Order Number 9325126

Concrete imagery and suffix effects in immediate memory: Changes with age and Alzheimer's disease

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City University of New York, 1993

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CONCRETE IMAGERY AND SUFFIX EFFECTS
IN IMMEDIATE MEMORY:
CHANGES WITH AGE AND ALZHEIMER'S DISEASE

by

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A dissertation submitted to the Graduate Faculty in Psychology in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1993

This manuscript has been read and accepted for the Graduate Faculty in Psychology in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

April 14, 1993
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Abstract

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by

Joan A. Mackell

Adviser: Professor Susan Karp Manning

The concreteness effect, superior recall of concrete compared to abstract words, was examined in normal young and elderly subjects and individuals with Alzheimer's disease (AD), with auditory presentation of both concrete and abstract nouns in two experiments: Serial recall and free recall. Recall in the control conditions was compared to the suffix conditions in which a not-to-be-recalled word was appended onto the end of the sequence. All subjects participated in a delayed recall task, and a subset of elderly and AD subjects participated in a delayed recognition task.

Immediate recall showed the expected small but significant decline in performance with age, and a substantial and significant performance decrement with AD. As expected, free recall performance was significantly better for all groups

compared to strict serial recall, and the suffix caused increasing interference in recall with age and AD. An analysis of intrusions, however, clearly differentiated the AD group from the normal groups, since the normal subjects virtually never intruded the suffix as a response in recall while the AD subjects frequently did, in spite of repeated instructions to disregard it. Other extra-list intrusion errors also suggested a severe deficit in response inhibition for the AD group.

The main effect of concreteness was not significant in strict serial recall using a strict scoring method, although it was significant and approximately equivalent in free recall for all groups. In the delayed recall condition, the number of words recalled declined significantly with age and markedly with AD, supporting evidence of a very rapid rate of forgetting in AD subjects. However, although the young and elderly subjects showed a significant and basically equivalent concreteness effect, the most striking finding was that the AD subjects virtually never recalled an abstract word in this delayed condition.

Delayed recognition for a subgroup of elderly and AD subjects also showed a significant concreteness effect for both groups, with diminished recognition performance for AD subjects. Hits and false alarms as measures of a subject's metamemory for performance accuracy, indicated significantly less sensitivity and more false alarms for the AD group.

Acknowledgment

I would like to express my deepest gratitude to Dr. Susan Karp Manning for unending encouragement and continued belief in me throughout the course of this project. Her probing and stimulating questions spurred me on at each step of this journey. I am particularly grateful to Joan Greenhut-Wertz, a fellow doctoral student, whose initial research led me down the path of investigation into the memory of AD subjects. Along the way, I was ably assisted by another doctoral student, Terry Wiseman, in running young subjects.

I have become indebted to many inspiring researchers at New York University Medical Center (ADRC) under whose expert guidance I have been fortunate enough to develop: Drs. Steven H. Ferris, Barry Reisberg, and Alan Kluger. They are an inspiring trio. I am particularly indebted to two ladies who taught me, through their boundless energy, that this path I chose brings growth and new energy at every turn. Thank you Emma Shulman and Gert Steinberg for showing me that learning never ceases, and inquisitive minds are ageless.

Most importantly, I would like to salute my supportive family, Mauro, Tom, Christina and Sean, for their unfailing understanding and encouragement throughout this lengthy process. They never deserted me, even while I temporarily deserted them. I wish to dedicate this research to four very important people who influenced me in countless ways, who encouraged me at the start of this endeavor but could not share in its completion: Dad, Poppie, Mama, and Patty.

Thank you, all.

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CONCRETE IMAGERY AND SUFFIX EFFECTS IN IMMEDIATE MEMORY: CHANGES WITH AGE AND ALZHEIMER'S DISEASE

Introduction

Largely because of advances in nutrition, science and public health, people are living longer today than ever before. It was reported by the National Center for Health Statistics (NCHS, 1989) that in 1987 the average life expectancy of Americans at birth was 71.5 years of age for males and 78.4 years of age for females compared to a life expectancy of 67.1 and 74.8 years for males and females respectively in 1970, or approximately a 4-year life span increase for both males and females within a 17-year period.

There is now a population of 33 million Americans 65 years of age and older, and approximately 10,000 of those elderly Americans are 100 years of age or older (NCHS, 1991). If a person reaches 65 years of age, he or she can expect to live another 15 to 19 years, which means that many Americans will live well past 80 years of age.

It is estimated that by the year 2020, the population of Americans 65 years of age and older will number well over 40 million. With this increasing human life span, we can expect that the number of frail elderly cared for in their homes by family members, or in institutions, will also increase. Diseases and ailments that are uncharacteristic of younger people, such as arthritis, coronary disease, osteoporosis and various dementing illnesses can likewise be expected to increase. This increase, coupled with the fact that medical technology now enables life to be prolonged not just through advances in early diagnosis and cure of many diseases but also through cardiac recussitation, artificial feeding methods and pulmonary respirators, compounds the health-care impact of an already spiraling elderly population.

Dementia of the Alzheimer type, commonly known as Alzheimer's disease (AD), increases exponentially with an increase in age (Riege & Metter, 1988) and is the primary focus of this study. Recent epidemiological evidence suggests there may be as many as 4.5 million Americans presently afflicted with AD (Evans, Funkenstein, Albert, Scherr, Cook, Chown, Herbert, Hennekens, & Taylor, 1989; Katzman, 1986). While this figure represents approximately 10 to 15% of the more than 33 million Americans over the age of 65, the percentage of persons with AD over the age of 85 has been reported to be from 40 to 50%. Considering that each victim may have at least two close family members involved in their care, the number of persons in the U.S. affected by this devastating illness may escalate to over 13 million people.

AD is the fourth leading cause of death in the United States, and is one of the longest lasting fatal diseases. If no cure is found, the estimates are that somewhere between 12 and 14 million people will be affected by the year 2040. AD also has a tremendous impact on society at large, and families in particular, from an economic point of view. As AD unrelentingly robs its victims of the ability to handle even the most basic of their daily living activities, continuous home care and, frequently, nursing home placement, is required at a cost of $50,000 per patient per year or more. The financial implications of these figures are enormous considering that the most severe stage of AD may last as long as seven or more years (Reisberg, 1986).

AD is a progressive degenerative dementia which appears to initially affect cognitive processes, creating gradually increasing memory deficits in its victims. Many aspects of this as yet incurable disease are presently being investigated at various research centers throughout the world. (At present, there are approximately 30 sites in the United States which have been designated by the National Institute on Aging as Alzheimer's Disease Centers [ADCs] with a focus on AD research.) Specific cognitive, anatomical, neurological and behavioral markers aid in the diagnosis of "possible or probable Alzheimer's disease" through the process of confirming characteristic symptoms and course, and eliminating other causes of dementia. At the present time, there is no test or diagnostic tool which enables a definitive clinical diagnosis of AD to be made. Only at autopsy, through microscopic examination of brain tissue, is the diagnosis definitive. Furthermore, no drug exists which can cure the illness or even halt its relentless progression. As efficacious drugs or treatments are developed, early diagnosis will be crucial, before deficits become too great and neuronal loss too pervasive.

Much more can be learned to identify early signs of the disease and the concomitant cognitive deficits. It is imperative that early signs be more systematically identifiable and quantifiable, since the impairment observed in AD patients is much more complex than a simple exaggeration of normal age-associated memory decline. There is a combination of quantitative as well as qualitative differences between aging and AD which can be observed. From this improved knowledge, then, we can more accurately determine how to minimize the early memory deficits universally exhibited by AD patients, and to maximize the patients' residual capacities.

Clinical changes accompanying the evolution of AD can be divided into three major, interrelated domains: cognitive, behavioral, and functional. Since the cardinal symnptom of AD, and perhaps the earliest, is memory decline, this project was designed to examine the nature of specific cognitive deficits observed in the early stage of AD through standard paradigms used in research on immediate and delayed memory.

Definitions and Hypotheses

To examine memory function and decline as it relates to normal aging as well as to dementia, it is useful to define its characteristic aspects for purposes of clarity in the present study. When words are the items to be remebered, concreteness refers to words which represent objects, materials or persons, whereas abstractness refers to words which represent an abstract concept that cannot be experienced by the senses (Paivio, Yuille, & Madigan, 1968). Linguistic imagery refers to the capacity of words to arouse mental images of things or events, and rating scales have shown that concrete nouns exceed abstract nouns in imagery ratings (Paivio, 1965). Words with both a high concreteness and a high imagery rating would be high in concrete imagery, as contrasted to abstract words which do not easily arouse a mental picture.

Researchers have developed various paradigms to examine information retrieval for both the auditory and the visual mode. The auditory mode refers to the presentation of stimuli through the auditory sense. The visual mode refers to the presentation of visual stimuli. Recall may be either immediate, in which response is made directly after the presentation of stimuli, or delayed, in which response is made either after the performance of a distractor task or tasks, and/or after a variable time period.

When subjects are presented with sequences of numbers, letters, or words for immediately recall following presentation of the entire sequence, the response condition may be either serial or free. Serial recall requires that items be repeated in the order in which they were presented. Free recall requires that items may be recalled in any order, regardless of the order of presentation.

Responses in serial recall in this study were scored in two ways: 1. Correct In Position (CIP) scoring, in which a response is counted as correct only if the item is recalled in the serial position in which it was originally presented; and 2. Correct by Point of Origin (CPO) scoring, in which a response is counted as correct as long as it is part of the presented sequence, regardless of its response position. However, in order to examine the serial position curve, the item is scored by the position in which it was originally presented, not by the position in which it was recalled. CPO scoring is utilized to determine whether items are actually lost (forgotten) or simply misplaced in terms of their original presentation position.

The typical finding in both free and serial recall is that items at the beginning and the end of a list are remembered better than items in the middle of the list. Primacy is superior recall of items at the beginning of a sequence compared to the middle items. Recency is superior recall of the final item in a sequence compared to the middle items. The mechanisms underlying both phenomena have been extensively studied (e.g., Glenberg & Swanson, 1986; Green & Crowder, 1984; Neath & Crowder, 1990).

The resulting graph of responses is called a serial position curve in a sequential recall task or a free recall task where presentation position is given. Recency is typically observed in auditory presentation of stimuli. This phenomenon is either not present or minimally present in recall of visually presented sequences. This greater recency with auditory as compared to visual presentation is termed the modality effect (Crowder, 1986; Greene, 1987; Manning & Greenhut-Wertz, 1990).

A suffix is defined as an extra not-to-be-recalled item appended onto a sequence of items to be recalled. The presence of a suffix as a minimal distractor item decreases or eliminates recency in the auditory mode but has little or no effect when stimuli are presented visually.[1]

Metamemory, a term Flavell (1971) used to describe a person's knowledge of

[1] There are numerous exceptions to the standard modality findings regarding suffix effects, such as those with lipread or mouthed visual stimuli (Campbell & Dodd, 1980; Nairne & Crowder, 1982), with moving visual stimuli (Manning & Gmuer, 1985) and with sign language stimuli (Shand & Klima, 1981; Manning, Koehler, & Hampton, 1990), or with auditory stimuli which are auditorily similar (Crowder, 1971; Manning & Robinson, 1989) which are not relevant to the present study.

his or her memory, is defined as an individual's understanding of his or her own memory abilities, and the operation of the memory system in general (Salthouse, 1982), rather than specific information within memory. Standard signal detection measures, such as confidence ratings using hits and false alarms, have shown utility in examining metamemory processes as well as differences with age and dementia in recognition tasks. A hit is defined as the correct identification of a word as a member of the sequence just presented (e.g., saying a word is correct when it is correct). A false alarm is defined as the incorrect identification of a word as part of the presented sequence (e.g., saying a word is correct when it is not). The hit rate for a particular subject is derived by dividing the number of hits by the total number of words which were correctly recalled (or the conditional probability of responding "yes" to a correct item). The false alarm rate for a particular subject is derived by dividing the number of false alarms by the total number of incorrect (non-sequence) words which were recalled (or the conditional probability of responding "yes" to an incorrect item).

Intrusions are defined as the inappropriate recall of items which are not part of the to-be-recalled sequence (Shindler, Caplan, & Hier, 1984). They may be distinguished from perseverations, which are the immediate inappropriate repetition of a prior response (Bayles, Tomoeda, Kaszniak, Stern, & Eagans, 1985). Extra-list intrusions are words given as a response which are not part of the stimulus set. They may or may not be semantically or phonologically related, and may be classified on a continuum from abstract to concrete. Within-list intrusions are words given as a response which are not from the specific test sequence but are part of the entire stimulus list. Both extra-list and within-list intrusions may also be perseverated: that is, either a correct response or an incorrect response may be repeated within a test situation.

My primary interest with respect to concrete imagery, serial and free recall, suffixes and other intrusions, was to examine two questions: (a) is the concreteness effect equally evident in both immediate and delayed recall of nouns for young, elderly normal and Alzheimer's disease (AD) subjects; and (b) are there quantitative and qualitative differences with aging and AD for serial and free recall, recognition and interference effects using the suffix paradigm in the auditory mode? These questions were examined with auditory presentation of concrete and abstract noun sequences, employing the suffix paradigm in a serial recall task, and subsequently in a free recall task.

This study systematically examined the following hypotheses which have been suggested by previous research:

Recall Performance

1. The concreteness effect, superior recall for words which evoke a visual image which has been established for young subjects (Lupiani, 1977; Paivio, 1969) in a variety of immediate memory paradigms, may be minimally attenuated with age but should be greatly attenuated with AD subjects. Even though the literature is mixed (Rissenberg & Glanzer, 1987) and limited regarding concreteness, aging and dementia, my expectation reflects evidence that memory failure in AD subjects

results in the disruption of retrieval from the semantic network and an inability to encode information with respect to its most salient attributes (Martin, Brouwers, Cox, & Fedio, 1985). This expectation is also based on evidence suggesting that AD subjects, to an even greater degree than young and elderly, access and utilize semantic information only in situations that make minimal demands on their attentional capacity (Nebes, Martin, & Horn, 1984). Therefore, the concreteness effect will be more evident in free recall compared to serial recall for all subject groups, since serial recall places increased demands on attentional capacity.

2. Immediate recall of nouns in both serial and free recall conditions is expected to show an attenuation with age and a further attenuation with AD, which is an obvious expectation based on age-associated and AD-related cognitive changes. Primacy and recency are expected to be evident in the three groups (Manning & Greenhut-Wertz, 1990), but performance levels for mid-sequence items is expected to exhibit a more severe impairment with age and AD, based on observations that cognitive operations are disproportionately impaired in AD, compared to the proportional slowing of mental operations with age (Nebes & Madden, 1988).

3. Scoring method differences are expected to be observed in serial recall when Correct In Position (CIP) scoring (strict serial recall scoring method) is compared to Correct by Point of Origin (CPO) scoring. Improved performance across the serial recall curve for all groups are likely to occur since CPO must be $\geq$ CIP scoring (Manning, 1980; Sebrechts, Marsh, & Seamon, 1989). However, an interaction between scoring methods and group is expected since there should be

increasing order confusion with the elderly and AD subjects, evidenced by a proportionately larger overall improvement in recall with age and dementia, due to the lenient scoring method being applied.

4. It is expected that performance will be enhanced in the free recall condition for all groups when compared to the strict serial recall condition. This expectation reflects greater attentional demands in the strict serial condition based on previous research showing a typical auditory U-shaped curve with free recall but a reduction in this serial position curve with serial recall (Murdoch, 1968), for normal subjects. Additionally, research has shown that strict serial recall places greater demands on the attentional capacity of AD subjects, suggesting that performance will be relatively better for all groups in the free recall condition, although elderly and AD groups should show relative decrements compared to the young group.

Interference

5. The suffix is expected to show increasing interference under both serial and free recall for concrete and abstract words with age and AD. This expectation is based on evidence that a suffix causes increasingly greater interference in elderly subjects (Manning & Greenhut-Wertz, 1990) and AD subjects (Mackell & Manning, 1990; Manning, Greenhut-Wertz, & Mackell, 1992) compared to young subjects. This expectation is also based on research which has shown that AD subjects have a greater impairment in selective attention compared to normal elderly subjects (Freed, Corkin, Growdon, & Nissen, 1989), suggesting that a minimal distractor will

negatively influence a possibly already impaired semantic association network (Nebes et al., 1984) as well as an already impaired attentional capacity in this group.

6. Young, elderly, and AD subjects are expected to show differences in specific aspects of metamemory and recognition memory. The utility of signal detection measures, specifically confidence ratings, have shown that impairment of episodic memory with aging may be a consequence of deficits in metamemory (Murphy, Schmitt, Caruso, & Sanders, 1987). Hit and false alarm rates, as gauges of metamemory, have been shown to be useful in describing accurate discrimination and bias measures (Snodgrass & Corwin, 1988), to distinguish performance between young, elderly and AD subjects. The expected differences in confidence ratings and recognition memory are based on studies which have demonstrated impairment in sensitivity for elderly subjects (Erber, 1974; Maylor, 1990) and dementia subjects (Diesfeldt, 1990; Ferris, Crook, Clark, McCarthy & Rae, 1980) relative to young adults, combined with an increasingly liberal response bias with dementia (Diesfeldt, 1990; Snodgrass & Corwin, 1988).

7. The AD subjects are expected to show significantly more intrusion errors, particularly more semantically unrelated extra list words, than either of the normal groups, based on the error and intrusion patterns reported by Fuld et al. (1982), Shindler et al. (1984), Loewenstein et al. (1989), and others (Manning et al., 1992).

8. Delayed recall of words is expected to support the concreteness effect, that is significantly more concrete words than abstract words will be recalled in the delayed recall condition for all subject groups since the semantic qualities of concrete

words have been shown to facilitate retention into and retrieval from long-term memory (LTM) (Day & Bellezza, 1983; Richardson, 1978). Although delayed recall performance should exhibit increased decrements with age and AD (Bruning, Holzbauer, & Kimberlin, 1975), the concreteness effect, which may or may not be attenuated with age, is expected to be maximally evident in AD subjects due to a deficit in abstract word retrieval which has been observed (Rissenberg & Glanzer, 1987), causing fewer abstract words to be retrieved from memory compared to concrete words.

It is intended that this study will add to the growing body of information focused on differentiating the normal elderly population from early AD subjects and enhancing our understanding of the complex nature of the early indices of memory loss in this population. It is specifically hoped that this study will have clinical implications in terms of an early marker for AD, enabling timely and at least partially remedial steps to be taken in the management of specific observed memory deficits.

Specifically, the main focus of this study is on the relationship between concrete imagery and immediate memory using both serial and free recall procedures with the standard suffix paradigm as a minimal distractor and a measure of interference. In addition, the study will explore the relationship between the imagery of nouns, concrete versus abstract, and immediate and delayed recall differences seen with age and mild AD.

Background and Significance

Cognitive Functioning

Theoretical Basis

Research into intellectual and cognitive functioning, including the loss of memory, has led to the formation and investigation of various theories on information processing, storage, and retrieval. The very nature of memory is not fully understood, nor is it clearly understood how the brain encodes and "stores" information, if that is, indeed, how memory is established and preserved.

In order to investigate the preservation and loss of memory, it is useful to distinguish between different types of memory function. Tulving (1972) proposed a classification of memory in which two subsystems, semantic and episodic memory, are functionally separate but closely interacting. According to Tulving's definition, semantic memory is a relatively context-free knowledge of words, concepts and their associations, along with rules for utilizing these concepts. This type of memory classification has been used to examined object naming (Perlmutter, 1982), vocabulary (Burke & Harrold, 1988) and concept attributes (Farmer, McLean, Sparks, & O'Connell, 1978), as well as to differentiate the impairments of AD subjects from other memory impaired populations (Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Martin & Fedio, 1983; Ober, Dronkers, Koss, Delis, & Friedland, 1986).

Episodic memory is an autobiographical record of unique experiences and events which are encoded and maintained in a temporal context. Many memory tasks, as Tulving (1972) suggested, do interact and involve aspects of both episodic and semantic memory, such as word, text or fact recall (Hultsch, Masson, & Small, 1991), involving a knowledge of word associations which may be encoded as a temporal event. This interaction between episodic and semantic memory has led to a description of episodic memory as a subsystem of semantic memory (Damasio, Eslinger, Damasio, Van Hoesen, & Cornell, 1985).

Memory has also been classified in terms of primary or short-term memory (PM or STM) and secondary or long-term memory (SM or LTM). For purposes of consistency, in the present study STM and LTM will refer to immediate and longer-term memory, respectively. When a sequence of items is presented for immediate recall, both the first items and the last items presented have a higher probability of being recalled than items presented in the middle of the sequence (Rae, 1979). The first items presented are thought by some to represent LTM, and the last items presented in the sequence are thought to represent STM. (Primacy refers to recall performance on the first item in a sequence, and recency refers to recall performance on the terminal and sometimes preterminal items in a sequence.) Thus, STM would be represented by recency, and LTM would be represented by primacy in a serial position curve, as well as by a delayed recall condition. More recently, however, the distinctions between STM and LTM have been deemphasized (Crowder, 1982). However, for the purposes of this study, I will refer to LTM and STM in the context of the primacy and recency portions of the serial recall curve.

Of further interest in human cognition is the concept of metamemory, which describes a person's understanding or awareness of his or her own memory (Tulving, 1985). Metamemory has been studied through a review of various strategies utilized in memory performance (Bruce, Coyne, & Botwinick, 1982; Murphy, Schmitt, Caruso, & Sanders, 1987) as well as through the evaluation of a person's "feeling of knowing" (Squire & Zouzounis, 1988) or confidence level. Since metamemory is important in the understanding of memory development (Flavell, 1977), it may also be valuable in an examination of memory decline in aging.

The existence of possible age differences in metamemory processes has important implications for general cognitive functioning. Inefficient processes may exaggerate existing age differences, while adaptive processes could possibly compensate in areas of memory which are deficient (Salthouse, 1982). We will examine metamemory processes using confidence ratings, measured by hit rates and false alarm rates.

Changes with Age

Traditionally, increasing age has been associated with a "natural" decline in mental functioning. Many memory functions may change as part of the normal aging process, just as the brain undergoes change with aging (Reisberg, Ferris, de Leon, & Crook, 1985; Schaie, 1967; Winocur, 1988). There is an enlargement of ventricles and a certain shrinking of white matter (Brinkman, Largen, Cushman, & Sarwar, 1986). Recall becomes slower, experiences may be less accurately remembered, naming ability is reduced (Albert, Heller, & Milberg, 1988; Bowles, Obler, & Albert, 1987), minor memory lapses are not uncommon (Ferris, Flicker, Reisberg, & Crook, 1989), and an increased susceptibility to interference, such as background noise and irrelevant stimuli, in conjunction with a concentration deficit, has been observed (Reisberg, Ferris, Franssen, Kluger, & Borenstein, 1986; Winocur, 1988).

Changes with age have also been found as verbal tasks become more complex (Riegel, 1959). Tasks involving greater attentional demands have been shown to suffer age-related decrements, and Rissenberg and Glanzer (1987) have theorized that these age-related decrements are due in part to less reliable communication among information stores in memory.

Other aspects of immediate memory, however, remain relatively unaffected by aging. Although there is considerable variation in data, many researchers have shown that tests of vocabulary do not decline systematically with increased age (Gardner & Monge, 1977; Schaie, 1967). Digit span forward, the ability to repeat a long sequence of numbers, remains fairly stable over the lifetime (Crook, Ferris, McCarthy, & Rae, 1980). Smith (1975) found no age differences in short-term memory between three groups of young (20-39), middle age (40-59) and elderly (60-80) subjects matched within groups for level of education and digit span, but did find differences between the two older groups in differential recall from long-term memory. Thus, a delay in time contributes to the more rapid forgetting. In his paired associate task, middle items of a list assumed to be recalled from long term memory were most affected by age. Yet, other researchers believe that short-term memory loss is one of the most characteristic deficiencies apparent as we grow into old age, and that this loss becomes more acute as we continue to grow older.

Impoverishment of communication between information networks, combined with a slowdown in retrieval, could account for these observed age differences. Furthermore, attentional demands could be a reason for conflicting results, since normal elderly subjects have shown deficits in screening irrelevant information from working memory[2] (Gerard, Zacks, Hasher, & Radvansky, 1991; Hasher & Zacks, 1988) as well as decrements with increasing task complexity (Smith, 1979, 1980).

Young and old adults may use similar strategies for performing certain cognitive tasks (Salthouse, 1992), although age differences have been noted in the production of these memory strategies (Murphy, et al, 1987). Cockburn & Smith (1991) studied 94 people between 70 and 93 years of age, comparing the relationship between cognitive abilities, social activities, and everyday memory. They used a comprehensive reading task involving situations in everyday life, the Rivermead Behavioural Memory Test (RBMT), to measure a cumulative body of general information (crystallized intelligence), and Raven's Colored Progressive Matrices (Burke and Bingham, 1969; Raven, 1969) which is thought to measure information processing and integration (fluid intelligence). Their results indicated that age was a significant predictor of overall crystallized intelligence (RBMT), and that fluid

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[2]The term *working memory* has been applied to the type of memory which is transiently available for a short period of time, on a scale of seconds. Working memory has been considered to be a single common resource with limited capacity (Baddeley, 1986).

intelligence is a good predictor of everyday competence. Yet, elderly adults may have more difficulty than younger (but still elderly) adults on certain memory tasks involving complex processing, even when fluid intelligence scores were similar. The age effect they found may indicate cognitive abilities not measured by tests of fluid intelligence alone, since participation in social activities and leisure pursuits was predictive of verbal, visual and spatial memory.

It has been established that there are age differences associated with both episodic memory (Craik, 1977) and semantic memory (Burke & Harrold, 1988). While younger adults often perform better than older adults on episodic tasks such as recall and recognition, older adults often perform as well as or better than young adults on semantic memory tasks which involve access of general knowledge without reference to specific contextual details. This would appear to reflect the differences observed between fluid and crystallized intelligence (Horn, 1982; Schaie, 1977) reflecting cognitive flexibility versus accumulated knowledge.

Hultsch et al. (1991), examined age difference inconsistencies in episodic and semantic memory. They suggested that direct memory tests (word, text, and fact recall) reflected both episodic and semantic memory, while indirect tests (word stem completion) were less likely to be influenced by either semantic memory or episodic memory since they require that a subject perform a task without reference to conceptual information or particular prior events. They found significant differences in favor of young subjects (19-36 years of age) when compared to two groups of elderly subjects 55-69 and 70-86 years of age) in both direct (recall tasks for world knowledge, narrative texts, and word lists) and indirect (word stem completion) memory tasks.

Foos (1989) studied young, middle age and older subjects to determine whether observed age differences in memory performance could be attributed to less efficient processing, to smaller memory storage, or both. In a task requiring linear orderings constructed from information presented in sentences (see Foos & Sabol, 1981, for a description of this type of task), he found no interaction between age and information processing, but his results did not rule out some processing deficit in the elderly. Although young subjects performed much better on four-item compared to five-item linear ordering tasks, the elderly subjects performed equally poorly for both four- and five-item orderings, which required equivalent processing strategies. When a three-item ordering was included, performance was much better and no performance differences were observed between the young and elderly groups.

Foos interpreted these results as support for the reduced storage hypothesis since a three-item ordering put less demand on total storage capacity. This appears to support the earlier suggestion by Craik (1977), that there is a reduction in storage capacity, rather than a slowing of cognitive processes with aging. If storage capacity is reduced with age while processing ability remains relatively stable, then a lowering of a serial position curve, but not a diminishing of the concreteness effect, would be expected with age.

Recognition memory has been shown to suffer from age related deficits. Madden (1988) presented young ($\underline{M}$ = 21.0 years) and older ($\underline{M}$ = 66.5 years) adults with a word/nonword discrimination task following presentation of a sentence. When the target was degraded, performance was poorer for the older group compared to the young group, than when the target was intact. This suggests that age related deficiencies in word recognition can be diminished through the contribution of a semantic context. Therefore, the semantic quality of concrete nouns should contribute to improved recognition for concrete compared to abstract words.

A decline in mental functioning with age can be a self-fulfilling prophecy (Perlmutter, 1982; Schaie, 1989). Memory deficits found in the healthy aged population are not clinically impairing and present no real problem for daily living (Horn, 1984). A more optimistic challenge to these long held beliefs in memory decline with age is emerging from recent literature in the field of gerontology, psychology, and geriatric medicine. Although studies of metamemory have shown no consistent age-related changes, older adults may not be as careful as young adults in monitoring the contents of memory. However, when asked to assess the accuracy of their recall performance, they are usually as proficient as young adults (West, 1984). The ability to sustain intellectual growth need <u>not</u> decline with advancing age (Salthouse, 1988; Schaie, 1989; Storandt, Botwinick, Danziger, Berg, & Hughes, 1984). Likewise, memory processes can be facilitated in order to maximize memory function throughout the life span.

Thus, all memory systems do not decline uniformly with age. A task such as the immediate recall of concrete and abstract words involves aspects of both episodic and semantic memory, and age differences can be expected since both episodic and semantic memory performance has been shown to be age dependent.

Changes with AD

The magnitude of memory decline observed in patients with AD is quite different from the cognitive changes observed in normal aging individuals. In AD subjects, declines in the ability to balance a checkbook, in the ability to recall details of recent events, even in the ability to associate names of familiar faces, are apparent upon clinical observation in the early to moderate stages of the disease (Reisberg, Ferris, Borenstein, Sinaiko, de Leon, & Buttinger, 1986). General information remains available, but specific information becomes less available (Flicker & Ferris, 1987). The generalized proportional slowing of cognitive operations frequently observed in the aging population can be contrasted to the disproportionate reduction in the speed of cognitive operations in AD patients (Nebes & Madden, 1988).

