1983; Huff, Corkin, & Growdon, 1986; Smith, Murdoch, & Chenery, 1989).

The PSE has not been assessed directly in the AD literature. Rissenberg and Glanzer (1986) examined this effect in a memory-impaired population, which they classified as primary degenerative dementia, and found no difference in recall between pictures and words, for either silent or overt naming viewing conditions. Although the PSE has not been studied directly in patients diagnosed with probable AD, given their nonverbal memory impairments and the absence of a PSE in a group of elderly individuals whose memory impairments are less substantial than those found in AD, one could reasonably hypothesize that their memory for pictures is no better than their memory for words.

Summary. The PSE, which refers to the typical memorial advantage of pictures over words, is robust with normal young subjects. It is generally preserved with normal aging, despite traditional age-related findings of poorer performance with nonverbal than verbal materials and the suggestion of perceptual identification inefficiencies. Several caveats apply to the preservation of the PSE in aging, however. First, although pictures are retained better than words for both young and old subjects, overall memory is still better in the young with both types of materials. Second, the effect is more pronounced on recognition as opposed to free recall measures. Finally, the effect is reduced in the elderly when study conditions do not mandate the activation of both verbal and visual codes, although it may be reinstated by ensuring that pictures are named as well as viewed. AD patients show deficits on virtually all explicit memory measures examined to date, and it is likely that they would show impaired retention of pictures relative to words, as has been demonstrated in a memory-impaired population. However, the PSE has not been assessed directly in AD patients.

Implicit Memory: Experimental Findings

Implicit and explicit memory were first dissociated in patients with amnesia. Thus, implicit memory (IM) in amnesia will be discussed before proceeding to a review of IM studies in young normal, elderly normal, and AD subjects.

Performance on Standard Implicit Memory Tests

Amnesics. Studies with amnesic patients reveal that despite a frank inability to acquire new information or explicitly remember recent experiences (see Butters & Cermak, 1980, and Squire, 1987, for extensive reviews), their ability to learn motor, perceptual, and cognitive skills is essentially normal (e.g., Milner, 1972; Moscovitch, 1984). For example, they improve with practice on a variety of tasks, including reading inverted text (Cohen & Squire, 1980), assembling a jigsaw puzzle (Brooks & Baddeley, 1976), applying a mathematical rule (Kinsbourne & Wood, 1975), mirror drawing (Starr & Phillips, 1970), pursuit rotor drawing (Milner, Corkin, & Teuber, 1968), serial pattern learning (Nissen, Willingham, & Hartman, 1989), and solving complex block arrangement problems, such as the Tower of Hanoi (Cohen, 1984). In each of these cases, learning is normal despite the amnesics' failure to remember having seen the materials before. Because memory is demonstrated in these studies by improvements in the execution of a task, rather than in statements about the task, it is frequently referred to as procedural, as opposed to declarative, memory (Cohen, 1984). The same phenomena have been couched in terms of "knowing how" versus "knowing that" (Cohen & Squire, 1980) or activation versus elaboration (Graf & Mandler, 1984).

Aside from skill learning, the other major area of preserved IM in amnesics involves priming effects (see Schacter, 1987b, Shimamura, 1986, and Squire, 1987, for reviews). In repetition, or identity, priming response latencies are shorter or performance is more accurate from initial to later exposures of the same stimulus (e.g., lexical decision or perceptual identification tasks). Initial demonstrations of normal repetition priming in amnesic patients were conducted by Warrington and Weiskrantz in a series of studies (1968, 1970, 1974, 1978). Following as many as three presentations of a list of familiar words, amnesics were severely impaired on tests of free recall and yes/no recognition. However, they were just as successful as matched control subjects in identifying visually degraded fragments of the previously presented words.

Similar results have been found with other types of partial stimuli (e.g., Cermak, Talbot, Chandler, & Wolbarst, 1985; Graf & Schacter, 1985; Graf, Squire, & Mandler, 1984; Jacoby & Witherspoon, 1982; Schacter & Graf, 1986b; Shimamura, 1986; Tulving, Schacter, & Stark, 1982). Typically, subjects are given a set of stimulus materials (e.g., a list of words) and told to perform some type of work on it (e.g., rate the words for likeability, count the number of vowels in each, use it in a sentence, etc.). Subsequently, another set of materials, composed of incomplete stimuli, is presented. Among the most commonly used stimuli are word fragments (e.g., A__a_si_ for assassin) or stems (e.g., but___ for butterfly). Fragments and stems that correspond to studied items have an increased probability of being completed with those items than with new items.

Interestingly, not only do amnesics display normal priming with familiar items that have pre-existing memory representations, such as individual words (Diamond & Rozin, 1984; Graf et al., 1984) or highly related words in paired associates (Shimamura & Squire, 1984) and idiomatic expressions (Schacter, 1985), but they also exhibit priming for material that requires them to extract new semantic knowledge, such as forming new associations between previously unrelated material, in the course of a learning episode (Glisky, Schacter, & Tulving, 1986a, 1986b; McAndrews, Glisky, & Schacter, 1987; Schacter, 1987a; Schacter, Harbluk, & McLachlan, 1984). The latter type of priming is referred to as implicit associative memory, and it is preserved despite impaired episodic explicit memory of the same material (but see Shimamura & Squire, 1989, for evidence of impaired priming of new associations in severely amnestic subjects).

In sum, despite some evidence that priming performance may be inversely related to severity of amnesia, the overall consensus is that IM is preserved in amnesia, whereas explicit memory is profoundly impaired. Particularly noteworthy is the finding that the crucial determinant of an amnesic's performance on a completion task is the nature of the task instruction. When subjects are told to complete the stem with the first word that pops into their head (i.e., implicit instruction), they show priming to the same extent as normals. When, however, they are told to complete the stem with a word they saw earlier (i.e., explicit instruction), they perform poorly (Graf et al., 1984).

Young normals. It is perhaps not so surprising that amnesic patients show a dissociation in their performance on different memory measures. If there are indeed functionally distinct memory systems, then it seems reasonable that one may be affected by a particular type of brain damage while the other is spared. What may be more surprising is the fact that studies of normal subjects have also revealed dissociations between implicit and explicit memory (for reviews, see Richardson-Klavehn & Bjork, 1988, and Schacter, 1987b).

In a series of studies by Jacoby and colleagues (Jacoby, 1983; Jacoby & Dallas, 1981; Jacoby & Witherspoon, 1982), two memory measures were differentiated in normal young subjects: (a) perceptual identification, an IM measure in which subjects are required to identify words following very brief exposures (35 ms) in a tachistoscope; and (b) recognition, an EM measure. Priming was operationally defined as the difference in accuracy between identification of studied and nonstudied items on the perceptual identification task. Performance on the two measures depended critically on the nature of the processing during the initial exposure of the material. Specifically, target items were either read passively in a neutral condition (e.g., XXX-*cold*) or a context condition (e.g., hot-*cold*), or they were subject-generated on the basis of a conceptual cue (e.g., hot-???). Results indicated that the generated words were recognized better than the words read in context, which, in turn, were recognized better than the words read in the neutral condition. The opposite trend was found for priming in the perceptual identification task, in which the words read out of context were identified with the greatest accuracy and the generated words facilitated perceptual identification the least. Jacoby (1983) suggested that the results were related to the amount of data-driven and conceptually driven processing invoked by the various tasks.

Elderly normals. Recently, the implicit/explicit memory distinction has been applied to studies of aging to determine if normal elderly individuals, like amnesics, might exhibit a differential pattern of performance on the two types of measures (for reviews, see Burke & Harrold, 1988; Howard, 1988; Light & Burke, 1988). In general, findings from aging studies have not been so uniform as those from the amnesia literature, although the data indicate that age differences may at the very least be substantially reduced, if not eliminated, on tests tapping IM (see Graf, 1990; Howard, 1991). For example, evidence of preserved IM in the elderly is found in studies involving: word-stem completion (Light & Singh, 1987; Light, Singh, & Capps, 1986); lexical decision tasks, both with repetition priming (Moscovitch, 1982) and associative, semantic priming (Burke, White, & Diaz, 1987; Howard, McAndrews, & Lasaga, 1981); cued recall of paired associates (Rabinowitz, 1986); generative naming of category examples (Light & Albertson, 1989); nonverbal, serial pattern learning (Howard & Howard, 1989); and repetition priming with both picture naming (Mitchell, 1989) and object naming (Schacter, Cooper, & Valdiserri, 1992) tasks.

Partially preserved IM in aging has been demonstrated by Howard, Heisey, and Shaw (1986) who found an equivalent degree of priming in their young and old subjects involving newly formed associations of nouns presented in sentences, but only when the sentences were presented two or more times. Similarly equivocal support for intact IM in aging comes from a study by Read (1988) in which elderly subjects improved in their identification of Gollin figures (i.e., perceptually degraded line drawings) with repeated exposures of the stimuli, thus demonstrating savings. At the same time, however, significant age differences were seen in the percentage of savings over both short and long intervals. Finally, Light and Singh's (1987) elderly subjects showed as much priming as their younger counterparts on a task requiring the identification of perceptually degraded words. However, the age constancy in performance only held for the 50% degradation level; when stimuli were more degraded, age differences emerged in favor of the young.

Results from other studies indicate that when sample sizes are large, thereby increasing statistical power to detect differences, age-related deficits in IM are more likely to be found. This is consistent with Light and Burke's (1988) acknowledgment of a trend toward an age difference favoring the young in their studies of repetition priming. Hultsch, Masson, and Small (1991) addressed this issue by using very large samples of subjects (584 community-dwelling elderly subjects stratified into three age groups) and found small but reliable age-related decrements on a word-stem completion (WSC) task. Similarly, Chiarello and Hoyer (1988) conducted an extension and replication of Light and Singh's (1987) study, which included WSC and cued recall tasks with both implicit and explicit instructions. Like Light and Singh, they found an age-related deficit on the explicit memory measures. In contrast to the earlier study, however, Chiarello and Hoyer's young subjects showed significantly more priming than did older subjects on the WSC task. Finally, failures to find age constancy in IM have also been found by Moscovitch (1982), as measured by the speed of reading inverted text upon repeated exposures, and by Rose, Yesavage, Hill, and Bower (1986) whose older subjects failed to prime on a spelling test in which certain homophones were biased.

In sum, the results of studies investigating the nature of IM in the elderly are mixed. It appears that small but reliable age differences may be found when sample sizes are large. When no age difference is found, there is usually a nonsignificant trend toward age-related deficits. In any case, one may conclude that age-related decrements in IM, where they do exist, are substantially reduced in comparison to performance on tests of explicit memory, where a variety of age-related deficits are typically found.

Alzheimer's disease. Given the findings of generally preserved IM in amnesia and only somewhat compromised IM in aging, the nature of IM performance in Alzheimer's disease has become a matter of considerable interest in recent research efforts. Results indicating impaired priming, normal priming, and even hyperpriming, a term used when patients show a greater degree of priming than age-matched control subjects, have all been reported for AD patients. Mixed results have recently been found within a single study: 6 of 10 patients showed preserved priming, while the other 4 actually showed negative priming (Albert & Milberg, 1989). One interpretation of this interesting finding is that degree of priming may change with the evolution of the disease

(Chertkow, Bub, Merling, & Bruemmer, 1990).

Analysis of the discrepant findings in the literature suggests that IM functions may be dissociated in AD. In general, priming paradigms employing response latencies as the dependent variable, which may invoke relatively "automatic" processing, tend to be preserved in AD (Ober, Shenaut, Jagust, & Stillman, 1991). For example, motor skill learning, as assessed by pursuit rotor tasks, remains intact in AD (Bondi & Kaszniak, 1991; Butters, Heindel, & Salmon, 1990; Butters, Salmon, Heindel, & Granholm, 1988; Eslinger & Damasio, 1986; Heindel, Salmon, Shults, Walicke, & Butters, 1989) as does reading mirror-reversed text (Moscovitch, 1982), learning an embedded, repeating sequence in a serial, visual reaction time task (Knopman & Nissen, 1987), and judging previously presented melodies as pleasant (Ergis, Deweer, & Fossati, 1992).

Further, in several variations of the lexical decision task (Scarborough, Cortese, & Scarborough, 1977), which is one of the most extensively studied IM paradigms in AD, patients generally demonstrate normal priming. In the standard paradigm, subjects decide whether a letter string constitutes a real word or a nonword. AD patients show normal repetition priming, which refers to the facilitation, as measured by decreased decision time, of having responded to the same word previously (Moscovitch, 1982; Nebes, Brady, & Huff, 1989; Ober & Shenaut, 1988). Lexical decision latencies are also shortened when the target stimulus is preceded by a related word or sentence prime. Results of studies investigating this type of associative priming indicate that so long as stimulus-onset asynchronies (SOAs) are short, inducing a reliance on automatic processing, AD patients exhibit normal priming in word naming, lexical decision, and category decision tasks (Nebes et al., 1989; Nebes, Boller, &

Holland, 1986; Nebes, Martin, & Horn, 1984; Ober & Shenaut, 1989, 1990).

More recently, evidence of hyperpriming in AD patients has been found (Bub & Chertkow, 1990; Chertkow, Bub, & Seidenberg, 1989). Specifically, AD patients exhibited greater semantic priming in a lexical decision task than did normal control subjects, and this was more pronounced for words that were shown in off-line semantic analyses on a subject-by-subject basis to have degraded representations. This finding is consistent with Huff et al.'s (1986) finding that information is lost in an item-specific fashion in AD. Further, Martin (1992) has argued that AD patients' degraded semantic representations are responsible for the finding of hyperfacilitation from semantically related primes but only normal repetition priming from identical primes. Essentially, semantic representation degradation leads to the loss of item distinctiveness, which, in turn, renders semantically related items more similar to an AD patient than to a healthy individual who distinguishes the items well. In this way, semantically related primes increase the magnitude of priming to a level approximating identity priming for AD patients but not for controls; hence, the net result is hyperfacilitation.

Earlier, it was noted that Alzheimer patients are impaired on nearly every aspect of every type of memory test that has been tested to date. It is therefore not surprising that a growing body of literature indicates that these demented individuals are impaired on a variety of IM tests, especially on tasks in which controlled processing is required for success, as, for example, with semantic priming in a lexical decision task using long SOAs (Ober & Shenaut, 1988). The most consistent findings of impaired performance on IM measures in AD come from studies employing completion paradigms. These have been broken down into lexical priming, measured by the WSC task, and semantic priming, measured by paired-associate testing following presentation of stimuli by semantically associated word pairs. There is substantial evidence of both impaired lexical priming (Butters et al., 1988; Heindel et al., 1989; Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991; Salmon, Shimamura, Butters, & Smith, 1988; Shimamura, Salmon, Squire, & Butters, 1987) and semantic priming (Brandt, Spencer, McSorley, & Folstein, 1988; Butters, 1990; Butters et al., 1988; Salmon et al., 1988; Salmon & Heindel, 1992) in AD.

However, two important qualifications may be made to the conclusion that lexical and semantic priming are deficient in AD when tested by completion paradigms. First, in the studies referenced above, the fact that AD patients showed significantly lower priming rates on a WSC task than did age-matched controls has been the basis of the claim that lexical priming is impaired in AD. However, these studies also reveal a significant difference between target and baseline stem completions in the AD group, indicating that previous exposure to items does prime subsequent WSC performance. Thus, the impairment appears to be due to reductions in priming magnitude relative to controls rather than to an absence of priming in AD on an absolute level. Secondly, recent evidence suggests that priming, at least as measured by WSC tasks, may be preserved in AD to the same extent as normal controls when patients are required to process study material at a semantic level. This idea will be discussed in more detail below (under the AD subsection of the following section on IM and levels of processing).

Summary. IM and EM were first dissociated in amnesic patients where it was shown that IM is preserved despite profound impairments on EM tasks. A number of interactions between study task and test performance in young normals indicates that EM and IM measures are dissociable in healthy subjects as well. Small but reliable age-related decrements are found on IM tests when sample sizes are large. Finally, AD patients are impaired on IM tasks that require controlled processing. However, IM is preserved in AD when reaction time is the dependent variable and the task relies on relatively automatic processing. Hyperpriming has been demonstrated when tasks involve items that are semantically degraded in a given patient.

Implicit Memory and Levels of Processing

Young normals. Many of the studies reviewed earlier focused on differences between EM and IM (for review, see Schacter, 1987b). One of the most widely touted differences between them has been the finding of traditional levels-of-processing (LOP) effects in EM tasks (e.g., Craik & Lockhart, 1972) and null effects of LOP in IM tasks (e.g., Graf, Mandler, & Haden, 1982). In a recent study, Roediger and Challis (1992) found no evidence of indirect, or conceptual, priming on a word-fragment completion (WFC) task, while finding large effects on free recall (but see Hirshman, Snodgrass, Mindes, & Feenan, 1990 for a positive effect of conceptual priming on WFC). In contrast, Roediger and Blaxton (1987a) found that the match between surface characteristics, such as typography or blurriness, at study and test is important for WFC but not for free recall. Roediger and Challis (1992) further itemized the differential effects of seven types of variables on WFC and free recall tests. The most parsimonious explanation of the differential effects was that perceptually based processes are important for WFC, whereas conceptually based processes are important for free recall (although see Squire, Shimamura, & Graf, 1987, Experiment 3 for a positive finding of LOP on WFC).

This dichotomy is reminiscent of Jacoby's (1983) distinction between conceptually driven and data-driven processing as the critical difference between explicit and implicit memory, respectively. It is also consistent with the claim that WFC requires a lexical search only, whereas free recall requires an additional semantic search (Nelson, Canas, Bajo, & Keelean, 1987; Nelson, Keelean, & Negrao, 1989). A similar idea has been posited by Graf and colleagues (Graf & Gallie, 1992; Graf & Mandler, 1984), who couch the dissociation in terms of integration versus elaboration. According to this view, the integration of processed words leads to increased accessibility, which has important implications for IM. Conversely, elaboration of processed words leads to increased retrievability, which has important implications for EM.

The notion that EM and IM task performances are dissociable has supported the claim that the tasks reflect retrieval of information from two different memory systems (Hayman & Tulving, 1989; Schacter, 1989, 1990, 1992; Tulving, 1985). However, recent studies have begun to fractionate IM itself, and divisions of IM are not easily accounted for by the systems view. One distinction that has received a lot of attention lately dichotomizes IM tasks along separable perceptual/conceptual dimensions, as was previously done for IM/EM differences (e.g., Roediger, Srinivas, & Weldon, 1989; Weldon, 1991). For example, while it is true that IM tasks are usually more data driven and EM more conceptually driven in their standard administrations (Roediger, Weldon, & Challis, 1989), hybrids may be devised to emphasize conceptual processing in IM (e.g., Toth & Hunt, 1990) and perceptual processing in EM (e.g., Hunt & Toth, 1990). Blaxton (1989) argues that transfer-appropriate processing (TAP) theory is better able to account for the results of such studies than is memory-systems theory (see also Graf & Gallie, 1992; Kolers & Roediger, 1984; Roediger, 1990a, 1990b). For an additional review of the processing view versus the multiple systems debate, see Ostergaard and Jernigan (in press).

As discussed previously, reading words at study produces superior priming relative to generated words on a perceptual identification task (Jacoby, 1983). This finding has been replicated numerous times (e.g., Schwartz, 1989) and extended to a WFC task as well (Blaxton, 1989). In contrast, generating words leads to enhanced priming relative to reading words when the test involves general knowledge questions (Blaxton, 1989; Hamann, 1990). Equivalent WSC priming effects of generated and read words have also been found, such as when the word-completion task involves the production of a five-letter word on the basis of a two-alternative, four-letter stem (Schwartz, 1989). These and other findings of interactions between encoding and IM test conditions suggest that certain IM tests, such as general knowledge retrieval and category exemplar generation (Hamann, 1990) or IM for new associations (Schacter & Graf, 1986a) are affected by LOP manipulations; such tasks may be described as conceptually driven. Other IM tests, such as perceptual identification and the various completion tasks, are very little or not at all affected by LOP manipulations; these tasks may be described as data driven. Alternatively, as suggested by a recent study (Keane et al., 1991), it may be that all priming tasks depend on perceptual processing to greater and lesser degrees (i.e., have a data-driven component), but that some depend on an additional contribution of conceptual processing (i.e., have both data-driven and conceptually driven components, thereby falling between purely perceptual and purely conceptual tasks). This claim is bolstered by the finding that WSC priming is attenuated but not eliminated by auditory as opposed to visual stimulus presentations (Graf, Shimamura, & Squire, 1985) and by studied pictures as opposed to words (Weldon, Roediger, & Challis, 1989).

While conceptual/perceptual dissociations between IM tasks appear quite elegant at first glance, a number of findings cloud the issue. For example, Roediger and Blaxton (1987a) found superior priming on a WFC task following visual rather than auditory study, which is in keeping with the notion of WFC as a data-driven task. However, they also noted that the auditory study condition facilitated WFC performance relative to a nonstudied condition. Such a finding indicates that cross-modal priming can occur on a putatively data-driven IM task, which introduces a conceptual component as well. Further, Challis and Brodbeck (1992) found that LOP manipulations affect WFC for between-subjects and blocked, within-in subjects designs. However, presenting semantic and physical orienting conditions in a mixed list eliminates LOP effects. Similarly, generating items from fragments at study enhances WFC priming if identical fragments are used in both instances (Gardiner, 1988). When the fragments presented at study are different from those at test, reading and generating produce equivalent priming on WFC. Taken together, the fact that LOP effects are fragile and inconsistent on certain IM tests underscores the need to parse both study and test tasks into their component parts, while emphasizing the reliance on conceptual versus perceptual processes necessary to perform each. In that way, seemingly discrepant findings may be clarified (see also Roediger & Blaxton, 1987b; Roediger & Srinivas, in press).

Elderly normals. In a large study of age-related effects (Hultsch et al., 1991), the lack of correlation between performance on an indirect memory task (i.e., WSC) and various direct memory tasks (i.e., fact, word, and story recall) led to the conclusion that, as in many studies with younger subjects, the WSC task reflected data-driven processes, whereas the direct measures reflected conceptually driven component processes. This conclusion is consistent with the findings of at least two studies (Chiarello & Hoyer, 1988; Light & Singh,

1987) in which the effects of LOP manipulations on IM tests were addressed directly in young and elderly subjects. Vowel comparison versus pleasantness rating encoding tasks were varied between subjects. In both studies, standard age and encoding effects were found on two EM tasks (free recall and recognition). As expected, a significant interaction of these two factors was found as well, whereby young subjects improved more with semantic encoding than did the elderly. Chiarello and Hoyer (1988) found the same pattern of significant effects on a WSC task; in contrast, there was no significant effect of age or encoding on WSC performance in the Light and Singh (1987) study. These findings therefore replicate the inconsistent differential effects of LOP manipulations on EM and IM tasks commonly found in studies with young subjects, thereby extending such findings to healthy elderly subjects.

Alzheimer's disease. Earlier, it was noted that AD patients are impaired on both lexical and semantic priming tasks. However, Grosse and her colleagues (Grosse & Wilson, 1989; Grosse, Wilson, & Fox, 1990) found intact priming on a WSC task in AD patients. A procedural difference between their study and studies demonstrating impaired priming on this task may account for the apparent discrepancy. Instead of instructing subjects to rate words for likeability upon initial presentation, as is customary prior to WSC, subjects were required to generate words themselves in the context of a sentence completion task (e.g., "He hit the nail with the ______."). The best-fit responses to the high-cloze sentences were then used as the target primes on a subsequent WSC task (e.g., HAM___). When tested this way, AD patients primed as much as normals. Grosse and Wilson suggested that priming is preserved in AD when it can be ensured that the items tested are in the subject's lexicon; in this case, lexical access was ensured by having subjects generate the words themselves.

Deficits seen in other IM studies may be due to inaccessibility of the semantic knowledge from the patients' partially decomposed semantic network rather than to a deficit in priming ability per se. This conclusion is also consistent with the notion of item-specific information loss in AD put forth by Chertkow et al. (1989, 1990).

Alternatively, or perhaps additionally, the critical difference between the Grosse and Wilson (1989) study and others may be in the depth of encoding allocated to the initial stimuli. That is, the sentence completion task likely provided more extensive and deeper encoding initially as compared to that invoked by likeability ratings. Perhaps the priming demonstrated in the Grosse and Wilson (1989) study is a reflection of the more elaborate processing performed on the target stimuli. The results of two recent studies would seem to support this conclusion. In one, Lussier et al. (1990) presented words initially as paired associates to AD patients. At test, they found preserved priming in a WSC task (although it should be noted that all of their stems constituted complete syllables, which is not a criterion in other studies). The authors attributed their patients' intact priming to the idea that words were better encoded initially in the context of paired-associate learning than in conventional presentation tasks. In another study, Partridge, Knight, and Feehan (1990) ensured that words were processed at a semantic level in the study phase by requiring their AD patients to define each of the presented words. As in many studies with amnesics (e.g., Graf et al., 1984), the study list was presented twice in succession prior to test. Using this method, elderly, moderately demented AD patients showed the same level of priming on a WSC task as did normal control subjects, which was again attributed to deep initial encoding.

Unfortunately, in each of the three studies (Grosse et al., 1990; Lussier et al., 1990; Partridge et al., 1990) concluding that deep encoding was responsible for the preservation of WSC priming in AD patients, the orienting task variable was never manipulated. The lack of such a manipulation places a severe limitation on the depth-of-encoding argument. Nevertheless, the suggestion that depth of encoding may determine AD patients' performance on IM measures is especially intriguing given that encoding manipulations typically do not improve recognition performance, an explicit measure, in these patients (Corkin, 1982; Wilson et al., 1982); further, as discussed above, encoding manipulations tend to have little or no effect on WSC performance in studies with normals (Schacter, 1987b; Schacter & Graf, 1986a).

Summary. Just as EM/IM dissociations have been related to conceptually driven versus data-driven processes, functional dissociations between various IM tasks may also be explained in terms of component processes varying along a perceptual/conceptual dimension in healthy young subjects, and, it appears, in healthy elderly subjects as well. The pattern of performance in AD patients is enigmatic. LOP manipulations known to have a large effect on EM tasks in normals typically do not affect EM performance in AD; yet, there is a suggestion that deeply encoded material may produce normal priming among AD patients on IM tests, where it is least expected in normals.

Implicit Memory and the Picture-Superiority Effect

Young normals. When both pictures and words are presented initially in mixed lists and IM is measured subsequently by WFC, the standard picture-superiority effect (PSE) is reversed: Word priming is superior to picture priming (Weldon & Roediger, 1987; Weldon et al., 1989). In other words, there is a greater probability of completing a word fragment with the target stimulus if it was encountered previously as a word than if it was encountered initially as a picture, which is the exact opposite of the performance pattern seen on EM tests such as free recall and recognition (e.g., Slamecka & Graf, 1978). More importantly, the PSE may be reinstated when a picture-fragment completion (PFC) task is used as the measure of IM rather than a WFC task. Specifically, Weldon and Roediger (1987) used a PFC test in which each stimulus was a single, degraded representation of previously studied words, previously studied pictures, and nonstudied items. Results followed a crossover pattern in which words primed WFC more than did pictures, and both were superior to nonstudied items. In contrast, picture study primed PFC more than did word study, which did not differ from nonstudied items, thereby reinstating the PSE.

Of note in the Weldon and Roediger (1987) study is the finding of even a small amount of picture priming on the WFC task, which indicates that WFC is not a purely data-driven task. Such cross-form priming of words by pictures has been observed before in a lexical decision task (Vanderwart, 1984), and facilitation of picture naming has been produced by words (Durso & Johnson, 1979). Thus, it appears that conceptual priming in fragment completion can occur, though to a lesser extent than does perceptual priming. For further reviews of within-form and cross-form facilitation effects by pictures and words in picture naming, categorization, and lexical decision tasks, see Bajo (1988) and Irwin & Lupker (1983).

In a later study, Weldon et al. (1989) found that words were superior to pictures on both WFC and WSC tasks whether the instructions were explicit or implicit, despite the finding of the standard PSE in free recall and on a cued recall task involving conceptually related cues. They concluded that the determination of whether words or pictures produce the most priming is dependent on the type of task used at test; in general, the closer the match between surface features of the stimuli used at study and test, or between the nature of the processing invoked between study and test, the greater the priming effects will be (see also Dunn & Kirsner, 1989). As in the processing account of dissociations between EM and IM tests (Roediger, Weldon, & Challis, 1989) and between verbal IM tests (e.g., Roediger & Challis, 1992), it appears that transfer-appropriate processing theory also accounts for dissociations between pictorial and verbal IM tests in healthy, young subjects (Weldon et al., 1989). As discussed earlier, this theory states that level of retention is a function of the degree to which processes invoked at study are recapitulated at test.

Snodgrass, Smith, Feenan, and Corwin (1987) have recently developed a test for measuring pictorial IM which differs from the task used by Weldon and Roediger (1987). In the study, or training, phase, fragmented versions of line drawings from the well-established Snodgrass and Vanderwart (1980) picture set are presented to subjects, beginning with the most incomplete (i.e., degraded) level of fragmentation. Progressively more complete versions of the stimulus are presented until the subject is able to identify it or the complete picture (i.e., undegraded) is reached. Each stimulus has eight levels of fragmentation. Identification thresholds can be computed for each subject by the average level of presentation required for successful naming. At test, fragmented versions of the original stimulus (i.e., old items) are presented, along with fragmented versions of new items. The difference in identification thresholds between new and training items thus provides a measure of general skill learning for this task, whereas the difference between old and new items represents implicit item learning (unconfounded by skill learning). Using this method, Corwin and Snodgrass (1987) found that young normal subjects show significant differences on both measures, thereby demonstrating both procedural (skill) learning and perceptual (item) memory.

Elderly normals. The literature on pictorial IM in healthy aging is very sparse. Certainly, perceptual identification tasks have been used to demonstrate small or nonexistent age differences in IM (e.g., Light et al., 1987), as discussed earlier, but such tasks comprise verbal materials rather than pictures. Ward, Corwin, Reeves, and Fukui (in press) have recently used the picture-fragment test developed by Snodgrass et al. (1987) to examine picture-fragment identification (PFI) in aging and AD. Although all subject groups found the same items relatively easy or difficult to identify, there was a main effect of group on threshold level, in which elderly subjects required more complete representations of the stimuli for correct identification than did young subjects. Group differences were apparent on the measure of item learning as well, with young subjects again outperforming elderly subjects. Unfortunately, this study did not explore the effect of word study on PFI, nor of PFI study on word completion, so the question of age influences on the reversals and reinstatement of the PSE found with young subjects cannot be answered.