It is a universal finding that language is disturbed in patients with AD (Martin & Fedio, 1983; Miller, 1975; Poon, 1985; Terry & Katzman, 1983). Syntactic operations appear to be relatively preserved while semantic operations appear to be increasingly impaired with AD in tasks such as object naming (Bayles & Tomoeda, 1983; Huff, Corkin, & Growdon, 1986), verbal fluency (Ober et al., 1986) concept attributes and similarities (Flicker, Ferris, Crook, & Bartus, 1987; Martin & Fedio, 1983; Miller, 1977), and word finding tasks which exhibit no age effect in normal elderly subjects (Nebes, 1989).

Word associations appear to be more influenced by the severity of the dementia, and the grammatical class of the stimulus word is important. Impaired semantic knowledge has been observed even in mildly impaired patients with AD in a task requiring word production and comprehension. Martin and Fedio (1983) found that AD patients frequently identified general categories of items, but were unable to produce specific examples within those categories. This was also noted by Bayles (1983) who found typical early-stage patients showed retention of fluency and articulation but loss of naming and comprehension.

Even in the early stages of the disease, AD subjects show qualitative differences in language patterns compared to normal elderly subjects (Houlihan, Abrahams, LaRue, & Jarvik, 1985), suggesting a clinical application in terms of early detection. Interestingly, a vocabulary decline relates quite robustly to the progressive dementia of AD (Reisberg, Ferris, Kluger, Franssen et al., 1989). Miller and Hague (1975) have shown that early dementia patients produced fewer low frequency words than controls in a word fluency task.

However, there appear to be conditions under which memory may be facilitated from semantic organization. Herlitz and Viitanen (1991) used free and cued recall for unrelated and semantically related words, and reported that mild AD subjects benefitted from semantic cues in free recall when stimulus words were organized into semantic categories. Knowledge of semantic attributes was also observed when mildly and moderately impaired AD subjects were tested in object sorting and item category tasks (Nebes, Brady, & Huff, 1989).

Shuttleworth and Huber (1988) compared 8 AD subjects with 25 age and education-matched controls longitudinally on a series of naming tasks. They found that linguistic errors were most common among AD subjects, and even early stage AD subjects exhibited perceptual-recognition and semantic naming errors. Using the Action Naming Test, which is similar to the Boston Naming Test but uses verbs instead of nouns, Bowles, Obler, and Albert (1987) presented action pictures to young and older adults, and to AD subjects. As expected, they found naming impairment in older adults (70-79) relative to younger adults (30-39) and much greater impairment in AD subjects compared to the two normal groups.

These findings support those of Schaie (1967) and Smith (1975) indicating that age differences observed in recall and recognition seem to begin to be evidenced around 70 years of age. Of interest in the Bowles et al. (1987) study, however, is the analysis of errors. The AD group made significantly more semantically unrelated naming errors reflecting problems in identifying the concept of the presented picture. Earlier, Schwartz, Marin, and Saffran (1979), in a case study of a dementia subject, described similar deterioration in semantic knowledge for visual picture naming and word matching, and for auditory word recall, and observed preserved syntactic and phonologic capacities in the face of market semantic loss with both visual and verbal stimuli. Therefore, word finding itself may not deteriorate on a continuum with the onset of dementia, but rather the semantic qualities utilized in retrieval may become less potent. Thus, there appears to be a marked difference in the error patterns in naming tasks between dementia patients and normal elderly persons.

The abnormally rapid decay in immediate verbal memory (Miller, 1977) seen in AD subjects is contrasted by their continued ability to repeat long sequences of numbers from immediate memory, which may be maintained until the moderate stage of Alzheimer's disease without noticeable or severe deterioration (Reisberg, Schneck, Ferris, Schwartz, & de Leon, 1983) even while other cognitive abilities are significantly hampered. (This preservation more likely represents procedural memory, such as highly learned information leading to automatic processing, which, according to Tulving's model [1983] may remain intact in spite of a disruption in semantic or episodic memory.)

Imagery and Concreteness Effects

Theoretical Basis

Many early researchers of verbal and imaginal processes (Kusyszyn & Paivio, 1966; Paivio, 1963, 1965, 1966, 1967; Paivio & Olver, 1964; Paivio & Simpson, 1966; Paivio & Yarmey, 1965; Paivio & Yuille, 1966) have examined correlates between linguistic abstractness-concreteness and semantics (the meanings of words), thus creating a demand for normative data on the relevant attributes of a great number of nouns for parameters of concreteness, imagery and associative meaning. Systematic measurement was accomplished in 1968 when Paivio, Yuille, and Madigan published a monograph establishing concreteness, imagery and meaningfulness values for a group of 925 nouns, originally chosen from Thorndike and Lorge (1944) and scaled separately for concreteness, imagery and meaningfulness by university students. Since then, the standard finding indicates that concreteness correlates with improved memory performance (Lupiani, 1977; Paivio, 1969; Rissenberg & Glanzer, 1986). Nouns with high concreteness and imagery ratings, therefore, can be described as providing a generally standard mental image, and words which easily evoke this standard image are said to have concrete imagery. In contrast, abstractness is the absence of this type of mental representation, the absence of a standard corresponding image. The ease with which images are generated depends partially on verbal to imaginal connections which may be more accessible, and perhaps more easily retrieved, for concrete than for abstract words (Paivio, Yuille, & Rogers, 1969).

The use of imagery has been well established as an advantage in recall for young subjects, with concrete words having a higher imagery value and being easier to recall than abstract words (Paivio, 1969, 1971). Imagery has been shown to facilitate both immediate and long term recall in both the auditory and the visual mode. In a visual presentation of words, Paivio et al. (1969) reported a series of four experiments on young subjects, measuring differences between high-low imagery and high-low meaningfulness in free and serial recall. They found a significant advantage for high-imagery words compared to low-imagery words using free recall, and also reported that imagery was more potent than meaningfulness in this free recall paradigm. They then used a strict serial recall paradigm, and even though the overall effects of imagery and meaningfulness were significant, the effect of imagery did not exceed that of meaningfulness. Thus, strict serial recall appears to eliminate the differential between meaningfulness and imagery in improving recall of visually presented stimuli.

Paivio (1971) proposed a dual coding theory to account for the facilitation of memory performance with imagery. He suggested that abstract words which could not be readily imaged would be coded verbally; concrete words which could be easily imaged would be coded in their verbal form, as well as visually. It had previously been suggested by Tulving and Wiseman (1965) that noun vividness, operationally similar to imagery, was effective in free recall because it facilitates the ease with which words can be grouped into higher order memory units. The vividness of imagery aroused by a particular word would be an index of the strength of the association between the verbal store and the imaginal store. Category judgments require processing at the semantic level, which according to Craik and Tulving (1975) represents a deeper level of processing than visual or auditory processing.

However, Paivio's suggestion of an alternative coding system was based on memory representation rather than on processing levels: That high imagery concrete nouns may be transformed into non-verbal images in addition to being stored as words, whereas low-imagery nouns are likely to be stored only in their verbal form. Thus, Paivio's Dual Coding Theory proposed that the greater availability of two coding systems, simply by virtue of redundancy, would enhance the probability of recall in a variety of verbal learning situations. The availability of both verbal and visual memory codes facilitates retention by providing an additional means of retrieval, and therefore facilitates recall in terms of the independent verbal and non-verbal (imaginal) cognitive systems (Paivio, Clark, & Khan, 1988).

Other research has suggested features which can be more potent than imagery alone in facilitating recall. Decker and Wheatley (1982) facilitated recall through spatial grouping of high and low imagery nouns, and found that grouped recall was significantly greater than ungrouped recall, independent of the level of imagery. Lupiani (1977) tested young subjects with auditorily presented nouns rated as having either high imagery or low imagery, with half of the subjects receiving imagery instructions. Imagery instructions were more effective than simple free recall instructions for both high and low imagery nouns, although more high imagery nouns were recalled than low imagery nouns in both conditions. These results, significant for both immediate and delayed recall, were discussed in terms of Paivio's dual coding theory, that the effectiveness of recall depends upon and increases with the availability of the two codes, verbal and visual. Thus, the more image-producing the stimuli, the more robust is the stimulation of the two memory codes.

DiVesta and Sunshine (1974) used mnemonic aids in the recall of abstract and concrete nouns in serial recall, which again was consistent with Paivio's dual process theory. Recall of concrete words was superior to abstract words, and there was a significant interaction between imagery ability and concreteness in facilitating recall. Concrete imagery then appears to facilitate immediate memory under both serial and free recall paradigms in the auditory modality.

In 1969 Paivio and Csapo compared free and serial recall of concrete words, pictorial representations of those words, and abstract words with a group of young subjects using different rates of presentation (5.3 items per second and 2 items per second). His results again were consistent with the theoretical model: The concreteness effect was present in both free and serial recall. Memory for pictures suffered at the fast rate in both recall conditions, possibly because the verbal code essential to performance in such tasks was less available than in the case of verbal stimuli. However, picture memory benefitted most by the slow rate of presentation presumably because the increased time for encoding enabled both memory codes to be accessed. Memory for abstract words was least affected by rate of presentation and showed the poorest performance when compared to both concrete words and to pictures in both free and in serial recall. What is of interest, however, is that pictures were significantly more potent than words alone in the free recall condition (the picture superiority effect), but pictures and concrete words were recalled equally well in the serial recall condition. The free recall condition apparently permitted the utilization of both visual and verbal information to a greater degree than did the serial recall condition.

Thus, the demands of serial recall may interfere with integration of our association networks in immediate memory, and thus with the activation of both visual and auditory memory codes. Further, Paivio and Csapo asserted that visual imagery is a parallel processing system, and verbal imagery is a serial processing system. Thus, the temporal nature of this auditory system would facilitate immediate recall of concrete items.

Richardson (1974) reinterpreted these results, suggesting that in free recall, there were not two coding systems, or processing systems as Paivio asserted, but two memory stores: a short-term limited capacity store, and a longer-term store of larger capacity. Concrete and abstract words were auditorily presented to young subjects, who were given free recall instructions. Even though there was a significant interaction between imagery and serial position in immediate recall, in delayed recall there was negative recency in the high imagery lists, indicating that the final items were not imaged in primary memory. Richardson found that imagery affected performance on the beginning and middle portions of the serial position curve, but not on the recency portion, suggesting that the effect of imagery in free recall can be associated with secondary memory, or a longer lasting memory store.

The results of this experiment, that under both immediate and final testing, imageability affected performance on the first six or seven items of a ten-item list but not on the last three items, can be questioned. It is possible that Richardson did not consider that a ten-item list may have been beyond a subject's memory span, and therefore that the last few items of any category might show reduced recency, particularly in a delayed test. However, if imagery does have a greater effect on a longer lasting memory store, it may be that imagery enhances consolidation and preservation in memory which would be evident in superior delayed recall of concrete compared to abstract words.

In a reexamination of Paivio's theory, Marschark and Hunt (1989), suggest an alternative interpretation of the role of concreteness and imagery in recall. In five visual experiments, they employed mixed combinations of concrete and abstract word pairs under a free recall condition, and subsequently in a cued recall condition. Concreteness effects were attenuated when relational processing (e.g., in a paired associate task) was inhibited either at encoding or at recall. They determined that the joint functioning of relational and distinctive information was the force behind the concreteness effect. Experimental conditions which explicitly or implicitly encourage interitem processing, as in paired associates, are more likely to show concreteness effects. From this rationale, conditions which inhibit interitem processing should attenuate the concreteness effects. Paired associate learning may show greater concreteness than serial or free recall of unrelated words, but distinctive association networks should still facilitate the emergence of concreteness effect.

Day and Bellezza (1983) had subjects rate the vividness of images for paired words which varied in concreteness and relatedness. They were subsequently tested for delayed recall. Subjects' ratings of images for related abstract pairs were reported as more vivid than images for unrelated concrete pairs, but more unrelated concrete words were recalled than related abstract words in the delayed condition. They rejected a dual coding explanation for superior recall of concrete words, emphasizing that the physical relationship (pairing) rather than memory representation was the reason for their results. Their interpretation of dual coding theory assumed that abstract nouns are represented only in the verbal system and inferred then that word pairs with lower imagery ratings should not be recalled as well as word pairs with higher imagery ratings.

Paivio, Clark, and Khan (1988) used the Day and Bellezza (1983) word pairs and an additional set of concrete and abstract word pairs with varying degrees of associative strength. They found that low relatedness depressed imagery ratings for unrelated concrete pairs. Imagery ratings were higher for related than for unrelated pairs, as well as for concrete compared to abstract pairs. Thus composite imagery and associative relatedness show a strong effect on subjects' ratings, even though the concrete words themselves may have larger association networks. The importance of concreteness was only partially obscured by the low relatedness of the unrelated concrete pairs since delayed recall did show evidence for concrete superiority. Paivio et al. (1988) therefore rejected the rejection, asserting that factors such as concreteness, relatedness and instructions interact to determine composite imagery ratings which still fit their theoretical constructs.

Changes with Age

The communication hypothesis in age-related cognitive decline attributes memory decline to a breakdown of the underlying network of associations (Rissenberg & Glanzer, 1987) which should be attenuated if activation of additional information is triggered. This is similar to the Dual Coding Theory of Paivio (1971) which states that pictures are more likely than words alone to activate both visual and verbal memory codes. Thus, multiple cues may serve as an associational technique. Could words which evoke mental pictures, then, serve as an associational technique and activate additional memory codes, thus improving recall and recognition in the elderly?

There is evidence that imagery associations decline with age (Rissenberg & Glanzer, 1987). Young subjects have better recognition and recall for concrete words over abstract words than do normal elderly people. This phenomenon appears to be associated with the more extensive encoding activated by high imagery words, the strength of which may diminish with age. Items presented in picture form have an advantage in memory since they are activating both verbal and visual stores.

Although attenuation of recall performance with aging has been observed, the pattern of recall and recognition is strikingly similar to that of young normal subjects. Bruning, Holzbauer, and Kimberlin (1975) examined effects of imagery on short-term (STM) and long-term (LTM) recall and recognition in young (18-27), elderly (65-79), and very old (80-94) subjects using two different retention intervals (0 sec. and 20 sec.) in a combined auditory/visual presentation of stimuli. They utilized high and low imagery words from Paivio's norms which were equated for meaningfulness. Decrements were observed in both STM and LTM as a function of age, and main effects of imagery were significant and relatively consistent across age groups. There were no interactive effects of imagery with age for immediate recall or delayed recognition. However, delayed recall did show a significant interaction between imagery and age since there were no low imagery words recalled by the older groups after 24-hours. The effect of a longer recall interval (0 seconds and 20 seconds) showed strong group differences, attributed to the increased probability of trace loss because of additional time spent in recall by older persons. Young subjects recognized significantly more words, both high and low imagery, than the two older groups in the delayed recognition task, and they also recognized significantly more high imagery words than low imagery words, a finding that was not seen in the two older groups, indicating the possibility of diminished ability to utilize imagery over time, or perhaps even a floor effect.

More recently, Smith, Park, Cherry, & Berkovsky (1990) found age differences when concrete and abstract pictures were presented to young and elderly subjects. They presented complex versus simple and concrete versus abstract pictures to young and old subjects. No age differences were observed when pictures were both concrete and complex, but performance was significantly worse for the old group compared to the young group when complexity was removed from the concrete pictures, making them simple line drawings. Age differences were also observed in the abstract picture condition. Performance was significantly worse for the old group compared to the young group, whether the abstract pictures were simple or complex drawings. This supports the theoretical view of cognitive aging proposed by Schaie (1989) that age differences may be minimized when cognitive tasks reflect contextual variables in a concrete environment.

Changes with AD

Errors for AD subjects in linguistic tasks appear to reflect difficulties in word finding, a loosening of the "association links" between words and the things which they represent (Appell, Kertesz, & Fisman, 1982; Rissenberg & Glanzer, 1987). However, Appell et al. (1982) noted that the comprehension of simple concrete sentences is less affected than the handling of abstract propositions even in the early stages of the disease. This accords well with clinical descriptions of the speech of patients with dementia of the Alzheimer type: Verbose but lacking meaningful content. They showed the independence of semantic and cognitive operations from phonemic and syntactic functions in a comparison of 25 AD subjects with normal controls and stroke patients using the Western Aphasic Battery. AD subjects differed from normal subjects on all language variables, and differed from stroke subjects who showed lower verbal fluency but higher comprehension than the AD group. This has far-reaching implications for the relationship between cognition and language in AD.

The simple ability to name concrete and familiar objects appears to be relatively preserved among subjects with early AD, compared to their ability to recall abstract names (Ferris, et al., 1989). Both Bayles (1982) and Gustafson, Edvinsson, Dahlgren, Hagberg, Risberg, Rosen, and Ferno (1978) showed that object-naming tasks presented less difficulty than more abstract word-finding tasks, such as finding similarities or opposites, sentence completion or word fluency, even in the early stages of Alzheimer's disease. This difference is also observed for AD subjects in comprehension tasks with abstract items, where a more pronounced loss is seen when compared to comprehension of concrete items (Rissenberg, & Glanzer, 1987).

Two studies by Rissenberg and Glanzer used a free recall procedure to examine the picture superiority effect (1986) and the concreteness effect (1987) in word finding for young, normal aged and demented subjects. Citing Paivio's dual coding theory, that pictures are more likely than words to activate both visual and verbal memory codes, and that the probability of remembering an event depends upon the extent to which it is put into communication with other relevant information held in memory (the communication hypothesis), they predicted that the activation of these memory stores would be reduced with age and AD based on the hypothesis that there is a breakdown of communication in the information network of memory with age.

The results of their first study showed an overall decline of memory with age and dementia when pictures were viewed silently. The picture superiority effect was greatest in the young group, smaller for the normal elderly and minimal for the AD group. However, they were able to restore picture superiority for the normal elderly group with overt verbalization of the stimuli by the subject. Thus, it would appear that older individuals are less likely than young normals to spontaneously activate the additional semantic and phonemic information that give pictures their memory advantage, but they can still activate that information when circumstances facilitate information processing. Since performance can be improved with this additional aid, the results appear to refute the hypothesis that reduced storage capacity is the reason for age differences in recall. This attempt to increase activation did not result in improved responses for the demented group, however. In this group, there appears to be not only a breakdown in the activation of memory stores, but reduced storage capacity combined with greater susceptibility to interference.

In their study of the effect of item concreteness on free recall and word finding ability, Rissenberg and Glanzer (1987) again hypothesized that memory effects which depend on more extensive activation produced by one stimulus over another will be attenuated in the elderly. In a mixed modality design (visual and auditory), lists of concrete and abstract words were viewed silently at the rate of 3 seconds per item. Immediate free verbal recall followed presentation of each list. Again, the young group recalled more than the old normal group, who in turn recalled more than the AD group. In the interaction of concrete versus abstract words within groups, the young showed the typical strong concreteness effect, but the normal elderly showed no effect of concreteness. Surprisingly, the AD group did show a strong concreteness effect even though their overall recall was poor: they recalled more concrete than abstract words.

The attenuation of the concreteness effect in the normal elderly was attributed to reduced activation in the memory network, as predicted by the communication hypothesis. But the reversal of that attenuation for the AD group was puzzling. Rissenberg and Glanzer then measured word finding ability using definitions of concrete words and abstract words. Both the young and the old normal subjects did well on word finding, and there was little difference between concrete and abstract items. AD subjects, as expected, were significantly impaired in the word finding task, and their performance was significantly poorer for abstract items than for concrete items. Rissenberg and Glanzer attributed the unexpected advantage of concrete words in the AD group during immediate recall to more severely impaired retrieval of abstract words compared to concrete words, superimposed on an overall communication deficit. However, if visual stimuli are mainly recoded into auditory format (Manning, Koehler, & Hampton, 1990), the concomitant reduction in performance could affect recall of abstract words, which are more difficult to image, to a greater degree than concrete words, which are easily imaged. Additionally, Rissenberg and Glanzer may not have considered that visual presentation of a word may not activate the network of associations to the degree that auditory presentation could.

Evidence indicates that AD subjects perform poorly on similarity tasks and object naming (Bayles, 1982; Ober, Dronkers, Koss, Delis, & Friedland, 1986; Ober, Koss, Friedland, & Delis, 1985) because their association networks are impoverished. Since the failure among subjects with AD to encode features such as semantic similarities or object categories has been established, it is expected that AD subjects will not be differentially aided by item concreteness and familiarity of nouns in immediate recall. The findings of Rissenberg and Glanzer (1987) appear to contradict this expectation. However, their results could be revealing a perceptual deficit in addition to an associational deficit, with implications of a more complex cognitive disability.

It would appear, however, that more concrete, image-producing words, as opposed to more abstract, non image-producing words, should be used when talking to a person with dementia in the early to moderate stages. Although this phenomenon has frequently been studied in different modalities using free recall and paired associate paradigms, it has not been thoroughly examined with auditorily presented words in a strict serial recall procedure comparing young, normal elderly, and AD subjects. Minimal research has examined the role of concreteness in word recall with AD subjects, and the utilization of these specific semantic deficits as an early marker for AD. Furthermore, the interaction of concreteness and serial recall in AD subjects needs to be examined in terms of the standard theoretical expectations evidenced in young and elderly subjects. The proposed study should provide a unique and important contribution to the literature in these respects.

Modality and Suffix Effects

Theoretical Basis

Modality and suffix effects have been well established with young subjects. The modality difference in immediate recall of stimuli was originally attributed to the sensory representations of terminal auditory items for up to three seconds (Crowder & Morton, 1969). Because the duration of the visual store is considered to be much shorter, this sensory representation is not present when items are presented visually. Iconic memory decays too rapidly to be useful to the subject, and thus recency is not observed. However, in the auditory modality this model of precategorical acoustic storage (PAS) predicts a robust recency effect. This theory was long a cornerstone of immediate memory research. More recent research by Crowder (1986) and others, however, has led to a revision of the original theory, and a variety of alternatives have been developed to account for the modality and suffix effects observed.

Nairne (1988) presented ideas relative to the interpretation of recency and modality effects based on modality dependent and modality independent features, and subsequently proposed a feature model (Nairne, 1990) to characterize recency and suffix effects based on the internal process of identification and categorization, which accounts for much of immediate serial recall phenomena, including temporal grouping effects and phonologic similarity effects. In immediate recall, there is a comprehensive matching process in which residual trace information in primary memory is compared to relevant features in secondary memory. To be recalled items are selected from a search set (see Glenberg & Swanson, 1986, for a temporal distinctiveness hypothesis) which includes fewer items when the set is temporally recent (to account for recency) and more items when the set is temporally distant. According to Nairne, recency effects reflect a greater number of identifying features possessed by end-of-list memory traces which survive overwriting and provide discriminative information about an item through a process of speechlike encoding of items into immediate memory, rather than a modality-dependent feature, such as PAS, in which specific auditory traces are responsible for recency effects.

In an acknowledgement of criticisms of the original PAS theory, Crowder (1986) examined auditory and temporal factors in the modality effect. His results showed no recency effects for moving visual stimuli with mouthed, whispered and aloud conditions in a series of immediate serial recall experiments, refuting the possible alternative hypothesis of "changing state" (ascribed to stimuli which change over time, such as lipread or spoken speech). Campbell and Dodd (1982) predicted and found recency with lipread stimuli, and attributed recency to changing vowel patterns and changing mouth patterns, although others (Manning & Gmuer, 1985) refuted this claim.

Penney (1989b) evaluated the various hypotheses for modality and suffix effects in verbal memory and proposed a separate-streams hypothesis to account for the range of effects observed in short-term memory: Verbal material presented either auditorily or visually is processed by different mechanisms in different parts of the memory system. Thus, although more recent findings with various types of auditory and visual stimuli have demonstrated considerable exception and serious challenge to Crowder and Morton's PAS theory, it is still of considerable interest. However, the scope of the variously proposed theories on recency and suffix effects highlight the fact that questions still remain as to specific underlying mechanisms of these effects. Yet, theoretically, there is an inherent mnemonic superiority of auditory memory traces (Craik, 1968; Murray, 1966; Nairne, 1988) which may facilitate encoding to and retention within a long term store. Subsequently, discussion for the present study will focus on the auditory modality.

The effects of recency have been shown to be influenced by the semantic properties of the sequence items (Greene & Crowder, 1984c), but how would semantic qualities of a suffix affect recency? The suffix effect has been diminished by utilizing a suffix which is semantically related to the sequence items. In a series of two experiments, Salter and Colley (1977) reported less interference with recall when a suffix was a synonym of the final list word when compared to either a non-associated word or a burst of noise. The diminished suffix effect in the synonym condition indicates the use of recall information when the acoustic trace is no longer available, and therefore there is a degree of semantic encoding. Consequently, semantic relatedness of the suffix appeared to enhance recall of the final item rather than to block encoding of the final item.

Dissimilarity between sequence items and the suffix can more effectively destroy the salience of the terminal item than can a suffix which is similar to the sequence items. Baddeley and Hull (1979) found that long suffixes produced less disruption in recency than short suffixes in a comparison of prefix and suffix effects on digit sequences. They did, however, find that long suffixes produced greater deficits in the middle portion of the sequence. Interestingly, Routh and Frosdick (1978) and others (Greene and Crowder, 1984b) found that the degree of recency reduction, or a reduction in the salience of the terminal item of a to-be-remembered list, was due to greater similarity of the suffix to the preceding sequence. They reinterpreted the findings of Salter and Colley (1977) and found that an unpredictable suffix (and thus distinctive) did not inhibit recency, and in fact the greatest suffix effects were found when the suffix matched the modality of the test items.

Frick (1988) attenuated the suffix effect in auditory presentation in a series of experiments which showed that memorial factors, such as grouping or proximity, improved recall while not excluding the suffix. Frick considered these memorial factors to be properties which lead to better short-term memory of to-be-recalled items even though the suffix was included in the auditory store. In 1989, Frick reported two experiments which supported the observation that grouping improves recall even when it is not facilitated during stimulus presentation. According to Frick, grouping produces its effects during recovery of information, and items adjacent to boundaries have an advantage in this process, such that primacy and recency can be effected for each group of to-be-recalled words.

In an examination of the differential effects of picture suffixes and word suffixes on recency, Cohen (1972) and others (Manning & Schreier, 1988) reported minimal suffix effects with pictures in serial recall, which supported Paivio's hypothesis of two memory codes (verbal and visual). In their 10-item immediate recall task, Cohen (1972) found that word suffixes diminished the final two positions in the serial position curve, while picture suffixes, although altering the serial position curve, did not interfere with final item recall. Greene and Samuel (1984) tested the hypothesis that recency and suffix effects in serial recall resulted from speech-specific processes. They demonstrated substantial recency effects with serial recall of musical notes played on a piano, and reduced recency when a "suffix" (either a piano chord or the word "start") was appended onto the sequence of notes. Thus speech-specific processes do not appear to be necessary for the demonstration of recency and suffix effects.

The predominating body of literature, therefore, supports the view that in immediate recall, auditory presentation of stimuli, whether speech specific or not, does indeed lead to significantly improved performance on items in the last one or two serial positions, and this performance is vulnerable to a greater or lesser degree to interference from a suffix. A suffix might also be expected to inhibit interitem processing of relational or distinctive information, and thus would attenuate possible concreteness effects if those concreteness effects were due to greater associational networks (as Rissenberg & Glanzer, 1985, have theorized).

Changes with Age

The timely and accurate retrieval of stored information appears to show age-related deficits. Assessment of cognition in the elderly indicates that tasks involving greater attentional demands suffer age-related decrements. Hasher and Zacks (1988) found age-related decline in the ability to screen out irrelevant information from working memory, and asserted that certain attributes of stimuli were encoded automatically, while others were encoded only with effort. These findings have also been supported by Gerard, Zacks, Hasher, and Radvansky (1991) who found that interference effects were significantly larger for older adults (M = 69.1 years) compared to young adults (M = 19.1 years) in both a recall and a recognition task.

The hypothesis that age related differences in immediate recall are limited to LTM (Craik, 1977) was challenged by Parkinson, Lindholm, and Inman (1982) and others (Salthouse, 1980) who found age differences in both STM and LTM as evidenced in an overall lowering of the serial position recall curve. An examination of suffix effects in strict serial recall (Manning & Greenhut-Wertz, 1990; Parkinson & Perey, 1980) has shown contrasting findings with elderly subjects. In two serial recall tasks using numeric stimuli, Parkinson and Perey (1980) determined that some age related deficits could be attributed to mechanisms determining digit span. Two identical experiments were performed, initially on a group of young subjects (M =

19.3 years) whose auditory digit spans were established, and subsequently on a group of older subjects (M = 69.3 years). A comparison was performed between the young and elderly groups having equivalent digit spans. Serial position curves for control and suffix conditions for both groups were similar, indicating no greater susceptibility to interference by the suffix for the older group. Their results appear to support the reduced storage hypothesis and refute the suggestion that older subjects are more susceptible to interference. However, when digit spans were not equated, performance for the elderly group was poorer. Since young and elderly subjects with equivalent digit spans were likewise tested with equivalent alphanumeric stimuli, their conclusions would indicate that immediate memory span for words will also be governed by the same factors.

Standard suffix effects for young and elderly subjects in auditory presentation were reported in a study using alphabetic stimuli (Manning & Greenhut-Wertz, 1990). Young and elderly subjects exhibited strong recency performance, and significant decrement on final item recall in the suffix condition. However, they found overall poorer performance for elderly compared to young subjects produced by the auditory suffix on auditory stimuli, suggesting that elderly subjects are more susceptible than young subjects to interference. Thus, standard suffix effects (reduction of recency for auditory stimuli with auditory suffixes) do interact with age, and modality-specific (auditory) attentional deficits were found for the elderly group.

Similarly, Bruning, Holzbauer, and Kimberlin (1975) found that interference effects increased substantially with age in a study of word imagery in young, old, and very old subjects. Under two recall conditions (0 sec. or 20 sec. delay) the older groups showed increasing decrements in recall. They speculated that the high level of intrusions exhibited by these groups indicated susceptibility to interference possibly due to an overloading of storage capabilities. It would appear, then, that the deficits observed in normal aged individuals may stem from a combination of a greater susceptibility to interference effects, from a reduced storage capacity, and from impoverished communication networks.

Changes with AD

Recall patterns of AD patients seem to be qualitatively similar to normal controls. Martin, Brouwers, Cox and Fedio (1985) found that memory impairment in AD patients, though significantly worse than controls, appeared to be due to inability to encode a sufficient number of stimulus features or attributes. They found, for patients with AD, an overall lowering of the serial position curve produced by the normal subjects but a similar pattern of memory performance: primacy and recency were not differentially affected. Digit span (forward) showed a mean of 6.1 for normal controls and 5.9 for AD subjects, which is consistent with the digit spans reported by Flicker, Ferris, and Reisberg (1991) for normal elderly and AD subjects. In the recall of a ten-word list in the assessment of dementia in the elderly, Harris and Dowson (1982) also showed that subjects with AD exhibited the same patterns and serial position effects established by the normal controls, although dementia had a greater effect on recall of words at the beginning of the list than at the end. This would indicate that the deficits in AD subjects are not solely a function of quantity, that is a further reduction in storage capacity, but also of quality. If the quality of memory deficits is affected, then a different serial recall pattern as well as an inconsistent pattern of deficits (i.e. non-linear), would be observed in the AD group.

Except for studies in this laboratory (Mackell & Manning, 1990; Manning et al., 1992), the suffix paradigm has not been utilized with AD subjects in examining the effects of interference on immediate recall. Additionally, the differential effect of a suffix on recall of concrete or abstract words has not been examined in this subject group. However, error patterns and concentration deficits observed in AD subjects (Beatty, Butters, & Janowsky, 1986; Beatty, Salmon, Butters, Heindel, & Granholm, 1988; Miller, 1975) in terms of extra-list and prior-item intrusions, would suggest that the suffix will have a more deleterious effect on recall in AD subjects, compared to young and normal elderly subjects.

Research in serial recall using the suffix paradigm with AD patients is extremely limited (Manning et al., 1992). Miller (1972) presented demented subjects with sequences of acoustically similar and semantically similar words in groups of 4, and did require immediate recall of words in their correct order. He found that, for the demented subjects, acoustic similarity had less effect on short-term recall than semantic similarity, supporting the hypothesis of increasing impairment in the coding of new material. However, even though serial recall was required, a sequence of four words may be too limited to derive any information regarding either reduced capacity of immediate memory or impaired encoding on the part of a dementia subject.

Qualitative as well as quantitative performance differences in AD compared to normal aging have been observed. Inappropriate intrusions and perseverations have been examined in verbal memory tasks and figural memory tasks with normal aged subjects (Bruning, et al., 1975; Manning & Greenhut-Wertz, 1990) and with patients with AD (Manning et al., 1992), as well as other types of dementias, i.e. Huntington's disease, Korsakoff's disease and aphasia (Bayles, 1982; Butters, Salmon, Cullum, Cairns, Troster, & Jacobs, 1988; Fuld, 1983b; Troster, Jacobs, Butters, Cullum, & Salmon, 1989).

Appell, et al. (1982) included intrusions in their definition of syllabic perseverations, identified as simple repetitions of the same word or syllable, a carryover to a present stimulus, a response appropriate to a previous stimulus, or a recurrence of a set of phrases or themes. They reported that syllabic perseverations were a frequent feature in their AD subjects compared to normal controls. Gewirth, Shindler, and Hier (1984) examined word associations with dementia, aphasia and normal subjects and found that perseverative responses more prevalent in dementia subjects, while noun stimuli elicited more semantically related responses from demented subjects than did verb stimuli in a word association task. Unfortunately, Gewirth et al. (1984) pooled their dementia subjects, because of the small size of each etiological group. Consequently, the mixed subject group (AD, hydrocephalus, multi-infarct, and dementia due to miscellaneous causes) cannot be considered representative of mild AD subjects.

Other researchers have investigated intrusions and language disorders in general among dementia patients. Shindler et al. (1984) performed a hour-long battery of vocabulary, word naming, and word association tasks, and reported that intrusions occurred in patients with AD as well as patients with other dementias, but that intrusions were rare in control subjects who did not have dementia. Ober et al. (1985) observed higher frequencies of test intrusions for AD subjects compared to normal elderly subjects in a cognitive task. In fact, the frequency of intrusion errors in list learning has distinguished AD patients from other patient groups as well as from normal controls (Fuld, Katzman, Davies, & Terry, 1982).

In a study of error patterns in episodic and semantic memory comparing AD, Parkinson's disease (PD) and normal elderly subjects, Helkala, Laulumaa, Soininen, & Riekkinen (1989) showed a different pattern of memory dysfunction for the AD group compared to the other two groups. When asked to recall short passages or words in list learning tests, AD subjects committed more extra-story and extra-list intrusion errors. They also committed more false positive errors in the recognition test than did the PD or normal subjects. This could indicate possible utility for intrusions as an early diagnostic tool for dementia, but not necessarily as a tool to discriminate AD from other dementias or from aphasia.

Loewenstein, Wilkie, Eisdorfer, Guterman, and Berkowitz (1989) performed an analysis of intrusion errors with mild AD, moderate AD and multi-infarct dementia (MID) subjects. They reported that the number of test intrusions (delayed perseverations) did not differ significantly between groups, indicating that all dementia subjects evidenced an inability to inhibit previously acquired memory traces. However, they did find that specific types of intrusions, words which were semantically or categorically unrelated to the sequence words, occurred much more frequently than other types of intrusive errors among AD patients when compared to non-AD dementia patients. Thus, any examination of intrusion errors would more likely be useful as an diagnostic early marker for AD dementia only if extra-list intrusions are discriminated from within-list intrusions and perseverations.

Signal detection measures have been used to determine subjective judgments of accuracy in recall tasks, as well as to characterize recognition memory. The ability to recall stimuli appears to involve different encoding mechanisms than the ability to recognize stimuli, and low frequency words have been reported to facilitate recognition memory while high frequency words facilitate recall (Diesfeldt & Vink, 1989; Glanzer & Bowles, 1976). A further quantitatively different performance in AD compared to normal aging has been shown in such discrimination tasks. AD subjects have shown significant deficits in recognition memory for words (Taylor & Gilleard, 1990) and for faces (Ferris et al., 1980) when compared to normal subjects, although non-verbal stimuli such as faces may trigger associational information to facilitate recall.

Diesfeldt (1990) used a mixture of concrete and abstract low frequency words and faces to discriminate recognition memory of normal elderly and AD patients. Although there was no differentiation between the two groups in word-face discrepancy scores, the AD group showed significant recognition deficits for both words and faces compared to the normal elderly subjects. Thus, the pattern of verbal and visual deficits in AD is different from that in normal aging. Would a recognition task involving high-frequency words likewise exhibit greater deficits for AD subjects, or would concrete words trigger associational information and facilitate better recognition than abstract words? In a face recognition task, Maylor (1990) reported that the number of hits (faces recognized) decreased with age, while the number of false alarms (recognizing unknown faces) increased with age. Older subjects were therefore less sensitive and less discriminating than young subjects.

In an examination of four theoretical models of yes-no recognition memory[3], Snodgrass and Corwin (1988) measured recognition memory based on a single pair of hit and false alarm rates derived from a corrected matrix for comparisons between populations having different discrimination or response bias patterns. These hit rates and false alarm rates were derived by adding 0.5 to each frequency and dividing by N + 1 where N is the number of correct or incorrect words recalled, in the case of a confidence rating in immediate recall, or when N is the number of old or new words in the case of a recognition trial. (This correction is applied routinely in the present study in the case of immediate recall confidence ratings elicited for Experiment 1 and Experiment 2, as well as in the recognition task for Experiment

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[3]Snodgrass and Corwin (1988) compared two signal detection models which propose that items presented for recognition lie along a continuum of familiarity or strength of memory, and two threshold models, which define discrete memory states. A one-high threshold theory defines one threshold for both recognition and nonrecognition, whereas a two-high threshold model defines old recognition, new recognition, and uncertainty. Items not reaching threshold for either model will be classified as old or new depending upon response bias of the subject.

2.) For purposes of the present study in immediate recall, a hit is defined as the correct identification of a word as a member of the sequence just presented (e.g., saying a word is correct when it is correct). False alarms are defined as the incorrect identification of words as part of the presented sequence (e.g., saying a word is correct when it is not).

Using the Two-High Threshold Model of recognition memory, Snodgrass and Corwin (1988) found that a signal detection model using P_r and B_r as measures of sensitivity and response bias (rather than *d prime* and beta [or *C*] which require assumptions of normality which we do not make) demonstrated independence between discrimination and response bias when there is a non-equivalent sample population. The discrimination index P_r is defined as the probability that an item will exceed its recognition threshold. The bias index B_r is defined as the probability of saying "yes" to an item when you are uncertain. They demonstrated that P_r was equivalent to *d prime* as a discriminator, but B_r was more sensitive to change than either *C* or beta, and thus recommended those measures for studies in which discrimination may vary as a result of subject population, such as the population of normal elderly and dementia subjects.

A signal-detection analysis of recognition memory for photographs and designs (Taylor & Gilleard, 1990) showed no difference in response bias for three groups: subjects with AD, subjects with vascular dementia and elderly depressed subjects. The AD group performed poorer in overall recognition than the other two groups, and reported differing sensitivity and response bias depending on the type of material presented. In their photograph test, the depressed group showed the most conservative bias and the AD group the least. In the design test, however, these results were reversed, suggesting that response bias may not be an important distinguishing feature in memory test performance for patient groups. Nevertheless, it may be a distinguishing feature in comparison of normal elderly and AD subjects. The discrimination and response bias differences expected with aging and dementia support the utility of using P_r and B_r as sensitivity and bias measures to analyze confidence ratings in immediate recall as well as in delayed recognition performance.

Summary

The reported findings regarding changes in immediate memory with aging and AD indicate the following conclusions: immediate recall is attenuated with age and dementia, although the pattern of recall is similar across subject groups; a suffix poses increasing interference with age and dementia; the memory advantage for concrete compared to abstract items may also show attenuation with age and dementia; and there are qualitative as well as quantitative differences in delayed recall and recognition particularly with AD subjects.

However, many questions remain unanswered. Would the concreteness effect be equally evident for all groups in immediate recall and delayed recall of nouns? Would responses in serial recall and free recall exhibit equivalent patterns for young, elderly and AD subjects? Can the concreteness effect minimize the observed deficits in immediate recall with age and AD? Does a suffix interfere with recency to the same degree for concrete words as for abstract words? Do young, elderly, and AD subjects exhibit differences in their perception of their own memory performance? These gaps in knowledge lead to the current studies.

Preliminary Studies

Young, normal elderly and AD subjects ($\underline{n}$ = 8 in each group) were studied using a suffix paradigm with serial recall of alphabetic stimuli in both the auditory and the visual modes (Manning et al., 1992). Eight rearranged sequences of the same 6 consonants were presented to subjects for serial recall in four conditions: visual control, visual suffix, auditory control, and auditory suffix. In the auditory and visual control conditions, a click and a dash, respectively, were the signals to begin recall of the sequence. In the auditory and visual suffix conditions, the letter *Y* was appended onto the sequence, and subjects were instructed that it was a not-to-be-recalled item.

Results showed overall poorer performance for the AD group than the other two groups, and a general visual performance deficit was found for AD subjects compared to young subjects, but not compared to elderly subjects. The visual suffix did not appear to reduce performance for any of the subject groups, while the auditory suffix showed increasingly greater effect with age and AD.

AD subjects showed a significantly greater number of both suffix intrusions and extra-list (other letters) intrusions than either of the two normal groups. Furthermore, all of the extra-list intrusions for all groups were letters of the alphabet, suggesting some degree of categorical information present. The young and elderly groups showed no suffix intrusions, and the suffix intrusions for the AD group were found in both the auditory and visual modalities, although no suffix intrusions were exhibited in the non-suffix conditions.

In a delayed recall task, the AD group showed significantly poorer performance than the two normal groups, and incorrectly recalled significantly more letters which were not part of the original stimuli, giving them a significantly lower hit rate, $M = 0.73$, than either the young, $M = 1.00$, or the elderly, $M = 0.98$, groups. In a delayed recognition task, a similar pattern was exhibited. The AD group showed poorer recognition performance than the two normal groups, incorrectly identified significantly more extra-list letters, and had a significantly poorer hit rate, $M = 0.52$, than either the young, $M = 1.00$, or the elderly, $M = 0.98$, groups.

Thus, certain qualitative similarities in immediate memory for young, elderly and AD subjects are contrasted by the qualitative and quantitative differences in delayed recall and recognition memory for these three groups.

This work with young, normal elderly and AD subjects, combined with the findings reported earlier regarding changes in immediate memory, delayed recall and concreteness effects with age and AD, suggests that further investigation may prove useful in differentiating normal aging from mildly impaired individuals.

Experiment 1

Overview

This study involves two experiments, designated as Experiment 1 and Experiment 2. In order to determine whether instructions in either serial recall or free recall alter the performance of the participants, the two experiments were performed with the same apparatus and design. In Experiment 1, subjects were instructed to recall and write concrete and abstract words, presented in sequences of six, in strict serial order, that is in the order in which they were spoken, and to rate their answers as to whether they believed the words they recalled were correct or incorrect. In Experiment 2 subjects were asked to write and rate, as correct or incorrect, the words in any order they recalled them regardless of the sequence of presentation.

A recognition task containing 20 of the experimental words (10 concrete and 10 abstract) embedded with 20 new concrete and abstract words was given to half the elderly and half the AD subjects in Experiment 2.

The two experiments were identical in all other respects.

Methods

Subjects

Forty-eight subjects, three groups of 16, participated in this experiment: The young normal subjects were college and graduate students from Hunter College of the City University of New York, and college, graduate and medical students from

New York University. The elderly normal subjects were from the community, Hunter College and the New York University Medical Center (NYUMC) Aging and Dementia Research Center (ADRC). The subjects with Alzheimer's Disease (AD) were participants in research studies at the NYUMC-ADRC. All subjects spoke English as a first language, although it may have been learned simultaneously with another language.

The 16 young normal subjects (5 male, 11 female) were students between 19 and 28 years of age (M = 21.4 years) with an average of 15.8 years of education. The 16 normal elderly subjects (5 male, 11 female) were active community residents, spouses or caregivers of AD patients, or university returnees between 62 and 82 years of age (M = 71.1). They had an average of 16.1 years of education. The 16 subjects in the AD group (6 male, 10 female) were all diagnosed with probable Alzheimer's disease (AD) and were participants in various research programs at the NYUMC-ADRC. The AD group ranged in age from 51 to 81 years (M = 70.1), with an average of 13.9 years of education. Characteristics of all the subject populations (gender, age, education and MMSE scores) are shown in Table 1.

The diagnosis of probable AD is based on the guidelines recommended in the report of the NINCDS-ADRDA[4] Work Group (McKhann, Drachman, Folstein, Katzman, Price, & Stadlan, 1984) and is given after complete clinical history, psychiatric, medical, neurologic and neuroradiologic examinations and cognitive psychometric assessments (see Appendix A for a complete list of assessment

[4]National Institute of Neurological and Communicative Disease Studies-Alzheimer's Disease and Related Disorders Association.

Table 1

Subject Characteristics in Experiment 1

Characteristics	Young N = 16	Elderly N = 16	AD N = 16
Sex			
Male	5	5	6
Female	11	11	10
Age			
Mean	21.4	71.1	70.1
Range	19 - 28	62 - 82	51 - 81
Education			
Mean Years	15.8	16.1	13.9
Range	13 - 20	12 - 20	8 - 20
Mini Mental State Exam			
Mean	29.3	28.1	20.9
Range	28 - 30	26 - 30	15 - 26

procedures used at the ADRC).

All AD subjects were assessed with the Global Deterioration Scale (GDS) of Reisberg, Ferris, de Leon, and Crook (1982) provided in Appendix B. This scale was developed as a global measure for the assessment of cognitive decline secondary to normal aging and AD, and was designed to delineate all stages throughout the entire course of the disease, from normal aging to the most severe dementia, and is based on five areas of functioning: (a) concentration, (b) recent memory, (c) remote memory, (d) orientation, and (e) functioning and self-care (Brief Cognitive Rating Scale, Reisberg & Ferris, 1982). The severity of the disease is divided into seven clinically identifiable stages, from Stage 1, normal, to Stage 7, severe cognitive decline, each stage encompassing specific criteria which are assessed in a clinical interview. The AD subjects in this study were all diagnosed as being in GDS stage 4, the first clinically diagnostic stage of AD.

GDS stage 4 is, in brief, termed a late confusional stage of dementia (mild Alzheimer's disease) that indicates clear-cut deficits on clinical interview, and involves moderate cognitive decline. The GDS descriptions have demonstrated excellent test/retest and interrater reliability in at least four separate studies conducted in disparate settings (Dura, Haywood-Niler, & Kiecolt-Glaser, 1990; Foster, Sclan, Welkowitz, Boksay, & Seeland, 1988; Gottlieb, Gur, & Gur, 1988; Reisberg, Ferris, Steinberg, Shulman, de Leon, & Sinaiko, 1989). The specific content validity of the GDS has been strongly supported by studies which have examined the concordance characteristics of each of the elements of the GDS (e.g., see Reisberg, Ferris, de Leon, & Crook, 1985), and by a study employing principal components analysis (Overall, Scott, Rhoades, & Lesser, 1990). Other studies have demonstrated the convergent validity of the GDS both in ostensibly normal and in progressively impaired patients (Johansson & Zarit, 1991; Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger, & Mir, 1988).

There is a high correlation between this global assessment of progressive cognitive impairment and independently developed mental status and behavioral scales. Reisberg et al. (1989) found a strong correlation between the Mini Mental Status Examination (MMSE) of Folstein, Folstein, and McHugh (1975), and GDS level (a Pearson correlation coefficient for GDS level is 0.89 for MMSE). The MMSE, an expanded form of the Mental Status Questionnaire (MSQ) of Kahn, Goldfarb, Pollack, and Peck (1960) is a brief test designed to elicit information about orientation, attention and calculation abilities, recall and copying ability, permitting the rapid assessment of dementia severity. GDS stage 4 subjects score an average of 20 points (out of a possible score of 30 points) on the MMSE (Reisberg et al., 1989) with a point range of 16-23 (Reisberg et al., 1985). The MMSE scores for the young subjects ranged from 28 to 30 ($\underline{M}$ = 29.3); the MMSE scores for the elderly subjects ranged from 26 to 30 ($\underline{M}$ = 28.1). The mean MMSE for the AD group was 20.4 (range = 15 to 26) which is consistent with the range and average MMSE scores reported for GDS stage 4 subjects (Reisberg et al., 1985; Reisberg et al., 1989). Since years of education has been shown to have an effect on MMSE scores (Uhlmann & Larson, 1991), determination was made of the equivalence of these three subject groups. A 1-way ANOVA comparing years of education for all subjects showed no significant difference between groups, $\underline{F}$ (2, 45) = 2.85, $\underline{MS}_e$ = 7.85.

Stimulus Lists

Seventy-two words, shown in Appendix C, were extracted from a list of 925 nouns rated on scales of imagery, concreteness, and meaningfulness by Paivio, Yuille, and Madigan (1968). Half of the nouns (36) chosen were rated high in imagery and concreteness, with a mean Imagery and Concreteness value of 6.4 or above on a 7-point scale. The other 36 nouns chosen were rated low in imagery and concreteness, with a mean Imagery and Concreteness value of 4.63 or below. There was no difference in frequency ratings between the high and low imagery lists. (The mean Meaningfulness value for the high imagery words is 7.0, and for the low imagery words is 5.5.)

The stimulus words were between three and seven letters in length and had frequency ratings of A or AA (Thorndike and Lorge, 1944). The 36 concrete words were used to make two taped lists by rearranging the word order. The 36 abstract words were also rearranged to create two lists. (Each concrete and abstract word was therefore presented twice, although in different order withdin each list.) These four lists were each subdivided into six 6-word sequences.

A practice list of 24 words with mixed imagery and concreteness ratings was also extracted from the Paivio et al. (1968) norms. These practice words, with imagery and concreteness ratings, the mean of those ratings, and their frequency ratings (Thorndike & Lorge, 1944) are also included in Appendix C.

Materials and Apparatus

The word lists presented from eight separate cassette tapes (numbered 1 through 8) were spoken by a female reader and delivered through Radio Shack Nova 45 earphones on a Radio Shack (Realistic) stereo cassette recorder. Tape 1 contained 36 concrete words with a suffix after each six-word sequence. Tape 2 contained the same concrete words as Tape 1, rearranged, also with a suffix after each six-word sequence. Tape 3 contained 36 abstract words, with a suffix after each six-word sequence. Tape 4 contained the same abstract words as Tape 3, rearranged, also with a suffix after each six-word sequence. Tapes 5 and 6 contained the same concrete words as Tapes 1 and 2, but with a tap heard after each six-word sequence. Tapes 7 and 8 contained the same abstract words as Tapes 3 and 4, but with a tap heard after each six-word sequence. All words were spoken at one-second intervals (with the same interval between the last word and the suffix or the tap), and there were 40 seconds between each six-word sequence. Rearranging the concrete and abstract words for Tapes 2, 4, 6, and 8 was intended to avoid order effects in the presentation of the word sequences. This also diminished the possible association of contiguous words within a particular sequence.

The four word lists were presented to the subjects using a balanced Latin square design to minimize presentation effects. Thus, the 16 subjects within each experimental group received a different arrangement of the four test conditions. This method decreased the possibility of order effects, such as all subjects receiving abstract word lists before concrete word lists and showing improvement due to practice, or receiving suffix lists before non-suffix lists and showing improved performance on the non-suffix list. Therefore, in each of the three groups, subjects 1 through 16 received a unique order of word lists and experimental conditions.

Control and Suffix Conditions

In the control conditions, each concrete and abstract six-word sequence was followed by a tap which served as the signal for the subjects to begin writing the list words they could recall. For the corresponding suffix conditions, a suffix with both intermediate imagery/concreteness ($\underline{M}$ I/C = 4.53) and frequency (f = 21) ratings, the word CODE, was appended at the end of each concrete and abstract six-word sequence. Each subject was presented with four separate 36-word lists (each containing six 6-word sequences) over earphones. The word lists, on individual cassette tapes, consisted of two concrete lists, one with a tap (control condition) at the end of each sequence and one with the suffix at the end of each 6-word sequence, and two abstract lists, one with the tap (control condition) and one with the suffix. Either the suffix or the tap was the subjects' signal to begin writing the list words which they were able to recall.

Procedure

Each subject was individually tested for strict serial recall in the cognitive psychology laboratory at Hunter College or at the NYUMC-ADRC. After signing a consent form, the subject sat at a desk and was presented with specially designed response sheets (included in Appendix D) with lines and boxes partitioned in groups of six per sequence to write the words which they were to recall. Instructions (included in Appendix D) read to each subject stated that they would be listening to lists of words, in sequences of six words each, over earphones from a cassette recorder. They were instructed that after each sequence of six words, either a tap or the word "code" would be their signal to begin writing as many words as they could recall in strict serial order, that is in the order in which the words were presented. Subjects were further instructed to provide confidence ratings as an estimate of their perceived response accuracy following each recall sequence. Following the immediate recall of each six-word sequence, they were to rate each word they recalled as being either correct or incorrect by placing either a "C" for correct or an "I" for incorrect in the box beneath each word.

Two practice trials were presented orally by the experimenter, one in the suffix condition and one in the control condition, so that each subject was exposed to twelve practice words. The purpose of this pretest practice for the subjects was to produce familiarity with the experimental procedures and to reduce anxiety in the testing situation for all subject groups. These practice trials also enabled the tester to assess the capacity of the subject, in the AD group in particular, to concentrate and follow instructions.

Following the practice trials, subjects placed the earphones in position and proceeded with the experiment.

Additional Tests

After administration of the four serially recalled word lists, each subject received the following procedures in the order listed:

1. An auditory digit span, extracted from the Wechsler Adult Intelligence Scale-Revised (WAIS-R) (Wechsler, 1981) was administered to each subject. Digits were spoken at the rate of one per second, and the subject was directed to repeat each sequence (forward only) in the order in which is was presented. The first sequence of digits consisted of three items, increasing by one item with each subsequent presentation. The task was discontinued after the subject failed to repeat two trials of a sequence.

2. A visual digit span, extracted from an alternate digit sequence of the WAIS-R (Wechsler, 1981) was also presented to each subject on 3 X 5 index cards at the rate of one per second. The subject was directed to write the digits in the order they were presented immediately after presentation of each digit sequence. As in the auditory digit span task, the first sequence of digits consisted of three items, increasing by one item with each subsequent presentation. The task was discontinued after the subject failed to correctly write two trials of a sequence.

3. A Mini-Mental State Exam (MMSE) (Folstein, Folstein, & McHugh, 1975) was given to provide a brief global cognitive assessment of the subject. The MMSE incorporates measures of initial and delayed recall, orientation, concentration and

calculation, language and vocabulary, comprehension, and praxis.

4. A delayed recall task was then given. The subject was presented with a plain sheet of paper, and was requested to write as many words as could be recalled from the original experimental list words. This task was untimed, and was discontinued when the subject stated that no further words could be recalled.

Results and Discussion

This strict serial recall paradigm, involving control and suffix conditions, was analyzed using two different methods to score the results: Correct In Position (CIP) scoring, and Correct by Point of Origin (CPO) scoring. In CIP scoring, a word is counted as correct only if it is (1) a word from the presented sequence, and (2) if it is in the correct order in which it was presented, and (3) if it is in the correct serial position (Positions 1 through 6) in which it was presented.[5] Therefore, if the final word in a presented sequence of six words was recalled in Position 5, it would be considered incorrect. In CPO scoring, the words need not be in the correct order or serial position in which they were presented; they must only be a word from the presented sequence. Thus, if the sixth word presented in a sequence was the first word written (i.e. in Position 1) during recall, it would be counted as correct in CPO scoring. However, it would be scored in Position 6. List words misplaced in serial

[5]For example, if a subject recalled words presented in Positions 1, 3 and 6, they would not be correct if the words were simply written in the correct order (i.e. Positions 1, 2, and 3), unless the correct number of spaces were left between each word by placing it in the correct serial position on the answer sheet.

position are still considered correct. Unless otherwise stated, all statistics are reported using an $a = \leq .05$ level of significance.

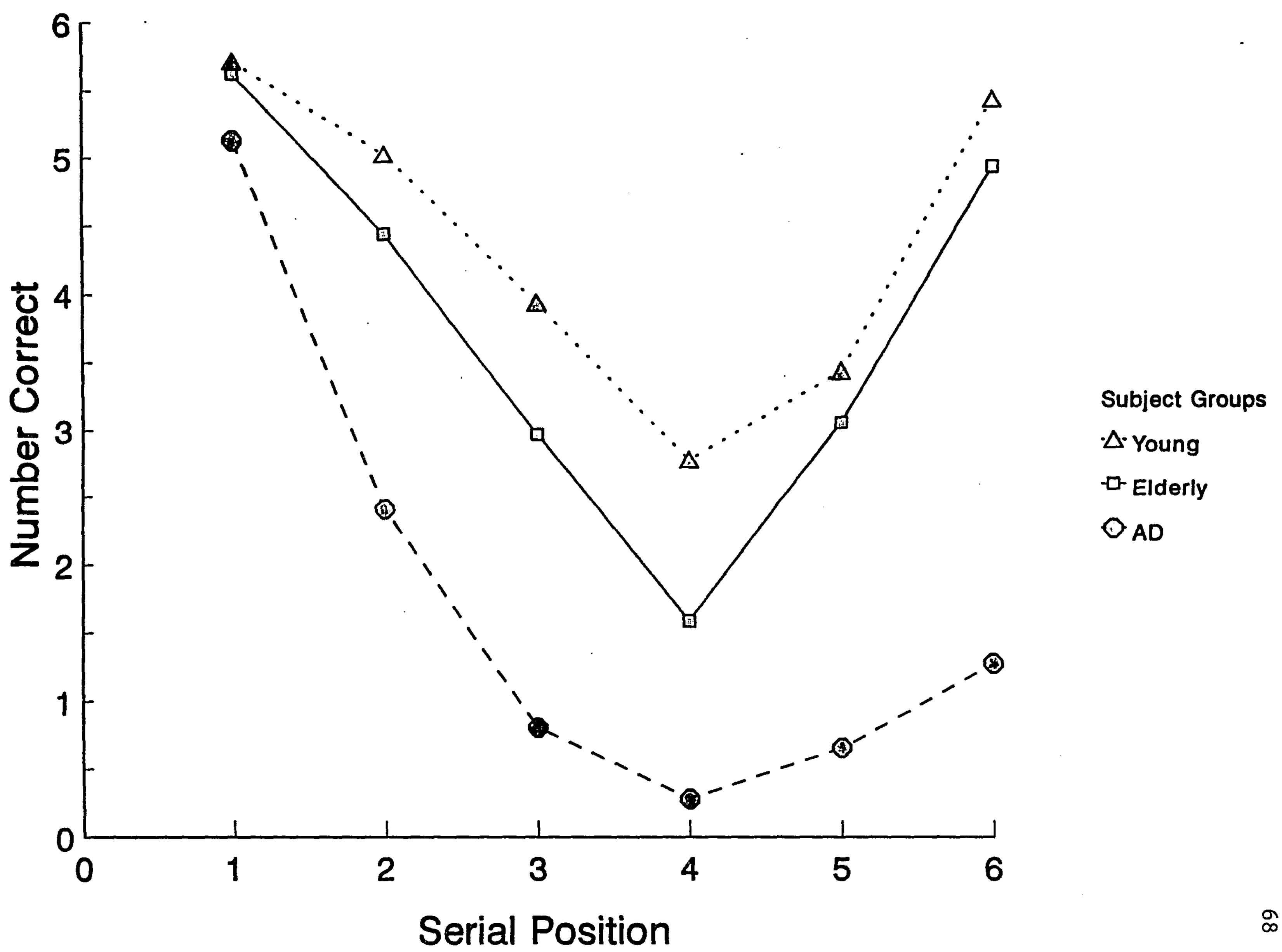
Control Condition

In order to evaluate group differences and concreteness effects independent of interference from a suffix, the control condition was analyzed separately.