Alzheimer's disease. Several recent studies have examined the nature of IM with pictorial materials in AD. As alluded to above, Ward et al. (in press) found significant group differences in both the initial identification of fragmented pictures and in perceptual memory between AD patients and elderly normal controls. In an earlier study (Corwin & Snodgrass, 1987) using the same method but with Gollin (1960) figures comprising five levels of fragmentation rather than the Snodgrass et al. (1987) figures comprising eight levels of fragmentation, a group of demented (9 AD and 2 Parkinson's disease) patients showed significant procedural learning in the absence of significant perceptual memory (i.e., non-item-specific skill learning). Similarly, Bondi and Kaszniak (1991) also used the Snodgrass et al. (1987) fragmented-pictures test with AD patients and found evidence of impaired perceptual memory despite intact performance on the skill-learning component of the test. (Interestingly, a group of Parkinson's disease patients showed the opposite pattern.)

In the studies detailed above, the same task was administered at study and test, albeit with the addition of novel fragments in the test phase. Another way to measure priming of fragmented pictures is to present complete pictures at study and then compare identification of fragmented versions of the studied items to identification of nonstudied items. Heindel, Salmon, & Butters (1990) did just that with several subject populations, including a group of AD patients. At study, subjects named line drawings. Semantic and/or phonemic cues were provided, if necessary, to ensure successful object naming. In order to make the test directly comparable to the WSC test (for which AD patients have shown impaired priming in numerous studies by these investigators), patients were instructed to respond with "the first thing you think of" when exposed to a fragmented stimulus. Four levels of fragmentation were used, with a fifth level representing the complete drawing. Perhaps importantly, subjects were allowed only 4 seconds to respond before the next item at the same level was presented. Results indicated that AD patients were able to name objects adequately in the study phase. However, patients had significantly higher naming thresholds (the mean level of fragmentation required to identify items on the fragment identification task) than did age-matched normal controls. Two different priming measures were computed to account for the unequal baseline identification levels, and AD patients were impaired on both.

On an EM version of the same task, in which they were reminded of the pictures they had named earlier and specifically instructed to identify the fragmented items "... to see if you can remember what they were" (Heindel et al., 1990, p. 287), the patients were also impaired. Further, EM was just as poor as IM, both of which were no better than their baseline naming threshold (identification of fragmented distractors). Normal controls, in contrast, performed better on the explicit (cued recall) than the implicit version of the test, both of which were superior to baseline identifications. Overall, this study extended the finding of impaired lexical and semantic priming using completion measures in AD to pictorial priming with a picture completion measure.

Summary. In an extension of functional dissociations between conceptually driven and data-driven verbal IM measures, Weldon, Roediger, and colleagues have found similar dissociations in young, healthy subjects between verbal and pictorial completion measures. Transfer-appropriate processing theory not only accounts for data spanning the diverse and extensive IM literature, but predicts reversals and reinstatements of the PSE whether instructions are implicit or explicit. The theory appears to account for findings with IM measures in studies of normal elderly subjects as well. Studies conducted to date indicate that AD patients do not show priming on picture-fragment completion tasks, even when they have previously studied the same fragments or the complete pictures of the fragmented items. In other words, they do not seem to benefit from the match between surface features at study and test as normal subjects do.

Overview

The literature reviewed in preceding sections made apparent several important features of EM and IM among and between various subject populations. Levels-of-processing manipulations strongly influence EM performance in young, healthy individuals. In contrast, such effects are typically absent on data-driven IM measures; however, they do occur on occasion with conceptually driven IM measures. Two examples of encoding manipulations reviewed here were subject-generated material and picture study, both of which improve explicit tasks, such as free recall or recognition, relative to more superficial study conditions. Within the IM literature, an argument was made that the specific task used is less important as a determinant of performance than is the nature of the processing invoked by it. Thus, generation-superiority and picture-superiority effects may be present or absent with implicit measures, depending on the particular processes required for successful demonstrations of IM with particular tasks. One of the most striking applications of this transfer-appropriate processing account of IM performance is the reversal and reinstatement of the PSE, demonstrated in a study by Weldon et al. (1987).

Among healthy, elderly subjects, substantial age differences in favor of the young are found with explicit measures, particularly when contextual support is reduced or lacking. Small but reliable age decrements are found in IM studies when sample sizes are large and statistical power is strong. The findings across measures involving subject-generated and pictorial material appear to follow this same pattern of relatively preserved IM in aging, but evidence for this is inconclusive. In particular, the Weldon et al. (1987) paradigm has not been examined in a healthy, elderly sample.

AD patients show profound impairments in EM, regardless of the nature of the stimuli or tasks used (i.e., no apparent benefit from generation or picture study conditions). Their performance in IM studies is not so consistent. Many studies show preserved priming in AD when reaction time is used as the dependent measure. However, unlike chronic, amnesic patients who show preserved IM on virtually all measures tested, AD patients are impaired on many lexical and semantic priming tasks involving completion measures. However, even this finding is qualified. Recent evidence suggests that WSC performance may be preserved in AD, so long as initial study materials are processed deeply, as in a generation study task. That is, there appears to be a levels-of-processing effect on IM performance in AD despite the absence of such an effect on their EM performance. Unfortunately, one of the problems with this theory is that it was derived on an ad hoc basis rather than empirically. To date, encoding has not been manipulated in the studies purporting to show encoding effects. Finally, AD patients show deficient perceptual memory on picture completion tasks, although they do improve in the skill-learning component of the picture-fragment completion task. This dissociation supports the notion of selectively preserved procedural and impaired item-specific aspects of IM in AD. Given previous findings of impaired WSC performance following word study and impaired perceptual memory on a PFC task, one would not expect to find crossover priming effects in AD. As in the aging literature, however, the Weldon et al. (1987) paradigm has not been assessed directly with AD patients, so the presence or absence of TAP-based crossover priming in AD remains unresolved.

The Present Study

Rationale and Design

As stated above, comparisons of verbal and pictorial study on verbal and pictorial IM measures have not been examined within a single study for either normal elderly subjects or AD patients. This gap in the literature of IM in aging and dementia served as the impetus for the study design implemented here. Specifically, this study examines the effects of initial study condition--word reading, picture naming, and sentence completion--on subsequent verbal (word-stem completion) and pictorial (picture-fragment identification) IM measures and one EM measure (yes/no recognition) in three groups of healthy subjects differing in age (young, young-old, and old-old) and one patient group (individuals with probable AD). The specific design involves both replications and extensions of previous research. Overall, it is expected that a transfer-appropriate processing view of memory will provide a parsimonious account of the findings.

Predictions

Predictions cannot be made for all possible interactions of subject, study, and test conditions, because existing data results are mixed; further, procedural differences between this study and others may mitigate the generalizablity of previous results. Instead, it is intended that the present results provide an empirical foundation for supporting or discounting current theoretical accounts of implicit memory. Having stipulated this general caveat, several predictions can be made nonetheless. They are:

1. Neuropsychological test results should reveal standard age-related declines in prose memory, confrontation naming, and fluency. Performance should be age-invariant on measures of receptive language, vocabulary, reading, and subjective ratings of depression. AD patients are expected to be impaired relative to the old-old group on all neuropsychological measures except the depression scale.

2. All control subjects should perform at ceiling on the study tasks. AD patients, too, are expected to perform flawlessly on the word reading task. They

should also demonstrate normal completion rates for sentences (i.e., unimpaired generation), because the sentences will all have high cloze values. However, given traditional findings of profound confrontation naming deficits in AD, they will likely be impaired on the picture naming study task.

3. Equivalent baseline performance is expected in the WSC task across all groups.

4. Among control subjects, priming in the word-stem completion (WSC) task should follow the pattern of: read words > generated words > items studied as pictures. The magnitude of priming will likely be greatest in the young control group. A contrasting pattern is expected for the AD group, which is expected to show preserved priming in the WSC task for words that were generated, but not for words that were read or studied as pictures.

5. Unequal baseline performance is expected in the PFI task across groups, with young subjects showing the lowest identification thresholds and AD patients showing the highest thresholds. Moderate identification thresholds are expected for the two elderly groups, with only a small performance difference between them, if any.

6. Among control subjects, priming in the picture-fragment identification (PFI) task should follow the pattern of: items studied as pictures > generated words > read words. Given recent findings of impaired perceptual priming in AD patients with incomplete-picture identification tasks, priming on the PFI task is not expected among AD patients in this study, regardless of study condition.

7. Recognition memory performance should yield standard picture-superiority and generation effects when comparing either studied pictures or generated words to words read in isolation. However, the difference between the picture and generate study conditions on subsequent yes/no recognition is

an empirical question. It is expected that AD patients will demonstrate impaired recognition memory relative to controls, regardless of study format. Among themselves, study format will likely have no effect on subsequent recognition memory (i.e., no picture-superiority or generation effects expected within the AD group).

Chapter 3

Method

Design

The experiment included a 4 (Group) x 4 (Study Format) x 2 (Test Format) mixed design to assess implicit memory. Group (Alzheimer's disease, young normals, young-old normals, old-old normals) served as the between-subjects factor. Study format (word, picture, sentence, nonstudied) and test format (word-stem completion and picture-fragment identification) were within-subjects factors. A recognition test was administered to assess explicit memory.

Subjects

Eighty subjects were studied, divided equally into four groups of 20 subjects each, composed of patients (individuals with Alzheimer's disease) and controls (young, young-old, and old-old). All subjects were instructed in English throughout their schooling and had normal or corrected-to-normal vision. Demographic characteristics and Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) scores of the four subject groups are shown in Table 1. All subjects participated in all study conditions (word reading, picture naming, and sentence-frame completion) and test conditions (word-stem completion, picture-fragment identification, and yes/no recognition). They were also all evaluated with a 30-minute battery of neuropsychological tests. Informed consent was obtained for all subjects (see Appendix A). With the AD patients, informed consent was also obtained from next-of-kin or a legal guardian. Subject payment was $10.00. Valet parking and lunch or dinner at the hospital cafeteria were also provided for individuals tested at Henry Ford Hospital, Detroit, Michigan.

Table 1

Demographic Data for Subject Groups

	Group[a]			
	AD	Young	Young-Old	Old-Old
Age				
Mean	75.35	27.20	66.70	76.55
(SD)	(6.01)	(5.91)	(3.34)	(3.14)
Education				
Mean	11.15	13.65	12.20	11.50
(SD)	(2.89)	(1.76)	(1.64)	(2.67)
Range	3-16	11-16	9-16	5-16
Sex				
Male	7	3	8	5
Female	13	17	12	15
Race				
Caucasian	12	14	18	15
Black	8	6	2	5
MMSE				
Mean	17.25	29.15	28.70	28.20
(SD)	(3.63)	(1.09)	(1.22)	(1.58)
Range	12-25	26-30	26-30	24-30
Predicted IQ[b]				
Mean	98.0	104.4	105.1	101.0
(SD)	(10.9)	(7.2)	(7.1)	(10.9)

[a]$\underline{n}$ = 20 for each group.

[b]based on Barona, Reynolds, and Chastain (1984) formula (see Appendix B)

Alzheimer's disease group. Twenty patients (M age = 75.35, range = 59-83; M education = 11.15 years) were recruited from various sources, including the dementia research subject pool at Henry Ford Hospital (12 patients), Detroit-area nursing homes (3 patients), a suburban geriatrician's office (3 patients), and suburban ADRDA support groups (2 patients). All patients met the clinical criteria of probable Alzheimer's disease as set forth by the NINCDS-ADRDA joint task force on Alzheimer's disease (McKhann et al., 1984). In accordance with the recommended guidelines, subjects were screened by a medical history, neurologic exam, neuropsychological testing, imaging (either MRI or CT), and routine blood tests. The diagnosis of Alzheimer's disease was made by a neurologist or geriatrician on the basis of symptom history, the documentation of dementia as revealed by neuropsychological testing, and negative medical findings with regard to other sources of dementia. Dementia severity was indexed by the MMSE (Folstein et al., 1975). In order to rule out patients with moderately severe or severe dementia, only individuals with MMSE scores $\geq$ 12 were accepted.

Exclusionary criteria included: (a) disturbed consciousness; (b) a history of severe head injury, alcoholism, seizures, or a serious and/or prolonged psychiatric illness; (c) current medication with anxiolytic or other psychotropic agents; (d) a score of 5 or more on the Rosen modification (Rosen, Terry, Fuld, Katzman, & Peck, 1980) of the Hachinski ischemia score (Hachinski et al., 1975; Hachinski, Lassen, & Marshall, 1974) in order to rule out multi-infarct dementia; or (e) a concurrent systemic or neurologic illness sufficient to cause dementia. The subject information sheet used for screening subjects is presented in Appendix C.

Control groups. Sixty normal, community-residing volunteers were divided into three groups of 20 subjects each on the basis of age (young control age range = 18-38; young-old control age range = 60-72; old-old control age range = 73-85). The groups (including AD patients) did not differ in terms of sex, $\chi^2(3, N = 80) = 3.6$, $p = .308$, or race, $\chi^2(3, N = 80) = 4.8$, $p = .18$, distribution. The groups were also equated for predicted IQ, $F(3,76) = 2.52$, $p = .06$, although there was a trend toward lower IQ estimates in the AD group. Predictably, there was a significant group difference on the MMSE, $F(3,76) = 143.5$, $p < .0001$, which was due to significantly lower MMSE scores in the AD group than each of the other three groups (post-hoc Tukey comparisons, $p < .05$), who did not differ. Education also differed between groups, $F(3,76) = 4.61$, $p = .005$, which was due to the younger group being slightly more educated than the old-old and AD groups ($p < .05$ with Tukey comparisons). This difference was desired in order to avoid a deleterious cohort effect that would be introduced by equating educational levels for young and old subjects. Most control subjects were recruited from a Henry Ford Hospital database of outpatients and from posted advertisements in an internal medicine clinic, but some family members of patients also participated. Only those with MMSE scores ≥ 24 were accepted. All other exclusionary criteria were the same as for the AD group.

Materials

Materials included: (a) words (W), pictures (P), and incomplete sentences (S) for study; (b) word stems, picture fragments, and a recognition list, including nonstudied items (N) and distractors, for test; and (c) a battery of neuropsychological measures. These three sets of materials are described separately, along with an explanation of their role in the study.

Study materials. Seventy-two familiar, concrete words were selected from Snodgrass and Vanderwart's (1980) picture norms. Three depictions were prepared for each item: (a) words were displayed by boldface, lowercase, typed lettering, .5" tall, for the word-reading study format; (b) the original Snodgrass and Vanderwart (1980) pictures were displayed as line-drawing depictions for the picture-naming study format; and (c) highly constrained sentence frames (e.g., He hit the nail with a _____) were displayed for the sentence-completion study format. The words in this condition were printed in boldface lettering, .25" tall, taking up one, two, or three lines of each card. In order to counterbalance items across subjects and study conditions, the items were assigned to four lists of 18 items each, matched for word frequency (Kucera & Francis, 1967). The lists were then labeled A-D for purposes of descriptive clarity only (see Appendix D).

For any given subject, three lists were studied (one list each for the three study formats), and one list was assigned to the nonstudied condition. Although the 18 items from the nonstudied list were not presented initially, they appeared later in an incomplete form at test (i.e., as word stems or picture fragments), at which time they were intermixed with incomplete forms of the previously presented items. The use of nonstudied items in the completion tasks was necessary to guage baseline completion rates against which completion performance for previously seen items was compared. The difference in performance for studied vs unstudied items served as the operational definition of priming, the measure of interest.

Three additional items were selected for use as samples for the various study formats; they also served as "buffers" to separate the presented lists. For ease of administration and consistency across subjects, these items were fixed. The word "flute," a picture of a hand, and the sentence "Before dinner, the mother asked her child to set the ______." were used as samples for the word-reading, picture-naming, and sentence-completion tasks, respectively. Each practice item was preceded by a card labeled "sample" and succeeded by a blank card.

The 72 target items and three samples were selected from the Snodgrass and Vanderwart (1980) pool of line drawings, in accordance with three constraints. First, the pictures each had at least an 80% rate of labeling consistency (name agreement) among the Snodgrass and Vanderwart normative sample. Second, the labels (names) for each line drawing were between four and nine letters long, and each word's stem (the initial three letters) was both unique in the set of 75 items and had at least 10 entries with alternative endings in Webster's Unabridged Dictionary. Finally, all stimulus items represented the best-fit completions for incomplete sentence frames. In order to meet this criterion, incomplete sentences ranging from 5-16 words were constructed and subsequently normed in a pilot study with 45 undergraduate psychology students at Wayne State University in Detroit, MI. Only sentences with at least a .95 cloze value (i.e., at least 95% of pilot subjects completed a given sentence with the target item) were used in the study.

Each stimulus item was laser-printed in black ink and centered on 8 1/2" x 5 1/2" white card stock for all three study formats. The cards were three-hole punched lengthwise and placed in looseleaf binders for presentation. The assignment of the four lists (A-D) to the four presentation formats (W, P, S, N) was counterbalanced across subjects and within group.

Test materials. For the word-stem completion (WSC) test, the initial three letters of each of the 72 critical items were printed in black, boldface, lowercase lettering, .5" tall, on 8 1/2" x 5 1/2" white cardstock. The cards were divided into two sets of 36 items, with each set corresponding to half of the items from each of the four 18-item target lists. The two sets were labeled A and B (for descriptive clarity only) and placed in looseleaf binders. The stem "hea___" was used as a fixed sample for both sets.

For the picture fragment identification (PFI) test, four drawings, all in black ink on a white background, were prepared for each of the 72 target items. Following Gollin (1960), the cards depicted gradations of completeness, such that the first in each series (level 1) was the most reduced representation of an object. Successive cards depicted progressively more complete representations, achieved by the incremental addition of contour lines and internal details (levels 2 and 3). The last card in each series (level 4) was the complete drawing of the object (i.e., identical to the picture cards prepared for the picture study condition). The Snodgrass and Corwin (1988a) fragmentation program, which produces eight levels of fragmented images per stimulus, was used. The four depictions for each item used in the present study corresponded to levels 2, 4, 6, and 8 (with 8 being the complete drawing) of the Snodgrass and Corwin fragmented stimuli. The complete set of 72 series was divided into two sets of 36 items with four levels each; as with the WSC sets, each PFI set corresponded to half of the items from each of the four target lists. Each set was placed in a looseleaf binder preceded by four fragmented images of a leaf, which served as a fixed sample for both sets.

Assignment of items to the completion test formats was counterbalanced so that items from every study format were subsequently presented as word stems and picture fragments an equal number of times across and within groups. The various study and implicit test depictions of the sample items are presented in Appendix E.

The recognition test consisted of the 72 target items and 54 distractor words printed in black, boldface, lowercase lettering, .5" tall, on 8 1/2" x 5 1/2" white cardstock. The items were interspersed randomly and placed lengthwise in a looseleaf binder. Distractors and targets were equated for word frequency (Kucera & Francis, 1967). Like the targets, the distractors were concrete nouns whose initial three-letter stems were unique in the pool of critical stimuli used in the study. Using all 126 items for yes/no recognition with each subject provided a means of measuring hits and misses for the 54 items studied at presentation (18 as words, 18 as pictures, 18 as sentence endings) as well as false positive responses to both the 54 "new" distractors and the 18 nonstudied items that were not presented initially, but were encountered in incomplete and/or complete forms as nine of the WSC items and nine of the PFI items.

Neuropsychological tests. A small battery of neuropsychological tests was constructed to assess mental status, explicit text recall, various language functions, visuoperception, and subjective mood. These measures, all of which are widely used in standardized neuropsychological assessment, were chosen both to assist in diagnosis of the AD patients and to provide normative data on the old-old subjects. The various functional abilities of interest and the tests used to assess them are presented below.

1. Mental status: the MMSE (Folstein et al., 1975);

2. Immediate and delayed memory of prose passages: the Logical Memory subtest of the Wechsler Memory Scale (Wechsler, 1945), comprising two story passages containing 23 phrases or bits of information each;

3. Comprehension: the 36-item version of the Token Test (de Renzi & Faglioni, 1978; Spellacy & Spreen, 1969);

4. Confrontation naming: the 15-item version (Mack, Henderson, &

Freed, 1988) of the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1978);

5. Verbal fluency with phonemic cues: the Controlled Oral Word Association Test (COWAT; Benton, Hamsher, Varney, & Spreen, 1983);

6. Verbal fluency with category cues: the Animal Generation subtest of the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1972) and the Supermarket subtest from the Mattis Dementia Rating Scale (Mattis, 1976);

7. Vocabulary: the Vocabulary subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R; Wechsler, 1981);

8. Single-word reading: the Word Recognition subtest of the Wide Range Achievement Test-Revised (WRAT-R; Jastak & Wilkinson, 1984);

9. Visual perception: Visual Form Discrimination test (Benton et al., 1983); and

10. Subjective mood: the Geriatric Depression Scale (GDS; Yesavage, Brink, Rose, & Adey, 1986).

Procedure

Subjects were tested individually. All 80 subjects participated in all three study conditions, administered as independent tasks. At no time during the study phase were subjects told that they would encounter any of the materials again. Because there were six possible orders of study condition and 20 subjects per group, perfect counterbalancing of study order could not be achieved within group. Instead, the 'picture' condition served as the first or second study task seven times each, but was last only six times; the 'word' condition was first seven times, second six times, and last seven times; and the 'sentence' condition was first six times and second or last seven times each. Nevertheless, the same 20 condition assignments were used for each group, so each study format served as the first, middle, and last study task an equal number of times across groups. All subjects also participated in the two implicit memory test conditions, counterbalanced for order (first or second) and item content (set A or B) across and within groups. The recognition memory test was also administered to all subjects. The session closed with administration of the battery of neuropsychological measures.

The specific assignment of list (A, B, C, or D) to study format (W, P, or S), presentation order of study format (WPS, WSP ... SPW), set assignment (A or B) to test format (WSC or PFI), and presentation order of test format (WSC-PFI or PFI-WSC) used for each subject is outlined in the Schedule of Conditions (see Appendix F). For example, in looking at Appendix F, one can see that subject 1, an Alzheimer's patient, first studied list C as pictures, followed by list D as sentence completions, and then list A as words. At test, the PFI task was administered first, using items from set A, followed by administration of the WSC task composed of set B items. The exact procedure for each study format and test condition is detailed below.

Word-reading study condition. In this condition, subjects were told "For this [first or next] test, I'm going to show you some words and I'd like you to read each one aloud in a clear voice. Let's start with a sample for practice [the word 'flute' was then presented]. How would you read this word? [Pause for response.] Good, let's try some more." The 18 words were then presented, one at a time. If a subject misread a word, the examiner said "That's not quite right. Look at it again." Words were exposed for a minimum of 3 seconds. Multiple attempts were allowed within a 10-second period, at which time the next item was presented. All responses were recorded on the Word reading record form (see Appendix G). Both lack of response and incorrect responses were recorded as failures; second or third (or more) attempts were scored as correct if given within the time limit.

Picture-naming study condition. Subjects were instructed "For this [next] test, I'm going to show you some drawings of common objects that all have a single, one-word name. Look at each picture and tell me what it's called. For example, [the sample picture of a hand was then presented], what would you call this? [Pause for response.] Good, that's how this test goes. [Turn to first study item.] And what would you call this?" The 18 pictures were then presented, one at a time. When subjects responded incorrectly, they were encouraged to guess again with various prompts (e.g., "That's not quite right. Look at it again," or "That's close, but I'm thinking of a different name. Can you think of anything else it might be called?"). Both correct and incorrect responses were recorded on the Picture naming record form (see Appendix H). If an item continued to be misnamed or was not named at all within 15 seconds, the next item was presented (minimum presentation time was 3 seconds). After the practice item, the examiner did not reveal the correct name if a subject failed to identify a picture correctly.

Sentence-completion study condition. Prior to presentation of 18 highly constrained incomplete sentences, subjects were told "For this [first or next] test, I'm going to show you some incomplete sentences. Each one is missing the last word--there's a blank where the last word should go. Your job is to read each sentence and think of the single, one-word answer that should go where the blank is--the one that makes the most sense. When you figure out the missing word, say it out loud. Let's do one together first, so you can see what I mean." The sample "Before dinner, the mother asked her child to set the _______." was then presented. Instructions continued as "How would you finish this sentence? What one word would make the most sense?" Items were presented at a maximum rate of 20 seconds per item. All subject responses were recorded on the Sentence completion record form (see Appendix I). Again, the examiner provided the correct response on the sample only (if needed).

Visual Form Discrimination Test. Although this test is one of the neuropsychological measures, it was administered as a filler between study and test conditions, rather than with the other neuropsychological measures. Administration followed standardized instructions. Subjects had to match a set of three figures on one page (two large and one small, peripheral figure) to its corresponding set on another page. The correct set was interspersed among three foils. Both pages were in full view simultaneously, and there was no time limit. One of the foils was a distortion and one a rotation of the two major figures; the third foil consisted of a displacement (up or down) or rotation of the peripheral figure. Self-corrections were allowed, but the examiner did not point out subject errors or encourage second attempts. Most subjects chose to turn the pages themselves at their own pace. For subjects who completed this task in less than 5 minutes, a 2- to 3-minute break was given before proceeding with the IM tasks.

Word-stem completion (WSC) test condition. Subjects were presented with a looseleaf containing 36 three-letter stems, corresponding to half of the words they had read earlier (i.e., nine of the items), half of the pictures they had named, and half of the missing words they had generated for the incomplete sentences. The remaining 9 stems corresponded to half of the nonstudied list, which they had not encountered previously. Instructions were: "I'm going to show you the beginning three letters of a word. Your job is to finish it off to make a real word. As you look at each one, tell me the first word you think of that begins with the letters on the page. The only rules are that it can't be a proper name, and it has to be a one-word answer. Let's do one for practice first, so you can see how it goes." [Turn to stem "hea___".] "What word can you think of that begins with 'hea'?" [Wait for response.] "That's a good one! You could also have said heavy or heart or head or headache or heater or health, etc. You see, there are lots of possible right answers on this test. You just tell me the first word that comes to mind." If subjects gave a proper name, a hyphenated or two-word response, or one that did not begin with the three letters presented, they were told to try again until a maximum of 30 seconds had elapsed. All responses were recorded on the WSC record form (see Appendix J).

Picture-fragment identification (PFI) test condition. For this test, subjects were presented with 36 series of line drawings, 9 each of which corresponded to the remaining half of the various study formats not tested in the WSC task. As outlined in the materials section, each series was composed of 4 levels of difficulty per item. Subjects were told "Now I'm going to show you some drawings of common objects, but some of the lines are missing--they got rubbed out. Your job is to think of what the picture would be if all the lines were there. [Turn to level 1, the most degraded, of the 'leaf' picture.] For example, what do you think this one might be when it's complete?" It is noted that all 80 subjects failed to identify the leaf in its most degraded form. Therefore, instructions continued for all subjects: "It's pretty hard to guess what it will be when it's finished. You really have to use your imagination on this test. Here's what it looks like with some of the lines added back in. Try and guess now what single thing it will be when it's complete." Misidentifications were pointed out, and subjects were encouraged to keep guessing. If they failed to identify level 2 of the sample within 15 seconds, the next level was presented, again for a maximum of 15 seconds. In the event of failure (misidentification or lack of response) at level 3, the complete picture was shown, and another 15 seconds was allotted for subjects to name the item. At this level, the task was identical to the picture-naming study condition. Subjects who identified the sample at level 2 or 3 were shown the remaining depictions in the series so they could see the full four-level progression of the leaf. The 36 test items were then presented, and all responses were recorded at each level on the PFC record form (see Appendix K). For the test items, once an item was identified, remaining images of that item were not presented. Instead, the examiner proceeded directly to level 1 of the next item.

Recognition. Subjects were reminded of the initial three study format conditions and told to think of the items from those tasks. In an effort to reduce false positive responses of items from the nonstudied list that were encountered in the PFI and perhaps generated in the WSC conditions, they were told that some items were seen only in the first three tasks, some were seen again in the IM tasks, and some were brand new. They were encouraged to say 'yes' only if they could remember either reading the word, naming it as a whole picture, or finishing an incomplete sentence with it in the early tests; they were instructed to say 'no' if the item was new or if it was encountered only during one of the completion tests. The entire set of 126 items was then presented in a fixed order for all subjects. The test was self-paced and self-administered (unless the subject required assistance in turning pages), with the examiner recording responses on the Recognition record form (see Appendix L).

Mini-Mental State Examination (Folstein et al., 1975). Standardized instructions were used to test subjects' mental status. Because of the ambiguity of the published instructions, it is worth noting that for all subjects, the items "key," "box," and "chair" were used as the three objects for registration and recall. The backward serial 7s task was always administered. Subjects who did not complete this task successfully were instructed to spell WORLD backward. The better of the two scores was used.

Immediate Logical Memory. The examiner read aloud the two story passages from the Wechsler Memory Scale (Wechsler, 1945). After each presentation, subjects were required to repeat back the story with as many details as they could remember, using as many of the same words the examiner had used as possible. No time limit was imposed, and responses were recorded verbatim by hand. At the end of their second recall, they were told to remember the stories because they would be tested again in a half-hour, although the stories would not be read to them again.

Token Test (de Renzi & Faglioni, 1978; Spellacy & Spreen, 1969). Twenty wooden tokens differing in shape (circle or square), color (red, blue, yellow, white, or green), and size (large or small) were laid out in the standardized, fixed arrangement. The abbreviated form was used, which consisted of 36 commands requiring subjects to touch or move certain tokens. For the first 23 items, if subjects made an error or failed to respond to the initial instruction, it was repeated. Correct responses on the second repetition were scored as 0.5 points each. There was no time limit.

Boston Naming Test (Kaplan et al., 1978). The 15-item version of this test (Mack et al., 1988) was used. Subjects were shown line drawings of concrete objects and instructed to name the items. If the subject clearly misperceived the item (e.g., umbrella for mushroom), indicated that they did not know what it was, or failed to respond within the 20-second time limit, the standardized semantic cue was provided. If they failed to identify the item correctly within another 20 seconds, the standardized phonemic cue was provided. If they responded with a synonym of the item (e.g., mouth organ for harmonica) or with another category member (e.g., squirrel for beaver), they were told that their answer was wrong and were allowed multiple attempts within the time limit. In those cases, when 20 seconds had elapsed, the examiner bypassed the semantic cue and provided the phonemic cue directly. All responses were recorded verbatim by hand. Administration time for this task was the most variable of all tasks administered in the study. Because the provision of cues is contingent on incorrect responses, subjects who performed better took significantly less time to complete the task.

Controlled Oral Word Association Test (Benton et al., 1983). Subjects were instructed: "I'm going to tell you a letter of the alphabet. Then I want you to tell me as many words as you can think of that begin with that letter. You can't say any proper names though. So, if the letter were 'B,' you couldn't say people, like 'Bob,' or places, like 'Boston.' Also, they all have to be different words. So, you couldn't say 'eat' and then 'eating,' because that would be two forms of the same word. For example, if the letter were 'S,' you could say sleep, son, shoe, stop . . . Can you think of other words that begin with 'S?'" Following two "S" words by the subject (with prompting, if necessary), the test was administered. The letters "C," "F," and "L" were used. All responses were recorded for each 60-second trial.