CIP Scoring Method. Figure 1 shows the mean differences in recall in the control conditions by group as a function of serial position using CIP scoring. Performance for the young and elderly across the serial position curve is consistent with previous reports of recall performance, showing the expected primacy in these subjects (Manning & Greenhut-Wertz, 1990). Furthermore, the primacy observed in the AD group is stronger than previous research has shown (Harris & Dowson, 1982) for more severely demented AD subjects. Bemelmans and Goekoop (1991) reported that primacy is not lost when a shorter (6-word) sequence is presented, which is supported by these results. Recency appears to be present for the young and the elderly groups, with recall of the final word in the sequence approaching the level of primacy.

The increasing demands of strict serial recall with age and dementia are evident across the serial position curve. There is gradually diminished performance with age and a much steeper drop in recall with dementia, as expected. Of interest, however, is that there is a minimal increase in the recency portion of the serial

Figure 1. Group differences in the control conditions of Experiment 1 as a function of serial position using CIP scoring.


Number Correct
Serial Position
0
1
2
3
4
5
6
Subject Groups
Young
Elderly
AD

position curve for the AD group compared to the middle portion.

To examine the magnitude of recency, paired $\underline{t}$ tests comparing performance at Positions 5 and 6 indicated robust recency for the young, $\underline{t}$ (15) = 8.43, and the elderly, $\underline{t}$ (15) = 6.62, groups. Recency was also observed in this strict recall procedure for the AD group, $\underline{t}$ (15) = 1.78, although to a much smaller degree than the recency observed in the two normal groups. A 1-way ANOVA comparing group differences in the size of recency indicated significant differences between groups, $\underline{F}$ (2, 45) = 4.85, $\underline{MS_e}$ = 1.26, and a Duncan multiple range test confirmed that there was a significant difference between the young and AD groups, and the elderly and AD groups, but no difference was found between the young and elderly groups, with critical ranges for r_2 and r_3 of 0.82 and 0.97, respectively.

The control conditions were analyzed using a 3 (Group [young, elderly, and AD]) X 2 (Concreteness [concrete and abstract nouns]) X 6 (Serial Position [1-6]) analysis of variance (ANOVA).

The main effects of group, $\underline{F}$ (2, 45) = 57.55, $\underline{MS_e}$ = 6.31, and of serial position, $\underline{F}$ (5, 225) = 82.65, $\underline{MS_e}$ = 2.32, were both highly significant. These effects reflected overall superior word recall for the young, $\underline{M}$ = 4.39, compared to the elderly, $\underline{M}$ = 3.77, and the elderly compared to the AD group, $\underline{M}$ = 1.76, as expected. Serial position effects reflected variable performance across the serial position curve for all three groups.

The interaction of Group X Serial Position, $\underline{F}$ (10, 225) = 6.07, $\underline{MS_e}$ = 2.32, was the only significant interaction observed and appears to be primarily due to an increasingly greater loss of items in the middle positions of the serial recall curve with age and dementia, and a much weaker recency performance for the AD subjects compared to the young and elderly subjects. One-way ANOVAs showed no difference between groups in mean performance at Position 1, $\underline{F}$ (2, 45) = 2.29, $\underline{MS}_e$ = 0.71, reflecting a consistent performance level for all groups for the first word recalled. However, a reliable difference between the three groups was found at Position 6, $\underline{F}$ (2, 45) = 36.76, $\underline{MS}_e$ = 2.24, indicating a significant difference in recall performance for the final item presented. A Duncan multiple range test showed no difference between the young and the elderly groups, but significantly poorer performance was revealed for the AD group, $\underline{M}$ = 1.28, compared to both the young group, $\underline{M}$ = 5.44, and to the elderly group, $\underline{M}$ = 4.94, at Position 6, with critical ranges for r_2 and r_3 of 1.09 and 1.29, respectively.

There were no main effects of concreteness evident in this strict serial recall paradigm, $\underline{F}$ (1, 45) = 3.28, $\underline{MS}_e$ = 2.10. Paivio and Csapo (1969) used young subjects and did find a concreteness effect in strict serial recall, although the effect was more robust using a free recall paradigm. Thus, a concreteness effect, albeit minimal, had been expected at least for the young group.

There was no further significant interaction using strict serial position (CIP) scoring, and a subsequent analysis was conducted utilizing a scoring method variation.

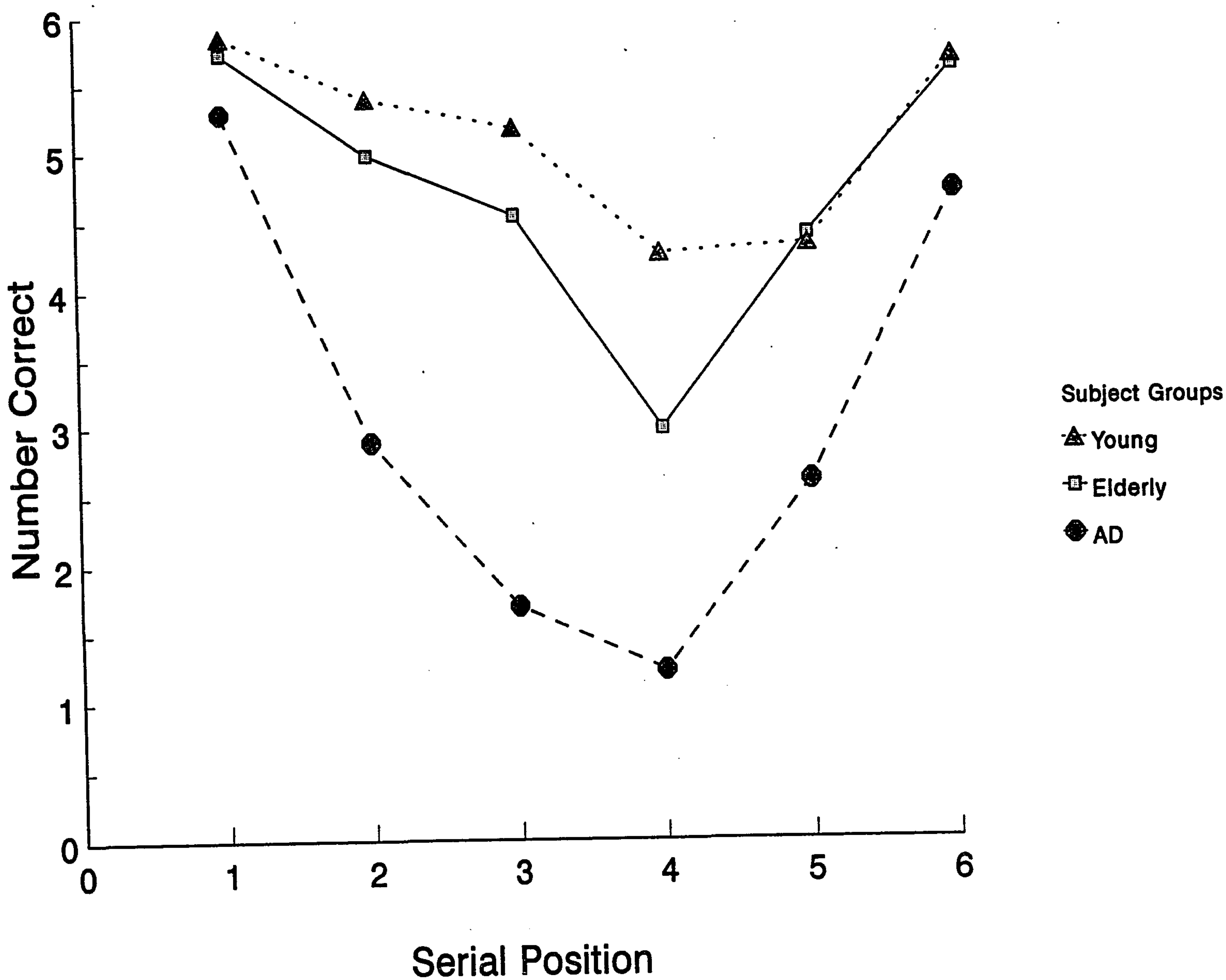
<u>CPO Scoring Method</u>. To determine the degree to which this more lenient scoring procedure would affect the results, a 3-way ANOVA, 3 (Group) X 2 (Concreteness) X 6 (Serial Position), revealed significant main effects of group, $\underline{F}$ (2,

45) = 39.30, MS_e = 5.71, of concreteness, F (1, 45) = 7.02, MS_e = 0.75, and of serial position, F (5, 225) = 71.62, MS_e = 1.48. These main effects reflected overall superior recall for the young compared with the elderly, and the elderly compared to the AD group, M = 5.10, 4.69 and 3.06 respectively. The main effects further reflected better recall for concrete compared to abstract words for all groups, as well as expected recall differences summed across the serial position curve.

Figure 2 illustrates the mean group differences across the six serial positions using CPO scoring. Primacy and recency are evident for all groups, and recall performance is diminished slightly in the middle portion of the curve for the young. Performance for the elderly group exceeds then equals the young group in the preterminal and terminal positions of the curve, respectively. Again, the magnitude of recency was examined by comparing performance at Positions 5 and 6 for the three groups. Paired t tests indicated robust recency for the young, t (15) = 6.81, the elderly, t (15) = 5.14, and the AD, t (15) = 7.41 groups. A 1-way ANOVA showed significant differences between groups in the size of recency, F (2, 45) = 3.84, MS_e = 0.93, and a Duncan multiple range test confirmed that both the young and the elderly groups differed significantly from the AD group, although the young and elderly groups did not differ from each other, with critical ranges for r_2 and r_3 of 0.70 and 0.83, respectively.

The AD group showed a steep decline in the middle positions of the curve compared to the young and the elderly. Possibly the demands on concentration for the AD group caused greater overwriting of words in this middle portion of the

Figure 2. Group differences in the control conditions of Experiment 1 as a function of serial position using CPO scoring.


Number Correct
0
1
2
3
4
5
6
0
1
2
3
4
5
6
Serial Position
Subject Groups
Young
Elderly
AD

curve. However, the high level of primacy seen here indicates that subsequently presented list words did not interfere with the unique quality of a word which holds the distinction of being the first word presented.

In spite of the quantitative difference in the recall curves for young, elderly and AD subjects, the recall patterns across the serial position curve for AD subjects using the more lenient scoring method appear qualitatively similar to normal control subjects, as suggested by Martin, Browers, Cox and Fedio (1985). Recall at Positions 1 and 6 was strong, and there was diminished performance for words in the middle of the sequence.

One-way ANOVAs to determine group differences in performance at Positions 1 and 6 were performed. No difference was found between groups at Position 1, F (2, 45) = 2.39, MS_e = 0.59. A Duncan multiple range test confirmed that no group differed significantly from any other, with critical ranges for r_2 and r_3 of 0.55 and 0.66, respectively.

For performance at Position 6, however, a significant difference was found between groups, F (2, 45) = 4.61, MS_e = 1.02. A Duncan multiple range test showed no difference between the young and elderly groups, but significantly poorer performance was found for the AD group, M = 4.69, compared to both the young and the elderly groups, 5.59 and 5.66 respectively, at the terminal position, with critical ranges for r_2 and r_3 of 0.74 and 0.87, respectively. Therefore, in terms of levels of performance, the AD group exhibited disproportionate effects of item presentation compared to performance for the young and elderly groups in recall of the first and last words presented.

If subjects are able to encode the semantic quality of the nouns under conditions of strict serial recall but simply recalled the nouns in the incorrect position, then concreteness may be observed under a more lenient scoring method. If the minimal recency observed for the AD group was due to the strict scoring method used, CIP scoring, which requires words to be in the correct order and correct serial position in which they were presented, then applying the CPO scoring method should enhance recency. This would indicate that words in the final position are being remembered, and would suggest that the AD group cannot attend to the directions to place the word in the correct position on the score sheet, while simultaneously attempting to hold the words in memory, although they might retain relative word position. It is also possible that the AD subjects simply forgot the directions to place the words in their correct position. There is, of course, the possibility that even these mildly demented subjects do not exhibit recency, in which case CPO scoring could uncover misplaced words without substantially altering recency performance.

The emergence of the main effect of concreteness, not previously observed in CIP scoring, appears to be due to the greater misplacement of recalled concrete items compared to abstract items for all subject groups, most likely at the end of the sequence. Previous literature has reported the potency of imagery in free recall, which may be attenuated but still evidenced in serial recall (Paivio & Csapo, 1969; Paivio, Yuille, & Rogers, 1969). Therefore, CPO scoring should uncover the effect, although since subjects were still performing under the demands of serial recall, there may be a diminished ability to encode the material. The overall mean recall, collapsed across groups, was 4.38 for concrete words and 4.19 for abstract words. Order, as required in CIP scoring, washed out the concreteness effect (M = 3.42 and 3.20 for concrete and abstract words, respectively, collapsed across groups), but it remained under conditions of serial recall with the application of lenient CPO scoring.

Although there was a significant main effect of concreteness, there was no reliable Group X Concreteness interaction, F (2, 45) = 1.01, MS_e = 0.75, suggesting that the difference between recall of concrete and abstract words was equivalent among groups. The group means for recall of concrete and abstract words are shown in Table 2, and reflect the trend in concrete superiority for all subjects. The lack of Group X Concreteness interaction may indicate quantitative similarities in the size of the concreteness effect, but does not rule out qualitatively different performance between groups. Possibly, since the task of recalling six words was not testing immediate recall limits for the young or the elderly, the concreteness effect may have been minimized for the young and elderly, since overall performance was high for these two groups. The length of the sequence was difficult for the AD group as a whole, and there was greater variation in performance among AD subjects, perhaps maximizing the strength of concreteness for that group, and resulting in seemingly equivalent concreteness effects for the three groups.

There was a significant interaction of Concreteness X Serial Position, F (5,

Table 2

Mean Number of Words Recalled in Control Conditions of Experiment 1 for Young, Elderly and AD Subjects as a Function of Concreteness and Serial Position using CPO[a] Scoring

	Serial Position					
	1	**2**	**3**	**4**	**5**	**6**
Young						
Concrete M = 5.14	5.81	5.44	5.25	3.88	4.56*	5.88*
Abstract M = 5.06	5.88	5.31	5.06	4.63	4.06	5.44
Elderly						
Concrete M = 4.78	5.63	5.06	4.81*	3.00	4.63*	5.56
Abstract M = 4.60	5.81	4.88	4.25	2.94	4.13	5.63
AD						
Concrete M = 3.22	5.38	3.44*	1.75	1.13	2.94*	4.69
Abstract M = 2.90	5.19	2.31	1.63	1.31	2.25	4.69

Note: * represents a significant Dunnett test, C-E = 0.31. Maximum score at each serial position is 6.00.

[a]: CPO = Correct by Point of Origin Scoring Method, in which a recalled word is counted as correct regardless of its serial position during presentation.

225) = 3.21, $\underline{MS}_e$ = 0.77, which reflects the differential recall, summed across groups, of concrete and abstract words across the recall curve, most apparent in the middle and final portions of the serial recall curve, and further examination of the Concreteness X Serial Position interaction was warranted. Table 2 shows the mean recall of concrete and abstract words as a function of serial position for each of the subject groups.

Preplanned Dunnett tests were performed using the Group X Concreteness X Serial Position interaction as the error term, C - E = .31. Significantly greater recall for concrete compared to abstract words was found at Positions 5 and 6 for the young group, at Position 3 and 5 for the elderly group, and at Positions 2 and 5 for the AD group. This inconsistent pattern may be a result of the strength of primacy regardless of the concreteness of a word, combined with the possibility that the recency portion of the serial position curve is more affected by the concreteness of a word. Concrete imageability may facilitate the immediate and spontaneous recall of an item rather than facilitating greater encoding or longer retention.

Again, as in CIP scoring, the interaction of Group X Serial Position, F (10, 225) = 8.33, $\underline{MS}_e$ = 1.48, is significant, due to the differential performance across the serial position curve for the young compared to the elderly, and the expected superior performance across all serial positions for the elderly compared to the AD group (observable in Figure 2).

Whether CPO scoring in a strict serial recall paradigm provides the same results as a free recall paradigm will be examined in Experiment 2. The subject is still under the pressure of recalling the list words in strict serial order and is unaware of a subsequent scoring change, and this pressure may have an affect on recall even though a more lenient scoring method may be applied.

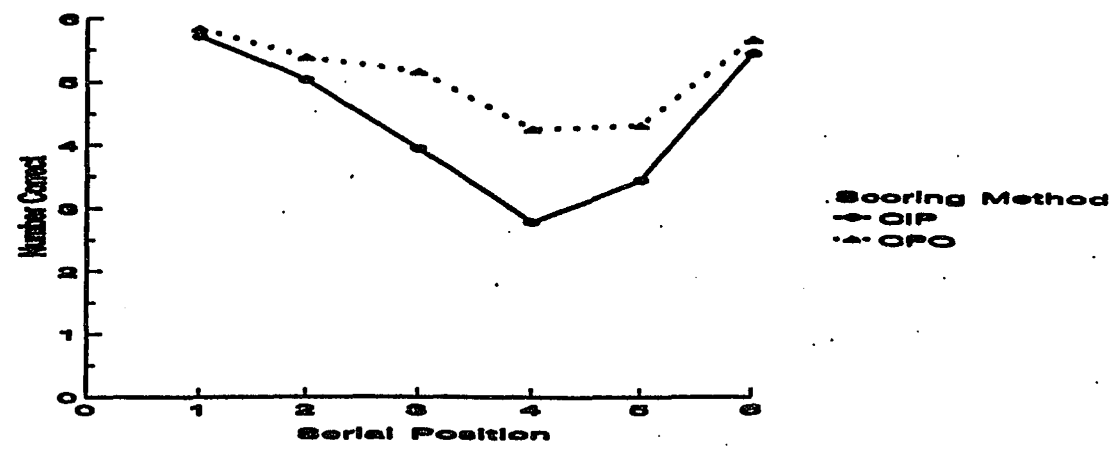
Comparison of CIP and CPO Scoring Methods. Figure 3 shows serial recall curves for each group, comparing CIP and CPO scoring. The improvement in recall with CPO scoring is strongly evident in the middle portion of the serial position curve for the young and the elderly, where there appears to be the most room for improvement. For the AD group, however, the improvement is greater at the end of the sequence.

The serial position curves in Figure 3 illuminate the difference between scoring method means for each of the three groups as a function of serial position, combining concrete and abstract performance. Recency was observed for the young and the elderly groups in CIP but enhanced with CPO scoring. For the AD subjects, the more lenient CPO scoring method strongly restored recency, which had been minimally observed with CIP scoring. This robust emergence of recency highlights a major disruptive function for the AD group in attending to the directions in the strict serial recall task.

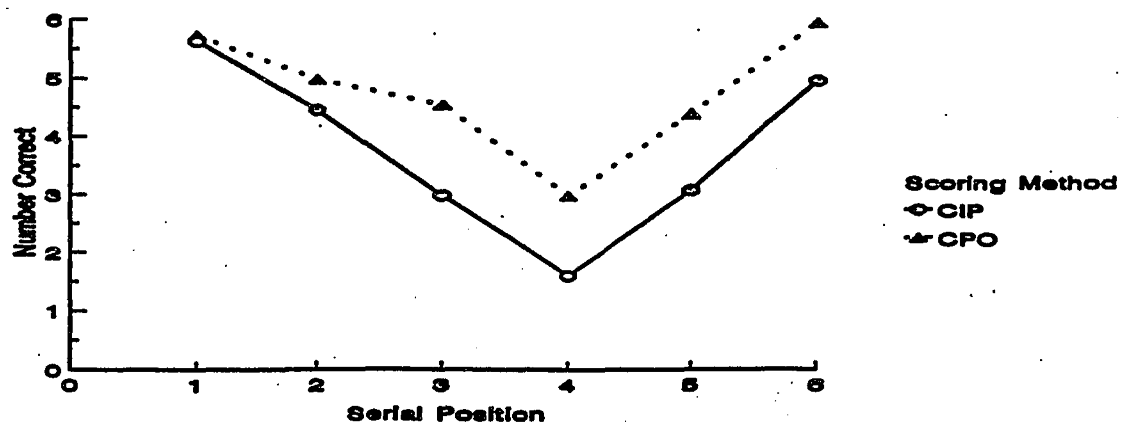
A 3 (Group) X 2 (Scoring Method) X 2 (Concreteness) X 6 (Serial Position) ANOVA was performed. Main effects were significant for all variables: group, F (2, 45) = 53.89, MS_e = 10.74; scoring method, F (2, 45) = 215.08, MS_e = 1.27; concreteness, F (1, 45) = 5.83, MS_e = 2.07; and serial position, F (5, 225) = 95.32, MS_e = 2.97. These main effects reflected the expected group recall differences with

Figure 3. Scoring method differences for young, elderly and AD subjects as a function of serial position in control conditions of Experiment 1.

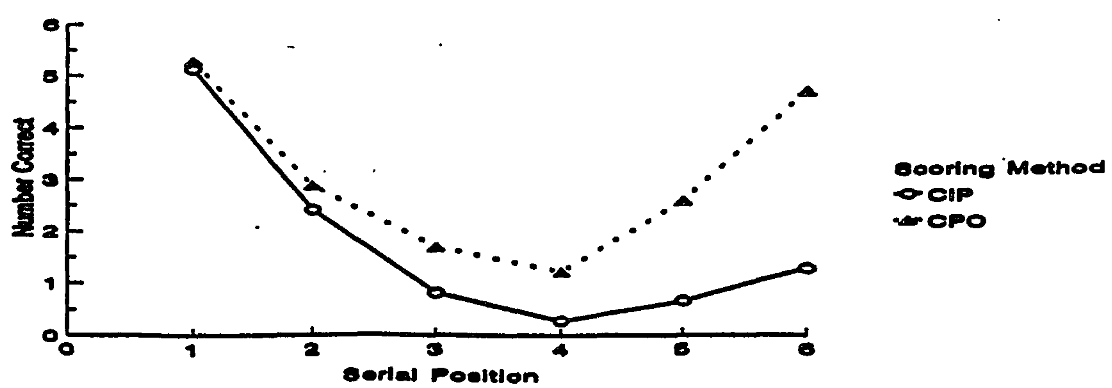
Young Subjects



Elderly Subjects



AD Subjects



*CIP = Correct in Position; CPO = Correct by Point of Origin.

age and dementia, definitive improvement in recall with more lenient scoring, overall differences in recall of concrete and abstract words as a result of the variation in scoring, and summed differences in recall across the serial position curve.

Although the main effect of concreteness was observed, due to the apparently greater misplacement of concrete words than abstract words for all groups, there was no reliable Scoring Method X Concreteness interaction in this ANOVA, $\underline{F} < 1.0$, suggesting that, summed across groups and serial positions, the two scoring methods retain the same ratio of correctly recalled concrete and abstract words.

Interactions of Group X Scoring Method, $\underline{F}$ (2, 45) = 6.69, $\underline{MS_e}$ = 1.27, Group X Serial Position, $\underline{F}$ (10, 225) = 5.72, $\underline{MS_e}$ = 2.97, and Scoring Method X Serial Position, $\underline{F}$ (5, 225) = 17.46, $\underline{MS_e}$ = 0.83 were significant. These interactions again reflected differentially improved performance between the groups due to the more lenient CPO scoring, and the presence of correct, but misplaced words at varying serial positions for each group. They further reflected improvement summed across groups at different positions in the serial recall curve. The effect of concreteness did not interact with any other variables.

A triple interaction of Group X Scoring Method X Serial Position, $\underline{F}$ (10, 225) = 11.39, $\underline{MS_e}$ = 0.83 was significant. Preplanned Dunnett tests were performed to examine group differences across the serial position curve comparing the two scoring methods, using the Group X Scoring Method X Serial Position interaction as the pooled error term, C-E = .32.

Table 3 shows the interesting pattern of improvement due to scoring method

Table 3

Mean Number of Words Recalled in Control Conditions of Experiment 1 as a Function CIP[a] and CPO[b] Scoring

	Serial Position					
	1	**2**	**3**	**4**	**5**	**6**
Young						
CIP	5.72	5.03	3.94	2.78	3.44	5.44
CPO	5.84	5.38*	5.16*	4.25*	4.31*	5.66
Elderly						
CIP	5.63	4.44	2.97	1.59	3.06	4.94
CPO	5.72	4.97*	4.53*	2.97*	4.38*	5.59*
AD						
CIP	5.13	2.41	0.81	0.28	0.66	1.28
CPO	5.28	2.88*	1.69*	1.22*	2.59*	4.69*

Note: * represents a significant Dunnett test, C-E = 0.32. Maximum score at each serial position is 6.00.

[a]: CIP = Correct In Position Scoring Method, in which a recalled word is considered correct only if it is recalled in the position in which it was presented.

[a]: CPO = Correct by Point of Origin Scoring Method, in which a recalled word is counted as correct regardless of its serial position during presentation.

across serial positions. There is no difference between scoring methods at Position 1 within each group. Primacy appears consistently strong in all groups, and the minimal improvement seen at that position is a result of the near perfect performance in recall for the first word presented. The middle of the serial position curve is where the young and elderly groups show the greatest improvement when recall is scored by CPO method. Indeed, improvement is seen at every other serial position for these two groups.

Improvement in performance due to CPO scoring at Position 6 shows a minimal trend toward improvement compared to CIP scoring for the young subjects, but shows increasingly greater improvement with age and dementia. This indicates very strong recency and few misplaced words for the young group, even in CIP scoring, and an increasing number of misplaced words with age and dementia as evidenced by the greater CIP - CPO differential, particularly in the terminal serial position. Therefore, AD subjects appear equivalent to young and elderly subjects in the strength of primacy and recency in strict serial recall when the scoring method is lenient.

The AD subjects showed generally poor performance under the strict scoring, yet recency was strongly restored with the more lenient scoring method. This indicates a reduced capacity to attend to directions and a reduced capacity to recall middle items of a 6-word list. However, the presence of primacy and recency suggests that there is a degree of cognitive processing and immediate memory retention in the AD group, although there may be reduced storage capacity compared to young and elderly subjects. The robust primacy exhibited by the AD group even under strict scoring is inconsistent with reports by Harris and Dowson (1972) who suggested that dementia has a greater deleterious effect on recall of words at the beginning of a list than on words at the end of a list. However, Harris and Dowson (1972) utilized a 10-word list, considerably longer than the present sequence of six words, and they included moderately impaired and severely impaired AD subjects.

Suffix Condition

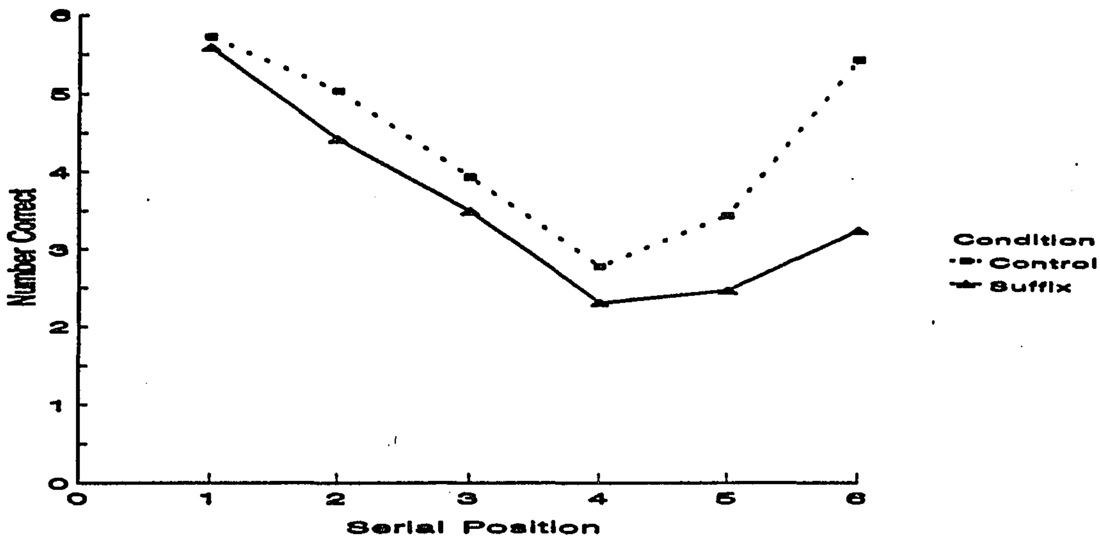
CIP Scoring Method.

Figure 4 shows a series of three recall curves, for the young, elderly and AD groups, comparing the control and suffix conditions as a function of serial position.

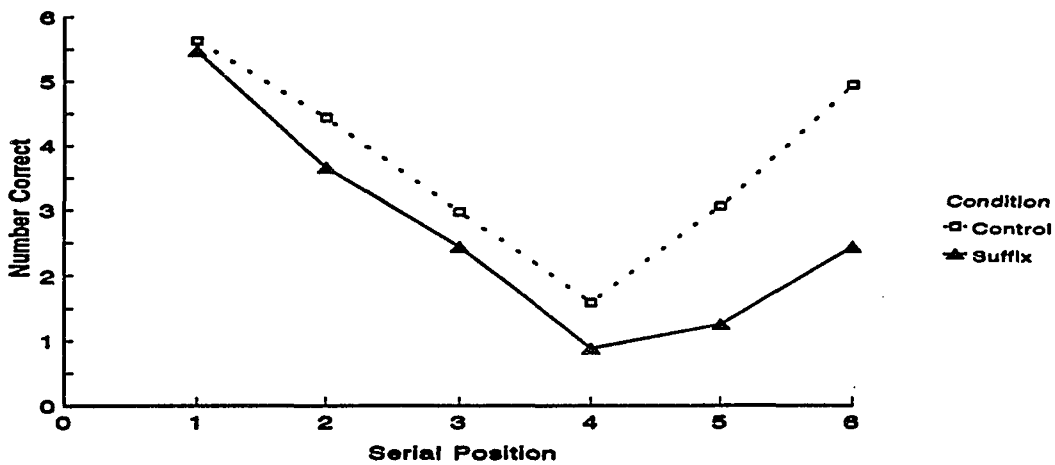
The level of performance at Position 1 appears strong for all groups, and there is decreasing performance for all groups through the middle portion of the curve. The suffix exerts its obvious effects on the recency portion of the curve. The differences between control and suffix conditions appear to be greatest for all subject groups at Positions 5 and 6. The smaller suffix effects for the AD group appear to be due to floor effects in recall performance for this group. Similarly poor recall performance for AD subjects compared with young and elderly subjects has been shown using alphanumeric stimuli in a suffix paradigm by Manning et al. (1992). The preterminal and terminal positions, 5 and 6, show as much of a decrement as can be expected given the poor level of performance. These serial position curves appear

Figure 4. Comparison of control and suffix conditions by group as a function of serial position using CIP scoring in Experiment 1.

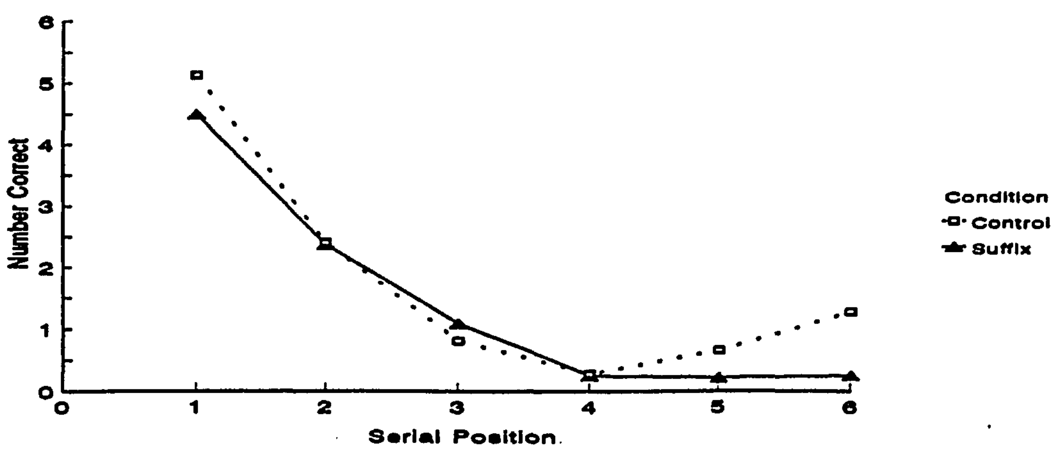
Young Subjects



Elderly Subjects



AD Subjects



consistent with previous literature (Crowder & Morton, 1969; Green, 1986; Manning & Greenhut-Wertz, 1990) indicating minimal interference with recall at the beginning of the sequence, but gradually increasing interference from the middle of the sequence to the final items.

A 4-way ANOVA, 3 (Group) X 2 (Concreteness) X 2 (Suffix) X 6 (Serial Position) was performed to determine the effect of the suffix in this experiment. The results, summarized in Table 4, showed main effects of group, F (2, 45) = 51.59, MS_e = 11.05, suffix, F (1, 45) = 143.12, MS_e = 1.08, and serial position, F (5, 225) = 125.62, MS_e = 3.15. These first two main effects reflected the expected decline in recall with age and dementia, and superior performance for all subjects in the control conditions compared with the suffix conditions. The serial position effects represented the usual effects of primacy and recency with diminished mid-sequence performance summed across all other variables.

The main effect of concreteness was not reliable, F (1, 45) = 2.07, MS_e = 1.94, and concreteness appeared not to interact with anything, as similarly observed in the control condition using CIP scoring. Strict serial recall appears to place attentional demands on the subjects, diminishing their ability to utilize concrete imagery to facilitate immediate recall.

Interactions of Group X Suffix, F (2,45) = 13.52, MS_e = 1.08, Group X Serial Position, F (10, 225) = 5.22, MS_e = 3.15, and Suffix X Serial Position, F (5, 225) = 16.43, MS_e = 1.23, were all significant. These interactions reflected the increasing effect of the suffix with age but small suffix effects with AD due to floor effects for

Table 4

Mean Number of Words Recalled in Control and Suffix Conditions of Experiment 1 as a Function of Subject Group and Serial Position Using CIP[a] Scoring

	Serial Position					
	1	**2**	**3**	**4**	**5**	**6**
Young						
Control	5.72	5.03	3.94	2.78	3.44	5.44
Suffix	5.59	4.41*	3.50*	2.31*	2.47*	3.25*
Elderly						
Control	5.63	4.44	2.97	1.59	3.06	4.94
Suffix	5.47	3.66*	2.44*	0.88*	1.25*	2.44*
AD						
Control	5.13	2.41	0.81	0.28	0.66	1.28
Suffix	4.50*	2.38	1.09	0.25	0.22*	0.25*

Note: * represents a significant Dunnett test, C-E = 0.38. Maximum score at each serial position is 6.00.

[a]: CIP = Correct In Position Scoring Method, in which a recalled word is considered correct only if it is recalled in the position in which it was presented.

this group, and the group differences in suffix effects across the serial position curve.

The triple interaction of Group X Suffix X Serial Position, $\underline{F}$ (10, 225) = 1.88, $\underline{MS}_e$ = 1.23, was also significant, reflecting group differences in end-of-sequence suffix effects. Preplanned Dunnett tests were performed to examine these interactions for the three groups using the Group X Suffix X Serial Position interaction as the pooled error term, C - E = .38. Collapsing across concreteness, Table 4 shows the mean number of words recalled in the control and suffix conditions across the serial positions for each group using CIP scoring. Both the young and the elderly subjects show a significant decrease in performance in the suffix conditions at Positions 2 through 6, but a slightly different pattern of performance is seen for the AD subjects.

The significant reduction of primacy in the suffix condition for the AD group appears to be an oddity rather than an indication that the suffix interferes with LTM as well as STM for this group. Significant suffix interference at Positions 5 and 6 was also observed for the AD subjects. Since it has been reported that end-of-sequence suffix effects may be different from pre-terminal suffix effects (Manning & Greenhut-Wertz, 1990), they were analyzed separately. A 1-way ANOVA comparing difference between performance in control and suffix conditions at Position 6 for young, $\underline{M}$ = 2.19, elderly, $\underline{M}$ = 2.50, and AD subjects, $\underline{M}$ 1.03, showed significant difference between groups, $\underline{F}$ (2, 45) = 5.00, $\underline{MS}_e$ = 1.92. A Duncan multiple range test indicated that the size of the terminal suffix effect for the AD group was significantly smaller than for the young and elderly groups, but there was no significant difference in the size of the terminal suffix effect for young and elderly subjects, with critical ranges for r_2 and r_3 of 1.01 and 1.19, respectively. The small suffix effect for the AD group reflected the poor recall performance observed at the end of the sequence.

As noted previously, further analysis is warranted to determine if a more lenient scoring method would change these results. Furthermore, the absence of a concreteness effect in all three groups prompted additional examination of this data utilizing the alternative scoring method to uncover possible concreteness effects and interactions.

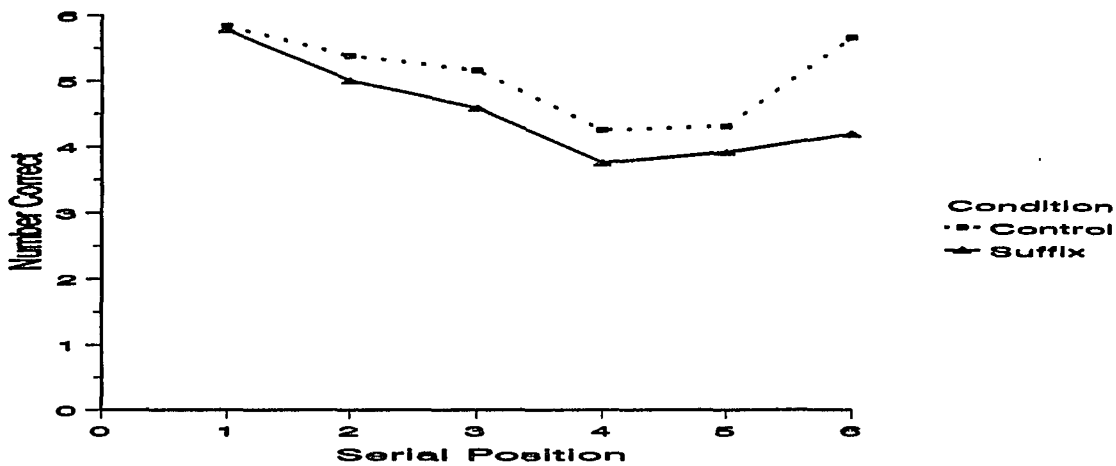
CPO Scoring Method. Figure 5 illustrates the effect of the suffix on performance across the serial position curve for the three subject groups using CPO scoring. Although overall performance is improved with CPO scoring, the suffix effects are obvious in the final positions of the recall curve for all subjects.

An analysis was performed using a 3 (group) X 2 (concreteness) X 2 (suffix) X 6 (serial position) ANOVA to determine differential effects of the suffix on concrete and abstract word recall for the three groups. Results are summarized in Table 5.

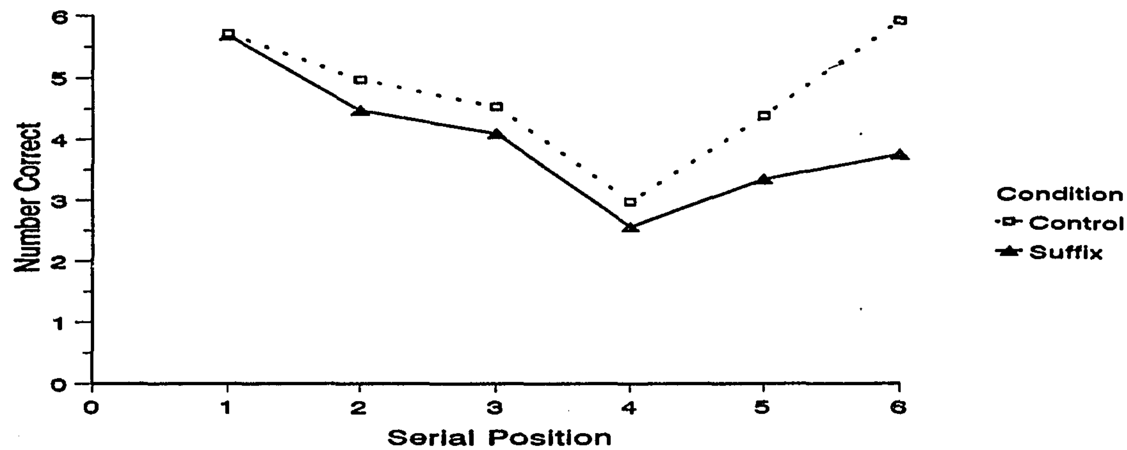
Significant main effects were seen for all variables: group, F (2, 45) = 45.95, MS_e = 9.42; concreteness, F (1, 45) = 10.84, MS_e = 0.8; suffix, F (1, 45) = 107.02, MS_e = 0.98; and serial position, F (5, 225) = 75.31, MS_e = 2.44. These main effects reflected the expected decline in recall with age and dementia, and overall superior recall for concrete compared to abstract words, in addition to the usual suffix effects and serial position effects summed over all measures.

Figure 5. Comparison of control and suffix conditions by group as a function of serial position using CPO scoring in Experiment 1.

Young Subjects



Elderly Subjects



AD Subjects

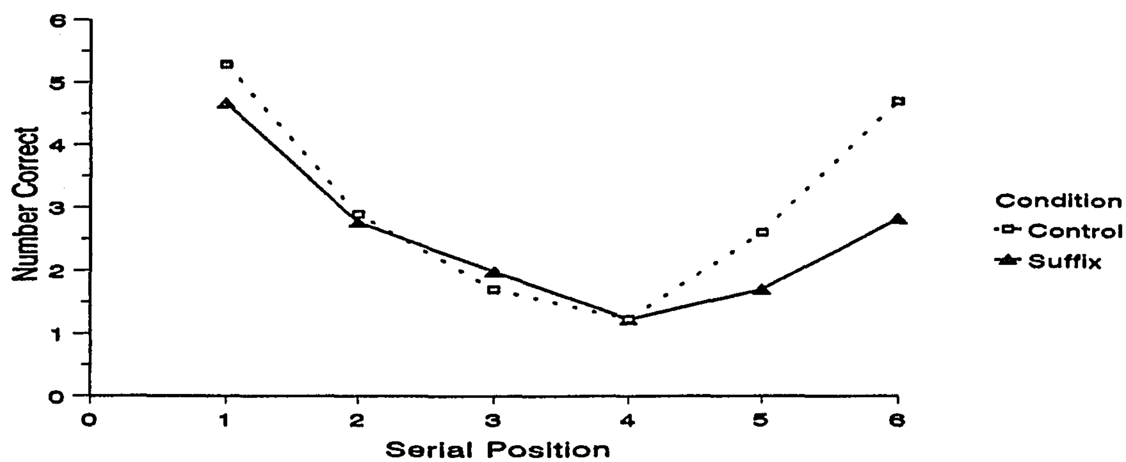


Table 5

Mean Number of Words Recalled in Control and Suffix Conditions of Experiment 1 as a Function of Subject Group, Concreteness, and Serial Position Using CPO[a] Scoring

	Serial Position					
	1	2	3	4	5	6
Young Concrete **M = 4.82**						
Control	5.81	5.44	5.25	3.88	4.56	5.88
Suffix	5.88	5.06*	4.50*	3.25*	4.13*	4.19*
Young Abstract **M = 4.82**						
Control	5.88	5.31	5.06	4.63	4.06	5.44
Suffix	5.69	4.94*	4.69*	4.25*	3.69*	4.19*
Elderly Concrete **M = 4.63+**						
Control	5.63	5.06	4.81	3.00	4.63	5.56
Suffix	5.75	4.81	4.50	2.44*	3.44*	3.94*
Elderly Abstract **M = 4.21**						
Control	5.81	4.88	4.25	2.94	4.13	5.63
Suffix	5.63	4.12*	3.69*	2.69	3.25*	3.56*
AD Concrete **M = 2.92+**						
Control	5.38	3.44	1.75	1.13	2.94	4.69
Suffix	4.69*	2.75*	2.57	1.19	1.63*	2.94*
AD Abstract **M = 2.65**						
Control	5.19	2.31	1.63	1.31	2.25	4.69
Suffix	4.63*	2.75	1.38	1.25	1.75*	2.69*

Note: * represents a significant Dunnett test, C-E = 0.34. Maximum score at each serial position is 6.00.

[a]: CPO = Correct by Point of Origin scoring method, in which a recalled list word is counted as correct regardless of the position in which it was presented.

+ represents a significant t test.

Again, as in the analysis of the control condition alone using CPO scoring, the emergence of the concreteness effect reflected the overall recall of more concrete compared to abstract words uncovered when this lenient scoring method is used. Responses which had been scored as incorrect because they were misplaced in serial position had, in fact, been encoded. Apparently, attentional demands of strict serial order affected all groups, but more concrete words compared to abstract words were misplaced rather than lost to recall.

The interaction of Group X Concreteness was not reliable, F (2, 45) = 2.72, MS_e = 0.80, although a concreteness effect had been expected to be evident for young subjects (Paivio, 1965, 1969; Paivio et al. 1969), while evidence for the elderly and AD subjects (Manning et al., 1992; Ober et al., 1986; Rissenberg & Glanzer, 1985) has been mixed and limited.

Paired t tests were performed on the difference between mean recall of concrete words and abstract words for each of the three groups. Summing concreteness over the suffix, no overall concreteness effect was observed for the young group, t (15) = 0.22. However, recall of concrete compared to abstract words was significantly greater for the elderly, t (15) = 2.33, and this significant trend became more pronounced for the AD group, t (15) = 3.5.

This increase in the concreteness effect for the elderly compared to the young group is not consistent with the diminished concreteness effect for elderly subjects reported by Rissenberg and Glanzer (1987), since they reported an attenuation of the concreteness effect for their elderly group. However, the greater concrete/abstract differential seen in our AD group was also seen for the AD subjects in Rissenberg and Glanzer's (1987) study. They utilized a free recall procedure which may have contributed to the discrepancy with our results, even though a lenient scoring method was applied to the present serial recall task. Rather than representing an ability to encode semantic information, the trend may reflect increasing difficulty in retrieval of abstract words compared to concrete words for both the elderly and the AD subjects, as Rissenberg and Glanzer (1987) suggested. However, our results are summed over control and suffix conditions, which may differentially bias the AD subjects. The differential effects of the suffix on concrete and abstract words may more accurately discriminate the three subject groups.

Table 5 also shows the mean recall of concrete and abstract words for each group, as well as the effect of the suffix on concrete and abstract words across serial positions. The interaction of Concreteness X Serial Position, F (5, 225) = 4.93, MS_e = 0.89, was reliable, reflecting more improved performance for concrete compared to abstract words in the middle of the sequence for all groups with the lenient scoring method, as seen by the less bowed recall curves in Figure 5.

Interactions were seen in Group X Serial Position, F (10, 225) = 5.91, MS_e = 2.44, and Suffix X Serial Position, F (5, 225) = 13.00, MS_e = 1.28, reflecting increasing differences in recall across the serial position curve with age and dementia, and a greater end of sequence reduction in performance in the suffix compared to the control condition. However, the Group X Suffix interaction was not reliable, F < 1.0, indicating similar overall effects of the suffix on performance for the three groups. In all groups, the suffix effect at Position 6 is larger than at any other location, as apparent in Figure 5, although a 1-way ANOVA comparing the difference between control and suffix conditions at Position 6 showed no significant difference between groups, $F < 1.0$.

There were no reliable triple interactions in this ANOVA, and the 4-way interaction of Group X Concreteness X Suffix X Serial Position was not significant, $F(10, 225) = 1.35$, $MS_e = 0.91$. However, because diminished recency due to the suffix was predicted for all groups, differences in the effect of the suffix on recall of concrete and abstract words across the serial position curve were examined. Preplanned Dunnett tests using the Group X Concreteness X Suffix X Serial Position interaction as the pooled error term, C - E = 0.34, show the locations of significant decrement across the serial position for each group.

As seen in Table 5, the patterns of performance decrements due to the suffix are similar across groups, with final position suffix effects greater than performance decrements at other positions. However, the AD group appear to show floor effects, which minimizes the apparent degree of interference from the suffix for this group.

The emergence of concreteness as a main effect in CPO scoring of this ANOVA raises questions of possible group differences in encoding semantic information, in interference effects and in complex interactions between concreteness and serial position. In order to better understand the improved performance observed when lenient scoring is applied to strict serial recall, a comparison of the two scoring methods is warranted.

Comparison of CIP and CPO Scoring Methods. The relationship between presentation order and recall information can be clarified by treating the two scoring methods as independent variables for purposes of analysis. The main effects of such analyses may be predictable, but the interactions could provide useful information (Manning, 1980). Therefore, to more closely examine the improvement observed when CPO scoring is applied, a 5-way ANOVA, 3 (Group) X 2 (Scoring Method) X 2 (Concreteness) X 2 (Suffix) X 6 (Serial Position) was performed.

The main effect of concreteness was reliable, F (1, 45) = 6.05, MS_e = 2.03. Even though concreteness was not a significant main effect in any of the CIP ANOVAs, and only emerged with the more lenient CPO scoring method, it could be expected that the pooling of these scoring methods may dilute any previously observed main effects. However, the fact that it remains when scoring methods are pooled may be a testimony to the strength of concreteness for all groups when uncovered by CPO scoring, but also could result from a near significant concreteness effect in CIP scoring combined with the increased d.f. There was no Scoring Method X Concreteness interaction in this ANOVA, $F < 1.0$, which was also the case when the scoring methods were compared in the control conditions alone, suggesting that summed across all other variables, the improved recall of concrete words was not significantly different than the improved recall of abstract words in the more lenient scoring method.

All other main effects were significant: group, F (2, 45) = 53.41, MS_e = 18.65; scoring method, F (1, 45) = 342.27, MS_e = 1.82; suffix, F (1, 45) = 167.39,

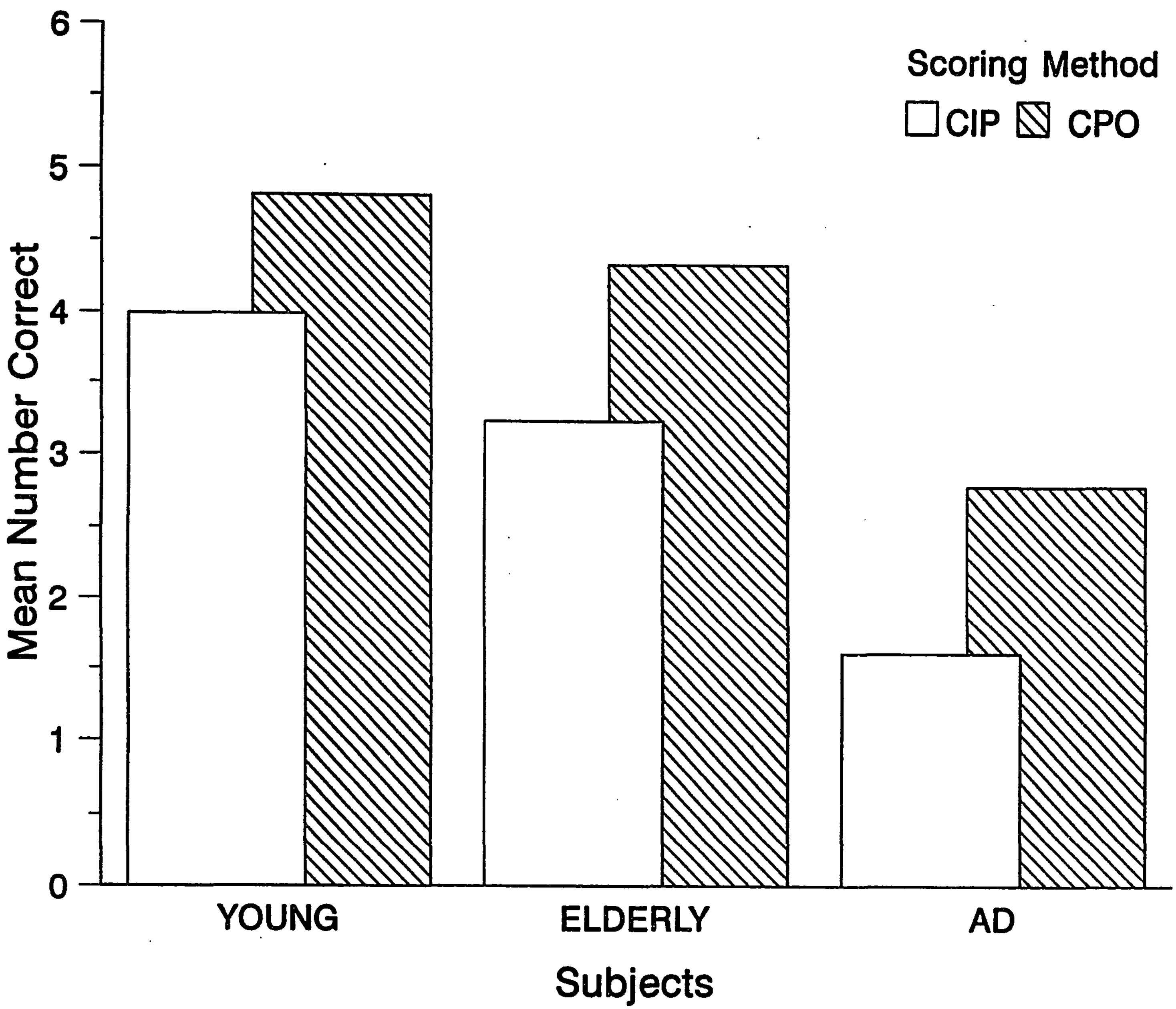
MS_e = 1.54; and serial position, F (5, 225) = 112.43, MS_e = 4.88. These effects are due to the expected performance decrements with age and dementia and to the obvious improvement for all subjects due to the more lenient scoring method applied. The main effects also reflect the expected standard suffix and summed serial position effects.

The triple interaction of Scoring Method X Concreteness X Serial Position, F (5, 225) = 2.39, MS_e = 0.39, reflected significant improvement due to lenient scoring at varying serial positions for concrete nouns compared to abstract nouns. Summed across all other measures, a comparison of mean performance for young, elderly and AD subjects is shown graphically in Figure 6.

The significant interaction of Group X Scoring Method, F (2, 45) = 3.69, MS_e = 1.82, shown in Figure 6, collapses concrete and abstract word recall, as well as differences across serial positions to emphasize these increasing scoring method differences with age and dementia.

The magnitude of the improvement in performance for all subjects with the more lenient CPO scoring method is consistent with previous literature utilizing both strict and lenient scoring methods (Sebrechts et al, 1989). Paired t tests showed that the magnitude of improvement with CPO scoring increased for the elderly compared to the young, and was even greater for the AD subjects compared to the elderly, t = 10.21, 10.78 and 11.14 for the young, elderly and AD groups, respectively. Strict serial recall, therefore, contributes to significantly poorer recall performance with age and dementia, which can be minimized with more lenient scoring.

Figure 6. Comparison of CIP and CPO scoring by group in Experiment 1.


Scoring Method
CIP
CPO
Mean Number Correct
0
1
2
3
4
5
6
YOUNG
ELDERLY
AD
Subjects

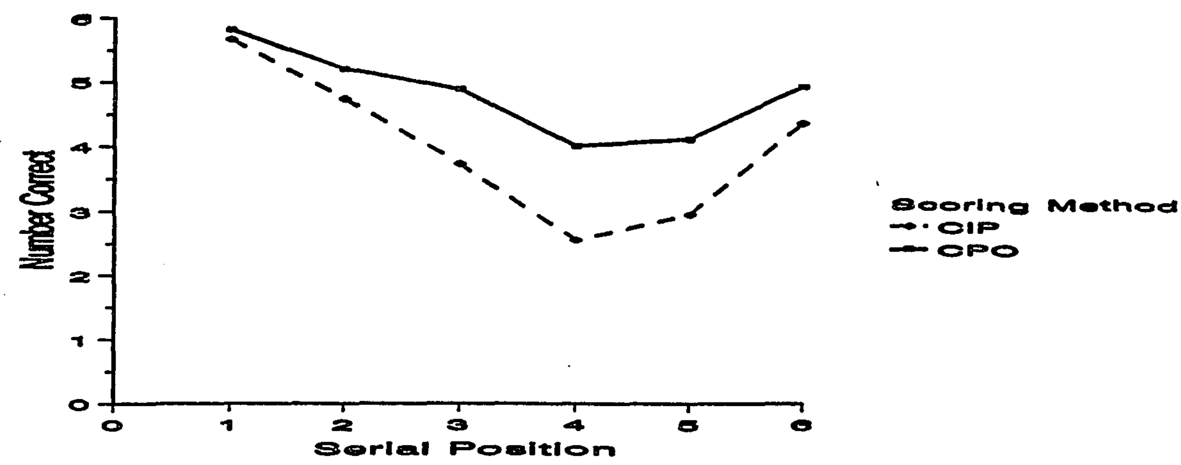
The significant interaction of Scoring Method X Serial Position, $\underline{F}$ (5, 225) = 43.51, $\underline{MS}_e$ = 0.71, and Group X Scoring Method X Serial Position, $\underline{F}$ (10, 225) = 16.21, $\underline{MS}_e$ = 0.71, is shown in the three serial position curves in Figure 7. Preplanned Dunnett tests, using the Group X Scoring Method X Serial Position interaction as the error term, C - E = .30, indicated significant improvement at Positions 2 through 6 for each group. The greatest area of improvement in recall for the young and the elderly subjects was in the middle portion of the serial position curve, indicating that more words in the middle of the sequence were misplaced than words either in the first or last positions.

Primacy is strong regardless of scoring method, and recency shows a significant improvement for all groups. A different pattern is observed for the AD group. No difference is seen in Position 1, and improvement due to scoring method gradually increases throughout the serial position curve, but a very steep improvement is seen at the terminal position. Immediate memory is functioning, but overshadowed by the demands of concentrating on the requirement of strict serial recall for the AD group. Indeed, the last item presented was frequently recalled but not placed in the last position.

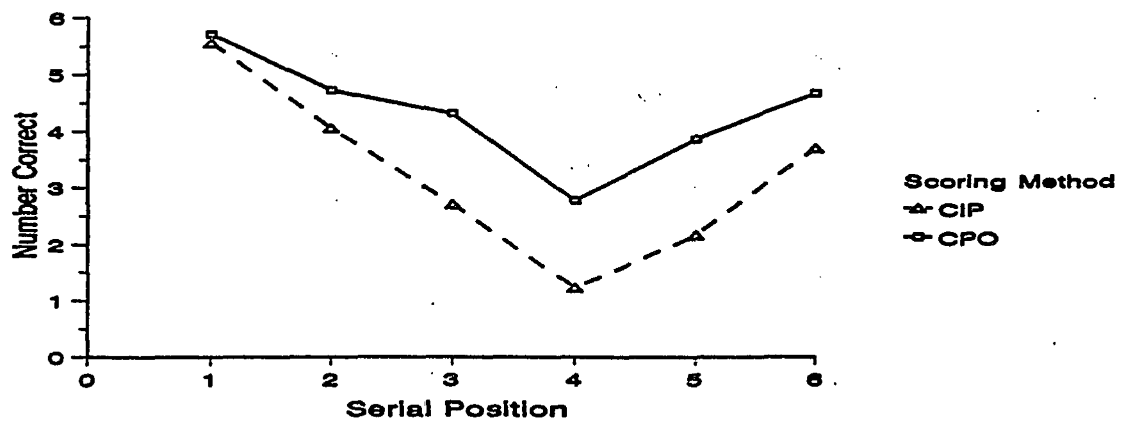
If there were a rapid decay in immediate memory for AD subjects (Miller, 1977), then this resurgence in recency would not be expected, even under lenient scoring conditions. This decay apparently affects the middle portion of the curve, but not the terminal portion, suggesting a possible difficulty with controlled processing or perhaps an interference effect. Although there is an overall diminished

Figure 7. Comparison of CIP and CPO scoring by group as a function of serial position in Experiment 1.