Supermarket fluency (Mattis, 1976). Subjects were told "I'd like you to name all the things you can find or buy in a supermarket. You have one minute to name as many different items as fast as you can." All responses were recorded. Credit was given for both specific items (e.g., apples) and nonspecific items (e.g., cereal, fruit).

Animal fluency (Goodglass & Kaplan, 1972). Instructions were: "I want to see how many different animals you can call to mind and name while I write them down. Any animals will do--they can be from the farm, the jungle, the ocean, the zoo, or house pets. For instance, you can start with dog." As per the standardized administration, all responses were recorded for 90 seconds (demarcated on the record sheet in six successive 15-second intervals). The total score was determined by each subject's most productive 60-second period (i.e., the sum of correct responses from four consecutive 15-second epochs).

Vocabulary. This subtest from the WAIS-R (Wechsler, 1981) was administered and scored according to published guidelines. The written words were presented for subject viewing, and the examiner read each word aloud as well. Unlimited time was given for subjects to define words, and all responses were recorded verbatim.

Single-word reading. The Word Recognition subtest of the WRAT-R (Jastak & Wilkinson, 1984) was administered according to published guidelines, with the exception that no time limit was imposed. Scoring adhered strictly to the pronunciations provided in the manual.

Geriatric Depression Scale (Yesavage et al., 1986). The 30 statements on this scale were read aloud by the examiner. Subjects had to respond "yes" or "no" to each item, according to how they had been feeling in the preceding week. Accurate scoring often required several repetitions of the item, because many subjects tended to make comments or answer "sometimes." Occasionally, the examiner had to prompt subjects by asking "Do you mostly agree or mostly disagree with this statement?" Response time was unlimited.

Delayed Logical Memory. This task was administered 30 minutes after the end of immediate recall. Subjects were asked, "Do you remember those two stories I read you a while ago?" If they answered "yes," they were told to repeat back as many of the details from the stories as possible. If they said "no," they were reminded that two stories had been read and they had said them back to the examiner. If they could not recall any details of either of the stories, a cue was provided. For the first story, the cue was "It was about a woman who was robbed." For the second story, the cue was "It was about a ship." Credit was given for all details in the subsequent recalls except those provided by the examiner.

Chapter 4

Results

Neuropsychological Tests

A few of the tests administered in the neuropsychological battery yielded multiple scores. For each test, however, a single score served as the dependent measure for subsequent analyses (with the exception of the Logical Memory subtest, which has two scores). The scores used are those that are most common in the neuropsychological literature. Group means and standard deviations are presented in Table 2. An initial 11 (test) by 4 (group) mixed-model multivariate analysis of variance (MANOVA) performed on those scores revealed a significant group effect, $F(3, 76) = 77.68$, $p < .0005$, $eta^2 = .75$. Group differences were explored further with four planned, pairwise comparisons for each test. The comparisons included all possible pair combinations of the control groups (i.e., young vs. young-old, young vs. old-old, and young-old vs. old-old) as well as one involving the AD and old-old groups. Because of the large number of t tests being conducted, a Bonferroni correction was implemented to maintain a familywise error rate of .05. Hence, all reports of significance in the following section reflect an alpha level equal to or less than .013. Between-group differences for each measure are reported below in the order in which the tests are presented in the table.

Logical Memory

Scores for Logical Memory, Immediate Recall were based on the number of information bits recalled by each subject directly following presentation of each of two prose passages. The maximum score was 46. Results of the pairwise comparisons showed that the control groups, whose scores fall in the clinically normal range, did not differ reliably in their immediate recall of the

Table 2

Neuropsychological Test Scores as a Function of Subject Group

	Group (n = 20 each)			
	Young	Young-Old	Old-Old	AD
Logical Memory, Immediate Recall (combined score, story A + story B)				
Mean	19.60	18.40	1[illegible].80	4.05
(SD)	(5.74)	(5.97)	(3.69)	(2.6)
Logical Memory, Percent Retained				
Mean	82.17	77.40	68.50	12.32
(SD)	(16.8)	(12.74)	(16.58)	(26.1)
Token Test				
Mean	34.78	33.83	33.15	25.68
(SD)	(1.06)	(1.23)	(1.93)	(5.08)
Boston Naming Test, 15-item version				
Mean	12.90	13.95	12.35	7.25
(SD)	(1.80)	(1.85)	(2.11)	(3.71)
Controlled Oral Word Association Test (raw score, C + F + L)				
Mean	40.95	36.75	34.05	16.15
(SD)	(10.71)	(9.55)	(13.60)	(10.96)
Supermarket Fluency				
Mean	27.45	22.0	21.0	8.40
(SD)	(5.57)	(4.92)	(5.00)	(5.72)
Animal Fluency				
Mean	23.40	20.15	15.45	6.90
(SD)	(4.89)	(4.67)	(4.75)	(5.05)
Vocabulary (raw score)				
Mean	44.25	50.15	46.85	30.25
(SD)	(10.28)	(11.84)	(11.67)	(12.13)
Wide Range Achievement Test-Revised, Word Recognition Subtest (raw score)				
Mean	61.20	64.20	62.70	48.20
(SD)	(10.0)	(11.0)	(12.24)	(10.95)
Visual Form Discrimination (total score)				
Mean	27.70	28.65	27.90	20.85
(SD)	(4.62)	(2.48)	(2.77)	(5.29)
Geriatric Depression Scale (items endorsed in the depressive direction)				
Mean	4.45	2.25	3.20	5.30
(SD)	(4.97)	(2.29)	(3.67)	(5.98)

stories. In contrast, the AD group recalled significantly less material than did the old-old group, $t(38) = 12.63$, $p < .001$. Recall scores after a 30-minute retention interval were expressed as a percentage of initially learned material and served as the scores for Logical Memory, Percent Retained. Results of the pairwise group comparisons indicated that the youngest subjects retained a greater proportion of their initial learning over the half-hour delay than did the oldest healthy subjects, $t(38) = 2.59$, $p = .013$. The young-old subjects retained a moderate amount of information relative to the other two control groups and did not differ reliably from either one. The old-old demonstrated significantly greater retention than did the AD group, $t(38) = 11.85$, $p < .001$. Despite the difference between young and old-old subjects on this task, delayed recall performance was in the clinically normal range for all control groups (Spreen & Strauss, 1991). In contrast, the difference between the old-old and AD groups underscores the grossly impoverished retention of the AD patients, whose mean retention was only 12.32%. In clinical neuropsychology, scores below 50% on this task are generally considered to be impaired.

Token Test

The maximum score on this test was 36.0. A significant age difference emerged on this measure, as indicated by group differences between the young subjects and each of the other control groups, $t(38) = 2.62$, $p = .013$ compared to young-old subjects and $t(38) = 3.31$, $p = .002$ compared to old-old subjects. Despite the statistical significance of these differences, it is noted that the scores for all control subjects fell in the clinically normal range on this task (de Renzi & Faglioni, 1978). In contrast, the AD group ($M = 25.38$) performed in the mildly impaired range, which was significantly worse than the old-old group ($M =$

33.15), $t(38) = 6.15$, $p < .001$.

Boston Naming Test

Although the 15-item version of this test was administered, the traditional scoring procedure for the 60-item test was employed. That is, subjects were credited for both spontaneous correct responses and those made following provision of a semantic cue. Responses made following phonemic cues were recorded, but did not contribute to subject scores. The maximum score was 15. Analyses revealed a marginally reliable age difference in visual confrontation naming, with the old-old subjects identifying fewer line drawings correctly than the young-old subjects, $t(38) = 2.55$, $p = .015$. Interestingly, although neither of the older subject groups differed from the youngest group, the absolute values of naming scores increased from young to young-old subjects before declining in the old-old subjects. This pattern is in line with reported lifespan changes in naming ability (Van Gorp, Satz, Kiersch, & Henry, 1986). As expected, the AD patients performed significantly worse than their age-matched controls, $t(38) = 5.34$, $p < .001$.

Controlled Oral Word Association Test

Raw scores for the total number of legitimate responses made on each of three 1-minute trials (for words beginning with the letters "C," "F," and "L") were summed to produce a single phonemic fluency score. There was no difference between control groups on this measure, all of whom performed within normal limits (Lezak, 1983). In contrast, the AD group produced significantly fewer credit-worthy responses than did the old-old group, $t(38) = 4.58$, $p < .001$.

Supermarket Fluency

The total number of supermarket items generated in one minute served as the score for this semantic fluency measure. Credit was given for both specific items (e.g., steak) and classes of items (e.g., meat). Nonfood items (e.g., toilet paper, magazines) found in most large supermarkets were also accepted. Healthy adults typically produce at least 20 items on this task (Mattis, 1976). Although the mean for each control group exceeded 20, results showed that the youngest subjects produced significantly more valid responses than did young-old, $t(38) = 3.20$, $p = .003$, or old-old, $t(38) = 3.85$, $p < .001$, subjects. The two elderly groups did not differ on this measure. As expected, the AD group produced even fewer items than the old-old subjects, $t(38) = 7.42$, $p < .001$, and their mean score (8.40) fell in the severely impaired range based on clinical norms (Mattis, 1976).

Animal Fluency

As with the other semantic fluency measure, the total number of valid responses (animal names) generated in one minute served as the score on this task. Scoring was again liberal, with credit given to both specific animals (e.g., Chihuahua, parakeet) and classes of animals (e.g., dog, bird). As with the supermarket task, scores decreased monotonically as a function of age. However, in this case, the old-old subjects obtained significantly lower scores than both the young-old, $t(38) = 3.15$, $p = .003$, and young, $t(38) = 5.21$, $p < .001$, subjects, who did not differ in fluency rates. As in the preceding measure, the AD group's performance was significantly lower than that of its control group, $t(38) = 5.52$, $p < .001$.

Vocabulary

Standard scoring was used on this test, as detailed in the WAIS-R manual (Wechsler, 1981), with two points possible for each item. Thus, the maximum score on this test was 70. There was no reliable difference between the control groups, whose mean raw scores were within normal limits

(Wechsler, 1981). Definitions provided by the AD group yielded significantly lower scores than those provided by the old-old group, $t(38) = 4.41$, $p < .001$. The mean raw score of the AD group corresponds to a standard score of 8 relative to healthy 65- to 74-year-olds (Wechsler, 1981), which falls in the low-average range (25th percentile).

Single-Word Reading

Raw scores for correct pronunciations (as detailed in the WRAT-R manual, Jastak & Wilkinson, 1984) served as the dependent measure on this test (89 points possible). Control groups did not differ in their ability to read words aloud. In contrast, AD patients were markedly impaired on this task relative to controls, $t(38) = 10.95$, $p < .001$. The mean score of the AD group (48.2) corresponds to a late 7th-grade reading level (Jastak & Wilkinson, 1984), which is above the estimated 3rd- to 4th-grade level needed to read items used in this study.

Visual Form Discrimination Test

Scoring on this test followed the standard procedure (Benton et al., 1983). That is, correct responses received two points, and errors involving the peripheral figure received one point. Errors involving rotations or distortions of one of the major figures were scored 0. The maximum score was therefore 32. All three control groups scored within normal limits based on clinical norms, which indicate that scores below 23 represent severely impaired performance (Benton et al., 1983). As expected, scores did not differ as a function of age. However, AD patients achieved significantly lower scores on this test than did the old-old subjects, $t(38) = 5.28$, $p < .001$.

Geriatric Depression Scale

Scores on this test represent the number of items (of 30 possible) endorsed in the depressive direction, so high scores indicate the presence of depression. There were no differences between any pair of groups compared on this measure. Notably, this was the only one of all the neuropsychological tests in which the AD patients did not differ from the old-old subjects. Considering that psychiatric symptomatology (including clinical depression) was an exclusionary criterion for study participation, it is not surprising that group means fell below levels suggestive of even a mild depression (i.e., scores ≥ 8; Spreen & Strauss, 1991). Nevertheless, 9 subjects in all did have scores of 8 or more (3 AD patients, 4 young subjects, and 2 old-old subjects). In each case, a follow-up interview was conducted with the subject (and a caregiver as well in the case of AD patients). Several young subjects expressed concerns about the Persian Gulf War and about diminished prospects for finding a job during the recession. However, no individual met DSM-III-R criteria for clinical depression (American Psychiatric Association, 1987).

Experimental Tasks

Both implicit and explicit memory scores were conditionalized such that items that were failed during the initial encoding tasks were excluded from subsequent analyses on a subject-by-subject basis. Results of the initial study tasks are presented first, followed by word-stem completion (WSC), picture-fragment identification (PFI), and recognition test results of both accuracy and response bias. Initial analyses of the implicit and explicit measures were conducted with mixed-model analyses of variance (ANOVAs) to assess the effects of study format (the within-subject factor), subject group (the between-subject factor), and their interaction on priming and recognition. When significant format effects were found, follow-up *t* tests were performed to determine which specific formats differed from each other (summed across all subjects). Because there were three levels of format, and therefore three format-pair comparisons (i.e., word vs. picture, word vs. sentence, picture vs. sentence), the acceptable level of significance was $p < .017$ (i.e., a Bonferroni familywise error rate of .05). In addition, as with the neuropsychological measures, when significant group effects were found, follow-up t tests were performed to explore individual group differences. As before, the pairwise comparisons included comparisons of young versus young-old, young versus old-old, young-old versus old-old, and old-old versus AD groups. Again, an alpha of .013 was imposed in order to reduce the likelihood of committing a Type I error. When specific a priori predictions involving within-group measures of priming were tested, alpha was set at .05.

Study Task Performance

Because subsequent implicit and explicit memory measures were conditionalized on initial encoding accuracy, it was important to determine if there were group differences in performance on the study tasks. Table 3 shows the average proportion correct on the three study tasks as a function of group. A 3 (Format) X 4 (Group) mixed-model ANOVA performed on the proportion of items encoded accurately in the three study conditions showed significant effects related to format, $F(2, 152) = 39.73$, $p < .001$, $eta^2 = .349$, and group, $F(3, 76) = 40.72$, $p < .001$, $eta^2 = .616$. As can be seen from the data in Table 3, AD patients performed as well as the control groups on the word-reading task. However, the patients were impaired disproportionately on the other two tasks, which was reflected in a significant interaction between format and group, $F(6, 152) = 21.56$, $p < .001$, $eta^2 = .463$.

Planned, pairwise format comparisons indicated that, across all subjects, the format effect was due to superior word reading ($\underline{M}$ = 1.0) relative to both picture naming ($\underline{M}$ = .940), $\underline{t}(79) = 5.48$, $\underline{p} < .001$, and sentence completion ($\underline{M}$ = .928), $\underline{t}(79) = 5.0$, $\underline{p} < .001$. Performance did not differ between the latter two tasks, so they were combined to produce an average performance for group comparisons.

Table 3

Encoding Accuracy on Initial Study Tasks

	Group (n=20 each)			
	Young	Young-Old	Old-Old	AD
Word reading				
Mean	1.0	1.0	1.0	.994
(SD)	(0.0)	(0.0)	(0.0)	(.02)
Picture naming				
Mean	.997	.989	.964	.811
(SD)	(.01)	(.03)	(.04)	(.12)
Sentence-frame completion				
Mean	.994	.986	.964	.769
(SD)	(.02)	(.03)	(.06)	(.16)

Examination of the univariate group effect with planned, pairwise comparisons revealed that the young control group ($\underline{M}$ = .996) identified a higher proportion of items from the combined picture/sentence condition with their target labels than did the old-old group ($\underline{M}$ = .964), $\underline{t}(38) = 3.21$, $\underline{p} = .004$, who, in turn, performed significantly better than the AD patients ($\underline{M}$ = .790), $\underline{t}(38)$

= 5.83, $p < .001$. The young-old group (M = .988) did not differ from either of the other two control groups on this measure. Despite the lower absolute scores of the old-old than the young group, the fact that all three control groups were at or near ceiling on the individual and combined tasks (i.e., all over 96%) renders the statistical difference inconsequential. Conversely, the AD group's 79% accuracy on the combined picture/sentence tasks suggests a much more pervasive encoding deficit.

Item Selection Effects

The primary concern regarding unequal encoding between subject groups involves the potential for item selection effects on subsequent analyses of priming. Essentially, it could be argued that conditionalizing IM performance on encoding accuracy (i.e., excluding items failed at study) artificially inflates priming magnitude. More specifically, because only those items that were successfully generated (or named) at study were analyzed subsequently on the IM measures, but all nonstudied items were analyzed, difference scores between target completions of studied and nonstudied items (the operational definition of priming magnitude) might spuriously indicate a priming effect when, in fact, the difference might be due to the differential selectivity of the items being compared. In order to address this concern, which involved primarily the AD group, two sets of analyses were conducted for each of the IM measures: (a) a conditionalized set (excluding items that were failed at study) and (b) an unconditionalized set (including all items, irrespective of encoding success). A comparison of the two sets of outcomes showed that there was no difference between the two for analyses involving the WSC. Therefore, only the results of the conditionalized analyses will be presented in that section. However, the two sets of analyses produced different results for the PFI test.

Specifically, the first set of analyses, which was conditionalized for encoding accuracy of items presented at study but included all baseline items, produced inflated measures of priming--a logical consequence of comparing performance on one set of items (i.e., the baseline items) comprising both difficult and easy items to another set from which difficult items were excluded (i.e., the studied items). In contrast, the second set of analyses reduced priming artifactually, because test performance involving items presented at study that were in fact never encoded successfully were compared to performance involving baseline items. Hence, when unconditionalized item analyses are used, those with the greatest encoding failure rate (i.e., AD patients) show the least priming, and group differences emerge--which may or may not be real--when they are compared to individuals with better initial encoding (i.e., the old-old group).

Given the disadvantages inherent in both of these measures, a third scoring procedure, which conditionalizes both study and baseline items, was developed. Dual conditionalizing in this way makes the comparison between baseline and studied items more equitable, thereby producing more accurate difference scores, which, in turn, renders findings of both significant priming and group differences more valid and believable than does either of the other two measures. The specific manner in which this conditionalizing was operationalized and applied will be discussed in the section on PFI below.

Word-Stem Completion (WSC)

Items excluded from WSC analyses. Prior to comparing difference scores between nonstudied and previously exposed items among and between groups, it was necessary to determine if there were any floor or ceiling effects for individual items that would skew subsequent measures of priming.

Therefore, an item-by-item analysis among the control subjects was conducted to answer two questions: (a) Were there any studied items that everybody failed (i.e., no healthy subject completed the stem with the target word despite having encoded it previously)? and (b) were there any nonstudied items that nobody failed (i.e., all healthy subjects completed the stem with the target word despite not having encoded it earlier)? This investigation yielded four problem stems--two involving a floor effect and two involving a ceiling effect. The floor-effect stems were (a) whe___ and (b) but___, neither of which was completed by any control subject as the targets "wheel" and "butterfly" subsequent to successful encoding at study. The ceiling-effect stems were (a) tig___ and (b) nos___, which were completed by all control subjects as the targets "tiger" and "nose" when serving as baseline items. Because the use of these stems would interfere systematically with the ability to detect priming, they were excluded from all analyses involving WSC.

Baseline performance. The proportion of nonstudied word stems completed to form target words in each group is represented by the open bars in Figure 1. As the figure shows, the baseline level remains constant across the three study formats within each group. Those scores were analyzed with a one-way ANOVA to determine if there was an overall group difference in baseline completion levels. The ANOVA failed to reveal a significant group effect, thereby confirming the impression suggested by the figure of uniform baseline performance across groups.

Priming performance. For this and all other analyses, priming was operationally defined as a difference score between (a) the number of stems completed with target items divided by the total possible (varying as a function of encoding accuracy and excluded items) for each format and (b) proportion of

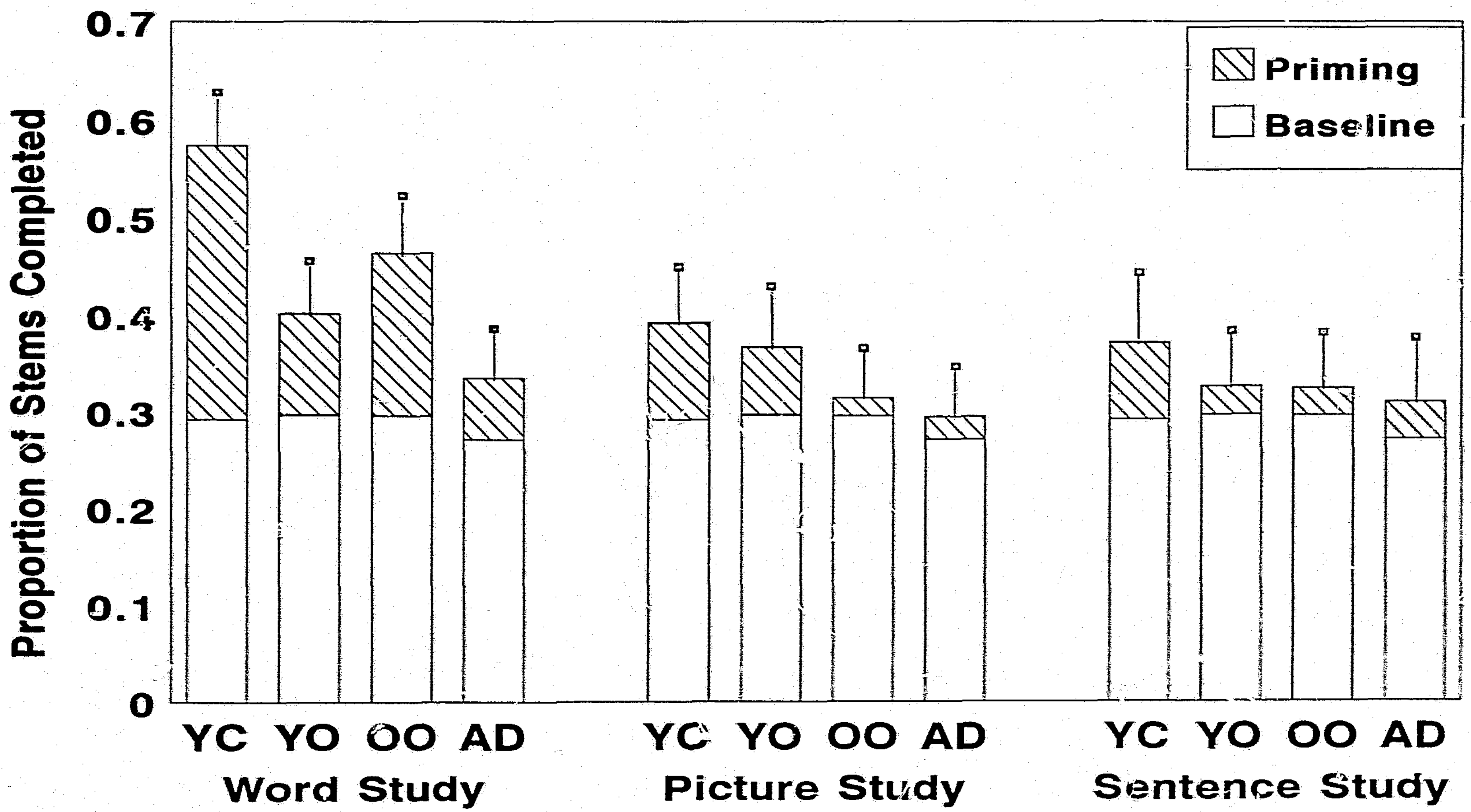


Figure 1. WSC performance as a function of study format and group.

baseline completions (as described above and represented by the open bars in Figure 1). The differences between baseline and completion as a function of study format and group are represented in Figure 1 by the hatched bars. A 3 (Format) X 4 (Group) mixed-model ANOVA, with format as the within-subject factor, was performed with WSC priming as the dependent measure. This analysis showed a significant effect of format, $F(2, 152) = 8.56$, $p < .001$, $eta^2 = .102$, which was due to a reliable difference in word-stem priming between items studied as words ($M = .155$) and those studied as pictures ($M = .053$), $t(79) = 3.6$, $p = .001$, or in sentences ($M = .044$), $t(79) = 3.29$, $p = .001$. In both cases, word study was superior in leading to the production of target completions with the word stems, as predicted by transfer-appropriate processing (TAP) theory. There was no differential effect on WSC of studying items as pictures versus sentence endings.

In previous sections, pairwise group comparisons were conducted as follow-up analyses to explore the source of significant main effects related to group. In this case, the group effect and Format X Group interaction were not significant. Nevertheless, pairwise comparisons of group differences (i.e., t tests) among the controls were conducted, but they were restricted to the priming measure associated with word study, because that condition produced superior priming relative to the other study formats. Analyses showed that no two control groups differed reliably in extent of priming on this measure (ps > .013), although the difference between the young and young-old groups approached an acceptable level of significance in favor of the young, $t(38) = 2.25$, $p = .031$.

The integrity of WSC priming resulting from word study in AD patients can be thought of in at least two ways: (a) Is there any priming at all in the AD group? and (b) is the magnitude of priming the same as matched controls? Previous studies (e.g., Salmon et al., 1988) have supported a "yes" to the first question, and a "no" to the second, which has been interpreted as impaired lexical priming in AD. To address the first question, a t test was performed within the AD group to determine if word study led to significantly more target than baseline stem completions (i.e., a test to determine if their difference score of M = .065 differed from zero). Contrary to previous studies (e.g., Heindel et al., 1989; Salmon et al., 1988), there was no reliable priming in this condition, $t(19) = 1.3$, $p = .105$, one-tailed. Thus, despite their ability to complete baseline stems with target words at the same rate as the control groups, the AD group did not show a reliable benefit in completion performance from having read words at study. This finding indicates that the superior priming produced by word study discussed above (summed over all subjects) must have been substantially accounted for by the control groups.

The second question, concerning whether the old-old and AD groups differed in WSC priming based on word study, was addressed by a pairwise comparison. Contrary to expectations, the groups did not differ reliably, $t(39) = 1.36$, $p = .182$, two-tailed, despite an absolute difference of .1 in their priming levels (M = .169 vs. .065 for old-old and AD subjects, respectively). As others have suggested for comparisons of priming between young and old subjects (e.g., Hultsch et al., 1991), the lack of a reliable difference between two groups on this measure may be interpreted as a lack of power to detect the small difference that exists rather than as an acceptance of the null hypothesis (i.e., stating that priming in AD is preserved to the same extent as healthy controls). In fact, the lack of reliable priming within the AD group indicates that words do not prime WSC performance among those patients.

As an additional note, one of the a priori predictions regarding WSC performance in AD stated that priming should be preserved for items that had been generated in the context of high-cloze sentence frames. A t test was performed to determine if the patients' WSC target completions following generation of sentence endings (M = .310) was superior to their baseline completion level (M = .272). Contrary to Grosse et al.'s (1990) finding of preserved WSC priming from this type of study, sentence study did not prime WSC performance among AD patients in this investigation.

Picture-Fragment Identification (PFI)

Problem items. As with the WSC task, there was a concern about ceiling and floor items on this IM measure. However, there were no baseline items that all healthy subjects identified at the first or even second levels of fragmentation (absolute and functional ceiling effects), nor was there a single studied item that no healthy subject was able to identify by the third level of fragmentation (therefore, no evidence of a floor effect). Thus, no items were excluded in a blanket fashion from the PFI analyses. Nonetheless, individual items were excluded in a selective fashion as warranted by the conditionalizing procedure. As described earlier, IM performance was conditionalized for encoding accuracy such that items failed at study were removed on a subject-by-subject basis from the PFI score. In addition, both studied and nonstudied items that were not identified by the fourth level (i.e., the complete picture) on the PFI test were also removed on a subject-by-subject basis. This type of selective item exclusion compensates for deleterious item selection effects produced by conditionalizing encoding accuracy alone, as discussed earlier. With this method, items for which fragment identification is being compared across groups and study formats are equated for overall nameability for each subject.

Scoring. Once it was determined that certain items would be excluded from the analyses, there was a question of how best to score the items that remained. Because other IM studies employing the same picture fragments are procedurally different from the method used here, it was not clear how best to determine identification levels. In other studies involving PFI, successive fragments are typically administered as a study task until a criterion (either successful identification or presentation of the complete picture) is reached. The fragment at which the picture is identified then serves as the picture identification threshold (PIT) for a given subject and a given item. This provides a weighting procedure, whereby low PITs correspond to better performance (i.e., identifications at the more difficult fragmentation levels). At test, successive fragments of new and old items are presented, and priming is defined as the difference in PITs between new and old items.

In an attempt to create an analogous scoring procedure for the present study, a weighting method was employed using the following equation for each study format:

$$\frac{3(\#\text{ of items identified at level 1}) + 2(\#\text{ at level 2}) + (\#\text{ at level 3})}{3(\#\text{ of items possible})}$$

The fourth level, which was unfragmented (i.e., the complete line drawing), was not included in the equation, because its one-to-one correspondence with items presented in the picture study condition precluded a measure of priming. (Note the contrast to repetition or identity priming studies in which identical items are presented at study and test; however, in those cases, reaction time is used as the dependent measure.)

Because the way in which picture fragments were used in this study was different from other studies, and the formula listed above had not been used before, it was not evident from the existing literature if this was the best method for scoring PFI. Therefore, two additional scoring measures, each involving a criterial measure that credited subjects for identifying the pictures by a given level, were developed and compared between groups. These unweighted procedures paralleled the priming measure used in the WSC task. However, it was found that both procedures had to be discarded, because the level-2 criterion produced a floor effect, and the level-3 criterion produced a ceiling effect. All analyses involving PFI reported in the following sections therefore represent weighted identifications in which higher scores correspond to better performance. For purposes of clarity and comparison with other studies, results are reported either as proportions or as difference scores from baseline.