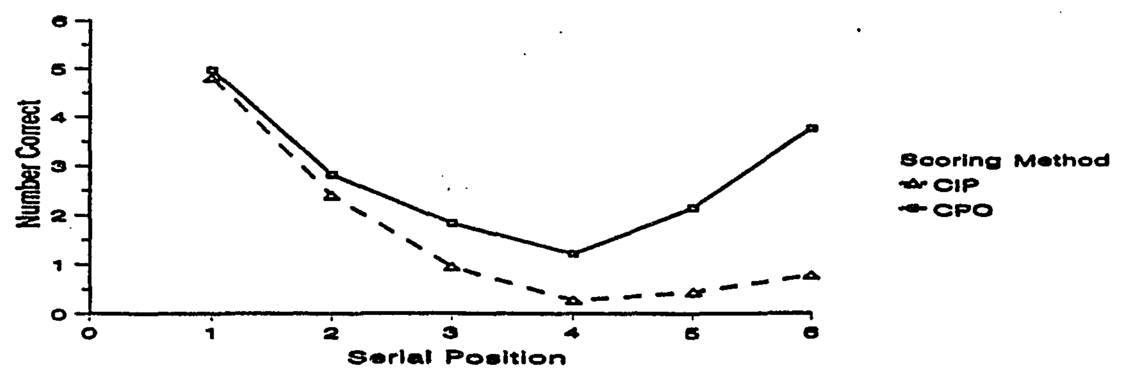
Young Subjects



Elderly Subjects



AD Subjects



performance for the AD subjects compared to the young and the elderly subjects, these serial position curves support previous studies which reported that primacy for AD subjects is not differentially affected when list length is controlled (Bemelmans & Goekoop, 1991).

Significant interactions of Group X Suffix, $\underline{F}$ (2, 45) = 6.88, $\underline{MS}_e$ = 1.54, and Suffix X Serial Position, $\underline{F}$ (5, 225) = 19.20, $\underline{MS}_e$ = 1.90, reflected the expected increasing interference by the suffix with age and dementia collapsed across scoring methods, and the differences across the serial position curve, as seen in Figure 7, caused by the suffix and due partially to significant end of sequence suffix effects for the AD group. The interaction of Scoring Method X Suffix, $\underline{F}$ (1, 45) = 4.53, $\underline{MS}_e$ = 0.53, reflected the obviously greater suffix effect with strict serial recall for all groups compared to a lenient scoring method.

The triple interaction of Group X Scoring Method X Suffix, $\underline{F}$ (2, 45) = 9.18, $\underline{MS}_e$ = 0.53, appears to reflect the differential improvement due to lenient scoring on control and suffix conditions, as well as serial position effects for the three subject groups. This also reflects the apparent reduction in the magnitude of the suffix effect for young and elderly but not for AD, as seen in Figures 4 and 5.

Confidence Ratings

Immediately following the recall of each six-word sequence in the four test conditions (e.g., concrete and abstract control conditions, and concrete and abstract suffix conditions), subjects were required to indicate whether they believed their answers were correct or incorrect. The signal detection measures of hits (the correct identification of a word as a member of the sequence just presented) and false alarms (the incorrect identification of words as part of the presented sequence) were compared for the three groups as discrimination indices in this metamemory measure. Our results, summarized in Table 6, indicate that this type of subject report is age-dependent, as Maylor (1990) also reported. The mean frequency of hits decreased with age, and the mean frequency of false alarms increased with age. These trends were magnified with the AD group: frequency of hits decreased by almost one-half, compared to the elderly group, while frequency of false alarms for the AD subjects nearly doubled compared to the elderly group.

The hit rates and false alarm rates were derived by adding 0.5 to each frequency and dividing by N + 1 (a correction recommended by Snodgrass & Corwin, 1988, for comparisons between populations having different discrimination or response bias patterns) where N is the number of correct or incorrect words recalled, in the case of a confidence rating in immediate recall, or when N is the number of old or new words in the case of a recognition trial. The sensitivity and response bias measures of P_r and B_r suggested by Snodgrass and Corwin (1988) in their theoretical description of measurements of recognition memory for demented and amnesic subjects, were calculated for the three groups. Sensitivity is measured and defined as the hit rate minus the false alarm rate (P_r = H-FA), and bias is measured and defined as the false alarm rate divided by the inverse of sensitivity (B_r = FA/1-P_r). Higher levels of P_r indicate better performance, while higher levels of

Table 6

Mean Hits, False Alarms, P_r and B_r for Three Subject Groups in Experiment 1

Group	Frequency Hits	Hit Rate	Frequency False Alarms	FA Rate*	P_r*	B_r
Young (N = 16)	90.25	.94	21.38	.75	.19	.92
Elderly (N = 16)	73.25	.94	24.00	.71	.23	.91
AD (N = 16)	36.06	.93	39.63	.91+	.03+	.93

*Indicates a significant ANOVA.
+Indicates a significant Duncan multiple range test.

B_r indicate a more liberal response bias.

Table 6 shows the mean frequency of hits and false alarms, the mean hit rate and false alarm rate, as well as the measures of sensitivity and bias, P_r and B_r.

A 1-way ANOVA comparing hit rates for the young, M = 0.94, elderly, M = 0.94, and AD, M = 0.93, groups indicated no difference between groups. Even though the mean frequency of hits was much lower for the AD group, the hit rate was based on the number of words correctly recalled rather than the number of words presented. A 1-way ANOVA comparing false alarm rates for the young, M = 0.75, elderly, M = 0.71, and AD, M = 0.91, groups indicated reliable differences between groups. A Duncan multiple range test showed no difference between the young and the elderly groups, but difference was reliable between the AD group and both the young and the elderly groups, with critical ranges for r_2 and r_3 of 0.13 and 0.05, respectively. This is consistent with previous reports (Diesfeldt, 1990; Helkala et al. 1989) of a liberal response bias on the part of AD subjects.

A 1-way ANOVA to determine group differences in sensitivity measure of P_r showed reliable differences, F (2, 45) = 12.55, MS_e = 0.02. Results reflect relatively poor sensitivity for all groups, although the AD group, M = 0.03, appears to be significantly less accurate in the correctness of their responses than either the young, M = 0.19, or the elderly, M = 0.23 groups. A Duncan multiple range test showed significantly poorer sensitivity for the AD group compared to both the young and the elderly, with critical ranges for r_2 and r_3 of 0.09 and 0.11 respectively.

A 1-way ANOVA to determine group differences in response bias was not reliable, $F < 1.0$. This appears to contradict the abnormally liberal, yeah-saying bias frequently attributed to AD subjects (Helkala et al., 1989). However, this is more likely a reflection of the decreased recall performance with age and AD found here, resulting in an overall lower number of words with age and dementia from which to identify those correct or incorrect. In this case, therefore, the sensitivity measure of P_r, in addition to the false alarm rate (rather than the Snodgrass & Corwin, 1988, bias measure of B_r) may more accurately discriminate the apparent differences with age and AD.

Intrusions

Intrusions, defined as words incorrectly included in recall which are not part of the sequence to be recalled, were divided into one of three categories: suffix intrusions, within-list intrusions, and extra-list intrusions. Suffix intrusions consisted only of the word "code" which was recalled despite instructions that it was not to be recalled. Within-list intrusions were words, either concrete or abstract, which were list words included in recall, but were not one of the six sequence words just presented. Extra-list intrusions consisted of words included in recall which were not part of the 72 experimental concrete and abstract nouns.

Table 7 shows the mean number of intrusions by group (M = 7.06, 4.63, and 13.13 for young, elderly and AD subjects respectively), as well as the group differences in the number of suffix, within-list, and extra-list intrusions. A 1-Way ANOVA showed significant differences between groups in the total number of

Table 7

Intrusion Errors by Group in Experiment 1

Group	All Intrusions*	M	Suffix Intrusions*	Within List Intrusions	M	Extra List Intrusions*	M
Young (N = 16)	113	7.06	0	88	5.50	25	1.56
Elderly (N = 16)	74	4.63	5	47	2.94	22	1.38
AD (N = 16)	210	13.13+	62+	93	5.81	55	3.44

*Indicates a significant ANOVA.
+Indicates a significant Duncan multiple range test.

intrusions observed, F (2, 45) = 6.52, MS_e = 47.03, although there was great variability. A Duncan multiple range test indicated no difference between the young and elderly groups in total intrusions, but the AD group differed significantly from both the young and elderly groups, with critical ranges for r_2 and r_3 of 5.01 and 5.92, respectively. The very large variance observed contributed to the lack of difference between means for the young and elderly subjects.

As seen in Table 7, the young group had no suffix intrusions, and the elderly group had only 5, 4 of which were made by a single subject, which precipitated a reexamination of that subject's data for the possibility of other deficits which would indicate problems with immediate recall. No evidence was found, and indeed all other data for that subject[6] was within normal age-appropriate limits. A 1-way ANOVA showed a not surprising significant group difference in the number of suffix intrusions between the three groups, F (2, 45) = 13.84, MS_e = 5.36. A Duncan multiple range test confirmed the lack of significant difference between the means for the young, M = 0.0, and elderly, M = 0.31, subjects, but an obvious significant difference was found between the means for the AD group, M = 3.88, and both other groups, with critical ranges for r_2 and r_3 of 1.69 and 2.00, respectively. Ober, et al. (1985) reported a similar increased frequency of test intrusions for AD patients compared to elderly controls.

As expected, the young and elderly groups appeared able to focus on the strict

[6] Immediate and delayed recall, digit span and MMSE (score of 27) were consistent with the group means. The MMSE is within normal age-appropriate limits (25-30) as reported by Reisberg et al., 1985.

serial task and disregard the word appended onto the end of the presented list in the suffix condition. At no time did the young subjects neglect to follow the instructions to disregard the suffix, and include it in their recall of presented words. This is consistent with results of Shindler et al. (1984), who noted that inappropriate intrusions are rare among healthy control subjects.

A breakdown of the other intrusion errors into within-list and extra-list words indicated, by the high number of within-list words, that subjects had encoded list words, even though they may have been recalled in the wrong six-word sequence. All subjects committed more within-list intrusions than extra list intrusions. A 1-way ANOVA indicated no difference between the three groups in the mean number of within-list intrusions, $\underline{F}$ (2, 45) = 1.65, $\underline{MS}_e$ = 24.08. The large within-group variance and the lesser number of output responses contributed to this lack of significance. A Duncan multiple range test likewise showed no difference between means of within-list intrusions for any of the subject groups, with critical values for r_2 and r_3 of 3.58 and 4.23, respectively. A negative trend in the frequency of within-list intrusions seen with the elderly subjects, $\underline{M}$ = 2.94, compared to the young, $\underline{M}$ = 5.50, and AD, $\underline{M}$ = 5.81, subjects may reflect a more cautious attitude toward guessing for the elderly group.

A 1-way ANOVA indicated significant group differences in the mean frequency of extra-list intrusions, $\underline{F}$ (2, 45) = 3.47, $\underline{MS}_e$ = 5.99. The extra-list words intruded by the young and elderly subjects were predominantly nouns, suggesting that they were cognizant of the semantic quality of the experimental list words. A

Duncan multiple range test, however, indicated no significant difference between the lowest and highest means (1.38 for elderly and 3.44 for AD subjects) limiting further testing of whether either of those means differed from the extra-list mean for the young subjects, 1.56, with critical ranges for r_2 and r_3 of 1.79 and 2.11, respectively. (The difference in means for the young and AD groups exceeds the shortest significant range calculated here, but it cannot be considered significant, according to Duncan [1981] since those two means are contained in a subset of means which has a nonsignificant range.)

As expected from previous literature (Shindler et al., 1984), the AD group had a significantly higher number of suffix intrusions, as well as more extra-list intrusions, than did the two normal groups. Similarly, in their comparison of intrusion errors for AD subjects, normal controls, and other dementia and aphasia subjects, Shindler et al. (1984) reported the occurrence of intrusions in 55% of their AD subjects (N = 22) but in only 1 normal elderly subject (N = 17) in a battery of vocabulary and naming tasks. (Intrusion occurrence for the other patient groups were 40% for stroke-related dementia patients, N = 22, and 20% in aphasia patients, N = 20.)

The findings of Gewirth et al. (1984), that nouns elicited more paradigmatic, or semantically related, intrusions from demented subjects than did verbs or adverbs, suggests that a judgment was made regarding the grammatical class of the stimulus words. They reported a significant decrease in paradigmatic responses with dementia severity, however. The robustness of this phenomenon, therefore, may be particular to mildly demented individuals, and as such provide valuable information in discriminating normal aging from early AD. The extra-list intrusions given by the AD subjects in the present study were often unrelated to the experimental nouns presented, whether concrete or abstract. Many of the words intruding were verbs, proper nouns, and other semantically and grammatically unrelated words. This supports the findings of Martin and Fedio (1983) and others (Butters et al., 1987; Ober et al., 1986) who found impaired semantic knowledge even in mildly impaired AD patients.

The qualitatively different intrusive errors in the AD group compared to the young and elderly groups may also reflect deficiencies in storage and consolidation, or may represent programming deficits, as suggested by Lowenstein et al. (1989) who also noted that unrelated intrusions occurred with greater frequency than other types of intrusions among AD patients compared to normal controls and subjects with vascular dementia. The trend toward greater frequency of extra-list intrusion errors for the AD group compared to the young and elderly is also consistent with Helkala et al. (1989) who reported greater extra-list intrusions and false positive errors for AD subjects compared to Parkinson disease (PD) subjects or normal controls.

Since the AD group in the present study also exhibited the greatest overall mean frequency of intrusions and the greatest mean frequency of suffix intrusions, the results appear to reflect their general inability to focus on the specific task, combined with a decreased ability to discriminate or to inhibit irrelevant information. However, the use of intrusion errors as a significant discriminator between normal and AD groups could be even more pronounced if a proportion were made of the total number of intrusions over the number of responses given. Since our AD group did show an overall decline in the number of words recalled, the proportion of intrusions may be an artifact of their poor recall performance.

Digit Spans

Auditory and visual digit spans were examined for the three groups, and the results are summarized in Table 8.

Paired t tests examined possible differences between auditory and visual digit spans within each of the three groups. There was no difference for the young and the AD subjects, t (15) = 1.31, t (15) = 1.72, respectively between auditory and visual digit spans, although the trend was in the direction of auditory superiority. There was, however, significant superiority for auditory compared to visual digit spans for the elderly group, t (15) = 3.50, possibly revealing better attentional processes or a larger storage capacity for stimuli presented auditorily for this group (Manning & Greenhut-Wertz, 1990; Schab & Crowder, 1989), or perhaps reflecting a subtle visual impairment in this elderly population. However, since the auditory spans were repeated orally, and the visual spans were written, the complexity of the visual span task may have differentially affected performance for the elderly group. Furthermore, the latency of the written response is longer than the oral response, and may stretch the limits of STM. This dissimilar response procedure obviously causes a confound in a comparison across modalities. It would have been preferable that both auditory and visual span tasks required either an auditory response or a

Table 8

Auditory and Visual Digit Span Means in Experiment 1

Modality	Young N = 16	Elderly N = 16	AD N = 16
Auditory**	8.13	7.25*	5.88
Visual**	7.75	6.50	5.25

* Indicates a significant t-test for auditory superiority.
** Indicates a significant difference between groups.

written response. However, the within-modality differences found are valid and interesting.

Reisberg et al. (1985) has reported that auditory digit span provides a significant discrimination between normal elderly and mild AD (GDS 4) subjects, which is examined in this data. A one-way ANOVA comparing auditory spans for the three groups indicated a significant difference, F (2, 45) = 13.93, MS_e = 1.48. A Duncan multiple range test indicated no difference between auditory digit span means for young, M = 8.13, and elderly, M = 7.25, subjects, but the AD group, M = 5.88, did differ significantly from both the young and elderly groups, with critical ranges for r_2 and r_3 of 0.89 and 1.05, respectively.

Crook, Ferris, McCarthy and Rae (1980) have reported no difference in standard auditory digit spans for young, elderly and demented subjects (7.3, 7.2, and 6.8, respectively). However, when response complexity was altered (e.g., dialing digits on a telephone apparatus), differences among the three groups were maximized. The auditory digit spans for the young and the elderly subjects in the present experiment appear consistent with those of Crook et al. (1980), although the AD group exhibited significantly poorer performance. (The digit spans for the elderly and AD groups are, however, similar to digit span means of 5.9 for AD subjects and 6.1 for normal controls, reported by Martin et al., 1985.)

Of particular interest were the highly significant group differences observed for the visual digit span, F (2, 45) = 20.09, MS_e = 1.24. A Duncan multiple range test confirmed this significant difference between mean visual digit span for all subject groups. The young group, M = 7.75, performed significantly better than both the elderly, M = 6.5, and the AD, M = 5.25, groups, and the AD group showed significantly poorer performance on mean visual span than both the young and the elderly groups, with critical ranges for r_2 and r_3 of 0.81 and 0.96, respectively.

The requirement of writing the numeric information after visual presentation may interfere with retention of information and cause more disruption in older and demented subjects than in young subjects, possibly as a result of the increased complexity of this task compared to the standard auditory digit span task, as suggested by Crook et al. (1980). However, since the elderly subjects were the only group to evidence a significant decrement in visual span, it may be that a comparison of auditory and visual spans could discriminate young and AD subjects, but not normal elderly and mildly demented subjects, supporting the utility of the more complex digit task as a discriminator between young, elderly and mild AD subjects. However, as previously stated, our between-modality results cannot accurately address this possible distinction because of the variation in response procedures for auditory and visual spans.

Delayed Recall

It has been well documented that it takes longer to recall verbal information as we get older. Information recalled after a filled delay, as in this experiment, is retrieved from LTM, and the ability to recall recently acquired, but not recently presented, information declines with age (Waugh, Thomas, & Fozard, 1978). Hart, Kwentus, Harkins, and Taylor (1988) have demonstrated a very rapid rate of forgetting for AD subjects. They suggested that a disruption in memory storage occurs within 10 minutes after presentation of information, but that remaining information could be organized or assimilated to develop stable memory representations. Since the delay in this experiment was approximately 30 minutes between presentation of sequences and delayed recall, we might expect minimal residual memory in a delayed recall task.

Table 9 shows the mean frequencies of both concrete and abstract words recalled in this delayed condition for the three groups, as well as the mean proportion of concrete compared to total words recalled. The total number of words recalled for the AD group was small, and for 6 subjects, no words were recalled at all in this delayed condition. Therefore, in examining the group differences in delayed recall of concrete and abstract words, only 10 AD subjects were included in the various analyses.

Absolute Scores. As expected in the delayed recall condition, the young subjects recalled a significantly greater mean number of words than did the elderly subjects, who in turn recalled significantly greater mean number of words than the did the AD group (14.06, 9.75, and 1.90, respectively). A between group comparison using means of the total number of words recalled in the delayed condition showed highly significant group differences, F (2, 41) = 33.62, MS_e = 13.56. Since 6 AD subjects had been omitted from analyses in the delayed condition, the number of subjects in each group was not equal. Therefore, to determine the location of these

Table 9

Delayed Recall of Concrete and Abstract Words in Experiment 1

Group	All Words	M**	Concrete Number	M	Proportion Concrete	Abstract Number	M
Young (N = 16)	225	14.06+	156	9.75*	0.69	69	4.31
Elderly (N = 16)	156	9.75+	103	6.44*	0.66	53	3.31
AD (N = 10)	19	1.90+	18	1.80*	0.95	1	0.10

*Indicates a significant t test.
**Indicates a significant ANOVA.
+Indicates a significant Duncan multiple range.

differences, an extension of Duncan's multiple range test (Kramer, 1956) for the case of unequally replicated means was performed which provided a more conservative measure of significance. The correction uses the basic rule for Duncan's test and applies it to a particular subset of means with adjusted ranges based on the square root of the average combined replications for that subset. Even with this more conservative correction, significant differences were found in delayed recall between all groups, with adjusted critical ranges for r_2 and r_3 of 3.30 and 3.90, respectively.

The severe drop in number of words recalled for the AD group is consistent with findings of Salmon, Granholm, McCullough, Butters, and Grant (1989), who have reported that mild and moderate AD subjects were significantly impaired on a delayed recall task of 15s and 2 minutes. However, when you consider the time delay between immediate recall of the sequences and the delayed recall in this study, which was approximately 30 minutes after the immediate recall tasks, the poor performance is seen in a less harsh light. Furthermore, several intervening activities, MMSE and both verbal and visual digit span, contributed retroactive interference. Therefore, the poor delayed recall performance for the AD group is expected.

Comparing the number of concrete and abstract words recalled, delayed recall showed a strong concreteness effect for all three groups, unlike the mixed and equivocal results for immediate recall. Within group differences in delayed recall of concrete and abstract words were compared using two-tailed, paired t tests. Concrete words were recalled more frequently than abstract words for all groups: young, t (15) = 5.11; elderly, t (15) = 3.69; and AD, t (9) = 5.67. Between group interactions in delayed recall of concrete and abstract words were also examined. A 3 (Group) X 2 (Concreteness) ANOVA showed a significant interaction, $\underline{F}$ (2, 78) = 3.72, $\underline{MS}_e$ = 6.29, revealing very potent differences between groups: There was a severely increasing decline in delayed recall with age and dementia, as well as variation in the degree of concreteness evident in the three groups.

Difference Scores. Between group comparisons were again conducted in the delayed recall condition using the difference between concrete and abstract words recalled for young, elderly, and AD subjects, $\underline{M}$ = 5.44, 3.13, and 1.70, respectively. A 1-way ANOVA showed a significant difference between concrete and abstract words in this delayed task with age and dementia, $\underline{F}$ (2, 41) = 4.04, $\underline{MS}_e$ = 11.58, indicating the decline across groups in the magnitude of difference between concrete and abstract word recall. A further examination of these difference scores was therefore conducted using the extension of Duncan's multiple range test for the case of unequally replicated means, as described for overall frequency of delayed recall. No difference was found between the young and elderly groups, or between the elderly and the AD groups. However, significance between means of the concrete/abstract difference was found between the young and AD groups, with adjusted critical ranges for r_2 and r_3 of 2.75 and 3.25, respectively. This greater concrete/abstract differential exhibited by the young group, however, reflects their significantly greater overall performance in the delayed condition.

Proportion Scores. To correct for group differences in the total number of words recalled and thereby to provide a more accurate measure of concreteness, the proportion (%) of each subject's delayed recall of concrete words over total words recalled was calculated for the young, M = 0.69, elderly, M = 0.66, and the AD, M = .95, groups (shown in Table 9). One-sample t tests showed significance for each group, and again, the 6 AD subjects who did not recall any words in the delayed condition were omitted from this analysis. Thus, for the young, t (15) = 4.86, for the elderly, t (15) = 3.84, and for the AD, t (9) = 24.00. The large t statistic for the AD group reflects the fact that even though the total number of words recalled for this group was minimal (a floor effect), those words which were recalled were entirely from the concrete list words with one exception: for the single AD subject who recalled the largest total number of words for the group (5 words), 4 of those 5 words were concrete list words.

Between group differences were again determined using the proportion scores. A 1-way ANOVA showed significant difference in proportion scores between the young, elderly and AD groups, F (2, 41) = 15.62, MS_e = 0.02. Again, applying the extension for Duncan's multiple range test to account for unequal groups, no difference was found between the young and the elderly groups, but a significant difference was found between the AD subjects and each of the two other groups in mean proportion of concrete over total words recalled in this delayed condition, with adjusted critical ranges for r_2 and r_3 of 0.12 and 0.14, respectively. Thus, in contrast to the findings using the difference scores, the AD group exhibits a much greater concreteness effect than young and elderly groups when proportions are used.

Welsh, Butters, Hughes, Mohs, and Heyman (1991) suggested that delayed recall may be a particularly useful discriminator of early AD, and the present results support these observations. Not only are the AD subjects showing significantly fewer overall number of words recalled in the delayed condition, but they can be discriminated from young and elderly on the basis of the large concreteness effect observed when proportion of concrete to total words recalled is analyzed.

Experiment 2

Overview

Based on previous literature and the present findings with regard to strict serial recall, specifically the lack of concreteness in immediate recall for all three groups using strict CIP scoring, the question remained as to why we did not observe concreteness in strict serial recall. Is attention so compromised by attending to the order of the presentation that it overrides the subject's ability to encode the semantic qualities of the nouns? An examination of free recall was performed altering only the directions to the subject.

Because of the emergence of the concreteness effect, particularly with the AD subjects, when CPO scoring was applied to strict serial recall, and to a greater degree in the delayed recall condition in Experiment 1, concrete words did apparently enter a memory store more accessible to retrieval than did abstract words. (It is possible that concrete words are more easily encoded and stored in long term memory than are abstract words, or perhaps because of association networks, concrete words are more easily retrieved from that long term store.)

The demands of strict serial recall may have contributed to the unique and seemingly disparate findings. The free recall procedure was hypothesized to free the subjects from the demands of strict serial order, and thus would be expected to enhance the recall of both concrete and abstract words. Similarly, the suffix appeared to have an equivalent effect on both concrete and abstract words for all three groups, and under both scoring methods. If there had been a strong concreteness effect, interference from the suffix would be expected to have been greater for abstract words than for concrete words. We determined, therefore, to examine free recall and measure concrete imagery and suffix effects in these three groups to evaluate the possible constraint which strict serial recall may place on the concreteness effect.

Methods

All aspects of Experiment 2, except those reported below, are the same as in Experiment 1.

Subjects

For Experiment 2, 48 new subjects (16 in each group) were recruited and matched with subjects from Experiment 1 in terms of age, years of education, and GDS level. The young, elderly and AD subjects were drawn from the same academic, community and medical subject population as those subjects in Experiment 1, and English was the first language for all subjects. The young subjects (3 male, 13 female) ranged from 20 to 30 years of age (M = 23 years) with an average of 15.9 years of education. The normal elderly subjects (8 male, 8 female) ranged in age from 58 to 85 years (M = 72.6 years) and had an average of 15.6 years of education. The AD subjects (7 male, 9 female) were all diagnosed with possible or probably AD (based on the criteria stated in Experiment 1) and had an average of 14.6 years of education. A 1-way ANOVA showed no difference in education level for subjects in the three groups, $\underline{F}$ (2, 45) = 0.83, $\underline{MS_e}$, = 9.03. Table 10 shows the equivalent subject characteristics for the young, elderly and AD groups in Experiment 2.

Procedure

A standard free recall procedure was used in this experiment. Instructions (included in Appendix C) varied from Experiment 1 only to the extent that the subjects were asked to write the list words in any order they recalled them. Answers were counted as correct if a sequence word was recalled regardless of the order of presentation.

Additional Tests

Auditory and visual digit spans, MMSE, and delayed recall of list words were performed and analyzed for Experiment 2 just as described for Experiment 1. Additionally, a delayed recognition task was administered to a subset (the last 8 subjects in each of the two groups) of the elderly and AD subjects participating in Experiment 2. Immediately following the delayed recall task, the subset of elderly and AD subjects participated in a word recognition task. Twenty words randomly chosen from the 72 experimental list words (10 concrete and 10 abstract words) were combined with twenty new words (10 concrete and 10 abstract words) extracted from the Thorndike and Lorge (1944) norms, but not part of the experimental set. These distractor words were all from 4 to 7 letters in length and had mixed imagery and concreteness ratings. Subjects were shown the list of 40 words (included in Appendix

Table 10

Subject Characteristics in Experiment 2

Characteristics	Young N = 16	Elderly N = 16	AD N = 16
Sex			
Male	3	8	7
Female	13	8	9
Age			
Mean	23.0	72.6	70.4
Range	20 - 30	58 - 85	55 - 85
Education			
Mean Years	15.9	15.6	14.6
Range	14 - 20	11 - 20	10 - 20
Mini Mental State Exam			
Mean	29.7	27.8	21.3
Range	29 - 30	26 - 30	11 - 27

C) randomly arranged in columns on a single sheet of paper. Subjects were instructed to circle any words which they recognized from the experimental list words previously presented to them. Based on earlier research (Branconier, Cole, Spera, & DeVitt, 1982; Salmon et al., 1989) recognition was expected to show ceiling effects for the normal elderly group but be less accurate for the AD group, both in terms of identifying the 20 list words and in terms of incorrectly recognizing non-list words.

Results and Discussion

In this free recall paradigm, scoring was accomplished using only one scoring method, Correct by Point of Origin (CPO) scoring, since subjects were instructed that word recall order was not considered in scoring the presented word sequences. Therefore, words were counted correct if they were part of the just presented sequence, regardless of the serial position in which they were presented or the position in which they were recalled.

Control Condition

Group differences and concreteness effects were initially analyzed in the control condition alone, independent of interference from the suffix.

The expectation of robust recency was examined by comparing performance at Positions 5 and 6 for the three groups. Paired t tests again indicated significant recency for the young, t (15) = 3.93, the elderly, t (15) = 7.81, and the AD, t (15) = 5.46 groups, although a 1-way ANOVA showed no differences between groups in the magnitude of recency, $\underline{F}$ (2, 45) = 2.14, $\underline{MS}_e$ = 1.29.

Using CPO scoring, the control conditions were analyzed using a 3-way ANOVA, 3 (Group) X 2 (Concreteness) X 6 (Serial Position). The main effects of group, $\underline{F}$ (2, 45) = 17.38, $\underline{MS}_e$ = 7.25, concreteness, $\underline{F}$ (1, 45) = 9.29, $\underline{MS}_e$ = 0.63, and serial position, $\underline{F}$ (5, 225) = 41.37, $\underline{MS}_e$ = 1.61, were all significant. These results, summarized in Table 11, reflect the expected group differences of a decline in recall with age and dementia, the expected superior recall of concrete compared to abstract words, and the differences in recall across the serial position curve summed across the various conditions.

As in Experiment 1, the interaction of Group X Concreteness was not significant, $\underline{F}$ < 1.00. The trend of improved recall for concrete compared to abstract words was apparent and reasonably equivalent for all groups, as seen by the concrete and abstract means reported in Table 11. Even though overall recall diminished with age and AD, the size and direction of this small trend in concrete superiority remained consistent across groups.

The interaction of Concreteness X Serial Position, $\underline{F}$ (5, 225) = 3.01, $\underline{MS}_e$ = 0.80, reflected differential and inconsistent variation in recall of concrete compared to abstract words across the serial position curve in all groups. The beginning of the sequence (Positions 1 - 3) appears to show a trend toward a greater concreteness effect than the final half of the sequence (Positions 4 - 6).

To further examine the effects of concreteness and group on recall, preplanned Dunnett tests were performed using the Group X Concreteness X Serial

Table 11

Mean Number of Words Recalled in Control Conditions of Experiment 2 as a Function of Subject Group, Concreteness, and Serial Position

	Serial Position					
	1	**2**	**3**	**4**	**5**	**6**
Young						
Concrete M = 5.19	5.69	5.69*	5.13	4.19	4.75	5.69
Abstract M = 4.99	5.69	4.94	5.19	4.00	4.44	5.69
Elderly						
Concrete M = 4.40	5.56*	4.56*	4.06*	3.00	3.56	5.63
Abstract M = 4.18	4.88	3.75	3.69	3.19	4.00	5.56
AD						
Concrete M = 3.56	4.81	3.38*	3.25*	2.56	2.69	4.69
Abstract M = 3.38	4.69	2.94	2.25	2.51	3.13	4.75

Note: * represents a significant Dunnett test, C-E = 0.32. Maximum score at each serial position is 6.00.

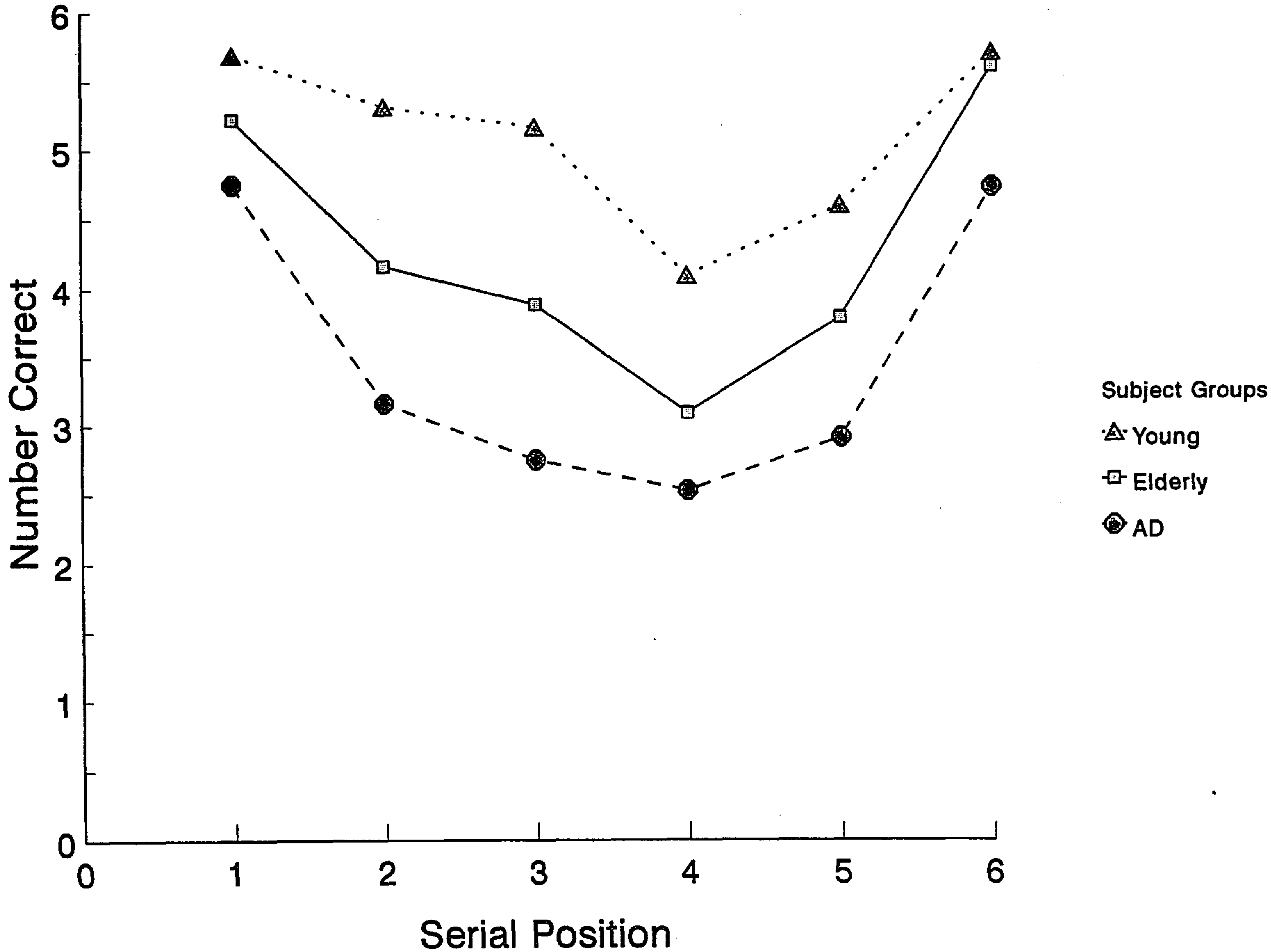
[a]: CPO = Correct by Point of Origin Scoring Method, in which a recalled word is counted as correct regardless of its serial position during presentation.

Position interaction as the pooled error term, C - E = .32. Table 11 provides some suggestion regarding the location of concreteness effects which, according to the Dunnett tests, are confined to the first half of the serial position curve. This appears to be consistent with Richardson (1978) who suggested that subjects do not image the last words presented in a free recall task. He reported that imagery affected the primary and middle portions of the recall curve.

Do subjects not image the final words because of a shortage of time before recalling the words? If so, those words would not enter a longer term storage and be available subsequently in a delayed recall task. Perhaps the concreteness of nouns is only expressed when greater processing is utilized in longer term storage compared to the immediate span of attention. The question arises as to which phenomenon occurs first: (a) the triggering of a greater number of relational memory codes by concrete compared to abstract words, facilitating processing into longer term storage; or (b) the greater processing of words in the first half of a recall sequence into long term storage, retrieval of which is facilitated by the degree of concrete imagery of the word. These questions cannot be adequately answered in the context of the present procedure, and may not be warranted considering the relatively weak findings, but certainly provide an interesting focus for future examination.

A significant interaction in this control condition ANOVA was also seen with Group X Serial Position, $\underline{F}$ (10, 225) = 2.07, $\underline{MS}_e$ = 1.61, which appears to be due to strong primacy and recency but increasingly diminished performance in the middle of the sequence with age and AD. Figure 8 shows the group differences in recall

Figure 8. Group differences in control conditions of Experiment 2 as a function of serial position.


Number Correct
0
1
2
3
4
5
6
0
1
2
3
4
5
6
Serial Position
Subject Groups
Young
Elderly
AD

across the serial position curve, summed across concreteness. These serial position curves, which represent the three groups using lenient CPO scoring in free recall, resemble those shown in Figure 3 representing group performance across the serial position curve using CPO scoring in serial recall. The free recall curves, however, are less bowed in the middle portion of the curve, which is the usual expectation due to the easier task which does not require recalling the words in the order of presentation.

Performance for the young group shows a minimal decrement in the middle positions of the curve, with increasing decrement with age and dementia. However, the overall recall curves for free recall (Experiment 2, Figure 8) indicates generally better performance compared to serial recall (Experiment 1, Figure 2). This will be examined further in a comparison of the two experiments.

Suffix Condition

Again using CPO scoring in this free recall paradigm, suffix effects were analyzed using a 3 (Group) X 2 (Concreteness) X 2 (Suffix) X 6 (Serial Position) ANOVA. Significant main effects were observed for all variables: group, F (2, 45) = 21.31, MS_e = 14.05, concreteness, F (1, 45) = 17.27, MS_e = 0.92, suffix, F (1, 45) = 144.83, MS_e = 0.75, and serial position, F (5, 225) = 47.14, MS_e = 2.43. These results, summarized in Table 12, were due to the expected decline in recall performance with age and dementia, superior recall for concrete compared to abstract words, an overall performance decrement for all groups in the suffix

Table 12

Mean Number of Words Recalled in Control and Suffix Conditions of Experiment 2 as a Function of Group, Concreteness, and Serial Position

	Serial Position					
	1	2	3	4	5	6
Young Concrete M = 4.98						
Control	5.69	5.69	5.13	4.19	4.75	5.69
Suffix	5.69	4.69*	4.75*	3.63*	4.75	5.13*
Young Abstract M = 4.76						
Control	5.69	4.94	5.19	4.00	4.44	5.69
Suffix	5.88	4.56*	4.19*	3.63*	4.31	4.56*
Elderly Concrete M = 4.10						
Control	5.56	4.56	4.06	3.00	3.56	5.63
Suffix	5.44	4.44	3.44*	2.69	3.38	3.50*
Elderly Abstract M = 3.81						
Control	4.88	3.75	3.69	3.19	4.00	5.56
Suffix	4.69	3.56	3.00*	3.19	2.81*	3.38*
AD Concrete M = 3.19						
Control	4.81	3.38	3.25	2.56	2.69	4.69
Suffix	4.63	3.13	2.63*	1.75*	2.00*	2.81*
AD Abstract M = 3.01						
Control	4.69	2.94	2.25	2.50	3.13	4.75
Suffix	4.25*	2.88	1.94	1.88*	2.06*	2.88*

Note: * represents a significant Dunnett test, C-E = 0.36. Maximum score at each serial position is 6.00.

condition, and serial position effects summed over all other variables. Table 12 shows the mean recall for suffix and control conditions as a function of group, concreteness, and serial position.

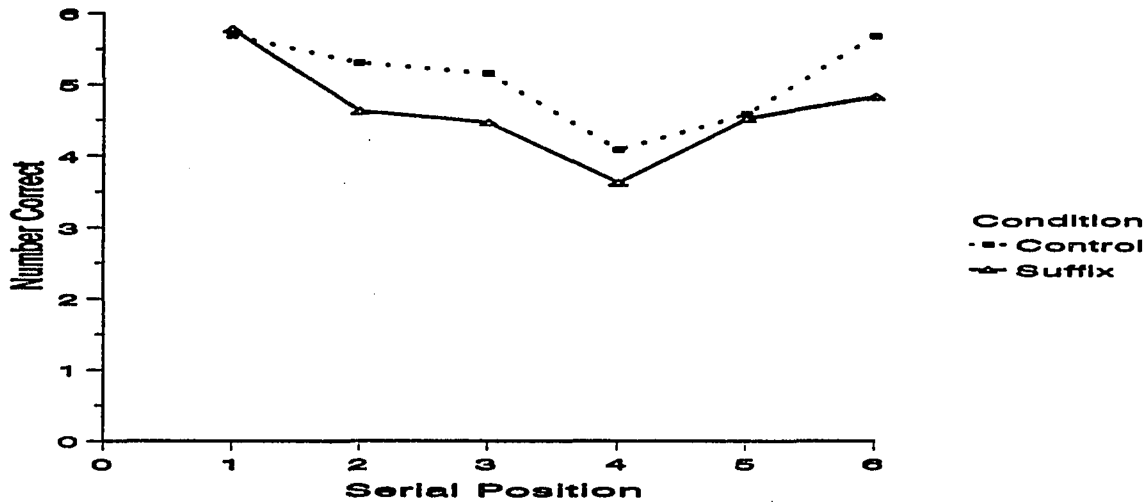
The Group X Concreteness interaction was not reliable, $\underline{F} < 1.0$, although the interaction of Concreteness X Serial Position, $\underline{F}$ (5, 225) = 3.18, $\underline{MS}_e$ = 0.97, showed significant variation in recall of concrete versus abstract words, summed across groups as well as control and suffix conditions, at different positions of the recall curve. As found in the control condition alone, the interaction of concreteness with serial position suggests that concrete and abstract words may be differentially affected by presentation position (e.g., concrete words presented in Position 1 may be recalled more easily than abstract words presented in Position 1). However, since there was no interaction between concreteness and the suffix condition, it appears that concrete and abstract words are not significantly differentially affected by interference from a suffix. There was no reliable interaction of concreteness with any other variable.

Figure 9 shows three serial position curves for young, elderly and AD subjects, respectively, showing the effect of the suffix throughout the serial positions in this free recall paradigm. Primacy, as well as a reduction in recency due to the presence of the suffix, is seen for all groups.

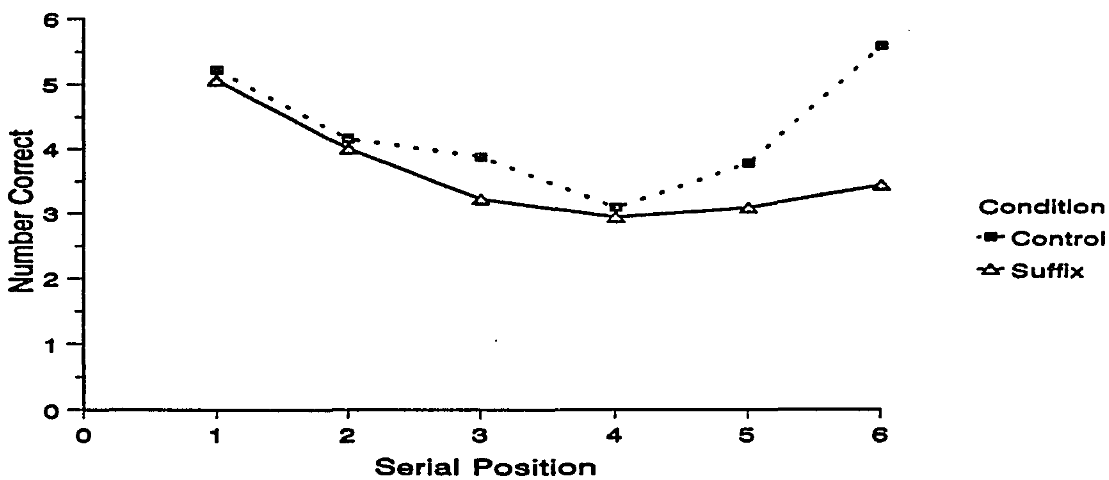
The interaction of Group X Suffix, $\underline{F}$ (2, 45) = 2.96, $\underline{MS}_e$ = 0.75, was not significant, reflecting the general equivalence of the suffix effect for the three groups. The interaction of Group X Serial Position, $\underline{F}$ (10, 225) = 1.20, $\underline{MS}_e$ = 2.43, was also

Figure 9. Comparison of control and suffix conditions by group as a function of serial position in Experiment 2.

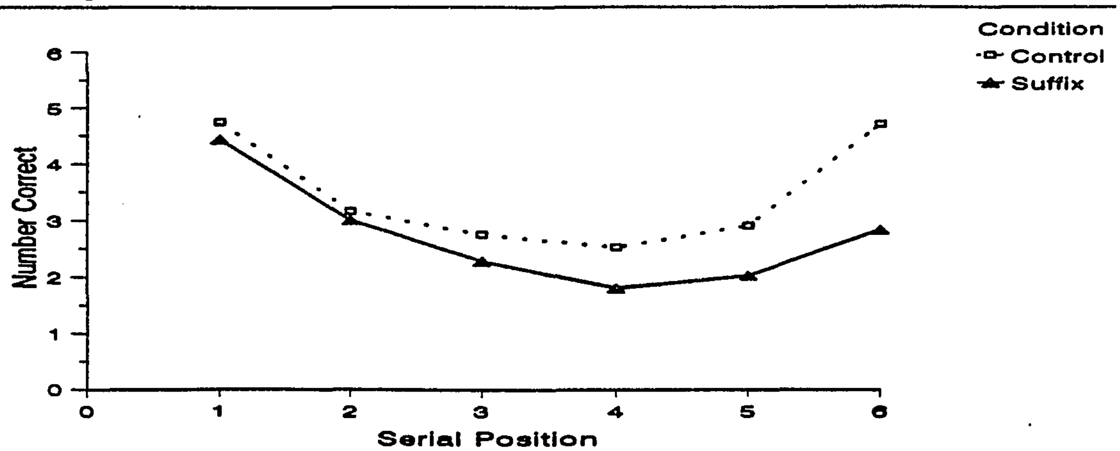
Young Subjects



Elderly Subjects



AD Subjects



not significant, reflecting the similarity in performance across the serial position for the three groups.

The significant interaction of Suffix X Serial Position, F (5, 225) = 13.38, $\underline{MS}_e$ = 0.99, reflects a robust reduction in recency due to interference from the suffix for all groups. In addition, the significant triple interaction of Group X Suffix X Serial Position, F (10, 225) = 2.44, $\underline{MS}_e$ = 0.99, reflects the differential effects of the suffix itions for the three groups.

The suffix exerts its significant effect in the middle and final positions of the serial recall curve. The elderly subjects show an overall lowering of the serial position curve compared to the young group, with the exception of their strong recency at the terminal position and a very distinct suffix effect evident at both the terminal and preterminal positions. The AD subjects, as expected, have an overall lowering of the serial position curve, but primacy and recency are still strongly evident. The suffix exerts a gradually increasing effect across the entire serial position, but most notably from Positions 3 through 6. This group, however, does not show the magnitude of the suffix effect at the terminal position compared to the elderly group. The serial position curve still exhibits recency, even though overall recall is diminished, probably due to near floor effects for the AD subjects.

To compare group and serial position differences due to interference from the suffix, preplanned Dunnett tests were performed using the Group X Concreteness X Suffix X Serial Position interaction as the pooled error term, C - E = 0.36. One consistency between groups is that both concrete and abstract words appear to be equally affected by the presence of a suffix at the terminal position (see Table 12), reflected also by the lack of a significant interaction.

A 1-way ANOVA comparing the difference between performance for control and suffix conditions at Position 6 for young, M = 0.91, elderly, M = 2.16, and AD subjects, M 1.84, showed significant difference between groups in the size of the suffix decrement, F (2, 45) = 5.61, MS_e = 1.21. A Duncan multiple range test indicated that the size of the terminal suffix effect for the young group was significantly smaller than for either the elderly or the AD groups, but there was no significant difference between the elderly and AD groups in the size of the terminal suffix effect, with critical ranges for r_2 and r_3 of 0.80 and 0.95, respectively. This supports findings that elderly and AD subjects may be more susceptible to interference than young subjects (Bruning et al., 1975; Mackell & Manning, 1990; Manning & Greenhut-Wertz, 1990; Manning et al., 1992).

Confidence Ratings

As described in Experiment 1, signal detection measures of hits and false alarms were compared for the three groups in Experiment 2 as discrimination indices in this metamemory measure. The results, summarized in Table 13, show quantitative and qualitative differences in this type of subject report with age and dementia.

The mean frequency of hits decreased with age and dementia, while the mean frequency of false alarms, although equivalent for the young and the elderly groups,

Table 13

Mean Hits, False Alarms, P_r and B_r for Three Subject Groups in Experiment 2

Group	Frequency Hits	Hit Rate	Frequency False Alarms	FA Rate*	P_r*	B_r
Young (N = 16)	114.88	.98	5.19	.49	.49⁺	.95
Elderly (N = 16)	93.13	.98	4.69	.58	.40	.95
AD (N = 16)	73.44	.98	15.56	.88⁺	.09	.97

*Indicates a significant ANOVA.
⁺Indicates a significant Duncan multiple range test.

roughly tripled for the AD group.

The hit rates and false alarm rates for each subject were derived by using the corrected matrix (Snodgrass & Corwin, 1988) described in Experiment 1, and the discrimination and response bias indices of P_r and B_r were calculated from the hit and false alarm rates.

One-way ANOVAs were performed comparing group differences for hit rates and false alarm rates, and results were similar to those for Experiment 1. No difference was found between groups for hit rates, $F < 1.0$, but significant group difference was found for false alarm rates, F (2, 45) = 13.43, MS_e = 0.05. The location of these group differences in false alarm rates, using a Duncan multiple range test, again showed no difference between the young, M = 0.49, and elderly, M = 0.58, groups, but significant differences were found between the AD group, M = 0.88, and each of the other two groups, with critical ranges for r_2 and r_3 of 0.17 and 0.20, respectively.

A 1-way ANOVA to determine group differences in sensitivity measure of P_r showed reliable differences, F (2, 45) = 15.33, MS_e = 0.05. Results reflect a decreasing sensitivity with age and dementia, M = 0.49, 0.40 and 0.09 for young, elderly and AD groups, respectively. A Duncan multiple range test showed significantly greater sensitivity for the young group compared to both the elderly and the AD groups, although the elderly and AD groups were not reliably different from each other, with critical ranges for r_2 and r_3 of 0.16 and 0.19, respectively.

A 1-way ANOVA to determine group differences in response bias was not reliable, F < 1.0. This appears to contradict the abnormally liberal, yeah-saying bias which is indicated by the false alarm rate, but may reflect the decreased recall performance with AD, resulting in an overall lower number of words from which to identify those correct or incorrect. Again, as in Experiment 1, the measure of sensitivity, P_r, appears valid in discriminating between groups, but the false alarm rates may more accurately reflect differences with age and AD than the response bias measure of B_r.

Discrimination for the elderly and AD groups, as seen in their hit rates, is inconsistent with the hypothesis of decreasing sensitivity with age and dementia (Rissenberg & Glanzer, 1987), although the overall frequency of hits decreases. If elderly and AD subjects are indicating "*correct*" to almost all their answers, the hit rate would naturally be high. However, a liberal response bias should likewise be observed. Possibly, a liberal response strategy could be hidden by a conservative immediate recall response. For example, if the elderly and AD subjects had only recalled words which they were sure were correct, and rarely guessed incorrectly, even if they indiscriminantly said all were "*correct*", a conservative response bias would be evident. However, we know that the frequency of false alarms, saying a word is correct when it is incorrect, increased with age and dementia, while there was negligible difference in the response bias measure. Therefore, poor performance may not be independent of response bias, as suggested by Snodgrass and Corwin (1988).

Intrusions

Table 14 shows the mean number of intrusions by group, M = 10.31, 8.38, and 12.63 for the young, elderly and AD groups, respectively, as well as the group means for suffix, within-list, and extra-list intrusions, as defined in Experiment 1. Unlike intrusion errors in Experiment 1, a 1-Way ANOVA showed no significant difference between the three groups in the total number of intrusions observed, F (2, 45) = 1.15, MS_e = 63.09. The large within group variation (as seen by the mean square error) masked any significant group differences, even though a trend toward a greater mean frequency of overall intrusions was seen for the AD group. A Duncan multiple range test confirmed the lack of difference between the means for the three groups, with critical ranges for r_2 and r_3 of 5.81 and 6.87, respectively.

The group differences in suffix intrusions, evident in Table 14, is consistent with the intrusion pattern observed in Experiment 1. The young group had no suffix intrusions in this experiment, and the elderly group had only two suffix intrusions, compared to 55 suffix intrusions for the AD subjects. A 1-way ANOVA again confirmed the obvious significant difference between groups, F (2, 45) = 18.53, MS_e = 3.28. A Duncan multiple range test indicated a lack of difference between the means for the young and elderly groups, although, not surprisingly, the AD group differed significantly from both the young and the elderly groups, with critical ranges for r_2 and r_3 of 1.31 and 1.55, respectively. The young and elderly were able to follow instructions and disregard the suffix. However, the AD subjects were generally unable to disregard the suffix or to consider it as a not-to-be-remembered item (only

Table 14

Intrusion Errors by Group in Experiment 2

Group	All Intrusions	M	Suffix Intrusions*	Within List Intrusions	M	Extra List Intrusions	M
Young (N = 16)	165	10.31	0	109	6.81	56	3.50
Elderly (N = 16)	134	8.38	2	89	5.56	43	2.69
AD (N = 16)	202	12.63	55	71	4.44	76	4.75

*Indicates a significant ANOVA.

3 AD subjects had no suffix intrusions), even though they were repeatedly reminded that it was not to be included as a recalled word.

A trend toward a gradual decrease in the frequency of within-list intrusions is seen with age and dementia, M = 6.81, 5.56 and 4.44 for young, elderly and AD groups, respectively, which was not found in Experiment 1 (M = 5.50, 2.94 and 5.81 for young, elderly and AD groups, respectively). This may reflect less caution on the part of young subjects, compared to elderly and AD subjects, under conditions of free recall. A 1-way ANOVA, however, indicated no reliable difference between the three groups, F = < 1.0., possibly due to the very large variance found (MS_e = 35.74). This finding appears to conflict with reports that AD subjects produce a greater number of intrusion errors from previously presented materials onto current performance in cognitive tasks (Jacobs et al., 1990). A Duncan multiple range test confirmed the lack of significant difference between any group's within-list intrusion means, with critical ranges for r_2 and r_3 of 4.38 and 5.18, respectively.

The frequency of extra-list intrusions, also shown in Table 14, indicates an increased trend in the AD groups, M = 4.75, compared to the young, M 3.50, and elderly, M 2.69, groups. This appears to support previous findings, that AD subjects make inappropriate intrusions which are often semantically unrelated to test words (Fuld, 1983; Martin & Fedio, 1983). A 1-way ANOVA, however, again indicated no reliable difference between groups, F (2, 45) = 1.33, MS_e = 13.03. The large between-subject variance, again, may have diminished any possible differences. A Duncan multiple range test confirmed the lack of significant difference between any of the three groups in mean extra-list intrusions, with critical ranges for r_2 and r_3 of 2.63 and 3.11, respectively.

Helkala, Laulumaa, and Soininen (1989) previously found that AD subjects committed more extra-story, and extra-list intrusion errors in a study of episodic and semantic memory using AD subjects, Parkinson's disease (PD) subjects and normal elderly controls in a story recall task. If the concreteness of nouns in the present study stimulated associational networks, leading to an increase in the intrusion of extra-list words for the young, and to a lesser degree, for the elderly, the expected extra-list intrusion pattern for the AD group could have been overshadowded. The results could be explained in terms of generally diminished number of words recalled rather than diminished triggering of associations for the concrete nouns. However, if the AD group were affected by the semantic quality of the nouns to the same degree as the other groups, then extra-list intrusions would be expected to be significantly greater for the AD group due to relative attentional deficits observed in this population when response suppression is required (Fuld et al., 1982).

These intrusion results, however, do support previous reports indicating that AD subjects exhibit a significantly greater number of suffix intrusions than either young or elderly groups (Fuld et al., 1982; Manning et al., 1992; Shindler et al., 1984).

Digit Spans

Auditory and visual digit spans were examined for the three groups, and the results are summarized in Table 15. These spans are higher than the digit span means reported by Martin, et al. (1985) of 5.9 for their AD group and 6.1 for normal controls.

Paired t tests indicated no within group difference between auditory and visual spans for the young group, t (15) = 0.68, or for the elderly group, t (15) = 2.15. However, there was a significant auditory superiority for the AD group, t (15) = 3.56. As noted for the digit span tasks in Experiment 1, however, a comparison of auditory and visual spans is confounded due to the differing response procedure.

A 1-way ANOVA comparing auditory spans across groups, as in Experiment 1, showed significant differences between groups, F (2, 45) = 4.60, MS_e = 1.69. A Duncan multiple range test indicated no difference between auditory digit span means for the young, M = 7.94, and elderly, M = 7.01, groups, but the AD group (M = 6.56) differed significantly from both the young and the elderly, with critical ranges for r_2 and r_3 of 0.95 and 1.12, respectively. These results strongly support the findings of Reisberg et al. (1985) and others (Crook et al., 1980; Orsini, Trojano, Chiacchio, & Grossi, 1988) that auditory digit span may provide significant discrimination between normal elderly and mild AD (GDS 4) subjects.

A 1-way ANOVA comparing young, elderly and AD subjects on the visual digit span task revealed highly significant group differences, F (2, 45) = 27.77, MS_e = 1.24. As noted in Experiment 1, the response complexity (requiring the subject to write the numeric information following visual presentation) may have contributed to the decline in performance with age and dementia, supporting Crook et al. (1980).

Table 15

Auditory and Visual Digit Span Means in Experiment 2

Modality	Young N = 16	Elderly N = 16	AD N = 16
Auditory**	7.94	7.06	6.56*
Visual**	8.13	6.63	5.19

* Indicates a significant t-test.
** Indicates a significant ANOVA.

A Duncan multiple range test showed that the young, M = 8.13, performed significantly better than both of the other groups, M = 6.63 and 5.19 for the elderly and AD groups, respectively. The performance for the young is surprising since visual digit span is usually lower than auditory span (as it was for the young in Experiment 1, M = 8.13 and 7.75 for auditory and visual digit spans, respectively). These findings nevertheless support the utility of this type of complex digit recall task in differentiating normal aging from mild dementia (Crook et al., 1980).

Delayed Recall

Table 16 shows the mean frequencies of both concrete and abstract words recalled in this delayed condition for the three groups, as well as the mean proportion of concrete compared to total words recalled. The total number of words recalled by the AD group was greater in Experiment 2 compared with Experiment 1 (41 compared to 19 for Experiment 1). This possibly suggests that free recall conditions may be more conducive to encoding and storage into LTM, as well as more facilitative toward retrieval, than strict serial recall conditions. However, the AD group still showed poor delayed recall. Five of the subjects in this group recalled no words at all in this delayed condition. Therefore, in examining the group differences, only 11 AD subjects were included in the various analyses.