Baseline performance. Fragment identification for nonstudied items was analyzed to determine if groups differed in baseline performance. The weighted and conditionalized PFI scores used in the analysis are represented for each group by the open bars in Figure 2. As with the WSC baseline levels, the value of the open bars within a given group is the same across the three study formats. However, in contrast to the WSC baseline rates, which were uniform across subject groups, visual inspection of Figure 2 reveals a clear-cut monotonic trend across groups, with the highest PFI baseline rate in the young group (M = .541), the lowest in the AD group (M = .187), and moderate rates in the older control groups (M = .431 and .300 for the young-old and old-old groups, respectively). A one-way ANOVA performed on this measure demonstrated that baseline PFI levels were reliably different between groups, $F(3, 76) = 36.94$, $p < .0001$, $eta^2 = .593$. Follow-up, pairwise comparisons

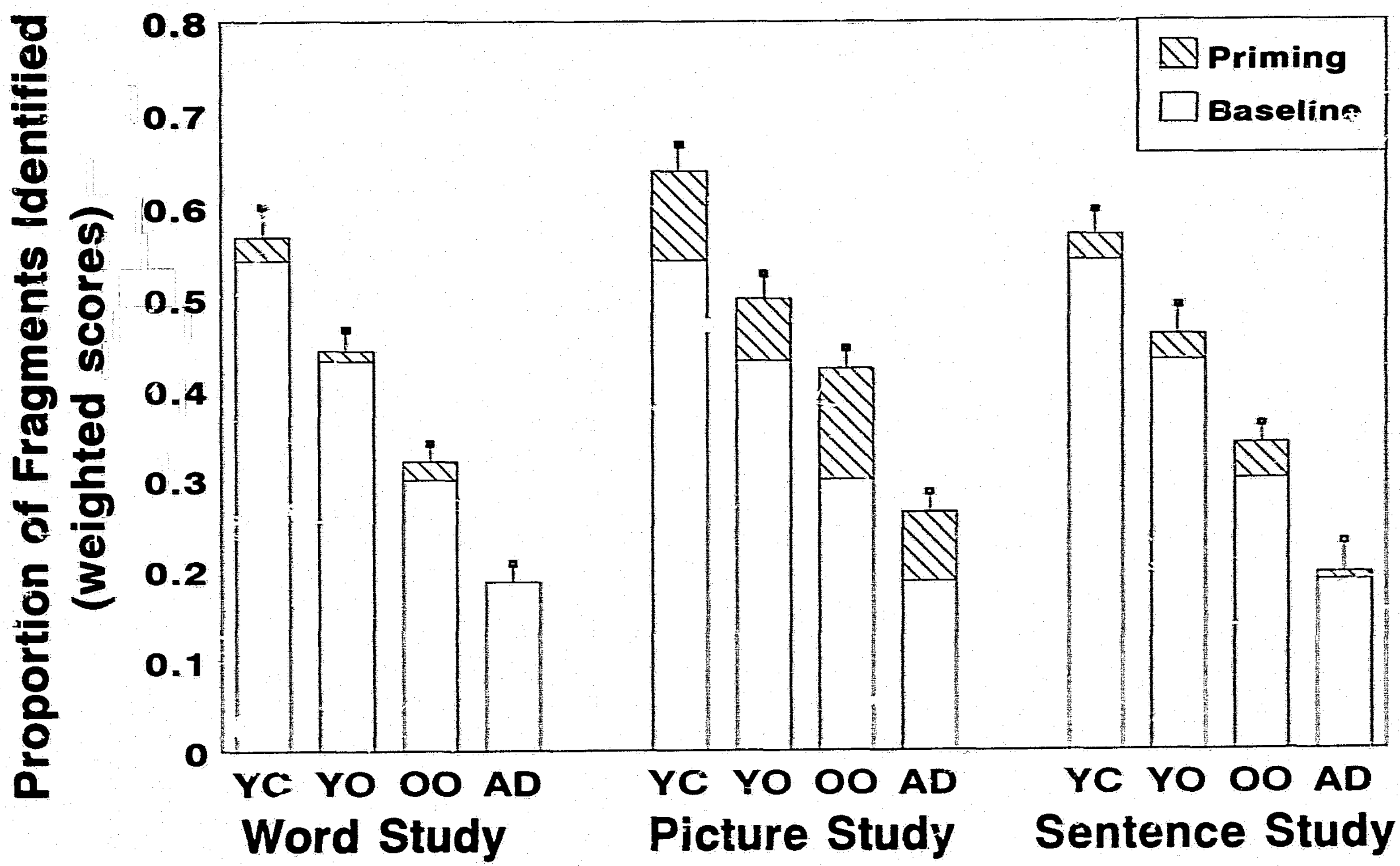


Figure 2. PFI performance as a function of study format and group.

conducted with t tests and alpha set at .013 showed that each control group differed from each of the other two (with younger outperforming older subjects in every case), and the old-old group scored higher than the AD group.

Priming performance. For this and all other analyses, priming was operationally defined as the difference between PFI scores for studied and nonstudied (i.e., baseline) items. As in the WSC analyses, proportions were used. These difference scores, representing extent of priming, are shown in Figure 2 by the hatched bars. Cursory inspection of the figure suggests that priming was differentially affected by initial study condition. A 3 (Format) X 4 (Group) mixed-model ANOVA, with format as the within-subject factor and PFI priming as the dependent measure, confirmed this observation by revealing a significant format effect, $F(2, 152) = 23.13$, $p < .001$, eta^2 = .235. There was no reliable difference between groups, nor was there a significant Format X Group interaction.

A series of follow-up 2 (Format) X 3 (Group) mixed-model ANOVAs were conducted to explore the effect of format among the control subjects. These analyses revealed differences in PFI priming between picture and word study, $F(1, 57) = 35.47$, $p < .001$, and between picture and sentence study, $F(1,57) = 19.0$, $p < .001$. In both cases, naming pictures at study facilitated fragment identification involving those same pictures (M priming = .091) more than did reading words corresponding to the fragments (M = .014) or generating their names as the terminal words of sentence frames (M = .026). This finding is consistent with predictions based on transfer-appropriate processing theory. There was no difference between word and sentence study on PFI.

Although there was no significant group effect in the 3 X 4 ANOVA reported above, pairwise comparisons of group differences (i.e., t tests) with alpha set at .010 were conducted among the control groups for the PFI priming measure associated with picture study. Group comparisons were restricted to that condition because it produced superior priming relative to the other study formats. Analyses showed that no two control groups differed reliably in extent of priming on this measure (young control $\underline{M}$ = .098; young-old $\underline{M}$ = .068; old-old $\underline{M}$ = .123).

There was also a question of whether IM, as measured by facilitated identification of picture fragments as a function of previous exposure to the same pictures, would be preserved in AD. Again, the notion of reliable priming could be conceptualized as enhanced performance relative to their own baseline or as unimpaired priming magnitude relative to matched controls. To address these questions, a $\underline{t}$ test was first performed on the PFI difference score associated with studied pictures and baseline items within the AD group. This test indicated that the AD patients enjoyed considerable benefit with regard to PFI level as a consequence of having encoded successfully the same pictures at study relative to identification of items they had not seen previously, $\underline{t}(19) = 3.34$, $\underline{p} = .003$, two-tailed.

The old-old and AD groups were then compared, along with the family of pairwise control-group comparisons reported above, to determine if they differed in their magnitude of PFI priming relative to matched controls. The difference in priming between the two groups (AD $\underline{M}$ = .076; old-old $\underline{M}$ = .123) was not significant, $\underline{t}(38) = 1.53$, $\underline{p} = .134$, two-tailed. Thus, it appears that AD patients not only showed reliable priming for items studied as pictures, but did so to the same extent as healthy elderly individuals.

Recognition Memory

Scoring. Traditionally, recognition is measured as the proportion of hits (i.e., yes responses to items encoded at study) minus false positives (i.e., yes responses to items that were not presented for study). In this case, there were two types of items that could contribute to false-positive scores: (a) the 18 nonstudied items that were presented subsequently on the IM tests (i.e., half as word stems and half as picture fragments) and (b) 54 distractor items, none of which had been encountered in any of the preceding tasks. Because the nonstudied items were familiar to subjects from their presentation in the IM tasks, while the new distractor items were completely unfamiliar in the context of the experiment, two separate recognition scores were derived. Table 4 displays group means for the proportion of true-positive responses (i.e., hits) for each study format and the proportion of false-positive responses for each foil type.

Recognition accuracy (discriminability). Recognition accuracy involving foils from the nonstudied condition (i.e., those used to determine baseline levels in the IM tasks) was defined as the hit rate for items encoded successfully at study minus the false-positive rate for baseline items. The resultant group means, expressed as proportions, are presented in Figure 3 for each study format. Recognition accuracy involving new distractor foils was defined as the same conditionalized hit rate minus the false-positive rate for the new distractor items. Figure 4 shows the group means, again as proportions, corresponding to that measure.

A 2 (Foil Type) X 4 (Group) X 3 (Format) ANOVA, with repeated measures on the first two factors, was carried out on the recognition accuracy scores. The analysis revealed a significant main effect of foil type, $F(1, 76) = 176.28$, $p < .001$, $eta^2 = .699$. Not surprisingly, the difference in foil types was due to better discriminability of items when new distractors were used as foils ($M = .546$) as opposed to items that were familiar from their exposure in the IM

Table 4

True-Positive and False-Positive Performance on the Recognition Test

	Group (n=20 each)			
	Young	Young-Old	Old-Old	AD
Proportion of hits for items studied as words				
Mean	.59	.55	.69	.62
(SD)	(.17)	(.2)	(.15)	(.29)
Proportion of hits for items studied as pictures				
Mean	.85	.85	.88	.57
(SD)	(.15)	(.15)	(.13)	(.27)
Proportion of hits for items generated from sentence frames at study				
Mean	.7	.69	.77	.57
(SD)	(.14)	(.15)	(.11)	(.27)
Proportion of false-positive responses corresponding to baseline items				
Mean	.31	.33	.48	.51
(SD)	(.22)	(.19)	(.14)	(.27)
Proportion of false-positive responses corresponding to new distractor items				
Mean	.05	.05	.09	.4
(SD)	(.05)	(.05)	(.08)	(.27)

tests (M = .285). There was also a significant interaction between group and foil type, $F(3, 76) = 8.48$, $p < .001$, $eta^2 = .25$, discussed below. Interactions involving foils and formats together could not be analyzed due to the linear dependence of those variables (a result of having the same hit rate for both foil types and the same false positive rate for each format).

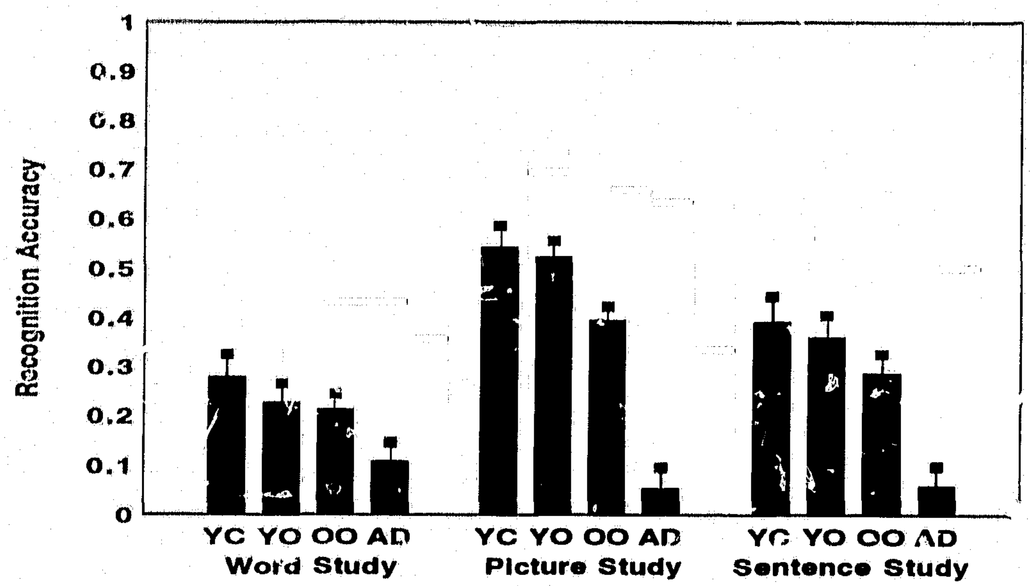


Figure 3. Recognition of studied minus baseline items by study format and group.

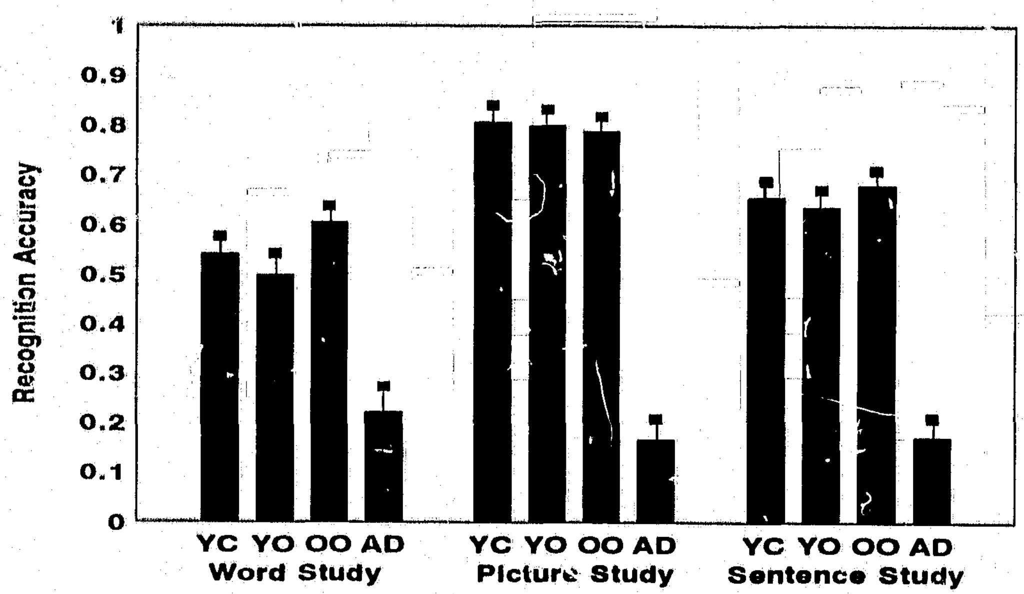


Figure 4. Recognition of studied items minus new foils by study format and group.

The ANOVA also revealed significant effects of group, $F(3, 76) = 57.55$, $p < .001$, eta^2 = .695, format, $F(2, 152) = 38.91$, $p < .001$, eta^2 = .338, and a Group X Format interaction, $F(6, 152) = 8.19$, $p < .001$, eta^2 = .244. However, prior to further analysis of these effects, the AD group was separated from the control groups for two reasons. First, it was apparent from the graphs that the AD group displayed a different pattern of performance across the recognition measures, which may have accounted substantially for the significant main effect of group and its involvement in the significant two-way interactions. Secondly, the effect of format on recognition accuracy in AD was of a priori theoretical interest.

If the significant group effect were due exclusively to the poor performance of the AD subjects, then groups should not differ when the AD group is removed from the analysis. Conversely, if there is an age-related decline in recognition accuracy as is traditionally found in studies of explicit memory, then the main effect of group should maintain. To test the effect of encoding and foil type manipulations on recognition, and to determine the pattern of age differences in normals, a 2 (Foil Type) X 3 (Format) X 3 (Group) mixed-model ANOVA was performed, with recognition score as the dependent measure. In this case, the main effect of group was not significant, indicating that the ability to discriminate hits from foils is age-invariant among healthy individuals. However, the analysis did reveal a significant main effect of foil type, $F(1, 57) = 187.36$, $p < .001$, eta^2 = .767, again favoring recognition involving new foils. In addition, there was a significant Group X Foil Type interaction, $F(2, 57) = 3.31$, $p = .043$, eta^2 = .106. As the graph shows there appears to be an age-related decline when subjects were required to discriminate studied words from familiar foils (M = .356 for healthy subjects); in contrast, the discrimination of studied and new words appears to be relatively age-invariant in healthy subjects (M = .666). This finding is consistent with other studies showing that age differences are most apparent on difficult tests.

There was also a significant format effect, $F(2, 114) = 60.19$, $p < .001$, eta^2 = .514. Bonferroni-corrected t tests of format pairs revealed significant differences in recognition accuracy between each format-pair combination. Specifically, recognition was best for items studied as pictures (M = .641), moderate for items generated in the sentence condition (M = .500), and worst for items that were read in isolation (M = .393). These results are consistent with both picture-superiority ($t(59) = 10.6$, $p < .001$, for pictures vs. words) and generation-effect predictions ($t(59) = 4.17$, $p < .001$, for generated sentence endings vs. read words); further, they establish that the former effect is stronger than the latter (t (59) = 7.63, $p < .001$, for pictures vs. sentences).

A final question regarding recognition performance within the control groups concerned previous reports showing the presence of a picture-superiority effect in aging, but with diminished magnitude relative to the young. To address this question, another series of planned, pairwise group comparisons were conducted with alpha set at .013 on the recognition score associated with picture study as a function of each foil type. Interestingly, the analyses revealed that the old-old group (M = .394) differed from both the young-old (M = .541) and the young (M = .541) groups in recognition accuracy for studied pictures when recognition involved the familiar baseline items (i.e., the more difficult discrimination index). In contrast, there were no significant group differences in recognition accuracy when new distractors served as foils to studied pictures (old-old M = .786, young-old M = .797, young control M = .804).

To test the effect of encoding and foil type manipulations on recognition in AD, a 2 (Foil Type) X 3 (Format) ANOVA with repeated measures on both factors was performed within the AD group alone. Like the controls, the patients also performed better when recognition accuracy involved new (M = .185) rather than baseline (M = .072) items, as indicated by the significant effect of foil type, $F(1, 19) = 8.22$, $p = .01$, $eta^2 = .302$. In contrast to the controls, however, the effect of format was not significant (word study M = .164, picture M = .109, sentence M = .114). Again, the Foil Type X Format interaction could not be analyzed because the variables were linearly dependent.

As discussed previously, picture-superiority and generation effects have not been explored fully in AD. To determine whether recognition in the AD group was differentially affected by the various encoding conditions, a series of pairwise format comparisons (six t tests in all) were performed on recognition scores within each foil type condition, with alpha set at .05. Interestingly, no significant differences between encoding-condition pairs emerged on the t tests. Thus, as Figures 3 and 4 show, recognition memory was flat across all items among AD patients, irrespective of study format and depth of encoding, and, in each case, was well below that of the control groups.

Response bias. Another measure of recognition besides discrimination is that of response bias. This measure is particularly important in characterizing the memory of AD patients who, along with other memory-impaired individuals, frequently demonstrate strong positive or negative biases on yes/no recognition tests (i.e., favoring a yes or no response set to a majority of both old and new items). The bias index used to determine the probability of saying yes to an item when uncertain is based on two-high-threshold theory, as described in Snodgrass and Corwin (1988b) and expressed by the following formula:

False Positives / [1 - (hits - false positives)].

With this formula, values can range from 0 to 1.0. A value of .5 indicates neutrality, whereby the subject is unbiased with respect to embracing and rejecting items as familiar. Values greater than .5 indicate liberal bias (i.e., a _yes_ response set), while those less than .5 indicate conservative bias (i.e., a _no_ response set). Of note, when the difference between hits and false alarm rates is 1.0, it produces a denominator of zero in the formula and must be excluded from analysis. However, no subjects were excluded from the bias analyses for this reason.

Because the false positive rate was fixed, computing separate bias values as a function of encoding format would reflect only differences in hit rates for the various formats, rather than reflecting a variable decision criterion operating on the various formats. Thus, bias values were collapsed across encoding format for each subject. In addition, because the two foil types were mixed together within a single recognition test, it would not be meaningful to compute separate bias values for the two foil types (i.e., the measures would be confounded by having two noise distributions with only one target, or signal, distribution). Thus, bias values were also collapsed across foil type, yielding a single measure of response bias for each subject. The mean response bias values for each group are displayed in Figure 5.

To determine whether response bias differed across groups, a oneway ANOVA was performed on the bias scores. The analysis revealed a significant effect of group, $F(3, 76) = 6.52$, $p = .0006$, $eta^2 = .20$, which was subjected to further analysis by planned, pairwise group comparisons. Results showed that old-old subjects, who were generally unbiased in their responses ($M = .471$),

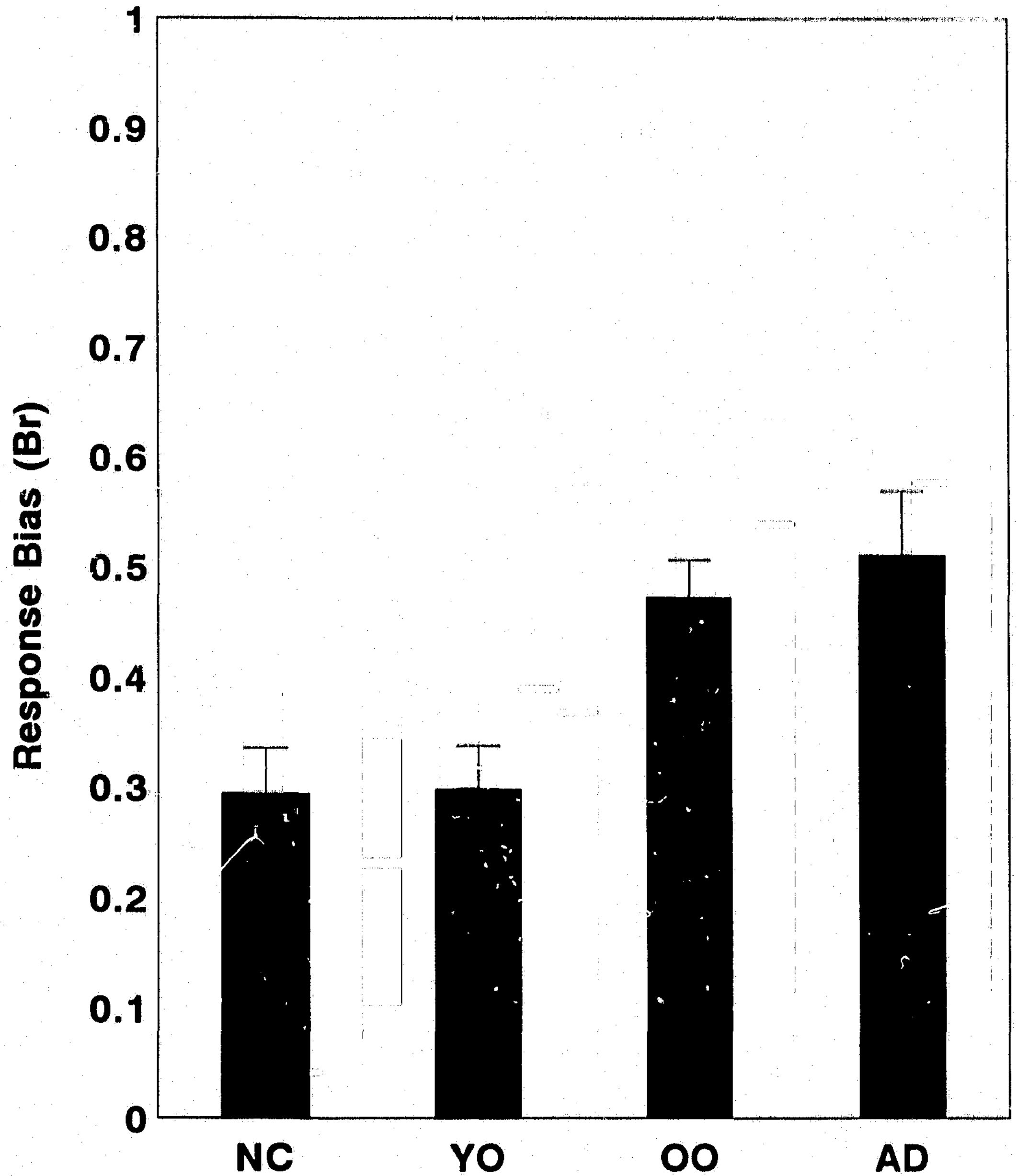


Figure 5. Response bias by group.

had higher bias scores than young subjects (M = .294), $t(38) = 3.29$, $p = .002$, and young-old subjects (M = .297), $t(38) = 3.27$, $p = .002$. Both young and young-old subjects tended to be conservative and did not differ in response bias. The AD subjects tended to be neutral in their responses, with mean bias values hovering around .5 (M = .526), which did not differ from the old-old subjects' responses.

Chapter 5

Discussion

This study compared the performance of three healthy control groups differing in age and a group of AD patients on 11 standardized neuropsychological measures, three study tasks, two implicit memory (IM) tests, and one explicit memory (EM) test. For several issues addressed here, previous studies were either lacking or conflicting. Thus, the present study was intended, in part, to provide new data and, in part, to help resolve inconsistencies in the literature. Overall, results were generally consistent with predictions. The primary findings are reviewed briefly below, followed by a more in-depth discussion of each issue with regard to previous studies and theoretical implications.

Review of Primary Findings

Results involving the neuropsychological measures indicate that subjects were assigned appropriately to control and patient groups. For some of the neuropsychological measures (e.g., Token Test, WRAT-R reading, Visual Form Discrimination Test--see Table 2), the present results provide normative data for old-old individuals and AD patients that are currently lacking, even though these tasks enjoy widespread use in clinical neuropsychological practice. On the study tasks, AD patients had difficulty completing high-cloze sentences with best-fit endings and naming common line drawings that had been selected for easy nameability.

Results of the IM tests revealed the exact pattern of crossover priming effects predicted by transfer-appropriate processing theory. That is, word study produced more priming on a word-stem completion (WSC) task than did picture study, but picture study was superior to word study for priming picture-fragment identification (PFI) among all control groups. This finding shows for the first time that the similarity between word reading and WSC and between picture naming and PFI is a crucial determinant of priming effects not only in younger subjects, but in young-old and old-old healthy subjects as well. Further, the effect was partially extended to AD patients, whose magnitude of priming on the PFI test following picture study was comparable to controls. In contrast to the control groups, however, word study failed to facilitate WSC performance beyond chance levels within the patient group. And, in contrast to recent studies claiming that deeply encoded study material primes WSC among AD patients, generated sentence endings did not benefit WSC performance among the patients in this study. That generated items did not produce priming on WSC among the controls either suggests that the lack of priming following generation in the patient group is normal.

Finally, among the control groups, results of the yes/no recognition test showed that studying items as pictures leads to better recognition than does generating items at study, which, in turn, is superior to reading words in isolation. This finding establishes that the picture-superiority effect is superior to the generation effect for yes/no recognition memory. Consistent with previous findings, AD patients demonstrated severely impaired EM performance relative to matched control subjects. Moreover, the patients failed to profit from encoding manipulations even among themselves, indicating a loss of picture-superiority and generation effects relatively early in the disease process of AD patients.

Neuropsychological Tests

Control subjects. As predicted, age-related declines were apparent on measures of prose memory (percent retained over a half-hour delay), confrontation naming, and semantic fluency (i.e., number of items generated to category cues). Results were also consonant with predictions of age invariance on several measures. Specifically, performance did not differ as a function of age on measures of vocabulary, single-word reading, or subjective ratings of depression. In general, the results of both impaired and preserved abilities observed here were congruent with previous research and clinical norms.

In addition, two unexpected findings were observed. First, both groups of healthy elderly subjects had lower scores relative to the young control group on the Token Test, a measure of receptive language in which subjects were instructed to follow increasingly complex commands. As pointed out previously, however, all control subjects were within clinically normal limits on this test, as predicted. Nevertheless, the finding of statistical significance between young and older subjects' scores on this test suggests that clinicians should perhaps use age-based norms to interpret performance on this test in the future (see Lezak, 1983, for a discussion of age effects on this test).

More curiously, there was no effect of age on phonemic fluency (i.e., timed generation of words beginning with a given letter). In clinical neuropsychology, this measure is widely believed to be highly sensitive to aging, brain damage, and other subject variables. In fact, raw scores are traditionally adjusted by adding corrections for age, education, and sex. The adjusted scores are then converted to percentile rankings (Lezak, 1983). Published norms for this test are based on age corrections that only extend to 64 years old. Because it would have been inappropriate to use age corrections established for younger subjects with subjects older than 64 in this study, raw scores were used instead. If anything, the use of raw scores should enhance age differences on this measure. Nevertheless, the finding of age invariance on these uncorrected scores supports the findings of a recent study examining predictors of verbal fluency in healthy elderly individuals (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1990). Among their sample of very healthy and well-educated subjects ranging in age from 39 to 89 years, verbal fluency was strongly associated with verbal intelligence (i.e., vocabulary) and moderately associated with gender, but not at all associated with age.

Other recent studies of verbal fluency have underscored the clinical utility of unconstrained semantic fluency tasks for the differential diagnosis of dementias of varying etiologies (e.g., Randolph, Braun, Goldberg, & Chase, 1993). Further, the category fluency test has recently been shown to have much greater sensitivity and specificity than letter (phonemic) fluency for the detection of dementia (Monsch et al., 1992). Hence, the present finding of age differences on category but not phonemic fluency supports the claim that category fluency is a more sensitive test in general.

The overall pattern of selectively impaired and preserved abilities on the various neuropsychological measures administered in this study is generally consistent with Horn and Cattell's (1966) theory of fluid and crystallized intelligence. According to the model, fluid intelligence (usually assessed by novel, nonverbal tasks) declines with aging, whereas crystallized intelligence (usually assessed by verbal, general knowledge tests) progressively increases throughout adulthood (for review, see Dixon et al., 1985). Although both confrontation naming and semantic fluency are verbal tasks, which are usually conceived as crystallized measures, they are self-generated, timed tasks. Hence, fluid component processes may contribute largely to success on these tasks, which would explain why they showed age-related declines in this study. This interpretation is similar to the conclusions of a recent study by Mitrushina and Satz (1990). They found age-related patterns of performance which were factor analyzed into crystallized and fluid intelligence factors, with deficits on the latter and relatively preserved performance on the former. In any case, the present results involving neuropsychological measures in control subjects were generally consistent with predictions based on previous studies and published norms, with the exception of an unexplained failure to find an age effect on a standardized phonemic fluency test.

AD subjects. In line with expectations, results indicated that AD patients were impaired relative to a matched control group on all neuropsychological measures, including immediate and delayed prose memory, receptive language (involving the ability to follow commands), confrontation naming, phonemic and category fluency, vocabulary, single-word reading, and visual perception (on an untimed, multiple-choice, matching task). Although these measures are commonly used in clinical neuropsychology practice, there are no published norms based on this population (i.e., mildly to moderately demented AD patients) for the WRAT-R reading subtest, Token Test, or the Visual Form Discrimination Test to date. The obtained data will therefore fill a gap in the normative base in clinical neuropsychology. Also as predicted, the patients did not differ from controls in subjective ratings of depression. Thus, their poor performances are not confounded by cognitive dysfunction associated with depression (e.g., Caine, 1986).

In light of diagnostic criteria for probable AD requiring impairments in memory and at least one other cognitive domain in addition to functional decline (McKhann et al., 1984), the overall findings involving the neuropsychological measures support the claim that subjects were classified appropriately as patients and controls.

Study Tasks

Control subjects. Control subjects performed at or near ceiling on the three study tasks. This finding reveals that the constraints placed on material selection, which were intended to ensure successful encoding of presented items, were effective. However, despite their very high rates of picture naming and sentence-frame completion (96% accuracy for both tasks), the old-old subjects were impaired relative to young and young-old subjects on both measures. Only the word-reading study task failed to show an age-related decline. The finding of a statistically significant drop in picture naming and sentence completion is functionally inconsequential, given the generally excellent scores on these two measures among the old-old subjects. Nevertheless, it underscores the results of the Boston Naming Test reported above, as well as the burgeoning literature on the neuropsychology of aging, both of which attest to age-related declines in confrontation naming (e.g., Borod, Goodglass, & Kaplan, 1980; Van Gorp et al., 1986). For example, the finding of a naming deficit in the old-old but not the young-old subjects (both on the picture study task and the Boston Naming Test), is consistent with Albert's (1988) finding that significant age decrements in confrontation naming (as measured by the Boston Naming Test) may not emerge until subjects reach their 70s. The results are also consistent with reported word-finding difficulties in spontaneous speech in healthy aging (Burke & Harrold, 1988).

Several lines of research on the neuropsychology of aging bear upon the present finding of lowered sentence-completion rates in old-old subjects. As discussed earlier, older adults tend not to engage in elaborative processing spontaneously, but they are capable of doing so in accordance with task instructions, as, for example, when required to generate words from incomplete sentence frames. At the same time, verbal fluency (frequently referred to as generativity) typically declines with age (e.g., Rosen 1980), which would lead one to expect less-than-perfect performance on subject-generated tasks, such as completing sentence frames. In this case, the old-old subjects' relative deficit on the sentence-completion task may be interpreted as a specific example of a more general word-finding difficulty. Yet, despite their inherent difficulties in generating target words, their performance was near ceiling because of the nature of the material (i.e., highly constrained sentence frames).

AD subjects. Unfortunately, the performance of the AD patients fell short of experimental intentions to ensure successful encoding, as indicated by their relatively low picture-naming and sentence-frame-completion rates (81% and 77%, respectively). Although disappointing because of the implications of reduced encoding on subsequent IM performance (discussed below), these impairments were not entirely unexpected. Besides impaired memory, word-finding difficulty is one of the most prominent cognitive deficits in AD (e.g., Huff, 1988). In particular, there is extensive evidence of deficits on confrontational naming tasks (Bayles & Tomoeda, 1983; Kirshner et al., 1984; Martin & Fedio, 1983). All the items presented in this study on the picture-naming study task were concrete, familiar, and readily nameable by healthy young subjects (Snodgrass & Vanderwart, 1980). In addition, subjects were allowed multiple attempts to correct their responses following feedback, and relatively generous time limits were provided. These material-selection and procedural decisions were incorporated with the specific intent of normalizing the AD patients' performance on the picture-naming task. The finding of impaired naming ability despite these efforts is in line with the well-established finding that naming is compromised even in early AD (e.g., Obler & Albert, 1985).

Sentence-completion performance was also impaired in the AD group. In a study by Grosse et al. (1990), AD patients completed 78% of sentences accurately, which is similar to the 77% completion rate observed in this study. In general, the patients' relative difficulty on this task is consistent with their well-known semantic memory deficits. Nevertheless, Nebes and Madden (1988) reported that AD patients were unimpaired on a sentence-completion task in which the appropriate endings were one of two high-frequency alternatives. The sentences used in this study were similarly highly constrained and were completed successfully by at least 95% of healthy young subjects in pilot testing. Again, the finding of impaired sentence completion despite efforts to support normal performance among the patients suggests that their difficulty in generating appropriate endings to sentence frames is not easily overcome, even in mild to moderate AD.

Implications of less-than-perfect study performance for subsequent IM performance. By definition, priming represents the facilitory effects of studied over nonstudied material on an independent task or trial. One may assume that the term studied used in this context refers to successful study (i.e., accurate encoding). Although extensive efforts were made to ensure successful encoding for all three study conditions in all four groups, these efforts were not realized fully in the old-old and AD groups with the picture-naming and sentence-completion tasks. Nevertheless, the 96% encoding rate observed on these two tasks in the old-old group arguably represents a functionally adequate score for its intended purpose in the context of this study (i.e., to constitute a pool of studied material sufficient to exert an influence on subsequent IM tasks), irrespective of the fact that this rate is statistically lower than that of the younger subjects. It is more difficult to argue for the adequacy of the lower encoding rates observed among the patient group. Admittedly, the reduced study performance in that group represents a methodological flaw in this study.

The issue of the impact of imperfect study performance on subsequent IM tasks has not been addressed directly in the IM literature. Healthy college sophomores, who serve as subjects in many IM studies, tend to perform at ceiling on study tasks; hence, the consequences of encoding inadequacies are rendered moot. Even when older or brain-damaged subjects are used in IM studies, encoding instructions typically require only likeability ratings of presented words, so there is no objective measure of accuracy. Again, the issue of imperfect study is not raised.

Despite this general neglect of the issue of processing accuracy at study, three notable exceptions may be found. In one study (Partridge et al., 1990), subjects (AD patients) who were unable to perform the orientating task, in which they were required to provide an appropriate meaning for each word presented, were excluded from the study. Thus, subsequent IM performance was based exclusively on subjects for whom successful encoding was ensured. Although the high standards set for subject inclusion in that study are commendable for addressing the issue of encoding accuracy, analogous concerns were not directed to baseline items, thereby introducing possible item-selection effects that could bias results in favor of priming. Notably, the preserved WSC priming among the AD patients in that study was attributed to deep encoding at study; the possibility of item-selection effects was not mentioned.

In another study, AD patients completed only 78% of sentence frames with best-fit words, which was significantly less than the 88% of sentences completed successfully by age-matched, normal control subjects (Grosse et al., 1990). The impact of the generation failures, which represented unsuccessful, or impoverished, encoding, was addressed by comparing WSC performance for all items to WSC for accessible items. There was an equivalent amount of priming for both accessible and total items in both patients and controls, who did not differ. The fact that stems were completed with target items beyond chance levels despite an inability to generate the very same items on command in the context of a meaningful sentence frame is intriguing, especially in contrast to the AD patients in this study, who did not demonstrate WSC priming even for items that were generated successfully.

Inconsistent accessibility, such as was observed in the Grosse et al. (1990) study, is reminiscent of clinical observations of confrontation naming failures involving words that AD and aphasic patients may use in spontaneous speech. These performance differences between test and conversational conditions may be best explained by their reliance on effortful versus automatic processing (e.g., Hasher & Zacks, 1979), respectively. Regardless of the explanation for fluctuations in item retrievability, it does not account for the discrepancy between the finding of preserved WSC priming among AD patients in the Grosse et al. study and the lack of WSC priming in other studies of AD patients (including this one). Considering that control subjects also failed to show WSC priming for generated items, and that the lack of such priming is consistent with predictions based on TAP theory, the present finding is in line with both theoretically based and the majority of empirically based expectations. Grosse et al.'s finding of WSC priming in AD, which they attribute to deep encoding despite the fact that some primed items were not generated at all during encoding, is a more untenable position that seems difficult to defend (for further discussion of the differences between this study and Grosse et al.'s study, see the subsection on "relation of AD findings to previous research" in the next section).

Finally, in a third study (Heindel et al., 1990), exceptional care was taken to address encoding inadequacies on a picture-naming task in AD patients. First, cues were provided as needed at study to bolster naming scores. Second, two different priming measures were developed to account for unequal baseline PFI rates between patients and control subjects. However, despite these efforts, the patients were impaired on both measures of priming, which was attributed to impaired perceptual item memory (priming) in AD. Given that some pictures required cues at study to be named successfully, there could have been a breakdown in lexical access for those items, thereby hindering their identification in degraded forms.

In the present study, items failed at study were selectively deleted from IM (and recognition) analyses. Conditionalizing priming scores on encoding accuracy ensures that stem completions and fragmented-picture identifications with "studied" targets truly reflect the influence of successfully studied over nonstudied material. At the same time, it must be acknowledged that this practice reduces the denominator when computing the proportion of successfully completed target items, which may yield an inflated magnitude of priming. Given this mathematical bias for enhanced priming, it is even more striking that the picture-naming and sentence-completion study conditions, which had the lowest encoding rates in the old-old and AD groups, did not produce priming on the WSC task.

Continuing with this line of reasoning, it could logically be argued that the normal magnitude of priming on the PFI task following picture study in the AD group is an artifact of the inflationary effect of their imperfect picture-naming performance at study. However, if artificial inflation were solely responsible for the priming seen on the PFI task, then the generated sentence endings, which had an even higher failure rate at study than did picture naming, should also have produced priming on the PFI task. Additional support for the legitimacy of the present results comes from the fact that a dual conditionalizing procedure was employed, in which both studied and nonstudied items that were not identified by the time the complete picture was presented were deleted on a subject-by-subject basis from the PFI analyses. This method compensates for potentially deleterious item-selection effects by eliminating the artifact associated with unilateral conditionalizing.

Implicit and Explicit Test Performance in Healthy Subjects

The main conclusions regarding implicit and explicit test performance among and between the three control groups in this study are as follows:

1. Study tasks alone do not determine either the presence or magnitude of priming effects.

2. The advantage of pictures over words commonly found on EM tests is reversed on WSC, a lexical IM task, but is reinstated on PFI, a pictorial IM task.

3. This reversal and reinstatement of the picture-superiority effect (PSE) is age-invariant.

4. Picture superiority is not solely a function of whether retrieval instructions are explicit or implicit.

5. The generation effect, which states that generated items are better remembered than passively studied items, can be eliminated on a pictorial IM task, reversed on a lexical IM task, and reinstated on an explicit test of recognition.

6. This elimination, reversal, and reinstatement of the generation effect is

age-invariant.

7. Across ages, the advantage of picture naming over passive reading is greater than the advantage of generated words over visually presented words when memory is tested by yes/no recognition. In other words, the picture-superiority effect is superior to the generation effect.

8. The particular pattern of crossover priming obtained with two IM tests, as well as the pattern of performance obtained on yes/no recognition, is in line with predictions based on transfer-appropriate processing (TAP) theory.

9. Just as implicit and explicit memory tests engage different retrieval processes, so too may lexical and pictorial IM tests be dissociated.

10. Standard age differences traditionally found on EM testing may be eliminated under certain conditions of optimal contextual support, as occurs when subjects are required to discriminate previously studied items from brand new distractors on a yes/no recognition test.

11. Age decrements are observed in recognition memory with the old-old group when contextual support is reduced, as occurs when subjects are required to make difficult discriminations.

12. Young and young-old subjects adopt a conservative response bias on yes/no recognition relative to old-old subjects, who tend to respond in a neutral manner.

<u>Theoretical accounts of the findings</u>. Taken together, the present results provide a strong confirmation of predictions based on TAP theory, which states that memory performance is determined by the degree to which processes invoked at study are recapitulated at test (Morris et al., 1977). Here, the processes engaged during word reading were re-engaged during WSC, whereas those processes involved in encoding pictures on a picture-naming

task were also involved to a large degree during PFI. Thus, word reading led to superior WSC priming, whereas picture naming led to superior PFI priming. In both cases, the overlap of processing operations between the study and test task pairs identified above was greater than the overlap between processes engaged during the test tasks and either of the other two study tasks. The most important point regarding this finding is that level of processing, or depth of encoding, alone does not determine priming magnitude, although it did influence recognition memory in predicted ways. Instead, the only a priori way to predict which encoding task will prime which IM test is to identify the component processes required by each and then order the degree of overlap along a continuum. Where there is a large degree of overlap, there will be large priming effects; where there is little overlap, there will be little or no priming.

One difficulty with the preceding discussion is that there is no objective, uniformly-agreed-upon method for identifying component processes of various tasks. Instead, both predictions and explanations of results are driven by a type of face validity in which similar processes are presumed to be involved in similar-appearing study and test tasks. Hence, the large priming effect in PFI associated with picture study is logically ascribed to the similarity between naming a complete drawing and identifying a fragmented version of the same drawing. Likewise, the reversal of the PSE on WSC is readily attributed to the greater match between word reading and WSC than between picture naming and WSC.

Attempts to account for the superiority of word reading over generation from the sentence-completion task on WSC priming is more ambiguous. Certainly, reading whole words and subsequently responding to the first three letters of those same words appear to involve similar processes. Specifically, lexical processing appears to be an important part of both tasks, which is why the benefit of word reading on WSC is often referred to as lexical priming. However, sentence completion appears to share similar processes with WSC as well. Specifically, both tasks require the active generation of a word on the basis of partial information (i.e., an incomplete sentence in one case, and an incomplete word in the other). The fact that word reading is superior to generated items for priming WSC determines empirically that lexical processes are more crucial than generative processes for WSC priming. Alternatively, the relevant dimension may be contextual. That is, both word reading and WSC comprise isolated items in a list, whereas the generation task comprises items bound contextually in meaningful sentences (see MacLeod, 1989, and Masson & MacLeod, 1992, for an account of context sensitivity in IM).

Traditional espousals of TAP theory distinguish data-driven from conceptually driven processes (e.g., Blaxton, 1989; Roediger, Weldon, & Challis, 1989). In this view, WSC, which primarily relies on data-driven processing, is more influenced by word reading than word generation because of the match between the surface characteristics of the word stems and the read words. In contrast, recognition memory, which is conceptually driven, benefits from the generation task, which is more semantically oriented than the word-reading task. Picture naming may lead to superior performance on both data-driven and conceptually driven tests, because the picture-study condition engages both data-driven (perceptual analysis of the presented pictures) and conceptually driven (generating the name, and hence the meaning, of the pictures) processes. One test, the perceptually based PFI task, recapitulates the data-driven processes associated with the study episode, while the other, yes/no recognition, recapitulates the conceptually driven processes that were engaged during initial encoding. This view is consistent with both dual-coding (Paivio, 1971) and sensory-semantic (Nelson, 1979) theories of picture processing, which state that named pictures are encoded for both image and meaning.

Besides dissociating IM from EM tests, dissociations between IM tests have also been explained under the umbrella of the traditional TAP framework (e.g., Roediger, Srinivas, & Weldon, 1989). For example, small but consistent effects of conceptual processing have been found recently on WFC (Challis & Brodbeck, 1992; Gardiner, 1988; Hirshman et al., 1990; Weldon, 1991) and WSC (see Challis & Brodbeck, 1992, for a review) tests. These findings suggest that WSC, though primarily data driven, has a small conceptual component, whereas perceptual IM tests, such as PFI, are purer measures of data-driven processes. To account for these findings, recent formulations by proponents of the traditional TAP perspective now acknowledge that the term data-driven tests may in fact be a misnomer, given that surface processing, lexical access, and conceptual processing all play a role in priming (Weldon, 1991). Nevertheless, Weldon argues that there is some utility in retaining this term as a general descriptor for a class of tests with shared features that differ from conceptually driven tests.

Data-driven and conceptually driven processes most likely comprise separate processing dimensions (Roediger & Challis, 1992; Weldon, 1991; Weldon et al., 1989). From this perspective, conceptual and data-driven processes do not necessarily compete with each other, as they would if they represented endpoints on a single continuum. Instead, they may be manipulated independently and make unique contributions to priming, which would account for findings in young subjects of very small priming effects on

WSC from picture and generation study tasks (Challis & Brodbeck, 1992; Hirshman et al., 1990; Weldon et al., 1989; Weldon & Roediger, 1987). In this study, it was shown that word study was superior to both picture and generation study conditions and that the latter two did not differ from each other. However, the question of whether there was any conceptual priming within a given group was not addressed directly in the analyses reported in the Results section. Because of the possibility that conceptual priming on WSC may be present only in young subjects, post-hoc analyses of that group's WSC performance following picture and generation study conditions were performed. Although studying items as pictures and generating items as sentence endings increased WSC in the young-control group by 10% and 8%, respectively, over baseline levels, neither of these rates were reliable ($t(19) = 1.67$, $p = .111$; $t(19) = 1.09$, $p = .291$, for picture and generation study, respectively). As Challis and Brodbeck (1992) have noted, the enhancement of WSC following picture study or other types of conceptual processing is generally quite small when it is found; when findings are not significant, they often reflect a trend in the direction of priming, as they do in this study.

A final theoretical challenge to findings of priming is the role of explicit recall as a contaminating factor on putatively implicit memory tasks (e.g., Challis & Brodbeck, 1992; Schacter, 1987b). In the past, the finding of stochastic independence between priming and recognition memory has been used to bolster the claim that EM and IM are functionally dissociable (e.g., Tulving et al., 1982). However, this practice has been criticized on the grounds that stochastic independence between two measures may be obtained even when they are dependent (Shimamura, 1985). In a cogent discussion of intentional retrieval and awareness of remembering during IM tasks, Schacter, Bowers, and Booker

(1989) state that in the purest, or most restrictive, view of IM, facilitated performance on a task may be said to tap IM when EM performance involving the same items is at or near chance levels. This issue was addressed here by a comparison of patterns of performance across implicit and explicit measures. In line with the strict view of IM, the comparison revealed that word study produced the greatest degree of priming on WSC, but the very same words were poorly recognized relative to generated words and items encoded as pictures when tested explicitly. If subjects were using explicit retrieval strategies on WSC, then they should have shown greater priming from items studied as pictures and generated as sentence endings than as isolated words, because those items were recognized much better than words read in isolation.

Despite the performance pattern differences on the IM and EM tests noted above, which provide strong support for classifying WSC as an IM task, the possibility that explicit retrieval strategies intruded on the PFI task merits consideration. In the present study, healthy subjects occasionally made spontaneous comments that indicated an awareness of the repetition of previously studied pictures on the PFI task. However, no such comments were made regarding the overlap between picture fragments and previously encountered items from the other two study conditions. Admittedly, this anecdotal observation may be consistent with the use of explicit retrieval strategies during PFI, to the extent that awareness of repetition may lead some subjects to adopt such strategies. As Schacter et al. (1989) note, when recollective awareness that an item was previously experienced occurs after retrieval of the target item is completed--particularly when other items are not recollected--it may be considered a post-retrieval phenomenon that does not preclude it from being defined as IM. When, however, subjects engage in intentional retrieval after becoming aware of the overlap between study and test items, performance may not justly be described as implicit. If the healthy subjects here were engaging in explicit retrieval on the PFI task, generated items should have produced greater PFI facilitation relative to items studied as words, in parallel with the pattern of recognition on the explicit test. However, there was no such difference between read versus generated items on the PFI test.

It is also worth noting that because IM testing always preceded recognition testing, the successful target completions constituted a second exposure of some of the study items, thereby providing a second learning opportunity for subjects. Thus, it is even more striking that, among the control subjects, items generated from sentence frames, which were identified from picture fragments at the same rate as words read in isolation and were used to complete word stems at a far lower rate than studied words, were nevertheless recognized much better than items from the word study condition. This finding strongly supports the classification of PFI as an implicit test in normals. Importantly, the AD patients demonstrated a normal amount of priming on this task, despite the finding of very poor recognition of items studied as pictures and the fact that none of them commented on the repetition of studied items on the PFI task. Thus, explicit retrieval cannot account completely for observed priming on PFI in the AD group either.

Finally, when subjects were debriefed at the end of the study, the vast majority expressed surprise regarding this aspect of the study design. Given that three different study tasks and the Visual Form Discrimination Test were administered prior to the IM tests, completing word stems and identifying picture fragments apparently were perceived as independent, de nouveau tasks, just as reading words, naming pictures, generating sentence endings, and matching geometric shapes were.

Findings relevant to aging. One of the primary findings resulting from this study is the evidence of preserved IM performance in two groups of elderly subjects. Most importantly, for the first time, both young-old and old-old adults demonstrated the same pattern of crossover priming effects previously established in young adults. Although it is tempting to conclude that age has no effect on IM, there are several reasons to refrain from fully endorsing this conclusion.

First, unless consistent results are found across several studies from several laboratories, it is difficult to argue for the null effect (i.e., the absence of group differences as evidence for age constancy in IM). Certainly, others have found spared IM with aging (for reviews, see Burke & Harrold, 1988; Graf, 1990; Howard, 1988; and Light & Burke, 1988). However, many studies find a trend toward age-related declines on IM tasks, even when performance differences do not reach conventional levels of statistical significance (e.g., Light et al., 1986; Light & Singh, 1987). More recently, small but reliable age decrements have become apparent in studies in which power is strong (e.g., Chiarello & Hoyer, 1988; Howard et al., 1986; Hultsch et al., 1991).

The possibility of insufficient power provides a compelling argument against the present findings of preserved IM across groups differing in age. For example, there was a trend toward greater WSC priming following word study in young relative to young-old subjects ($p = .031$). However, because four pairs of groups were being compared, only alpha levels $\leq .013$ were accepted as significant. Had these two groups been the only ones studied, a conventional alpha level of .05 would have been used, and the ensuing result would have led to a conclusion of an age-related decline in priming magnitude as measured by WSC. Instead, this study provided an opportunity to compare several groups of healthy subjects representing different points across the lifespan. Thus, even if the young and young-old groups did differ significantly in WSC priming, the difference could not be solely attributable to age, because the magnitude of priming observed in the old-old group fell between the other two. If WSC priming decreases with age, then old-old subjects should show less priming than young-old subjects.

Group comparisons of priming magnitude on the PFI task were more complicated because of the unequal baseline performances for the various groups. That is, if priming was operationally defined as a proportional increase in target over baseline identification rates, the old-old group would actually show the greatest magnitude of priming. This finding would be spurious, however, because the base rate of young subjects was much higher than that of old-old subjects. In contrast, no group differences emerged when priming was defined as the difference between baseline and target identification rates. Yet, again, it is unclear how unequal baseline rates contribute to subsequent measures of priming. It should be emphasized, though, that in either case, there is no evidence of even a nonsignificant trend toward age-related declines on this IM task.

There was evidence of an age-related decline in recognition accuracy when subjects were required to discriminate targets from familiar foils (i.e., items used in the baseline measures), but not when recognition involved discrimination of targets from new distractors. This group by foil interaction is most likely attributable to the differential difficulty of the two types of discrimination. Overall recognition accuracy (i.e., summed over group) was much lower in the foil condition in which age decrements were observed in the old-old group. This finding is consistent with a host of other studies reporting that age differences in favor of the young are most apparent on tasks that are difficult or in which contextual support is reduced (e.g., Craik et al., 1987).

To the extent that baseline items presented in the IM tests are remembered during recognition testing, accurate recognition judgments necessarily require source memory (see Schacter, 1987c, for a discussion of source memory). That is, it is not enough to remember that a target or baseline item occurred; one must also remember when it occurred. Subjects were reminded of the initial three study tasks and told explicitly that some of the items may have appeared again in incomplete forms in the PFI and WSC tasks. However, they were instructed to say yes only if they remembered the item as being (a) one of the words they read in isolation, (b) one of the whole pictures they named earlier, or (c) one of the items they had generated to fill in the blank of the incomplete sentences--whether or not the same item was encountered again in a later task.

Of course, all explicit, episodic memory tests rely to greater and lesser degrees on source memory. For example, when a list of familiar words is presented and subsequently tested by yes/no or multiple-choice recognition, subjects must dissociate previous encounters with each item from their most recent encounter with the item in the context of the present learning experience. However, there is a relatively greater demand for source memory in the recognition measures involving baseline items (which were also presented in the context of the experiment) as opposed to new distractors (which were not presented). Considering that age-related declines in source memory are well-documented (e.g., Craik, Morris, Morris, & Loewen, 1990; McIntyre & Craik, 1987; Schacter, 1987c), it is not surprising that group by foil interactions emerged in which the old-old subjects were impaired relative to younger subjects on the measure of recognition involving baseline items.

Findings and implications of response bias. The old-old subjects responded consistently more liberally than either of the other control groups on the recognition test. It may be that recognition judgments based on what Mandler (1980) has termed a "feeling of familiarity" (which may be an implicit contribution to recognition judgments) leads to yea-saying responses in old-old subjects. Alternatively, given that the old-old group tended to be neutral overall (M response bias = .471), the age difference in response bias could more accurately be attributed to a conservative bias among the young and young-old subjects. That is, when faced with uncertainty, the young and young-old groups adopted a stringent decision criterion. Mere familiarity was not sufficient to elicit a yes response in these groups. Instead, they imposed a higher threshold of certainty for affirmative responding on the recognition test.

Implicit and Explicit Test Performance in AD Subjects

The main findings of implicit and explicit test performance in the AD group are as follows:

1. Mildly to moderately demented AD patients exhibit a normal general ability to complete word stems to form real words, as determined by baseline completion rates.

2. AD patients exhibit an impoverished general ability to identify fragmented pictures, as determined by baseline identification rates.

3. The reversal and reinstatement of the PSE on WSC and PFI tasks, respectively, which is found among both young and old healthy adults, is not fully maintained in AD.

4. AD patients do not show priming on WSC, regardless of study condition.

5. Perceptual priming, as measured by PFI rates following picture study, is preserved at a normal level in AD.

6. Standard generation and picture-superiority effects in recognition memory are absent in AD.

7. Given that picture study primes PFI at a normal rate among AD patients, for whom the same pictures are not explicitly remembered, perceptual priming cannot be accounted for by the intrusion of explicit retrieval strategies in this population.

8. As a group, AD patients are unbiased in their recognition responses, although individual patients may have extreme nay-saying or yea-saying response sets. The combination of neutral responses and very low recognition accuracy likely reflects chance guessing on yes/no recognition in this population.

Relation of AD findings to previous research. The finding of impaired WSC rates following word study among the AD patients in this study, despite preserved baseline completion rates, is consistent with previous research documenting impaired lexical priming in AD with this task (Heindel et al., 1989; Salmon et al., 1988; Shimamura, et al., 1987). However, in previous studies (e.g., Keane et al., 1991; Salmon et al., 1988), AD patients exhibited priming among themselves (i.e., significantly more target than baseline completions); their impairment was only apparent in comparison to the greater priming magnitude observed in age-matched controls. In contrast, the patients in this study did not exhibit priming at all (p = .105, one tailed). The discrepancy did not appear to be due to insufficient power to detect the presence of priming in the present study, because 20 patients were examined here, whereas there were only 13 patients in the Salmon et al. (1988) study. Further, a similar number of critical three-letter stems corresponding to previously presented words was used in the two studies (10 for Salmon et al., 9 here). In order to determine the power of the present study to detect an equivalent or greater effect size than that obtained in the Salmon et al. (1988) study, the minimum effect size obtained in their AD group was calculated to be 1.06 standard deviations (assuming that target completions for studied and nonstudied items were completely uncorrelated). The correlation between studied and baseline target completions in the present study was .40, resulting in a power estimate of .99 at an alpha level of .05 to obtain the minimum effect size found by Salmon et al. Thus, the different results obtained between the two studies was not because of low power in this study.

One might initially think that the most obvious explanation of the different findings is that the subjects in this study, whose average MMSE score was 17.25 of a possible 30, were more demented than those of Salmon et al. (1988), whose average Dementia Rating Scale (DRS) score was 116 (of a possible 144). Although it is difficult to compare these two scores directly, they are both typically characterized as moderate dementia. It should be noted that patients in the Salmon et al. study had only an approximately 12% baseline completion rate (which was equivalent to other patient and control groups' rates); patients and controls in this study had approximately 30% completion rates. Higher baseline rates may require proportionally greater enhancement of WSC with target items to reveal statistically significant priming.

Whatever the reason for the discrepancy regarding within-group priming in AD, there is no question that AD patients are uniformly impaired on WSC following word study relative to controls. Where the present results deviate more drastically from previous research is in regard to WSC priming for deeply encoded material. As discussed earlier, several recent studies have found preserved WSC priming in AD when study tasks involved either generating words to incomplete sentence frames (Grosse et al., 1990), encoding in the context of paired-associate learning (Lussier et al., 1990), or providing definitions of presented words (Partridge et al., 1990). In all three cases, the preserved WSC priming was attributed to deep initial encoding, though depth of encoding was not manipulated in any of the studies.

This study specifically manipulated study tasks to determine if depth of encoding would indeed influence WSC priming in AD. Not only did the generation and picture study tasks fail to prime WSC above chance levels, but raw target completion rates were lower in the generation than the word-study condition. If these results represented only a failure to replicate the three studies cited above (particularly the Grosse et al., 1990 study, which was modeled quite closely in the present design), then the discrepancy could perhaps be discussed in terms of power or of various differences in the subjects, materials, or design. However, the fact that depth of encoding was experimentally manipulated, and that results revealed greater absolute (though nonsignificant) WSC priming following words read passively in isolation than words actively generated in the context of meaningful sentences (which were additionally assured of being in the subject's lexicon, which cannot be said for the read items), makes a strong case against depth of encoding as the explanation for recent observations of preserved WSC priming in AD.

It appears, then, that the findings of preserved WSC priming in other studies are not due to deep encoding at initial study, despite the claims of previous investigators. Having said that, there remains an unsettled account of the discrepancy between those studies and the present study. The so-called deeply encoded study tasks employed by Lussier et al. (1990) and Partridge et al. (1990) are quite different from the sentence-completion task used here. Thus, performance differences could easily be due to task differences. Procedural differences between the Grosse et al. (1990) study and this one merit a closer look, however, given that the sentence-completion task used was the same in both studies.

First, the patients in the two samples appear to be similar in age and MMSE score, although Grosse et al.'s patients may have been more educated (M education = 15 years vs. 11 here). More importantly, Grosse et al. (1990) tested WSC on four separate trials, each of which immediately followed presentation of a study block consisting of 10 sentence frames. In the present study, WSC was tested only once. It followed all three study conditions (with the sentence-frame task occurring last only one third of the time) and an intervening distractor test. Further, only a single block of 18 sentence frames was presented at study. Several of these differences could be critical for the disparate findings, but definitive identification of the particular procedural feature, or combination of features, most responsible for the discrepant results requires further study.

Interestingly, although the AD patients in this study did not exhibit WSC priming following a sentence-frame completion task, they did exhibit item-specific priming on a perceptual IM test following picture study where others have failed to observe such priming (cf. Bondi & Kaszniak, 1991; Corwin & Snodgrass, 1987; Heindel et al. 1990; Ward et al., in press) or have found only marginal priming (Grafman et al., 1990). Thus, the present findings suggest that perceptual IM may be demonstrated in AD under certain conditions. Although this finding deviates from the results of the studies cited above, it is not an entirely anomalous finding. For example, there are several well-established findings of both the preservation of perceptual IM in AD on tasks such as reading mirror-reversed text (Moscovitch, 1982) and normal repetition priming on lexical-decision tasks (Nebes et al., 1989; Ober & Shenaut, 1988; see also Nebes, 1992a, 1992b for reviews). In these cases, however, reaction times were used as the dependent measure. In both the present study, in which perceptual IM was found to be intact, and in studies finding perceptual IM to be impaired, PFI performance served as the criterial task.

Again, it is not clear why the present results involving AD patients are so discrepant from previous studies. At least in this case, the discrepancy is in the opposite direction of the discrepancy observed in WSC performance following the generation task (i.e., a lack of WSC priming following generation where others have found evidence of priming, coupled with a positive finding of PFI priming following picture study where others have failed to find such priming). Thus, it cannot be that the study design involved too many tasks (or too much interference) between study and test to produce reliable priming. Nor can the differences be simply attributed to subject differences (if so, the pattern of difference should be either uniformly positive or negative). More likely, there must be procedural differences between this study and other studies showing impaired PFI priming in AD patients. If, indeed, item-specific perceptual priming is so sensitive in AD that it can be eliminated by a number of procedural variations that do not affect the priming rates of control subjects, then one must be especially cautious in interpreting the present results as a preserved function, per se, in AD.

Recent reports suggest that AD is a heterogeneous disease with distinct subtypes characterized by qualitatively different cognitive profiles (e.g., Brandt et al., 1989; Martin et al., 1986). Using a principal-components factor analysis on a comprehensive neuropsychological test battery, Martin et al. (1986) found that a two-factor solution accounted for 70.5% of the total variance among their 42 AD patients. Aside from their shared memory deficits, some patients had prominent visual perception and construction deficits, whereas others displayed prominent language deficits. The implication of this finding is that groups matched for overall dementia severity likely comprise individual patients with diverse profiles of impaired and preserved cognitive abilities. The appearance and disappearance of priming effects across studies may therefore reflect this diversity in the various patient samples. From another standpoint, the greater variability observed in AD populations relative to normals may obscure all but the most robust phenomena. Given that priming effects observed in normals vary as a function of task and procedural changes, it is not surprising that findings involving AD patients are even more variable.

With regard to the probable factors associated with the discrepancy between the present results and those of Heindel et al. (1990), three stand out. First, as mentioned earlier, patients in the Heindel et al. study were provided with cues when they did not name pictures correctly; in this study, items that subjects could not name spontaneously were deleted from the priming analyses. Second, Heindel et al. used a 4-second presentation rate in the PFI task. Here, subjects were given up to 15 seconds to identify each fragment. Given the well-known finding of increased response latencies in AD, 4 seconds may have been insufficient for patients to visually analyze the perceptual material, conduct a search for the lexical associate of the item, and emit the appropriate response. Third, Heindel et al., presented all pictures at the same level of degradation before proceeding to presentation of the next level. Here, increasing levels of completeness were presented successively on an item-by-item basis. The discontinuity of the Heindel et al. approach may have disrupted the fragile perceptual-closure operations involved in processing fragmented pictures, so that each fragment necessitated a new imaging schemata. The procedure employed here allows for continual building on fragmentary percepts associated with the degraded form of a given item. Such continuity may be more beneficial to AD patients than to healthy adults, who do not suffer from such debilitating attentional and orienting deficits.

Regardless of the specific reason for the discrepancy between the present and previous results of PFI performance following picture study, one can definitely conclude that item-specific perceptual IM is not globally impaired in AD, and, in fact, may be perfectly intact under certain conditions. Interestingly, AD patients also exhibited intact perceptual priming on a task involving the perceptual identification of briefly presented words despite showing impaired word-completion priming (Keane et al., 1991). The fact that Keane et al. found the same pattern of impaired lexical priming and preserved perceptual priming as was found here, despite the use of different study tasks and materials, suggests that the present findings are not entirely anomalous.

The finding of across-the-board impairments in explicit recognition memory among the AD patients is entirely consistent with the large literature of deficient EM in AD (e.g., Kaszniak, 1986; Nebes, 1992a; Schacter et al., 1991) and of impaired recognition memory in particular (Shimamura et al., 1987). A more striking finding is the contrast between EM/IM performance differences in the patient group. Normal individuals traditionally perform better on explicit, as opposed to implicit, tests, presumably due to the use of effortful retrieval strategies on the former. Although EM/IM test performance was not compared directly in the data analysis, it is nevertheless obvious that the AD patients in this study actually performed worse on recognition (approximately 13% accuracy across foils and formats) than on either WSC (approximately 33% completion rate across formats) or PFI (approximately 21% identification rate across formats). Although Nebes et al. (1989) determined that semantic priming in AD patients is not entirely accounted for by automatic processes, the finding of worse recognition than IM performance in these AD patients is consistent with the notion that they suffer from a severe disturbance in self-directed memory search (e.g., Nebes, 1992a).

Finally, AD patients exhibited neutral responses on the recognition memory test. However, it is noted that some patients imposed a completely negative bias (i.e., responding "no" to all items, irrespective of initial encoding), while others demonstrated a highly positive response set (i.e., responding "yes" to all items). Anecdotally, these biases were expressed by a few patients who remarked that they could not remember having seen any item in the course of the study, and one patient who insisted that he was familiar with all the items and had seen them previously (although not necessarily in the study context). Thus, despite a group finding of general neutrality, individual AD patients may be characterized anywhere along a continuum from extreme conservatism to extreme liberalism on recognition memory. The finding of neutral responses among the AD patients contrasts recent claims that AD patients tend to adopt a liberal response set when uncertain (Brandt, Corwin, & Krafft, 1992; Snodgrass & Corwin, 1988). Overall, given the patients' very poor recognition accuracy in general, their neutral response set is presumed to reflect a guessing strategy.

Theoretical accounts of the findings. The most controversial issue in IM research is whether dissociations between IM and EM are produced by distinct memory systems associated with distinct brain regions (e.g., Heindel et al., 1989; Squire, 1987; Tulving & Schacter, 1990; but see Ostergaard & Jernigan, in press, for a critique of this view) or, rather, by differences in processing operations invoked by the two types of tests (e.g., Graf & Gallie, 1992; Masson, 1989; Roediger et al., 1989).

The finding that AD patients show intact PFI priming following picture study despite very poor explicit recognition of the same pictures certainly seems to indicate that the two tasks elicit distinct cognitive processes. Where the structuralist/proceduralist debate enters the fray, however, is in the instantiation of the claim that performance on one or the other type of task is subserved by a particular brain structure. The systems' theorists continually make this claim, and actually go one step further, which is to state that there are a number of independent memory systems, each of which is referable to a particular brain region whose actions and interactions are responsible for both implicit and explicit memory phenomena. Support for this argument comes from double dissociations on implicit and explicit tests between subject populations having identifiable and dissociable regions of brain damage.

For example, the finding of preserved IM and profoundly impaired EM in amnesics serves as the basis of the claim that the medial temporal lobes are not involved in IM (e.g., Squire, 1987). Similarly, double dissociations, such as impaired WSC performance and preserved motor-skill learning in AD and vice versa in Huntington's disease (HD) patients, have been used as evidence for the claim that motor-skill learning depends on the corticostriatal system that is damaged in HD, whereas lexical priming is more critically dependent on the neocortical association areas damaged in AD (e.g., Butters et al., 1990; Heindel et al., 1989). In this case, two different IM tasks, rather than IM and EM in general, are believed to represent the operations of two different memory systems.

One of the problems with this line of reasoning is that for every dissociation observed between IM tasks within a particular population, there arises a claim for the existence of two more memory systems or subsystems. A recent example of this proliferation of memory systems comes from a dissociation within AD patients that parallels the present findings. Specifically, Keane et al. (1991) found impaired conceptual priming as measured by WSC and preserved perceptual priming as measured by the perceptual identification of briefly presented words in AD. They argued that the impaired conceptual priming was produced by an impaired lexical-semantic memory system, referable to temporoparietal cortex (the site of extensive neuropathology in AD); the preserved perceptual priming, in contrast, was said to be mediated by a preserved structural-perceptual memory system, presumably subserved by the occipital lobe, which is relatively spared in AD. This same argument could be made for the present results, where impairments were also found in conceptual priming, as measured by WSC, and preserved perceptual priming was found in a PFI task following picture study in the AD patients.

Processing theorists, on the other hand, account for dissociations between IM and EM tests, or between classes of IM tests, by differential demands on the types of processing operations required for successful performance on the different tasks, variously termed as conceptually driven versus data-driven (e.g., Roediger, Srinivas, & Weldon, 1989; Roediger, Weldon, & Challis, 1989), integrative versus elaborative (Graf & Gallie, 1992), or initial interpretative and subsequently elaborative (Masson & MacLeod, 1992) processing. As Roediger (1990a) notes, the processing explanation of dissociations is generally favored by experimental (cognitive) psychologists, whereas the distinct memory systems view is primarily advocated by neuropsychologists.

As an experimental, cognitive, geriatric, neuropsychologist, I would argue for a position straddling these two camps. Neuropsychology, by definition, is the study of brain-behavior relationships, and it would be unreasonable to disregard known neuroanatomical and neuropathological findings that distinguish various subject populations to speak solely of disembodied processes loosely described as cognitive. At the same time, a strict systems view is unappealing, because, although descriptive of extant results, the potential for wild multiplication of systems and subsystems inherently lacks elegance and parsimony. Instead, it seems justifiable to bridge these two views by a middle-ground view that emphasizes the overlap of processing operations at study and test as a primary determinant of priming effects, thereby instantiating the original transfer-appropriate processing (TAP) model of Morris et al. (1977), while, at the same time, acknowledging that certain brain regions are more involved than others in carrying out the various operations. That is not to say that particular processes are localized to particular brain regions, just because intact integrity of those regions may be necessary for the successful execution and application of the processing operations.

In this way, an argument may be made that structural-perceptual processes are involved in both picture study and PFI. Although these processes do not reflect the operation of an independent memory system, they may nevertheless be subserved by primary sensory cortical regions, which are relatively spared in AD (Kemper, 1984; Strub & Black, 1988). Both word reading and WSC may induce lexical-semantic processing among normal individuals. That is, the actual reading of individual words may require only lexical-perceptual processes, but a simultaneous translation of the word's meaning may occur automatically in healthy adults. AD patients, in contrast, who have degraded knowledge representations (Martin, 1992) and other defects in their semantic knowledge (for review, see Nebes, 1989), may engage lexical-perceptual processes only on the word-reading task, which may not be sufficiently similar to the processes necessary for WSC to produce priming. With the exception of Keane et al.'s (1991) attribution of this finding to an impairment in an independent memory system devoted exclusively to lexical-semantic processes, this argument is essentially consistent with their conclusion that priming effects are dissociable in AD as a function of different demands on perceptual and conceptual processing.

Summary

In sum, the present results are best understood in terms of TAP theory, which states that memory performance is determined by the degree of overlap between processes engaged at study and test. As predicted, the greatest magnitude of WSC priming occurred for words that were read in isolation at study; PFI priming was greatest following a picture-naming study condition. These crossover priming effects obtained for all three groups of healthy subjects, indicating that such effects are age-invariant. AD patients displayed normal priming on PFI following picture study, suggesting that structural-perceptual processes may be spared in the mild to moderate stage of this disease. WSC priming was impaired in the patient group, regardless of study condition, which may reflect either the lack of power to detect a small but significant effect or the loss of lexical-semantic processing at this relatively early stage of the disease.

Among the controls, recognition memory was best for items studied as pictures, moderate for items generated in the context of sentence frames, and worst for words read in isolation. AD patients' recognition memory was uniformly impaired for all study conditions, indicating a failure to benefit from encoding manipulations on this measure of explicit memory. Nevertheless, it is possible that generation and/or picture study would benefit recogniti...ı memory in AD if tested immediately after study rather than following a delay with several intervening tasks.

Limitations of the Present Study

As discussed previously, the reduced performance of the AD group in the picture-naming and sentence-completion study tasks decreases power, because unsuccessfully encoded items from the study conditions were selectively deleted from the priming and recognition analyses. To the extent that a small but significant priming effect may exist among AD patients on WSC for items generated in the context of sentence frames, the failure to observe such a finding may be attributable to insufficient power. Notably, this argument cannot be applied to the failure to find WSC priming among AD patients following word study, because encoding was at ceiling in that condition. Hence, the generalizability of the priming results for the patient group may be only partially limited.

Probably the greatest limitation of the present findings pertains to the complexity of the design. Most other IM studies employ a single study task, which may or may not be followed by a distractor task, prior to administration of the priming task. In this study, three study tasks and a distractor task were administered prior to the two priming measures. How this aspect of the design may have affected the priming results is not entirely clear. One defense of the multiple-task design is among the five most well-documented dissociations between EM and IM (Schacter, 1987b), namely that interference disrupts the former while having no effect on the latter (Graf & Schacter, 1987). If this purported dissociation is true, then administering several successive study conditions should not be problematic for the generalizability of the priming results. In any case, the study tasks were presented in a blocked fashion, which is more effective for producing priming than is presentation of items in mixed lists (Challis & Brodbeck, 1992).

Recognition performance, in contrast, very likely was detrimentally affected by the study design. First, the failure to find generation and picture-superiority effects among the AD patients may have been due to the number of intervening tasks and concomitant time delay between study and test. Thus, the present results may not generalize to conditions in which recognition immediately follows study. Recent findings of equivalent yes/no recognition between Huntington's disease (HD) and AD patients on the Hopkins Verbal Learning Test (Brandt et al., 1992), in which recognition is administered immediately after initial learning, and poorer recognition memory in AD versus HD patients on the California Verbal Learning Test (Delis et al., 1991), in which recognition is assessed after a 20-minute delayed recall trial, suggests that verbal recognition in AD is influenced by time delays and task interference.

Secondly, item exposure in the context of the priming tasks allowed for additional encoding beyond that which took place at initial study. Specifically, half the study items were presented a second time in the context of the PFI task, while the stems of the remaining half were presented in the context of the WSC task (a variable number of which were completed with target items), and approximately 65% of the baseline items that served as distractor items on the recognition task were exposed in the priming tasks as well. This aspect of the design limits the findings of recognition accuracy that were reported as a function of initial study format alone. The fact that recognition was significantly lower for the measure involving baseline foils as opposed to new foils indicates that item exposure during priming did indeed affect subsequent recognition. This finding may reduce the generalizability of the recognition results.

Finally, it almost goes without saying that there is always a general limitation of making inferences about age-related declines on the basis of age-related differences in a cross-sectional rather than a longitudinal design (e.g., Schaie, 1993). Young subjects were more educated than old-old subjects, in line with suggested guidelines for subject selection in aging research (Poon, Kraus, & Bowles, 1984). Nevertheless, the possibility remains that the reported age-related differences on the neuropsychological measures are due to cohort effects rather than reflecting age-related declines in skills and functions.

Suggestions for Future Research

In light of the limitations of the present study outlined above, it would be interesting to assess priming in a modification of this design, whereby WSC and PFI were tested immediately following individual study conditions. Previous studies attributed WSC priming in AD patients to deeply encoded material, yet encoding was not manipulated. Encoding was manipulated in this study, but AD patients had reduced study performance relative to controls. Certainly, encoding manipulations leading to successful study in the patient group, as well as manipulations involving depth of encoding, would be desirable in future studies. In particular, Challis and Brodbeck's (1992) report that small but consistent effects of conceptual processing on WSC among healthy young subjects was not fully supported here, as the enhancement of WSC following picture study only approached significance in the young control group. This suggests that conceptual priming on data-driven tests is a fragile phenomenon. The conditions under which conceptual priming does and does not occur on various IM tasks is just beginning to be explored in the IM literature. If successful, such efforts will go a long way in explaining memory phenomena outside the realm of priming.

The next programmatic step in the study of implicit memory, particularly among neuropsychological populations, is to correlate priming and neuropsychological performance with measures purported to invoke similar processes. If, indeed, certain IM tasks rely on lexical-semantic processes, then measures such as WRAT-R word reading or perhaps WAIS-R vocabulary might be correlated with WSC performance. The Visual Form Discrimination Test, which involves perceptual discrimination of geometric designs, should be strongly correlated with PFI performance. To the extent that the underlying component processes of various neuropsychological, encoding, and IM measures are identified, predictions of priming based on TAP theory may be made with increasing specificity. As predictions become more specific, and ensuing results conform to those predictions, we will be left with a greater understanding of the processes involved in both normal and abnormal implicit and explicit memory. Further, the identification of spared processing operations in memory-impaired populations can ultimately serve as the basis for remediation efforts.

References

Albert, M., & Milberg, W. (1989). Semantic processing in patients with Alzheimer's disease. Brain and Language, 37, 163-171.

Albert, M. S. (1988). Cognitive function. In M. S. Albert & M. B. Moss (Eds.), Geriatric neuropsychology (pp. 33-53). New York: Guilford.

Albert, M. S., & Heaton, R. K. (1988). Intelligence testing. In M. S. Albert & M. B. Moss (Eds.), Geriatric neuropsychology (pp. 13-32). New York: Guilford.

Alzheimer's Disease and Related Disorders Association (1987). Alzheimer's disease and related disorders: A description of the dementias. Chicago, IL: Author.

American Psychiatric Association (1987). Diagnostic and statistical manual of mental disorders-revised (3rd ed.). Washington, DC: Author.

Appell, J., Kertesz, A., & Fisman, M. (1982). A study of language functioning in Alzheimer patients. Brain and Language, 17, 73-91.

Bäckman, L., Mantyla, T., & Herlitz, A. (1990). The optimization of episodic remembering in old age. In P. B. Baltes & M. M. Baltes (Eds.), Successful aging: Perspectives from the behavioral sciences (pp. 118-163). New York: Cambridge University Press.

Bajo, M.-T. (1988). Semantic facilitation with pictures and words. Journal of Experimental Psychology: Learning, Memory and Cognition, 14, 579-589.

Barona, A., Reynolds, C. R., & Chastain, R. (1984). A demographically based index of premorbid intelligence for the WAIS-R. Journal of Consulting and Clinical Psychology, 52, 885-887.

Bayles, K. A. (1982). Language function in senile dementia. Brain and Language, 16, 265-280.

Bayles, K. A., & Kaszniak, A. W. (1987). Communication and cognition in normal aging and dementia. Boston: College-Hill Press.

Bayles, K. A., & Tomoeda, C. K. (1983). Confrontation naming impairment in dementia. Brain and Language, 19, 98-114.

Begg, I., Snider, A., Foley, F., & Goddard, R. (1989). The generation effect is no artifact: Generating makes words distinctive. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 977-989.

Benton, A. L., Hamsher, K. deS., Varney, N. R., & Spreen, O. (1983). Contributions to neuropsychological assessment. New York: Oxford University Press.

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 657-668.

Blessed, G., &Tomlinson, B. E., & Roth, M. (1968). The association between quantitative measures of dementia and of senile change in the cerebral grey matter of elderly subjects. British Journal of Psychiatry, 114, 797-811.

Bolla, K. I., Lindgren, K. N., Bonaccorsy, C., & Bleecker, M .I. (1990). Predictors of verbal fluency (FAS) in the healthy elderly. Journal of Clinical Psychology, 46, 623-628.

Bondi, M. W., & Kaszniak, A. W. (1991). Implicit and explicit memory in Alzheimer's disease and Parkinson's disease. Journal of Clinical and Experimental Neuropsychology, 13, 339-358.

Borod, J., Goodglass, H., & Kaplan, E. (1980). Normative data on the Boston Diagnostic Aphasia Examination, parietal lobe battery, and Boston Naming Test. Journal of Clinical Neuropsychology, 2, 209-215.

Brandt, J., Corwin, J., & Krafft, L. (1992). Is verbal recognition memory really different in Huntington's and Alzheimer's disease? Journal of Clinical and Experimental Neuropsychology, 14, 773-784.

Brandt, J., Mellits, E. D., Rovner, B., Gordon, B., Selnes, O. A., & Folstein, M. F. (1989). Relation of age at onset and duration of illness to cognitive functioning in Alzheimer's disease. Neuropsychiatry, Neuropsychology, & Behavioral Neurology, 2, 93-101.

Brandt, J., Spencer, M., McSorley, P., & Folstein, M. F. (1988). Semantic activation and implicit memory in Alzheimer disease. Alzheimer Disease and Associated Disorders, 2, 112-119.

Brooks, D. N., & Baddeley, A. D. (1976). What can amnesic patients learn? Neuropsychologia, 14, 111-122.

Brumback, R. A., Leech, R. W., Carella, J., & Miner, G. D. (1990). Dementia: The importance of clinical evaluation, autopsy confirmation, and research. Journal of the Oklahoma State Medical Association, 83, 109-118.

Bub, D., & Chertkow, H. (1990, February). Semantic priming and semantic memory loss in Alzheimer's disease. Paper presented at the 18th annual International Neuropsychological Society meeting, Kissimmee, FL.

Burke, D. M., & Harrold, R. M. (1988). Automatic and effortful semantic processes in old age: Experimental and naturalistic approaches. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 100-116). New York: Cambridge University Press.

Burke, D. M., & Light, L. L. (1981). Memory and aging: The role of retrieval processes. Psychological Bulletin, 90, 513-546.

Burke, D. M., White, H., & Diaz, D. L. (1987). Semantic priming in young and older adults: Evidence for age constancy in automatic and attentional processes. Journal of Experimental Psychology: Human Perception and Performance, 13, 79-88.

Butters, N. (1990, February). Dissociation of implicit memory in dementia. Paper presented at the 18th annual International Neuropsychological Society meeting, Kissimmee, FL.

Butters, N., & Cermak, L. S. (1980). Alcoholic Korsakoff's syndrome: An information-processing approach to amnesia. New York: Academic Press.

Butters, N., Granholm, E., Salmon, D. P., Grant, I., & Wolfe, J. (1987). Episodic and semantic memory: A comparison of amnesic and demented patients. Journal of Clinical and Experimental Neuropsychology, 9, 479-497.

Butters, N., Heindel, W. C., & Salmon, D. P. (1990). Dissociation of implicit memory in dementia: Neurological implications. Bulletin of the Psychonomic Society, 28, 359-366.

Butters, N., Salmon, D. P., Heindel, W., & Granholm, E. (1988). Episodic, semantic and procedural memory: Some comparisons of Alzheimer's and Huntington's disease patients. In R. Terry (Ed.), Aging and the brain (pp. 63-87). New York: Raven Press.

Caine, E. D. (1986). The neuropsychology of depression: The pseudodementia syndrome. In I. Grant & K. M. Adams (Eds.), Neuropsychological assessment of neuropsychiatric disorders (pp. 221-243). New York: Oxford.

Cermak, L. S., Talbot, N., Chandler, K., & Wolbarst, L. R. (1985). The perceptual priming phenomenon in amnesia. Neuropsychologia, 23, 615-622.

Challis, B. H., & Brodbeck, D. R. (1992). Level of processing affects priming in word fragment completion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18, 595-607.

Chertkow, H., Bub, D., Merling, A., & Bruemmer, A. (1990, February). Evolution of semantic priming changes in dementia of the Alzheimer's type. Paper presented at the 18th annual meeting of the International Neuropsychological Society, Kissimmee, FL.

Chertkow, H., Bub, D., & Seidenberg, M. (1989). Priming and semantic memory loss in Alzheimer's disease. Brain and Language, 36, 420-446.

Chiarello, C., & Hoyer, W. J. (1988). Adult age differences in implicit and explicit memory: Time course and encoding effects. Psychology and Aging, 3, 358-366.

Cohen, N. J. (1984). Preserved learning capacity in amnesia: Evidence for multiple memory systems. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (pp. 83-103). New York: Guilford.

Cohen, N. J., & Squire, L. R. (1980). Preserved learning and retention of pattern-analyzing skill in amnesia: Dissociation of "knowing how" and "knowing that." Science, 210, 207-210.

Corkin, S. (1982). Some relationships between global amnesias and the memory impairments in Alzheimer's disease. In S. Corkin, K. L. Davis, J. H. Growdon, E. Usdin & R. J. Wurtman (Eds.), Aging: Vol. 19. Alzheimer's disease: A report of progress (pp. 149-164). New York: Raven Press.

Corwin, J., & Snodgrass, J. G. (1987). The picture memory and fragmented pictures tests: Use with cognitively impaired populations. Psychopharmacology Bulletin, 23, 286-290.

Craik, F. I. M. (1977). Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (pp. 384-420). New York: Van Nostrand Reinhold.

Craik, F. I. M. (1979). Levels of processing: Overview and closing comments. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 447-461). Hillsdale, NJ: Erlbaum.

Craik, F. I. M. (1984). Age differences in remembering. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (pp. 3-12). New York: Guilford.

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F. I. M. Craik & S. E. Trehub (Eds.), Aging and cognitive processes (pp. 191-211). New York: Plenum Press.

Craik, F. I. M., Byrd, M., & Swanson, J. M. (1987). Patterns of memory loss in three elderly samples. Psychology and Aging, 2, 79-86.

Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. Journal of Verbal Learning and Verbal Behavior, 11, 671-684.

Craik, F. I. M., Morris, L. W., Morris, R. G., & Loewen, E. R. (1990). Relations between source amnesia and frontal lobe functioning in older adults. Psychology and Aging, 5, 148-151.

Cummings, J. L., & Benson, D. F. (1983). Dementia: A clinical approach (pp. 1-72). Boston: Butterworths.

Cummings, J. L., & Benson, D. F. (1984). Subcortical dementia: Review of an emerging concept. Archives of Neurology, 41, 874-879.

Danziger, W. L., & Salthouse, T. A. (1978). Age and the perception of incomplete figures. Experimental Aging Research, 4, 67-80.

Davis, H. P., & Bernstein, P. A. (1992). Age-related changes in explicit and implicit memory. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (2nd ed., pp. 249-261). New York: Guilford.

Delis, D. C., Massman, P. J., Butters, N., Salmon, D. P., Cermak, L. S., & Kramer, J. H. (1991). Profiles of demented and amnesic patients on the California Verbal Learning Test: Implications for the assessment of memory disorders. Psychological Assessment: A Journal of Consulting and Clinical Psychology, 3, 19-26.

De Renzi, E., & Faglioni, P. (1978). Normative data and screening power of a shortened version of the Token Test. Cortex, 14, 41-49.

Diamond, R., & Rozin, P. (1984). Activation of existing memories in anterograde amnesia. Journal of Abnormal Psychology, 93, 98-105.

Dixon, R. A., Kramer, D. A., & Baltes, P. B. (1985). Intelligence: A life-span developmental perspective. In B. B. Wolman (Ed.), Handbook of intelligence: Theories, measurements, and applications (pp. 301-350). New York: John Wiley & Sons.

Dunn, J. C., & Kirsner, K. (1989). Implicit memory: Task or process? In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), Implicit memory: Theoretical issues (pp. 17-31). Hillsdale, NJ: Erlbaum.

Durso, F. T., & Johnson, M. K. (1979). Facilitation in naming and categorizing repeated pictures and words. Journal of Experimental Psychology: Human Learning and Memory, 5, 449-459.

Emery, O. B. (1988). Language and memory processing in senile dementia Alzheimer's type. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 221-243). New York: Cambridge University Press.

Ergis, A. M., Deweer, B., & Fossati, P. (1992, February). Explicit and implicit memory in Alzheimer's disease (AD). Paper presented at the 20th annual International Neuropsychological Society meeting, San Diego, CA.

Eslinger, P. J., & Damasio, A. R. (1986). Preserved motor learning in Alzheimer's disease: Implications for anatomy and behavior. Journal of Neuroscience, 6, 3006-3009.

Evans, D. A., Funkenstein, H. H., Albert, M. S., Scherr, P. A., Cook, N. R., Chown, M. J., Hebert, L. E., Hennekens, C. H., & Taylor, J. O. (1989). Prevalence of Alzheimer's disease in a community population of older persons: Higher than previously reported. JAMA, 262, 2551-2556.

Eysenck, M. W. (1974). Age differences in incidental learning. Developmental Psychology, 6, 936-941.

Eysenck, M. W. (1979). Depth, elaboration, and distinctiveness. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 89-118). Hillsdale, NJ: Erlbaum.

Folstein, M. F., Folstein, S. W., & McHugh, P. R. (1975). "Mini-mental state": A practical method for grading the cognitive state of patients for the clinician. Journal of Psychiatric Research, 12, 189-198.

Gardiner, J. M. (1988). Generation and priming effects in word-fragment completion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14, 495-501.

Glisky, E. L., & Rabinowitz, J. C. (1985). Enhancing the generation effect through repetition of operations. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 193-205.

Glisky, E. L., Schacter, D. L., & Tulving, E. (1986a). Computer learning by memory-impaired patients: Acquisition and retention of complex knowledge. Neuropsychologia, 24, 313-328.

Glisky, E. L., Schacter, D. L., & Tulving, E. (1986b). Learning and retention of computer-related vocabulary in memory-impaired patients: Method of vanishing cues. Journal of Clinical and Experimental Neuropsychology, 8, 292-312.

Gollin, E. S. (1960). Developmental studies of visual recognition of incomplete objects. Perceptual and Motor Skills, 11, 289-298.

Goodglass, H., & Kaplan, E. (1972). Assessment of aphasia and related disorders. Philadelphia: Lea & Febiger.

Graf, P. (1990). Life-span changes in implicit and explicit memory. Bulletin of the Psychonomic Society, 28, 353-358.

Graf, P., & Gallie, K. A. (1992). A transfer-appropriate processing account for memory and amnesia. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (2nd ed., pp. 241-248). New York: Guilford.

Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. Journal of Verbal Learning and Verbal Behavior, 23, 553-568.

Graf, P., Mandler, G., & Haden, P. E. (1982). Simulating amnesic symptoms in normal subjects. Science, 218, 1243-1244.

Graf, P., & Schacter, D. (1985). Implicit and explicit memory for new associations in normal and amnesic subjects. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 501-518.

Graf, P., & Schacter, D. L. (1987). Selective effects of interference on implicit and explicit memory for new associations. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13, 45-53.

Graf, P., Shimamura, A. P., & Squire, L. R. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. Journal of Experimental Psychology: Learning, Memory, and Cognition, 11, 386-396.

Graf, P., Squire, L. R., & Mandler, G. (1984). The information that amnesic patients do not forget. Journal of Experimental Psychology: Learning, Memory, and Cognition, 10, 164-178.

Grafman, J., Weingartner, H., Newhouse, P. A., Thompson, K., Lalonde, F., Litvan, I., Molchan, S., & Sunderland, T. (1990). Implicit learning in patients with Alzheimer's disease. Pharmacopsychiatry, 23, 94-101.

Grosse, D. A., & Wilson, R. S. (1989, February). Preserved implicit memory in Alzheimer's disease. Paper presented at the 17th annual meeting of the International Neuropsychological Society, Vancouver, British Columbia.

Grosse, D. A., Wilson, R. S., & Fox, J. H. (1990). Preserved word-stem-completion priming of semantically encoded information in Alzheimer's disease. Psychology and Aging, 5, 304-306.

Hachinski, V. C., Iliff, L. D., Phil, M., Zihka, E., DuBoulay, G. H., McAllister, V. L., Marshall, J., Russell, R. W. R., & Symon, L. (1975). Cerebral blood flow in dementia. Archives of Neurology, 32, 632-637.

Hachinski, V. C., Lassen, N. A., & Marshall, J. (July 27, 1974). Multi-infarct dementia: A cause of mental deterioration in the elderly. The Lancet, 207-209.

Hamann, S. B. (1990). Level-of-processing effects in conceptually driven implicit tasks. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 970-977.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. Journal of Experimental Psychology: General, 108, 356-388.

Hayman, C. A. G., & Tulving, E. (1989). Is priming in fragment completion based on a "traceless" memory system? Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 941-956.

Heindel, W. C., Salmon, D. P., & Butters, N. (1990). Pictorial priming and cued recall in Alzheimer's and Huntington's disease. Brain and Cognition, 13, 282-295.

Heindel, W. C., Salmon, D. P., Shults, C. W., Walicke, P. A., & Butters, N. (1989). Neuropsychological evidence for multiple implicit memory systems: A comparison of Alzheimer's, Huntington's, and Parkinson's Disease patients. The Journal of Neuroscience, 9, 582-587.

Hirshman, E., Snodgrass, J. G., Mindes, J., & Feenan, K. (1990). Conceptual priming in picture fragment completion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 634-647.

Hochanadel, G. & Kaplan, E. (1984). Neuropsychology of normal aging. In M. L. Albert (Ed.), Clinical neurology of aging (pp. 231-244). New York: Oxford University Press.

Hodges, J. R., Salmon, D. P., & Butters, N. (1991). The nature of the naming deficit in Alzheimer's and Huntington's disease. Brain, 114, 1547-1558.

Horn, J. L., & Cattell, R. B. (1966). Refinement and test of the theory of fluid and crystallized general intelligences. Journal of Educational Psychology, 5, 253-270.

Howard, D. V. (1988). Aging and memory activation: The priming of semantic and episodic memories. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 77-99). New York: Cambridge University Press.

Howard, D. V. (1991). Implicit memory: An expanding picture of cognitive aging. In K. W. Schaie & M. P. Lawton (Eds.), Annual review of gerontology and geriatrics (pp. 1-22). New York: Springer.

Howard, D. V., Heisey, J. G., & Shaw, R. J. (1986). Aging and the priming of newly learned associations. Developmental Psychology, 22, 78-85.

Howard, D. V., & Howard, J. H., Jr. (1989). Age differences in learning serial patterns: Direct versus indirect measures. Psychology and Aging, 4, 357-364.

Howard, D. V., McAndrews, M. P., & Lasaga, M. I. (1981). Semantic priming of lexical decisions in young and old adults. Journal of Gerontology, 36, 707-714.

Huff, F. J. (1988). The disorder of naming in Alzheimer's disease. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 209-220). New York: Cambridge University Press.

Huff, F. J., Corkin, S., & Growdon, J. H. (1986). Semantic impairment and anomia in Alzheimer's disease. Brain and Language, 28, 235-249.

Hultsch, D. F., & Dixon, R. A. (1984). Memory for text materials in adulthood. In P. B. Baltes & O. G. Brim, Jr. (Eds.), Life-span development and behavior (Vol. 6, pp. 77-108). New York: Academic Press.

Hultsch, D. F., & Dixon, R. A. (1990). Learning and memory and aging. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (3rd ed., pp. 258-274). San Diego: Academic Press.

Hultsch, D. F., Masson, M. E. J., & Small, B. J. (1991). Adult age differences in direct and indirect tests of memory. Journal of Gerontology: Psychological Sciences, 46, P22-30.

Hunt, R. R., & Toth, J. P. (1990). Perceptual identification, fragment completion, and free recall: Concepts and data. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 282-290.

Intraub, H., & Nicklos, S. (1985). Levels of processing and picture memory: The physical superiority effect. Journal of Experimental Psychology: Learning, Memory and Cognition, 11, 284-298.

Irwin, D. I., & Lupker, S. J. (1983). Semantic priming of pictures and words: A levels of processing approach. Journal of Verbal Learning and Verbal Behavior, 22, 45-60.

Jacoby, L. L. (1983). Remembering the data: Analyzing interactive processes in reading. Journal of Verbal Learning and Verbal Behavior, 22, 485-508.

Jacoby, L. L., & Craik, F. I. M. (1979). Effects of elaboration of processing at encoding and retrieval: Trace distinctiveness and recovery of initial context. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 1-21). Hillsdale, NJ: Erlbaum.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. Journal of Experimental Psychology: General, 3, 306-340.

Jacoby, L. L., & Witherspoon, D. (1982). Remembering without awareness. Canadian Journal of Psychology, 36, 300-324.

Jastak, S., & Wilkinson, G. S. (1984). The Wide Range Achievement Test-Revised: Administration manual. Wilmington, DE: Jastak Associates.

Jenkins, J. J. (1979). Four points to remember: A tetrahedral model of memory experiments. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 429-446). Hillsdale, NJ: Erlbaum.

Johnson, M. K., & Hasher, L. (1987). Human learning and memory. Annual Review of Psychology, 38, 631-668.

Jorm, A. F. (1986). Controlled and automatic information processing in senile dementia: A review. Psychological Medicine, 16, 77-88.

Joynt, R. J., & Shoulson, I. (1985). Dementia. In K. M. Heilman & E. Valenstein (Eds.), Clinical neuropsychology (2nd ed., pp. 453-479). New York: Oxford University Press.

Kaplan, E. F., Goodglass, H., & Weintraub, S. (1978). The Boston Naming Test. Boston: E. Kaplan & H. Goodglass.

Kaszniak, A. W. (1986). The neuropsychology of dementia. In I. Grant & K. M. Adams (Eds.), Neuropsychology of neuropsychiatric disease (pp. 172-220). New York: Oxford University Press.

Katzman, R., Brown, T., Thal, L. J., Fuld, P. A., Aronson, M., Butters, N., Klauber, M. R., Wiederholt, W., Pay, M., Renbing, X., Ooi, W. L., Hofstetter, R., & Terry, R. D. (1988). Comparison of rate of annual change of mental status score in four independent studies of patients with Alzheimer's disease. Annals of Neurology, 24, 384-389.

Keane, M. M., Gabrieli, J. D. E., Fennema, A. C., Growdon, J. H., & Corkin, S. (1991). Evidence for a dissociation between perceptual and conceptual priming in Alzheimer's disease. Behavioral Neuroscience, 105, 326-342.

Kemper, T. (1984). Neuroanatomical and neuropathological changes in normal aging and in dementia. In M. L. Albert (Ed.), Clinical neurology of aging (pp. 9-52). New York: Oxford University Press.

Kinsbourne, M., & Wood, F. (1975). Short term memory and the amnesic syndrome. In D. D. Deutsch & J. A. Deutsch (Eds.), Short-term memory (pp. 258-291). New York: Academic Press.

Kirshner, H. S., Webb, W. G., & Kelly, M. P. (1984). The naming disorder of dementia. Neuropsychologia, 22, 23-30.

Knopman, D. S., & Nissen, M. J. (1987). Implicit learning in patients with probable Alzheimer's disease. Neurology, 37, 784-788.

Kolers, P. A., & Roediger, H. L., III. (1984). Procedures of mind. Journal of Verbal Learning and Verbal Behavior, 23, 425-449.

Kucera, H., & Francis, W. N. (1967). Computational analysis of present-day American English. Providence, RI: Brown University Press.

Lezak, M. K. (1983). Neuropsychological assessment (2nd ed.). New York: Oxford University Press.

Light, L. L., & Albertson, S. A. (1989). Direct and indirect tests of memory for category exemplars in young and older adults. Psychology and Aging, 4, 487-492.

Light, L. L., & Burke, D. M. (1988). Patterns of language and memory in old age. In L. L. Light & D. M. Burke (Eds.), Language, memory, and aging (pp. 244-271). New York: Cambridge University Press.

Light, L. L., & Singh, A. (1987). Implicit and explicit memory in young and older adults. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13, 531-541.

Light, L. L., Singh, A., & Capps, J. L. (1986). Dissociation of memory and awareness in young and older adults. Journal of Clinical and Experimental Neuropsychology, 8, 62-74.

Lussier, I., Belleville, S., Peretz, I., Fontaine, F., Chatelois, J., Van der Linden, M., & Coyette, F. (1990, February). Preserved implicit memory in patients with dementia of the Alzheimer type. Paper presented at the 18th annual meeting of the International Neuropsychology Society, Kissimmee, FL.

Mack, W. Henderson, V. W., & Freed, D. (1988, April). Boston Naming Test: Shortened versions for use in Alzheimer's disease. Paper presented at the meeting of the American Academy of Neurology , Cincinnati, OH.

MacLeod, C. M. (1989). Word context during initial exposure influences degree of priming in word fragment completion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 398-406.

Madigan, S. (1983). Picture memory. In J. C. Yuille (Ed.), Imagery, memory, and cognition: Essays in honor of Allan Paivio (pp. 65-89). Hillsdale, NJ: Erlbaum.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. Psychological Review, 87, 252-271.

Martin, A. (1992). Degraded knowledge representations in patients with Alzheimer's disease: Implications for models of semantic and repetition priming. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (2nd ed., pp. 220-232). New York: Guilford.

Martin, A., Brouwers, P., Cox, C., & Fedio, P. (1985). On the nature of the verbal memory deficit in Alzheimer's disease. Brain and Language, 25, 323-341.

Martin, A., Brouwers, P., Lalonde, F., Cox, C., Foster, N. L., & Chase, T. N. (1986). Towards a behavioral typology of Alzheimer's patients. Journal of Clinical and Experimental Neuropsychology, 8, 594-610.

Martin, A., & Fedio, P. (1983). Word production and comprehension in Alzheimer's disease: The breakdown of semantic knowledge. Brain and Language, 19, 124-141.

Masson, M. E. J. (1989). Fluent reprocessing as an implicit expression of memory for experience. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), Implicit memory: Theoretical issues (pp. 123-138). Hillsdale, NJ: Erlbaum.

Masson, M. E. J., & MacLeod, C. M. (1992). Reenacting the route to interpretation: Enhanced perceptual identification without prior perception. Journal of Experimental Psychology: General, 121, 145-176.

Mattis, S. (1976). Mental status examination for organic mental syndrome in the elderly patient. In L. Bellack & T. Katasu (Eds.), Geriatric psychiatry: A handbook for psychiatrists and primary care physicians (pp. 77-121). New York: Grune and Stratton.

McAndrews, M. P., Glisky, E. L., & Schacter, D. L. (1987). When priming persists: Long-lasting implicit memory for a single episode in amnesic patients. Neuropsychologia, 25, 497-506.

McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. Canadian Journal of Psychology, 41, 175-192.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price, D., & Stadlan, E. M. (1984). Clinical diagnosis of Alzheimer's disease: Report of the NINCDS-ADRDA work group under the auspices of Department of Health and Human Services task force on Alzheimer's disease. Neurology, 34, 939-944.

Milner, B. (1972). Disorders of learning and memory after temporal lobe lesions in man. Clinical Neurosurgery, 19, 421-446.

Milner, B., Corkin, S., & Teuber, H.-L. (1968). Further analysis of the hippocampal amnesic syndrome: 14 year follow-up study of H. M. Neuropsychologia, 6, 215-234.

Mitchell, D. B. (1989). How many memory systems? Evidence from aging. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 31-49.

Mitchell, D. B., Hunt, R. R., & Schmitt, F. A. (1986). The generation effect and reality monitoring: Evidence from dementia and normal aging. Journal of Gerontology, 41, 79-84.

Mitrushina, M., & Satz, P. (1990, February). Changes in cognitive functioning associated with normal aging. Paper presented at the 18th annual meeting of the International Neuropsychological Society, Kissimmee, FL.

Monsch, A. U., Bondi, M. W., Butters, N., Salmon, D. P., Katzman, R., & Thal, L. S. (1992). Comparisons of verbal fluency tasks in the detection of dementia of the Alzheimer type. Archives of Neurology, 49, 1253-1258.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. Journal of Verbal Learning and Verbal Behavior, 16, 519-533.

Morris, R. G., & Kopelman, M. D. (1986). The memory deficits in Alzheimer-type dementia: A review. The Experimental Psychology Society, 38, 49-76.

Moscovitch, M. (1982). A neuropsychological approach to perception and memory in normal and pathological aging. In F. I. M. Craik & S. Trehub (Eds.), Aging and cognitive processes (pp. 55-78). New York: Plenum.

Moscovitch, M. (1984). The sufficient conditions for demonstrating preserved memory in amnesia: A task analysis. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (pp. 104-114). New York: Guilford.

Moss, M. B., & Albert, M. S. (1988). Alzheimer's disease and other dementing disorders. In M. S. Albert & M. B. Moss (Eds.), Geriatric neuropsychology (pp. 145-178). New York: Guilford.

Nebes, R. D. (1989). Semantic memory in Alzheimer's disease. Psychological Bulletin, 106, 377-394.

Nebes, R. D. (1992a). Cognitive dysfunction in Alzheimer's disease. In F. I. M. Craik & T. A. Salthouse (Eds.), The handbook of aging and cognition (pp. 373-446). Hillsdale, NJ: Lawrence Erlbaum Press.

Nebes, R. D. (1992b). Semantic memory dysfunction in Alzheimer's disease: Disruption of semantic knowledge or information-processing limitations? In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (2nd ed., pp. 233-240). New York: Guilford.

Nebes, R. D., & Boller, F. (1987). The use of language structure by demented patients in a visual search task. Cortex, 23, 87-98.

Nebes, R. D., Boller, F., & Holland, A. (1986). Use of semantic context by patients with Alzheimer's disease. Psychology and Aging, 1, 261-269.

Nebes, R. D., Brady, C. B., & Huff, F. J. (1989). Automatic and attentional mechanisms of semantic priming in Alzheimer's disease. Journal of Clinical and Experimental Neuropsychology, 11, 219-231.

Nebes, R. D., & Madden, D. J. (1988). Different patterns of cognitive slowing produced by Alzheimer's disease and normal aging. Psychology and Aging, 3, 102-104.

Nebes, R. D., Martin, D. C., & Horn, L. C. (1984). Sparing of semantic memory in Alzheimer's disease. Journal of Abnormal Psychology, 93, 321-330.

Nelson, D. L. (1979). Remembering pictures and words: Appearance, significance, and name. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 45-76). Hillsdale, NJ: Erlbaum.

Nelson, D. L., Canas, J. J., Bajo, M. T., & Keelean, P. D. (1987). Comparing word fragment completion and cued recall with letter cues. Journal of Experimental Psychology: Learning, Memory, and Cognition, 13, 542-552..

Nelson, D. L., Keelean, P. D., & Negrao, M. (1989). Word-fragment cuing: The lexical search hypothesis. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 388-397.

Nelson, D. L., Reed, V. S., & McEvoy, C. L. (1977). Learning to order pictures and words: A model of sensory and semantic encoding. Journal of Experimental Psychology: Human Learning and Memory, 3, 485-497.

Nissen, M. J., Willingham, D., & Hartman, M. (1989). Explicit and implicit remembering: When is learning preserved in amnesia? Neuropsychologia, 27, 341-352.

Ober, B. A., Dronkers, N. F., Koss, E., Delis, D. C., & Friedland, R. P. (1986). Retrieval from semantic memory in Alzheimer-type dementia. Journal of Clinical and Experimental Psychology, 8, 75-92.

Ober, B. A., Koss, E., Friedland, R. P., & Delis, D. C. (1985). Processes of verbal memory failure in Alzheimer-type dementia. Brain and Cognition, 4, 90-103.

Ober, B. A., & Shenaut, G. K. (1988). Lexical decision and priming in Alzheimer's disease. Neuropsycholcgia, 26, 273-286.

Ober, B. A., & Shenaut, G. K. (1989, February). Abnormalities of semantic priming in Alzheimer's disease. Paper presented at the 17th annual International Neuropsychological Society meeting, Vancouver, British Columbia.

Ober, B. A., & Shenaut, G. K. (1990, February). Automatic versus controlled priming in Alzheimer's disease: A synthesis of current findings. Paper presented at the 18th annual International Neuropsychological Society meeting, Kissimmee, FL.

Ober, B. A., Shenaut, G. K., Jagust, W. J., & Stillman, R. C. (1991). Automatic semantic priming with various category relations in Alzheimer's disease and normal aging. Psychology and Aging, 6, 647-660.

Obler, L. K., & Albert, M. L. (1985). Language skills across adulthood. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (2nd ed., pp. 463-473). New York: Van Nostrand Reinhold.

Ostergaard, A. L., & Jernigan, T. L. (in press). Are word priming and explicit memory mediated by different brain structures? In P. Graf & M. Masson (Eds.), Implicit memory: New directions in cognition, development and neuropsychology. Hillsdale, NJ: Erlbaum.

Paivio, A. (1971). Imagery and verbal processes. New York: Holt, Rinehart & Winston.

Paivio, A. (1983). The empirical case for dual coding. In J. C. Yuille (Ed.), Imagery, memory, and cognition: Essays in honor of Allan Paivio (pp. 307-332). Hillsdale, NJ: Erlbaum.

Park, D. C., Puglisi, J. T., & Sovacool, M. (1983). Memory for pictures, words, and spatial location in older adults: Evidence for pictorial superiority. Journal of Gerontology, 38, 582-588.

Partridge, F. M., Knight, R. G., & Feehan, M. (1990). Direct and indirect memory performance in patients with senile dementia. Psychological Medicine, 20, 111-118.

Poon, L. W. (1985). Differences in human memory with aging: Nature, causes, and clinical implications. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging (2nd ed., pp. 427-462). New York: Van Nostrand Reinhold.

Poon, L. W., Krauss, I. K., & Bowles, N. L. (1984). On subject selection in cognitive aging research. Experimental Aging Research, 10, 43-49.

Potter, M. C., & Faulconer, B. A. (1975). Time to understand pictures and words. Nature, 253, 437-438.

Rabinowitz, J. C. (1986). Priming in episodic memory. Journal of Gerontology, 41, 204-213.

Randolph, C., Braun, A. R., Goldberg, T. E., & Chase, T. N. (1993). Semantic fluency in Alzheimer's, Parkinson's, and Huntington's disease: Dissociation of storage and retrieval failures. Neuropsychology, 7, 82-88.

Read, D. E. (1988). Age-related changes in performance on a visual-closure task. Journal of Clinical and Experimental Neuropsychology, 10, 451-466.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. Annual Review of Psychology, 39, 475-543.

Rissenberg, M., & Glanzer, M. (1986). Picture superiority in free recall: The effects of normal aging and primary degenerative dementia. Journal of Gerontology, 41, 64-71.

Roediger, H. L., III. (1990a). Implicit memory: A commentary. Bulletin of the Psychonomic Society, 28, 373-380.

Roediger, H. L., III. (1990b). Implicit memory: Retention without remembering. American Psychologist, 45, 1043-1056.

Roediger, H. L., III, & Blaxton, T. A. (1987a). Effects of varying modality, surface features, and retention interval on priming in word fragment completion. Memory and Cognition, 15, 379-388.

Roediger, H. L., III, & Blaxton, T. A. (1987b). Retrieval modes produce dissociations in memory for surface information. In D. S. Gorfein & R. R. Hoffman (Eds.), Memory and cognitive processes: The Ebbinghaus centennial conference (pp. 349-379). Hillsdale, NJ: Erlbaum.

Roediger, H. L., III, & Challis, B. H. (1992). Effects of exact repetition and conceptual repetition on free recall and primed word-fragment completion. Journal of Experimental Psychology: Learning, Memory, and Cognition, 18, 3-14.

Roediger, H. L., III, & Srinivas, K. (in press). Specificity of operations in perceptual priming. In P. Graf & M. E. J. Masson (Eds.), Implicit memory: New directions in cognition, development, and neuropsychology. Hillsdale, NJ: Erlbaum.

Roediger, H. L., III, Srinivas, K., & Weldon, M. S. (1989). Dissociations between implicit measures of retention. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), Implicit memory: Theoretical issues (pp. 67-84). Hillsdale, NJ: Erlbaum.

Roediger, H. L., III, Weldon, M. S., & Challis, B. H. (1989). Explaining dissociations between implicit and explicit measures of retention: A processing account. In H. L. Roediger, III, & F. I. M. Craik (Eds.), Varieties of memory and consciousness: Essays in honour of Endel Tulving (pp. 3-41). Hillsdale, NJ: Erlbaum.

Rose, T. L., Yesavage, J. A., Hill, R. D., & Bower, G. H. (1986). Priming effects and recognition memory in young and elderly adults. Experimental Aging Research, 12, 31-37.

Rosen, W. G. (1980). Verbal fluency in aging and dementia. Journal of Clinical Neuropsychology, 2, 135-146.

Rosen, W. G., Terry, R. D., Fuld, P. A., Katzman, R., & Peck, A. (1980). Pathological verification of ischemic score differentiation of dementias. Annals of Neurology, 7, 486-483.

Salmon, D. P., & Heindel, W. C. (1992). Impaired priming in Alzheimer's disease: Neuropsychological implications. In L. R. Squire & N. Butters (Eds.), Neuropsychology of memory (2nd ed., pp. 179-187). New York: Guilford.

Salmon, D. P., Shimamura, A. P., Butters, N., & Smith, S. (1988). Lexical and semantic priming deficits in patients with Alzheimer's disease. Journal of Clinical and Experimental Neuropsychology, 10, 477-494.

Salthouse, T. A. (1985). A theory of cognitive aging. Amsterdam: North-Holland.

Scarborough, D. L., Cortese, C., & Scarborough, H. S. (1977). Frequency and repetition effects in lexical memory, Journal of Experimental Psychology: Human Perception and Performance, 3, 1-17.

Schacter, D. L. (1985). Priming of old and new knowledge in amnesic patients and normal subjects. Annals of the New York Academy of Sciences, 444, 41-53.

Schacter, D. L. (1987a). Implicit expressions of memory in organic amnesia: Learning of new facts and associations. Human Neurobiology, 6, 107-118.

Schacter, D. L. (1987b). Implicit memory: History and current status. Journal of Experimental Psychology, Learning, Memory, and Cognition, 13, 501-518.

Schacter, D. L. (1987c). Memory, amnesia, and frontal lobe dysfunction. Psychobiology, 15, 21-36.

Schacter, D. L. (1989). On the relation between memory and consciousness: Dissociative interactions and conscious experience. In H. L. Roediger, III., & F. I. M. Craik (Eds.), Varieties of memory and consciousness: Essays in honour of Endel Tulving (pp. 355-389). Hillsdale, NJ: Erlbaum.

Schacter, D. L. (1990). Introduction to "Implicit memory: Multiple perspectives". Bulletin of the Psychonomic Society, 28, 338-340.

Schacter, D. L. (1992). Understanding implicit memory: A cognitive neuroscience approach. American Psychologist, 47, 559-569.

Schacter, D. L., Bowers, J., & Booker, J. (1989). Intention, awareness, and implicit memory: The retrieval intentionality criterion. In S. Lewandowsky, J. C. Dunn, & K. Kirsner (Eds.), Implicit memory: Theoretical issues (pp. 47-65). Hillsdale, NJ: Erlbaum.

Schacter, D. L., Cooper, L. A., & Valdiserri, M. (1992). Implicit and explicit memory for novel visual objects in older and younger adults. Psychology and Aging, 7, 299-308.

Schacter, D. L., & Graf, P. (1986a). Effects of elaborative processing on implicit and explicit memory for new associations. Journal of Experimental Psychology, Learning, Memory, and Cognition, 12, 432-444.

Schacter, D. L., & Graf, P. (1986b). Preserved learning in amnesic patients: Perspectives from research on direct priming. Journal of Clinical and Experimental Neuropsychology, 8, 727-743.

Schacter, D. L., Harbluk, J. L., & McLachlan, D. R. (1984). Retrieval without recollection: An experimental analysis of source amnesia. Journal of Verbal Learning and Verbal Behavior, 23, 593-611.

Schacter, D. L., Kaszniak, A. W., & Kihlstrom, J. F. (1991). Models of memory and the understanding of memory disorders. In T. Yanagihara & R. C. Petersen (Eds.), Memory disorders: Research and clinical practice (pp. 111-134). New York: Marcel Dekker.

Schaie, K. W. (1993). Ageist language in psychological research. American Psychologist, 48, 49-51.

Schneck, M. K., Reisberg, B., & Ferris, S. H. (1982). An overview of current concepts of Alzheimer's disease. American Journal of Psychiatry, 139, 165-173.

Schwartz, B. L. (1989). Effects of generation on indirect measures of memory. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 1119-1128.

Shepard, R. N. (1967). Recognition memory for words, sentences, and pictures. Journal of Verbal Learning and Verbal Behavior, 6, 156-163.

Shimamura, A. P. (1985). Problems with the finding of stochastic independence as evidence for multiple memory systems. Bulletin of the Psychonomic Society, 23, 506-508.

Shimamura, A. P. (1986). Priming effects in amnesia: Evidence for a dissociable memory function. The Quarterly Journal of Experimental Psychology, 38A, 619-644.

Shimamura, A. P., Salmon, D. P., Squire, L. R., & Butters, N. (1987). Memory dysfunction and word priming in dementia and amnesia. Behavioral Neuroscience, 101, 347-351.

Shimamura, A. P., & Squire, L. R. (1984). Paired-associate learning and priming effects in amnesia: A neuropsychological study. Journal of Experimental Psychology: General, 113, 556-570.

Shimamura, A. P., & Squire, L. R. (1989). Impaired priming of new associations in amnesia. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15, 721-728.

Slamecka, N. J.,& Graf, P. (1978). The generation effect: Delineation of a phenomenon. Journal of Experimental Psychology: Human Learning and Memory, 4, 592-604.

Smith, S. R., Murdoch, B. E., & Chenery, H. J. (1989). Semantic abilities in dementia of the Alzheimer type. 1. Lexical semantics. Brain and Language, 36, 314-324.

Snodgrass, J. G., & Corwin, J. (1988a). Perceptual identification thresholds for 150 fragmented pictures from the Snodgrass and Vanderwart picture set. Perceptual and Motor Skills, 67, 3-36. (Monograph Supplement 1-V67).

Snodgrass, J. G., & Corwin, J. (1988b). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. Journal of Experimental Psychology: General, 117, 34-50.

Snodgrass, J. G., Smith, B., Feenan, K., & Corwin, J. (1987). Fragmenting pictures on the Apple Macintosh computer for experimental and clinical applications. Behavior Research Methods, Instruments, & Computers, 19, 270-274.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. Journal of Experimental Psychology: Human Learning and Memory, 6, 174-215.

Spellacy, F. J., & Spreen, O. (1969). A short form of the Token Test. Cortex, 5, 390-397.

Spreen, O., & Strauss, E. (1991). A compendium of neuropsychological tests: Administration, norms, and commentary. New York: Oxford University Press.

Squire, L. R. (1987). Memory and brain. New York: Oxford University Press.

Squire, L. R., Shimamura, A. P., & Graf, P. (1987). Strength and duration of priming effects in normal subjects and amnesic patients. Neuropsychologia, 25, 195-210.

Starr, A., & Phillips, L. (1970). Verbal and motor memory in the amnesic syndrome. Neuropsychologia, 8, 75-88.

Strub, R. L., & Black, F. W. (1988). Neurobehavioral disorders: A clinical approach (pp. 140-195). Philadelphia: F. A. Davis.

Terry, R. D., & Katzman, R. (1983). Senile dementia of the Alzheimer type. Annals of Neurology, 14, 497-506.

Toth, J. P., & Hunt, R. R. (1990). Effect of generation on a word-identification task. Journal of Experimental Psychology: Learning, Memory, and Cognition, 16, 993-1003.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), Organization of memory (pp. 382-403). New York: Academic Press.

Tulving, E. (1979). Relation between encoding specificity and levels of processing. In L. S. Cermak & F. I. M. Craik (Eds.), Levels of processing in human memory (pp. 405-428). Hillsdale, NJ: Erlbaum.

Tulving, E. (1983). Elements of episodic memory. New York: Oxford University Press.

Tulving, E. (1985). How many memory systems are there? American Psychiatrist, 40, 385-398.

Tulving, E., Schacter, D. L., & Stark, H. A. (1982). Priming effects in word-fragment completion are independent of recognition memory. Journal of Experimental Psychology: Learning, Memory, and Cognition, 8, 336-342.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. Psychological Review, 80, 352-373.

U. S. Department of Health and Human Services Task Force on Alzheimer's Disease (1984, May). Alzheimer's disease: A scientific guide for health practitioners. NIH Publication No. 84-2251.

Van Gorp, W. G., Satz, P., Kiersch, M. E., & Henry, R. (1986). Normative data on the Boston Naming Test for a group of normal older adults. Journal of Clinical and Experimental Neuropsychology, 8, 702-705.

Vanderwart, M. (1984). Priming by pictures in lexical decision. Journal of Verbal Learning and Verbal Behavior, 23, 67-83.

Ward, A. S., Corwin, J., Reeves, A., & Fukui, T. (in press). Picture fragment identification in aging and Alzheimer's disease. International Journal of Neurosciences.

Warrington, E. K., & Weiskrantz, L. (1968). New method of testing long-term retention with special reference to amnesic patients. Nature, 217, 972-974.

Warrington, E. K., & Weiskrantz, L. (1970). Amnesic syndrome: Consolidation or retrieval? Nature, 228, 628-630.

Warrington, E. K., & Weiskrantz, L. (1974). The effect of prior learning on subsequent retention in amnesic patients. Neuropsychologia, 12, 419-428.

Warrington, E. K., & Weiskrantz, L. (1978). Amnesia: A disconnection syndrome? Neuropsychologia, 20, 233-248.

Wechsler, D. (1945). A standardized memory scale for clinical use. Journal of Psychology, 19, 87-95.

Wechsler, D. (1981). WAIS-R manual. New York: Psychological Corporation.

Weingartner, H., Kaye, W., Smallberg, S., Cohen, R., Ebert, M. H., Gillin, J. C., & Gold, P. (1982). Determinants of memory failure in dementia. In S. Corkin, K. L. Davis, J. H. Growdon, E. Usdin & R. J. Wurtman (Eds.), Aging: Vol. 19. Alzheimer's disease: A report of progress (pp. 171-176.). New York: Raven Press.

Weldon, M. S. (1991). Mechanisms underlying priming on perceptual tests. Journal of Experimental Psychology: Learning, Memory, and Cognition, 17, 526-541.

Weldon, M. S., & Roediger, H. L., III. (1987). Altering retrieval demands reverses the picture superiority effect. Memory and Cognition, 15, 269-280.

Weldon, M. S., Roediger, H. L., III, & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. Memory and Cognition, 17, 95-105.

Wilson, R. S., Bacon, L. D., Kramer, R. L., Fox, J. H., & Kaszniak, A. W. (1983). Word frequency effect and recognition memory in dementia of the Alzheimer type. Journal of Clinical Neuropsychology, 5, 97-104.

Wilson, R. S., Kaszniak, A. W., Bacon, L. D., Fox, J. H., & Kelly, M. P. (1982). Facial recognition memory in dementia. Cortex, 18, 329-336.

Winograd, E., Smith, A. D., & Simon, E. W. (1982). Aging and picture superiority effect in recall. Journal of Gerontology, 37, 70-75.

Yesavage, J. A., Brink, T. L., Rose, T. L., & Adey, M. (1986). The Geriatric Depression Rating Scale: Comparison with other self-report and psychiatric rating scales. In L. Poon (Ed.), Handbook for clinical memory assessment of older adults (pp. 153-167). Washington, DC: American Psychological Association.

Appendix A

Informed Consent

The purpose of this study is to examine how perception, language, and thinking change with aging and brain disease in the elderly. The understanding of these functions in people like you may help in the future care or diagnosis of patients in the early stages of Alzheimer's disease.

I understand and agree to the following:

1. I have been asked to participate in a research study which will involve an individual test session with measures of perception, language, and thinking. The tests will take about 1 to 1 1/2 hours to complete.

2. I am aware that a possible discomfort resulting from my participation is that I may experience some fatigue or test anxiety during the session. These risks will be minimized as much as possible by rest breaks between tests.

3. The benefits which I may reasonably expect include the knowledge that I may be helping in the understanding of changes in thinking that occur with aging and brain disease in the elderly. I realize that no medical benefit will necessarily come to me as a result of my participation in the study. However, I will receive $10.00 for my time and transportation costs.

4. I understand that study information identifying me will remain confidential and will not be put in my medical chart. The information that identifies me will not be disclosed outside the hospital except with my written permission or as required by law.

5. I have discussed this study with Jill Rich, and she has offered to answer any questions I may have concerning the procedures involved. I am aware that I should contact Jill Rich or Dr. Gregory Brown at 876-2526 and/or the Research Office at 876-2024 if I have any questions regarding the research, research subjects' rights or my participation in the study and its outcome, or when an injury results from the research procedures involved.

6. In giving my consent, I acknowledge that my participation in this research study is voluntary, and that I have the alternative of not participating in this study or withdrawing from it at any time without prejudice to me. If I do decide to drop out part way through the study, I will still be paid.

7. I understand that I will be told of any significant new findings that develop during this study which may relate to my willingness to continue to participate in this study.

8. In the event of a medical emergency involving me, emergency medical treatment will be rendered. The cost for said treatment may be covered by my medical insurance. However, I understand that there is no federal, state or private program established to provide research subjects with compensation and medical treatment costs for injuries resulting from research procedures.

Signature of patient	Date
Assent of next of kin or legal guardian	Date
Print name if other than patient	
Witness' signature	Date
Investigator's signature	Date

Appendix B

Predicted IQ for the WAIS-R*

Estimated Full Scale IQ

Age	____	X	.47 =	____
Sex	____	X	1.76 =	____
Race	____	X	4.71 =	____
Education	____	X	5.02 =	____
Occupation	____	X	1.89 =	____
Region	____	X	.59 =	____
			+	54.96

Estimated FSIQ = ____

AGE: 16-17=1 18-19=2 20-24=3 25-34=4 35-44=5 45-54=6 55-64=7 65-69=8 70-74=9

SEX: Female=1 Male=2

RACE: Black=1 Other ethnicity=2 White=3

EDUCATION: 0-7 years of school=1 8 years=2 9-11 years=3

OCCUPATION: Farm laborers, farm foremen, and laborers (unskilled workers)=1 Operatives, service workers, farmers, and farm managers (semiskilled workers)=2 Not in labor force=3 Craftsmen and foremen (skilled workers)=4 Managers, officials, proprietors, clerical and sales workers=5 Professional and Technical=6

RESIDENCE: Urban=2 Rural=1

REGION: Southern region=1 North Central region=2 Western region=3 Northeast region=4

* based on Barona et al. (1984)

Appendix C
Subject Information Sheet

Name________________________________group______ID_____

Contact Person______________________phone_______________

DOB________ current age____ sex_____ race_____ educ____

Occupation____________________________________ hand_____

Physician_____________________________phone____________

Medical history MRN____________________

Stroke (TIAs) Y N ____________________________________

Alcoholism Y N ______________________________________

Psychiatric hx Y N __________________________________

Continuous cog. complaint tied to head injury Y N _____

LOC > 1 hour Y N ____________________________________

Seizures Y N ____

Cancer Y N ____

HTN Y N ____

Diabetes Y N ____

Heart Disease Y N ___________________________________

MRI/CT findings _____________________________________

B12 ____

Thyroid ____

Folate ____

VDRL/FTA (syphilis) __________________________________

Medications ____

Additional comments __________________________________

Appendix D

Word Lists

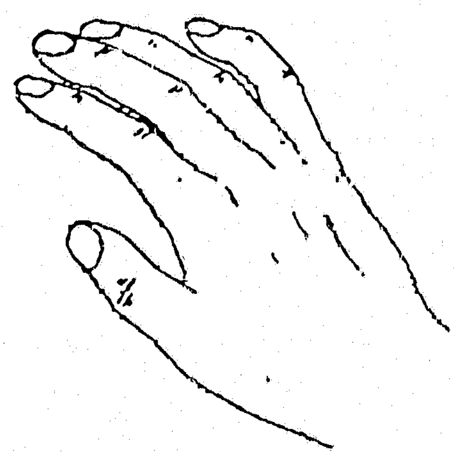
List A	List B	List C	List D
arrow	alligator	bell	anchor
ashtray	apple	broom	book
banana	ball	cherry	bottle
basket	bird	corn	bread
bear	bowl	donkey	butterfly
brush	candle	door	camel
fork	drum	envelope	carrot
glass	elephant	glove	chair
grapes	flag	knife	clock
harp	flower	nose	hammer
lobster	frog	potato	ladder
seal	giraffe	snake	needle
shirt	ring	snowman	piano
sock	shoe	spider	pumpkin
star	squirrel	sweater	sandwich
tiger	tomato	thumb	skirt
train	truck	vase	spoon
wheel	watch	window	whistle

distractors	distractors	distractors
accordion	barrel	cake
celery	bicycle	desk
chicken	dress	eagle
coat	finger	fence
crown	fish	horse
duck	hair	iron
foot	kangaroo	jacket
lips	kite	kettle
moon	lamp	lemon
mouse	lion	lettuce
necklace	pencil	mushroom
onion	pepper	nail
orange	pineapple	rabbit
peanut	scissors	suitcase
sailboat	swan	swing
stove	tree	umbrella
telephone	vest	wagon
toaster	violin	zebra

Appendix E

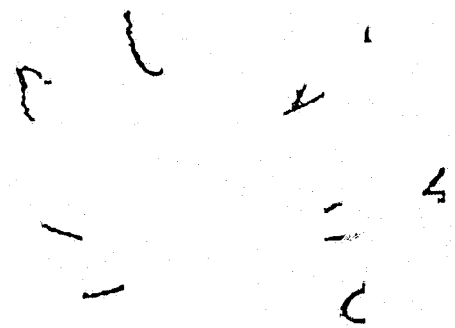
Sample Items

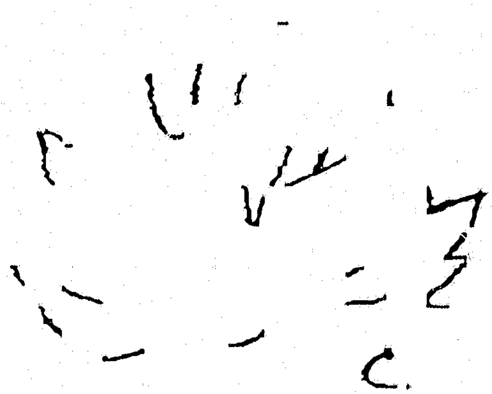
flute

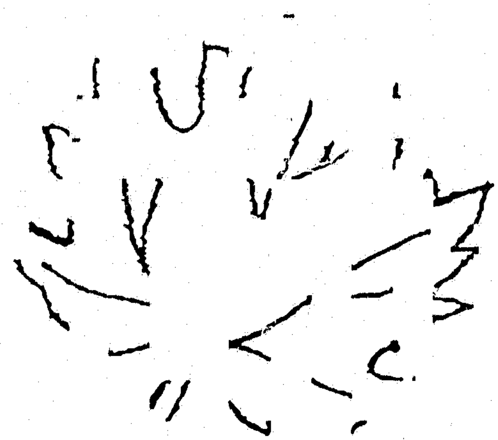


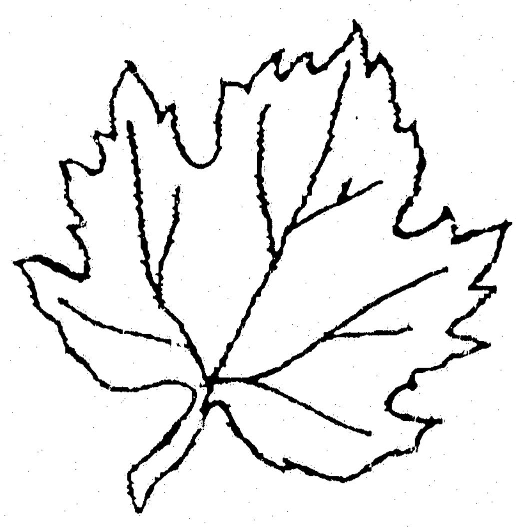
Before dinner, the mother asked her child to set the ______ .

hea____









Appendix F

Schedule of Conditions

	AD (59-83)				YC (18-38)				YO (60-72)				OO (73-85)		
	WPS				WPS				WPS				WPS		
1	ACD	PSW	AP-BW	21	DCB	SPW	BP-AW	41	ABC	WPS	AP-BW	61	DBA	WSP	AW-BP
2	ACB	WSP	BP-AW	22	DAB	WPS	BW-AP	42	ABD	PWS	BW-AP	62	CDB	SPW	AP-BW
3	DBA	WSP	AW-BP	23	BCA	SWP	BW-AP	43	DCB	SPW	BP-AW	63	ABD	PWS	BW-AP
4	BCA	SWP	BW-AP	24	CDB	SPW	AP-BW	44	DAB	WPS	BW-AP	64	DCB	SPW	BP-AW
5	CAD	WSP	BP-AW	25	CDA	WPS	BW-AP	45	ACD	PSW	AP-BW	65	CDA	WPS	BW-AP
6	CBA	PWS	BP-AW	26	ACD	PSW	AP-BW	46	CDA	WPS	BW-AP	66	BCD	WPS	AW-BP
7	CDA	WPS	BW-AP	27	DAC	SWP	AP-BW	47	BAD	SPW	AW-BP	67	DAC	SWP	AP-BW
8	DAC	SWP	AP-BW	28	DBC	PSW	BW-AP	48	BCD	WPS	AW-BP	68	BCA	SWP	BW-AP
9	ABC	WPS	AP-BW	29	BDC	PWS	BP-AW	49	BDA	PSW	AP-BW	69	ABC	WPS	AP-BW
10	DCB	SPW	BP-AW	30	BDA	PSW	AP-BW	50	DAC	SWP	AP-BW	70	BAD	SPW	AW-BP
11	BDC	PWS	BP-AW	31	BAD	SPW	AW-BP	51	ADC	SWP	AW-BP	71	BDA	PSW	AP-BW
12	BCD	WPS	AW-BP	32	BCD	WPS	AW-BP	52	BDC	PWS	BP-AW	72	DAB	WPS	BW-AP
13	CAB	PSW	AW-BP	33	ADC	SWP	AW-BP	53	BCA	SWP	BW-AP	73	CBA	PWS	BP-AW
14	DBC	PSW	BW-AP	34	CAD	WSP	BP-AW	54	CDB	SPW	AP-BW	74	BDC	PWS	BP-AW
15	CDB	SPW	AP-BW	35	CBA	PWS	BP-AW	55	CBA	PWS	BP-AW	75	ADC	SWP	AW-BP
16	BAD	SPW	AW-BP	36	ABD	PWS	BW-AP	56	CAD	WSP	BP-AW	76	ACD	PSW	AP-BW
17	ADC	SWP	AW-BP	37	DBA	WSP	AW-BP	57	DBC	PSW	BW-AP	77	CAB	PSW	AW-BP
18	BDA	PSW	AP-BW	38	ABC	WPS	AP-BW	58	ACB	WSP	BP-AW	78	DBC	PSW	BW-AP
19	ABD	PWS	BW-AP	39	CAB	PSW	AW-BP	59	CAB	PSW	AW-BP	79	ACB	WSP	BP-AW
20	DAB	WPS	BW-AP	40	ACB	WSP	BP-AW	60	DBA	WSP	AW-BP	80	CAD	WSP	BP-AW

Appendix G

Word Reading

ID______________ Date________________

sample: flute______

List A		List B		List C		List D	
1	harp______	1	drum ______	1	bell _______	1	skirt _______
2	grapes_____	2	squirrel ____	2	window ____	2	needle_____
3	bear______	3	apple______	3	snake______	3	bottle ______
4	glass ______	4	elephant ___	4	door_______	4	clock ______
5	arrow______	5	frog _______	5	vase _______	5	hammer___
6	seal _______	6	ring _______	6	potato _____	6	piano_____
7	brush______	7	ball _______	7	thumb _____	7	pumpkin___
8	train_______	8	truck ______	8	spider _____	8	butterfly ___
9	ashtray_____	9	tomato _____	9	knife ______	9	ladder _____
10	lobster_____	10	shoe_______	10	nose_______	10	book_______
11	banana ____	11	bowl_______	11	envelope____	11	sandwich___
12	fork_______	12	alligator ____	12	snowman___	12	chair_______
13	basket _____	13	candle _____	13	glove ______	13	anchor_____
14	star_______	14	watch______	14	sweater ____	14	camel______
15	shirt _______	15	giraffe _____	15	broom _____	15	carrot______
16	sock_______	16	flower______	16	corn_______	16	whistle_____
17	wheel _____	17	flag _______	17	cherry______	17	bread______
18	tiger_______	18	bird _______	18	donkey_____	18	spoon______
# correct	_______	# correct	_______	# correct	_______	# correct	_______

Appendix H

Picture Naming

ID____________ Date____________

sample: hand____________

	List A			List B	
1.	harp		1.	drum	
2.	grapes		2.	squirrel	
3.	bear		3.	apple	
4.	glass		4.	elephant	
5.	arrow		5.	frog	
6.	seal		6.	ring	
7.	brush		7.	ball	
8.	train		8.	truck	
9.	ashtray		9.	tomato	
10.	lobster		10.	shoe	
11.	banana		11.	bowl	
12.	fork		12.	alligator	
13.	basket		13.	candle	
14.	star		14.	watch	
15.	shirt		15.	giraffe	
16.	sock		16.	flower	
17.	wheel		17.	flag	
18.	tiger		18.	bird	
# correct			# correct		

Picture Naming

ID____________ Date_______________

sample: hand_______________________

List C		List D	
1.	bell ________	1.	skirt ________
2.	window ________	2.	needle ________
3.	snake ________	3.	bottle ________
4.	door ________	4.	clock ________
5.	vase ________	5.	hammer ________
6.	potato ________	6.	piano ________
7.	thumb ________	7.	pumpkin ________
8.	spider ________	8.	butterfly ________
9.	knife ________	9.	ladder ________
10.	nose ________	10.	book ________
11.	envelope ________	11.	sandwich ________
12.	snowman ________	12.	chair ________
13.	glove ________	13.	anchor ________
14.	sweater ________	14.	camel ________
15.	broom ________	15.	carrot ________
16.	corn ________	16.	whistle ________
17.	cherry ________	17.	bread ________
18.	donkey ________	18.	spoon ________
# correct ________		# correct ________	

Appendix I

Sentence Completion

List A

ID____________ Date______________

sample: Before dinner, the mother asked her child to set the ____________.

1. The angels played beautiful music on the ____________________.
2. At the fruit store, she bought a bunch of seedless, green____________.
3. The child had a cuddly stuffed teddy ____________________.
4. She poured pop and ice into her tall drinking ____________________.
5. He loved to shoot his bow and ____________________.
6. The animal balancing the ball on its nose is the trained ____________.
7. To paint the house, you need a paint ____________________.
8. For Christmas, the children got a choo-choo ____________________.
9. He put his cigarette out in an ____________________.
10. At the seafood festival in Maine, we ate shrimp, crab, and____________.
11. The monkey likes to peel and eat the yellow ____________________.
12. You should eat salad with a ____________________.
13. It was a sunny day, so we packed a lunch in our picnic____________.
14. Amy's favorite nursery rhyme is Twinkle, twinkle little ____________.
15. Robert bought a pair of cufflinks to go on the sleeves of his new ________.
16. When his shoes were off, the boy's toe showed through the hole in his___.
17. To drive around the corner, you have to turn the steering ____________.
18. A jungle animal with stripes and a loud roar is a ____________________.

correct______________

Sentence Completion

List B

ID____________ Date______________

sample: Before dinner, the mother asked her child to set the ____________.

1. In the band, he made a lot of noise banging and pounding the ________.
2. An animal that collects acorns is the bushy-tailed ________________.
3. He couldn't wait to bite into the juicy, red____________________.
4. At the zoo, the children petted the long, gray trunk of the giant ________.
5. A tadpole turns into a ______________________________.
6. There were four diamonds in her engagement ________________.
7. Marie bounced the round, rubber ____________________.
8. He drove across the bumpy road in a pick-up ________________.
9. Harry ordered a sandwich of bacon, lettuce, and ______________.
10. She went to the repair shop after the heel came off her____________.
11. She poured the hot soup into the ___ ____________________.
12. It's hard to tell the difference between a crocodile and an ___________.
13. The lights went out, so she lit a wax____________________.
14. I didn't know what time it was, because I forgot to wear my __________.
15. The animal with the longest neck is a ______________________.
16. A rose is a beautiful ____________________________.
17. There are 50 stars and 13 stripes on the American ______________.
18. Looking up from its nest in the tree was a baby________________.

correct______________

Sentence Completion

List C

ID____________ Date____________ __

sample: Before dinner, the mother asked her child to set the ____________.

1. We went to Philadelphia to see the crack in the Liberty ____________.
2. Johnny threw a rock at the house and broke a ____________.
3. A boa constrictor is almost as dangerous as a rattle ____________.
4. At night the old woman locked the ____________.
5. The flowers looked nice in the crystal ____________.
6. You can put butter or sour cream and chives on your baked ____________.
7. Each hand has four fingers and one ____________.
8. The fly caught in the web made a good lunch for the hungry ____________.
9. He carved the turkey with an electric ____________.
10. Her allergies were so bad, she had to keep blowing her ____________.
11. Before mailing a letter, be sure and seal the ____________.
12. In the winter, children often play outside and build a tall ____________.
13. The boxer couldn't sign his autograph because he was wearing his boxing ____________.
14. It was too cold in the house, so Sue put on a cardigan ____________.
15. Ron swept the floor with a ____________.
16. The farmer looked out in his field and counted hundreds of ears of yellow ____________.
17. The sundae comes with whipped cream, nuts, and a big, red ____________.
18. The children played pin the tail on the ____________.

correct____________

Sentence Completion

List D

ID____________ Date______________

sample: Before dinner, the mother asked her child to set the ____________.

1. For her birthday, Lori got two blouses and a pleated____________.
2. She sewed the button on with some thread and a____________.
3. The baby was too small to use a cup, so we gave her milk in a ________.
4. You can hear the chimes ring every hour from the big, grandfather_____.
5. He hit the nail with the____________________.
6. Liberace was a master at playing the grand ____________.
7. Every Halloween, we make a jack-o-lantern from a big, orange _______.
8. We watched the caterpillar turn into a pretty ____________.
9. Some people think it's unlucky to walk under a____________.
10. A dictionary is a thick ____________________.
11. For lunch Mary ordered a grilled cheese____________.
12. After dinner, the father sat in the reclining ____________.
13. So the boat wouldn't drift away, Jim dropped the____________.
14. In the desert, Lisa saw a two-humped____________.
15. Bugs Bunny loves to munch on a crunchy, orange____________.
16. We knew there was a foul when we heard the referee blow the _______.
17. They baked many loaves of ____________________.
18. You should eat soup with a____________________.

correct____________

Appendix J

Stem Completion
A stems

ID_________ Date ___________ sample: hea ______________

1. (C) bro ________	19. (A) bas ________
2. (D) boo ________	20. (C) sno ________
3. (A) ban ________	21. (A) sea ________
4. (B) gir ________	22. (D) cha ________
5. (B) tru ________	23. (B) fro ________
6. (A) whe ________	24. (C) cor ________
7. (A) gla ________	25. (C) swe ________
8. (A) bru ________	26. (C) spi ________
9. (A) tig ________	27. (B) squ ________
10. (B) all ________	28. (C) thu ________
11. (D) anc ________	29. (C) kni ________
12. (C) che ________	30. (A) lob ________
13. (B) fla ________	31. (C) env ________
14. (D) but ________	32. (D) cam ________
15. (B) sho ________	33. (D) ski ________
16. (B) wat ________	34. (B) bow ________
17. (A) tra ________	35. (D) spo ________
18. (D) lad ________	36. (D) pum ________

Targets correct:

word priming (List____)__________ picture priming (List____) __________

sentence priming (List____) _______ nonstudied (List____) __________

Stem Completion

B stems

ID________ Date ____________ sample: hea ____________

1.	(A)	for ____________	19.	(D)	clo ____________
2.	(C)	pot ____________	20.	(B)	bal ____________
3.	(B)	app ____________	21.	(B)	dru ____________
4.	(D)	ham ____________	22.	(C)	sna ____________
5.	(B)	tom ____________	23.	(D)	bot ____________
6.	(D)	car ____________	24.	(C)	glo ____________
7.	(D)	pia ____________	25.	(D)	nee ____________
8.	(A)	har ____________	26.	(A)	shi ____________
9.	(A)	bea ____________	27.	(C)	win ____________
10.	(C)	doo ____________	28.	(A)	soc ____________
11.	(B)	can ____________	29.	(C)	bel ____________
12.	(B)	flo ____________	30.	(B)	rin ____________
13.	(D)	bre ____________	31.	(C)	nos ____________
14.	(C)	don ____________	32.	(D)	whi ____________
15.	(A)	arr ____________	33.	(C)	vas ____________
16.	(D)	san ____________	34.	(A)	ash ____________
17.	(B)	bir ____________	35.	(A)	gra ____________
18.	(B)	ele ____________	36.	(A)	sta ____________

Targets correct:

word priming (List____)__________ picture priming (List____) __________

sentence priming (List____) ______ nonstudied (List____)__________

Appendix K

Picture Fragment Identification

A fragments

ID________ Date __________

sample:		leaf	1______	2______	3______	4______
1.	(C)	broom	1______	2______	3______	4______
2.	(D)	book	1______	2______	3______	4______
3.	(A)	banana	1______	2______	3______	4______
4.	(B)	giraffe	1______	2______	3______	4______
5.	(B)	truck	1______	2______	3______	4______
6.	(A)	wheel	1______	2______	3______	4______
7.	(A)	glass	1______	2______	3______	4______
8.	(A)	brush	1______	2______	3______	4______
9.	(A)	tiger	1______	2______	3______	4______
10.	(B)	alligator	1______	2______	3______	4______
11.	(D)	anchor	1______	2______	3______	4______
12.	(C)	cherry	1______	2______	3______	4______
13.	(B)	flag	1______	2______	3______	4______
14.	(D)	butterfly	1______	2______	3______	4______
15.	(B)	shoe	1______	2______	3______	4______
16.	(B)	watch	1______	2______	3______	4______
17.	(A)	train	1______	2______	3______	4______
18.	(D)	ladder	1______	2______	3______	4______

A fragments continued

19.	(A)	basket	1________	2________	3________	4________
20.	(C)	snowman	1________	2________	3________	4________
21.	(A)	seal	1________	2________	3________	4________
22.	(D)	chair	1________	2________	3________	4________
23.	(B)	frog	1________	2________	3________	4________
24.	(C)	corn	1________	2________	3________	4________
25.	(C)	sweater	1________	2________	3________	4________
26.	(C)	spider	1________	2________	3________	4________
27.	(B)	squirrel	1________	2________	3________	4________
28.	(C)	thumb	1________	2________	3________	4________
29.	(C)	knife	1________	2________	3________	4________
30.	(A)	lobster	1________	2________	3________	4________
31.	(C)	envelope	1________	2________	3________	4________
32.	(D)	camel	1________	2________	3________	4________
33.	(D)	skirt	1________	2________	3________	4________
34.	(B)	bowl	1________	2________	3________	4________
35.	(D)	spoon	1________	2________	3________	4________
36.	(D)	pumpkin	1________	2________	3________	4________

Total correct:

words	(List____)	______	pictures	(List____)	______
sentences	(List____)	______	nonstudied	(List____)	______

Picture Fragment Identification

B fragments

ID________ Date ____________

sample:		leaf	1________	2________	3________	4________
1.	(A)	fork	1________	2________	3________	4________
2.	(C)	potato	1________	2________	3________	4________
3.	(B)	apple	1________	2________	3________	4________
4.	(D)	hammer	1________	2________	3________	4________
5.	(B)	tomato	1________	2________	3________	4________
6.	(D)	carrot	1________	2________	3________	4________
7.	(D)	piano	1________	2________	3________	4________
8.	(A)	harp	1________	2________	3________	4________
9.	(A)	bear	1________	2________	3________	4________
10.	(C)	door	1________	2________	3________	4________
11.	(B)	candle	1________	2________	3________	4________
12.	(B)	flower	1________	2________	3________	4________
13.	(D)	bread	1________	2________	3________	4________
14.	(C)	donkey	1________	2________	3________	4________
15.	(A)	arrow	1________	2________	3________	4________
16.	(D)	sandwich	1________	2________	3________	4________
17.	(B)	bird	1________	2________	3________	4________
18.	(B)	elephant	1________	2________	3________	4________

B fragments continued

19.	(D)	clock	1____	2____	3____	4____
20.	(B)	ball	1____	2____	3____	4____
21.	(B)	drum	1____	2____	3____	4____
22.	(C)	snake	1____	2____	3____	4____
23.	(D)	bottle	1____	2____	3____	4____
24.	(C)	glove	1____	2____	3____	4____
25.	(D)	needle	1____	2____	3____	4____
26.	(A)	shirt	1____	2____	3____	4____
27.	(C)	window	1____	2____	3____	4____
28.	(A)	sock	1____	2____	3____	4____
29.	(C)	bell	1____	2____	3____	4____
30.	(B)	ring	1____	2____	3____	4____
31.	(C)	nose	1____	2____	3____	4____
32.	(D)	whistle	1____	2____	3____	4____
33.	(C)	vase	1____	2____	3____	4____
34.	(A)	ashtray	1____	2____	3____	4____
35.	(A)	grapes	1____	2____	3____	4____
36.	(A)	star	1____	2____	3____	4____

Total correct:

words	(List____)	______	pictures	(List____)	______
sentences	(List____)	______	nonstudied	(List____)	______

Appendix L

Recognition Test

ID_______________ Date_______________

1.	(A)	train	Y	N	43.	(A)	brush	Y	N	85.	(*)	sailboat	Y	N
2.	(*)	chicken	Y	N	44.	(*)	wagon	Y	N	86.	(B)	bowl	Y	N
3.	(B)	ring	Y	N	45.	(C)	nose	Y	N	87.	(*)	violin	Y	N
4.	(B)	tomato	Y	N	46.	(*)	crown	Y	N	88.	(*)	cake	Y	N
5.	(*)	duck	Y	N	47.	(D)	hammer	Y	N	89.	(*)	eagle	Y	N
6.	(C)	cherry	Y	N	48.	(A)	seal	Y	N	90.	(C)	donkey	Y	N
7.	(*)	pepper	Y	N	49.	(A)	grapes	Y	N	91.	(*)	barrel	Y	N
8.	(*)	peanut	Y	N	50.	(*)	necklace	Y	N	92.	(*)	vest	Y	N
9.	(C)	sweater	Y	N	51.	(C)	window	Y	N	93.	(C)	thumb	Y	N
10.	(*)	orange	Y	N	52.	(B)	alligator	Y	N	94.	(*)	kite	Y	N
11.	(*)	fish	Y	N	53.	(*)	iron	Y	N	95.	(A)	ashtray	Y	N
12.	(C)	snake	Y	N	54.	(*)	mouse	Y	N	96.	(*)	finger	Y	N
13.	(*)	hair	Y	N	55.	(*)	swing	Y	N	97.	(D)	chair	Y	N
14.	(A)	harp	Y	N	56.	(*)	lamp	Y	N	98.	(*)	kangaroo	Y	N
15.	(B)	giraffe	Y	N	57.	(B)	candle	Y	N	99.	(D)	butterfly	Y	N
16.	(*)	fence	Y	N	58.	(C)	snowman	Y	N	100.	(*)	stove	Y	N
17.	(A)	sock	Y	N	59.	(A)	tiger	Y	N	101.	(D)	needle	Y	N
18.	(C)	knife	Y	N	60.	(*)	foot	Y	N	102.	(A)	arrow	Y	N
19.	(*)	suitcase	Y	N	61.	(D)	ladder	Y	N	103.	(D)	bread	Y	N
20.	(A)	lobster	Y	N	62.	(*)	toaster	Y	N	104.	(*)	moon	Y	N
21.	(*)	kettle	Y	N	63.	(B)	watch	Y	N	105.	(D)	sandwich	Y	N
22.	(*)	tree	Y	N	64.	(*)	lettuce	Y	N	106.	(D)	pumpkin	Y	N
23.	(B)	drum	Y	N	65.	(D)	skirt	Y	N	107.	(D)	camel	Y	N
24.	(B)	flower	Y	N	66.	(*)	scissors	Y	N	108.	(*)	swan	Y	N
25.	(*)	jacket	Y	N	67.	(D)	spoon	Y	N	109.	(*)	bicycle	Y	N
26.	(*)	celery	Y	N	68.	(C)	glove	Y	N	110.	(D)	carrot	Y	N
27.	(D)	anchor	Y	N	69.	(*)	desk	Y	N	111.	(C)	bell	Y	N
28.	(*)	lips	Y	N	70.	(B)	frog	Y	N	112.	(A)	shirt	Y	N
29.	(A)	glass	Y	N	71.	(B)	truck	Y	N	113.	(D)	clock	Y	N
30.	(B)	elephant	Y	N	72.	(*)	coat	Y	N	114.	(*)	lion	Y	N
31.	(A)	basket	Y	N	73.	(B)	bird	Y	N	115.	(B)	flag	Y	N
32.	(*)	accordion	Y	N	74.	(*)	zebra	Y	N	116.	(C)	vase	Y	N
33.	(*)	umbrella	Y	N	75.	(A)	wheel	Y	N	117.	(D)	piano	Y	N
34.	(*)	lemon	Y	N	76.	(C)	corn	Y	N	118.	(*)	dress	Y	N
35.	(*)	pineapple	Y	N	77.	(C)	door	Y	N	119.	(A)	star	Y	N
36.	(B)	ball	Y	N	78.	(*)	horse	Y	N	120.	(B)	squirrel	Y	N
37.	(C)	spider	Y	N	79.	(*)	nail	Y	N	121.	(A)	bear	Y	N
38.	(D)	whistle	Y	N	80.	(*)	telephone	Y	N	122.	(*)	rabbit	Y	N
39.	(D)	book	Y	N	81.	(C)	envelope	Y	N	123.	(*)	onion	Y	N
40.	(B)	apple	Y	N	82.	(B)	shoe	Y	N	124.	(*)	pencil	Y	N
41.	(A)	banana	Y	N	83.	(D)	bottle	Y	N	125.	(A)	fork	Y	N
42.	(C)	potato	Y	N	84.	(C)	broom	Y	N	126.	(*)	mushroom	Y	N

True Positives (hits):

words (List____) ________ pictures (List____) ________

sentences (List____) ________ Total hits ____________

False Positives:

nonstudied (List____) ________ new distractors (*) ________