Absolute Scores. Total words recalled in this delayed condition decreased with age and dementia. The severe drop in the number of words recalled is consistent with previous literature citing significant impairment for AD subjects on

Table 16

Delayed Recall of Concrete and Abstract Words in Experiment 2

Group	All Words	$\underline{M}$**	Concrete Number	$\underline{M}$	Proportion Concrete	Abstract Number	$\underline{M}$
Young (N = 16)	277	17.31^{+}	171	10.69*	0.62	106	6.62
Elderly (N = 16)	162	10.06^{+}	123	7.69*	0.75	38	2.38
AD (N = 11)	43	3.91^{+}	37	3.36*	0.89	6	0.55

*Indicates a significant $\underline{t}$ test.
**Indicates a significant ANOVA.
$^{+}$Indicates a significant Duncan multiple range test.

delayed recall tasks (Salmon et al., 1989). A 1-way ANOVA using means of the combined concrete and abstract words recalled in the delayed condition indicated significant differences between the groups, F (2, 42) = 34.71, MS_e = 17.33. An extension of Duncan's multiple range test for the case of unequally represented means (Kramer, 1956) showed reliable differences between the means for each group, as expected. The young group, M = 17.31, recalled a significantly greater mean number of words than the elderly, M = 10.06, who in turn recalled a significantly greater mean number of words than did the AD group, 3.91, with adjusted critical ranges for r_2 and r_3 of 3.37 and 3.98, respectively.

Again as in Experiment 1, delayed recall showed a strong concreteness effect which was not reflected to the same degree in immediate free recall. Within group differences in recall of concrete and abstract words were compared using two-tailed, paired t tests. Concrete words were recalled more frequently than abstract words for all groups, young, t (15) = 3.34, elderly, t (16) = 4.68, and AD, t (10) = 4.38.

Difference Scores. Using the difference between concrete and abstract words recalled in this delayed condition, a 1-way ANOVA showed no reliable difference between young, elderly and AD groups, F (2, 42) = 1.16, MS_e = 17.75. This lack of significance was surprising, but may have been due to the large variance within groups. Again, applying the extension of Duncan's multiple range test for unequal means (Kramer, 1956), no difference was found between any of the groups, with adjusted critical ranges for r_2 and r_3 of 3.41 and 4.03, respectively. All subjects, therefore, showed equally strong concreteness effects in this delayed recall condition.

Proportion Scores. When controlling for differences in the total number of words recalled, proportion (%) scores for each subject's delayed recall of concrete words over total words recalled was calculated. The concreteness effect again emerged for all three groups when one-sample t tests were performed utilizing these proportion scores: young: t (15) = 3.42; elderly: t (15) = 4.03; and AD: t (10) = 6.61. Results for the AD group again reflect the fact that even though there were a small number of words recalled when compared to the young and elderly groups, those few words which were recalled were predominantly concrete words by nearly a 6:1 ratio.

Using the proportion scores, between group differences were compared in a 1-way ANOVA, and significant differences were found, F (2, 42) = 6.05, MS_e = 0.04, reflecting the gradually increasing mean proportion of concrete compared to total words recalled with age and dementia (young M = 0.62, elderly M = 0.75, AD M = 0.89). The extension for the Duncan multiple range test verified this significantly greater mean proportion of concrete words recalled between all groups, with adjusted critical ranges for r_2 and r_3 of 0.14 and 0.16, respectively.

These results, similar to the delayed recall results for Experiment 1, further support the utility of specific aspects of delayed recall (overall delayed word recall and delayed recall of concrete compared to total words) to discriminate between normal aging and early AD.

Recognition

The recognition task, which involved 8 elderly and 8 AD subjects, used 20 of the original 72 concrete and abstract list words presented with 20 concrete and abstract distractor words. Results are summarized in Table 17. In this recognition task, a hit is defined as a *yes* response to an old item, and the hit rate, H, as the conditional probability of responding *yes* to an old item, P(yes/old). A false alarm is defined as a *yes* response to a new item, and the false alarm rate, FA, as the conditional probability of responding *yes* to a new item, P (yes/new). A correct rejection is a negative response to a new item, and a miss is a negative response to an old item. Since the sum of the hit and miss rates is 1.0, and the sum of the false alarm and correct rejection rates is also 1.0, the hit rates and false alarm rates are sufficient to describe the recognition task.

The total number of list words recognized was relatively poor for both groups, as expected from the findings of Ferris et al. (1980) who noted poorer recognition performance for normal elderly and AD subjects compared to young normals in a facial recognition task, although they found no difference among hit rates for their three groups. For the present recognition task, the eight elderly subjects did have significantly more hits than the AD group. They recognized 59% ($\underline{M}$ = 11.75) of the 20 original list words, and the AD group recognized 37% ($\underline{M}$ = 7.38) of the 20 original words, which is much poorer recognition performance than reported by Salmon et al. (1989), who reported recognition of 91% for normal subjects and 54% for their mild AD group (of 14 words originally presented), although their delay

Table 17

Mean Hits, False Alarms, P_r and B_r for Elderly and AD Subjects in Recognition Task of Experiment 2

Group	Frequency Hits[a]	Hit Rate	Percent Concrete	Frequency False Alarms	FA Rate	P_r	B_r
Elderly (N = 8)	11.75*	.59*	.63⁺	1.88	.11	.47*	.25
AD (N = 8)	7.38	.38	.68⁺	2.88	.16	.22	.22

[a]Maximum number correct = 20
*Indicates a significant difference between groups.
⁺Indicates a significant concreteness effect.

intervals (15 s and 2 min) were considerably less than the delay in the present task.

An independent t test confirmed this significantly poorer overall recognition performance for the AD group compared to the normal elderly group, t (15) = 2.15. These results, although limited due to the small sample, support the findings of Landrum and Radtke (1990) who reported that both mildly and moderately impaired AD subjects demonstrated significantly reduced recognition performance compared to normal elderly adults. The mean frequencies of false alarms was also compared using a two-tailed independent t test. No significant difference was exhibited between the elderly (M = 1.88) and AD (M = 2.88) groups in the number of non-list words identified, t (15) = 1.33. Thus, errors for both groups consisted primarily of omission rather than of commission. The AD group did not appear to be more liberal than the elderly group in their identification of non-list words.

The hit rates and false alarm rates for the two groups were derived from the frequencies of hits and false alarms using the corrected matrix described earlier (Snodgrass & Corwin, 1988). A 1-way ANOVA of hit rate means indicated better performance for the elderly group compared to the AD group, F (1, 14) = 4.55, MS_e = 0.04. A 1-way ANOVA comparing group means for false alarm rates indicated no reliable difference, F (1, 15) = 1.91, MS_e = 0.01.

The discrimination index of P_r and B_r indicated poorer sensitivity by the AD subjects compared to the elderly subjects, P_r = 0.47 and 0.22, respectively. A 1-way ANOVA indicated significantly poorer sensitivity for the AD subjects compared to the elderly subjects, F (1, 14) = 9.65, MS_e = 0.03, suggesting that AD subjects may not have encoded the list words into LTM, or perhaps the AD group was more susceptible to the effects of retroactive interference (and thus exhibited more rapid forgetting) than was the elderly group. Another 1-way ANOVA, surprisingly however, showed no difference in response bias, B_r = 0.25 and 0.22, respectively, $\underline{F} < 1.0$. The elderly and AD groups showed the same conservative response bias. Helkala et al. (1989) and others (Bigler, Rosa, Schultz et al., 1989) have reported that AD subjects recognized more false positive targets than normal elderly controls or subjects with dementia other than AD, which is in agreement with the characterization of discrimination and bias deficits described by Snodgrass and Corwin (1988), but is only supported in the present recognition task by the frequency of false alarms, possibly because of the small sample size. Abnormal bias, from numerous sources, appears to be a component of abnormal memory, as suggested by Branconnier et al., (1982) and others (Mohs and Davis, 1982), although the present recognition results do not overwhelmingly confirm these findings using the bias measure suggested by Snodgrass and Corwin (1988).

Although results indicate poorer overall recognition performance than expected, the subset of elderly and AD subjects tested in this recognition task produced quantitatively different but qualitatively similar results in the number of concrete and abstract words which were correctly recognized. Recognition memory for both groups was significantly better for concrete compared to abstract words. Of those words correctly recognized by the elderly group, 63% ($\underline{M}$ = 7.4) were concrete. For the AD group, 68% ($\underline{M}$ = 5.0) of the correctly recognized words were concrete.

Paired t tests indicated a significantly greater number of concrete words compared to abstract words recognized for both the elderly, t (7) = 3.46, and the AD group, t (7) = 4.20, although a 2-way ANOVA, Group X Concreteness, indicated no interaction, $F < 1.0$, suggesting a similar effect of concrete imagery on delayed recognition for elderly and AD groups.

Denney, Miller, Dew and Levav (1991) found that older adults did not have greater deficit in contextual memory than in memory for target information when compared to younger adults. These findings also are consistent with Glanzer and Bowles (1976) and others (Diesfeldt & Vink, 1989), who suggest that subjects are more accurate in a recognition task when the words are rare, or of low normative frequency rather than of high normative frequency, which facilitates recall. The distinctiveness of a unique item, rather than the commonness and familiarity of the item, is what appears to enhance recognition. Whereas, the familiar item is easier to recall than the unfamiliar one. Therefore, our list words, which are rated high in normative frequency (Thorndike & Lorge, 1944) may be easier to recall but less distinctive when embedded in a recognition task. The concrete words do appear to maintain a measure of distinctiveness when compared to abstract words, since they were significantly more often recognized by both the elderly and the AD groups. However, the overall poorer recognition performance than expected for both groups could have been due to the variety of intervening tasks between immediate recall and delayed recognition.

Comparison of Experiments 1 and 2

If strict serial recall using strict, CIP, scoring were compared to free recall using CPO scoring, an obvious improvement in performance would be observed for all groups[7]. However, to determine more subtle effects of instructions to recall words in strict serial order on performance, a comparison of strict serial recall using CPO scoring was made with the free recall condition.

If the serial recall instructions, themselves, contributed to diminished performance in immediate recall by adding complexity to the task, then using a lenient scoring in an experimentwise comparison would more accurately enable an assessment of actual recall performance in both experiments. If the instructions put constraints on performance, free recall would be expected to show an improvement over serial recall using the lenient scoring procedure. If, however, it was the stricter scoring procedure which contributed to the apparent poorer recall in the serial condition, then the elimination of that strict scoring procedure would result in equivalent performance for the two experiments.

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[7]A 2-way ANOVA, 3 (Group) X 2 (Experiments) was performed comparing strict serial recall performance in Experiment 1, CIP, with free recall performance in Experiment 2, CPO, by groups, summed across all other variables. The main effects of group, F (2, 90) = 66.70, MS_e = 0.52, and experiments, F (1, 90) = 49.13, MS_e = 1.34, were highly reliable, as expected. The interaction of Group X Experiments was not reliable, F (2, 90) = 66.70, MS_e = 1.34, indicating that improvement in free recall compared to strict serial recall did not interact with groups.

Results and Discussion

The comparability of the CPO scoring methods in both Experiment 1 and Experiment 2, were analyzed using a 3 (Group) X 2 (Experiments) X 2 (Concreteness) X 2 (Suffix) X 6 (Serial Position) ANOVA. The main effect of experiments was not significant, $F < 1.0$, indicating no difference in performance between these two experiments, summed across all other variables. There were, however, significant main effects for all other variables, as expected from the analyses performed separately on the two experiments: group, $F\ (2, 45) = 80.10$, $MS_e = 8.85$; concreteness, $F\ (1, 45) = 26.06$, $MS_e = 0.92$; suffix, $F\ (1, 45) = 257.94$, $MS_e = 0.83$; and serial position, $F\ (5, 225) = 127.81$, $MS_e = 2.29$. There were no reliable interactions of experiment (serial and free recall) with any other variable, further confirming the equivalence of scoring methods under both serial and free recall conditions.

The absence of a difference between these two experiments, when scoring methods were comparable, suggests that strict serial recall instructions do not, of themselves, contribute to diminished recall or to any greater susceptibility to interference from a suffix. Since previous research has indicated superior performance under conditions of free recall compared to serial recall (Paivio, Yuille, & Rogers, 1969; Watkins, Watkins, & Crowder, 1974), those differences were most likely a result of different scoring criteria for serial and free recall. In the present comparison, the lenient scoring method equalized a difference which would certainly be expected in a standard comparison of strict serial recall and free recall. However, since a comparison of CIP and CPO scoring has already been shown to significantly improve overall recall performance for all groups in Experiment 1, redundancy is not warranted. Therefore, instructions to recall words in the order in which they were presented may place greater positional constraints on the subject for accurate recall, but those instructions apparently may not diminish the encoding, storage or retrieval of the words, since performance was equivalent in Experiment 1 and Experiment 2 when scoring criteria were equated.

General Discussion

Summary of Results

In the present study, as expected from the literature and as predicted by the hypotheses, immediate memory performance showed an attenuation with age and a further degradation with AD. This pattern was consistent for immediate memory, in both serial and free recall, as well as for digit spans, delayed recall and delayed recognition. Improved performance was seen for all groups in free recall compared to serial recall. Although single word reading and naming of common objects may be largely automatic or reflexive because of years of practice, actively attending to and organizing items for recall requires more complex processing, which appears to diminish with age and to be impaired even in mild AD.

There was no concreteness effect in serial recall, although it emerged in the control condition with the application of the lenient scoring method, CPO scoring. Again, the concreteness effect emerged for all groups in free recall, and to a much greater degree in delayed recall.

The suffix also showed increasing effects with age, although its effects on the AD group were mediated by poor performance in strict serial recall. An equivalent suffix effect on recency performance in free recall was observed for the three groups.

Cognitive Functioning

The nature of the relationship between normal aging and dementia has been examined through various methodologies and paradigms. Qualitative and quantitative differences have been observed which give support to the evidence that AD is neither a normal consequence nor an exaggeration of normal aging; nor is aging a "subclinical case" of dementia, as has been suggested (Petit, 1982). If AD were merely an accelerated form of aging, the relationship from young to elderly to AD on a variety of cognitive and psychometric tasks would be strongly linear and consistent across various tasks.

Qualitative differences indicating a disproportionate deterioration of one or more cognitive operations (Nebes & Madden, 1988) has previously been observed, and is supported by the present research. Becker (1988) has suggested that multiple cognitive impairments are responsible for the various deficits observed in immediate memory of AD subjects, and the variability of performance exhibited in the present study lends further support to these observations.

Concreteness

The concreteness effect, which was expected in serial recall, was not evident for any subject group in Experiment 1 using CIP scoring, in spite of concreteness having been previously reported in both serial recall and free recall (Paivio et al., 1969). The findings of the present study suggest that under strict serial recall conditions, using a strict scoring procedure, CIP scoring, the concrete imageability of nouns does not contribute to improved performance compared to abstract nouns. Applying a more lenient scoring procedure, CPO scoring, the concreteness effect emerged in the control condition to a greater degree for the AD group than for the young and elderly groups. It would appear that the misplacement of words was contributing to this improved concreteness for the elderly and AD subjects. Since the young group did not show a significant effect of concrete imagery, although they did show a trend in that direction, the ceiling effects observed for this group may have obscured any concrete superiority. The short sequence of six words was well within their immediate memory span, perhaps obliterating the need to process additional associations in order to facilitate performance.

The hypothesized attenuation of the concreteness effect with elderly and AD subjects was supported in strict serial recall using CIP scoring, but that was apparently due to the expected overall diminished performance with age and dementia. In CPO scoring, evidence of the concreteness effect was relatively equivalent for all groups. This may have been a result of the greater difficulty in abstract word retrieval for the elderly and AD groups, similar to the greater retrieval deficit for abstract compared to concrete words previously reported by Rissenberg and Glanzer (1987). However, the overall magnitude of the concreteness effect increased in the free recall condition compared to the serial recall condition for all subjects, as expected.

According to Tulving's (1972) classification of memory, the tasks in the present study combined episodic (word list recall and a temporal relationship) with semantic (word meaning) information. Episodic memory reflects the influence of recent experience, for which attenuation has been found in elderly and AD populations. Conversely, semantic memory reflects established knowledge of words, independent of recent experience, and appears resistant to the effects of aging, as Hultsch et al. (1991) suggested, but somewhat more susceptible to degradation in individuals with dementia (Martin et al., 1985; Nebes et al., 1984). As evidenced by the discrepant findings of semantic memory loss in AD (Kaszniak, 1988; Martin & Fedio, 1983), the possibility of levels or degrees of semantic knowledge must be considered.

Rissenberg and Glanzer (1987) interpreted the large concreteness effects they observed in their AD group as stemming from a greater impairment in word finding for abstract items compared to concrete items. However, if AD subjects have deficits in concept identification, as suggested in the literature (Bayles, et al., 1989; Butters et al., 1987; Flicker et al., 1987; Martin & Fedio, 1983), word retrieval should be equivalent for concrete and abstract items since the concreteness effect is based on both visual (imaginal) and verbal characteristics which stimulate greater associational networks.

AD subjects are certainly impaired in word retrieval, but do show retention of some aspects of semantic knowledge. The semantic qualities of concrete words do appear to contribute to superior recall compared to abstract words for AD subjects as suggested by Albert and Milberg (1988), as seen with the application of CPO scoring, even though overall recall performance was greatly diminished in relation to young and elderly subjects. This remains consistent with the abstract retrieval deficit found by Rissenberg & Glanzer (1987), and indicates that there is not a total loss of concept identification.

Nairne (1988) has described modality-dependent and modality-independent features in the context of a framework for interpreting recency effects in immediate serial recall. It is possible that the concreteness effect is also a modality-independent feature, according to Nairne's definition. The features that survive overwriting for young, elderly and AD subjects provide discriminative information about an item, and those features may be utilized as a discriminative cue in recall. Concrete words may be more easily grouped and encoded because of the discriminative information they provide, activating both visual and auditory associations, compared to abstract words which provide primarily auditory information.

Additionally, recall of concrete words may be less effortful than recall of abstract words. The deficits exhibited by the AD group may have resulted from the requirement of effortful processing (Hasher & Zacks, 1979) in the performance of immediate recall rather than from a differential semantic loss, since the proportion of concrete to total words recalled was greatest for the AD group compared to the young and elderly groups under all recall conditions in Experiment 1. The AD group did not show greater concreteness than young and elderly subjects in Experiment 2, although the trend was in the direction of concrete superiority.

Are words in the beginning of a sequence easier to recall if they are concrete words rather than abstract words? The interaction of concreteness and serial position in control conditions using CPO scoring suggested middle and end of sequence benefits for concrete words in Experiment 1, but beginning and middle of sequence benefits under free recall (Experiment 2) conditions. Most likely, the interaction in Experiment 1 may have been due increased rehearsal for both concrete and abstract words in the beginning of the sequence causing equivalent performance, while, in the presence of superior recall, a greater misplacement of concrete words in the remainder of the sequence caused differential improvement between concrete and abstract words. The interaction in Experiment 2 appeared to reflect the early emergence of the concreteness effect with the easier recall task (since items presented last may have been written first and subsequent retrieval of the rest of the concrete words was easier than subsequent retrieval of the remaining abstract words within each sequence).

As Richardson (1978) suggested, the concrete imagery of words may influence recall at the beginning of the serial position curve. The first words presented, possibly because of heightened initial attention, may be more easily encoded because attentional demands are minimally strained. They may likewise be more available for retrieval, particularly for subjects with mild attention deficits.

Immediate Recall Effects

Overall immediate recall performance in these two experiments showed an obvious and expected decline with age and dementia, and the expected serial position effects, consistent with previously reported empirical evidence. Primacy was observed in both serial recall and free recall for young, elderly and AD groups. Since the absence of the primacy effect has been demonstrated in AD subjects (Bemelmans & Goekoop, 1991), when longer word lists are used, the results of the present study suggest that the list length (six words) does not exceed the processing capacity of mild AD subjects such as those in the present study. Harris and Dowson (1989) also found decreased primacy with AD subjects, but they used a 10-word sequence, which would similarly appear to be beyond the span of even mildly demented subjects.

Recency was also observed and measured for all three groups in both serial and free recall. The AD group, not surprisingly, exhibited minimal recency in serial recall under conditions of strict serial recall scoring. Those words they could recall were immediately written and frequently placed in the first few serial positions. This "dumping" on the part of AD subjects may have reflected their inability to attend to the strict recall instructions or their effort not to lose items, and when combined with the overall fewer words recalled within each presentation resulted in numerous blank spaces at the end of the response lines.

The hypothesized equivalent recency expected for all groups was not observed in strict serial recall under CIP scoring due to obvious floor effects for the AD group. However, when CPO scoring was applied, the degree of improvement between Positions 5 and 6 was significantly greater for the AD group than for either the young or the elderly groups, because of the previously mentioned "dumping" upon immediate recall, and in spite of the overall lowered recall performance. In free recall, the strength of recency was equivalent for all three groups, supporting the hypothesis that mildly impaired AD subjects exhibit qualitatively similar but quantitatively different responses compared to young and elderly subjects.

The obvious differences observed between CIP and CPO scoring methods was expected, and the hypothesized interactions between groups, scoring methods and serial positions were confirmed, reflecting the increasing improvement (because of greater room for improvement) with age and AD across most of the sequence. (Equally strong performance at Position 1 was observed under both scoring procedures for all groups, so this serial position was the only one which did not show significant improvement.)

Suffix and Interference Effects

The suffix used in these experiments produced definitive end of sequence suffix effects. Certainly in CIP, but even in CPO scoring for serial and free recall, there were significant end of sequence decrements for all groups. The suffix used in this study, the word *code*, is related to the list words in that it has the same morphologic and syntactic structure (being a noun) as the concrete and abstract list words, although it is no more semantically related (in terms of specific meaning) to the list words than they are to each other. It is rated intermediate in concreteness, imagery and frequency, and therefore is neither concrete nor abstract. Therefore, the word *code* could be considered a dissimilar suffix.

We would expect that the less similarity between the suffix and the preceding sequence, the greater would be the interference contributed by the suffix. It may additionally be considered that abstract words are more susceptible to retroactive interference, as well as having fewer associational networks to facilitate encoding and/or retrieval, although this supposition was not systematically assessed in the present study.

Additionally, our suffix diminished recency because it was in the same modality as the test words. Thus, less distinctiveness between the suffix and the presentation items may require greater encoding effort to disregard it, leading to greater interference with recency. This may reflect more cognitive mechanisms, as suggested by Baddeley and Hull (1979), and is consistent with the hypothesis that attentional deficits impair semantic processing with increasing age, resulting in memory decrements (Burke, White, & Diaz, 1987). Perhaps the resulting decrease in recency was caused by a combination of processes: A suffix demanding attention because it was presented in the same modality as the list words, while impaired semantic processing with age and dementia inhibited discrimination of the suffix from the list words, requiring a greater effort to disregard it.

If elderly subjects were more susceptible to interference compared to young subjects, they would have exhibited greater decrements in the suffix conditions compared to the control conditions, or a greater mean difference between suffix and non-suffix conditions. This difference was not significant for the young and the elderly subjects in Experiment 1. There was an overall lowering of the serial position curve, but not a greater decrement in the experimental versus control conditions when compared to the young subjects, suggesting no greater susceptibility to interference effects. In the AD group, there was a significant difference between the experimental and the control conditions. Since both proactive and retroactive interference has been observed to be greater in AD subjects than in controls (Delis et al., 1989; Helkala et al., 1989), this interference combined with an inability to inhibit irrelevant information could have contributed to the poor overall performance across the serial position curve for AD subjects.

However, in Experiment 2 the performance decrement caused by the suffix at Position 6 was smaller for the young group than for the elderly or AD groups, which is consistent with the findings of others (Manning & Greenhut-Wertz, 1990; Manning et al., 1992). Why the effects of interference would be greater in free recall with age, compared to serial recall, is puzzeling. Perhaps the demands of serial recall minimized differences between young and elderly subjects in terms of their susceptibility to interference, which became evident under conditions of free recall.

Metamemory Measures

The results of the confidence ratings in the present study are in line with impaired sensitivity observed with age (Maylor, 1990) and AD (Diesfeldt, 1990; Ferris et al., 1980). Generally, hits decreased with age and AD, and false alarms increased with age and AD, which is consistent with previous research (Diesfeldt, 1990; Helkala et al., 1989; Taylor & Gilleard, 1990). Other findings, however, have indicated that moderately impaired AD subjects are aware of the accuracy of their recall from episodic memory (Pappas, Sunderland, Weingartner, Vitiello, Martinson,

& Putnam, 1992). Therefore, the AD subjects in this study may not have been representative, although it is doubtful that mild AD subjects would exhibit a deficit which is not evident in moderately impaired AD subjects. It is possible that, even though awareness of their overall accuracy may be present, their tendency to deny or to cover up their deficits, particularly in the early stages of the disease, may lead to an apparent insensitivity. The results may also reflect a lack of confidence on the part of AD subjects, due to a preserved insight into their deficit. Either the AD group was consistently unable to distinguish correct from incorrect items in their review of their immediate recall performance, or they were consistently attempting to cover up their poor performance (e.g., saying "yes" may be an adaptive response).

This non-parametric measurement of metamemory was based on diminishing performance with age and AD. Although the results did clearly distinguish performance between the two normal groups and the AD group in measures of sensitivity and false alarm rates, sensitivity for the elderly group was equivalent to the young in Experiment 1 but significantly different from both the young and the AD groups in Experiment 2. Since results in the former experiment showed a trend in the direction of decreased sensitivity, these results do appear to be in line with the majority of previous studies (Erber, 1974; Maylor, 1990) demonstrating impaired sensitivity for elderly individuals.

The response bias measure used in the present study showed less utility than false alarm rates in demonstrating the typically liberal and indiscriminating biases frequently associated with demented populations (Snodgrass & Corwin, 1988). This inconsistency may have been caused by the overall poor recall performance, having so few words from which to determine correctness, rather than to a more normal response bias for the AD group.

Intrusions

In the analysis of intrusions in the present study, quantitative and qualitative differences were again observed for AD subjects compared to young and elderly subjects. As hypothesized, the AD group showed a significantly greater number of overall intrusions than either the young or the elderly group in Experiment 1. Overall intrusion frequency in Experiment 2, although in the same direction, was not significantly different between groups. The high frequency of intrusion errors we found in both experiments for the AD group are consistent with intrusion errors reported by others (Butters et al., 1987). Our AD group consisted only of mildly demented subjects. Since Salmon et al. (1989) reported an even greater number of intrusion and perseverative errors in their moderately demented AD group, the utility of these errors may prove clinically useful in describing the progression or severity of dementia. Furthermore, Hart, Smith & Swash (1986b) have suggested that intrusion errors could be useful in differentiating AD from other dementing disorders, as previously suggested by Fuld et al. (1982) and Fuld (1983a).

The suffix intrusion results in this study are consistent with the clear-cut deficit reported even in mildly impaired AD subjects in attentional capacities and response inhibition (Fuld, 1983a and b) particularly with auditory stimuli (Manning et al., 1992). The AD group was clearly unable to disregard the suffix, often including it in recall, and was clearly unable to follow instructions to disregard the suffix. This unique deficit was not found at all in the young, and was observed in only four elderly subjects in the two experiments combined, indicating its utility as a discriminating measure between normal elderly and mildly demented subjects.

There was a significant difference between groups in the frequency of extra-list intrusions for Experiment 1, consistent with previous research (Loewenstein et al., 1989; Shindler et al., 1984), although aftercomparisons did not verify any reliable difference between the means for any group, most likely because of the large variation within subject groups. No reliable group differences were found in Experiment 2, although the trend was in the direction seen in the first experiment. The greater total frequency extra-list intrusions by all groups in Experiment 2 compared to Experiment 1 may have been a function of relatively less demand in attention for free recall compared to serial recall, or perhaps that a free recall paradigm was more conducive to triggering associations since attention to serial position was not required. Since Manning et al. (1992) reported extra-list intrusions were more prevalent with visually presented stimuli compared to stimuli presented auditorily, the present findings with respect to the generally more frequent within-list intrusions compared to extra-list intrusions may reflect the more easily accessed auditory information which was just presented, rather than a more difficult search for information which would be required if extra-list words were retrieved. The more common within-list intrusion errors are also consistent with the type of proactive interference errors previously reported in free recall by Fuld et al. (1982) and Fuld (1983).

Perseverative errors were not included in this analysis, but supposedly would have contributed to a variation in within-list intrusion results. It appears that word intrusions may ultimately be linked to the severity of the disease process, and that the qualitatively different types of intrusions, unrelated intrusion errors, may ultimately be linked to a differential diagnosis in dementia. Further investigation needs to be initiated to determine the specificity for AD of these qualitatively different intrusion errors, and to examine sensitivity of these errors with increasing severity of the disease.

Digit Spans

There were robust, significant differences between the three groups for auditory digit span, as well as for the more difficult visual digit span. Although the auditory span results do not appear consistent with previous literature indicating little or no attenuation of standard verbal digit span with age and dementia (Ferris et al., 1980), the complexity of the visual digit span task, incorporating a written response, produced results consistent with previous findings (Crook et al., 1980) for more complex digit-span responses. There was very little variation in performance within any of the groups, which could have affected the results. However, results are consistent with Reisberg et al. (1985) and others (Crook et al., 1980; Orsini et al., 1988), since aftercomparisons indicated no difference between young and elderly, but a significant difference between those two groups and the AD group for both auditory and visual digit spans. The significantly poorer performance by the AD group for both auditory and visual spans reflects a reduced storage capacity, as well as a greater concentration deficit, compared to young and elderly subjects.

Thus, both a standard auditory digit span, as well as a more complex visual span, may prove valuable in discriminating normal elderly from mild AD subjects. Additionally, the utility of the complex visual task may be useful as a measure of dementia severity.

Delayed Recall

In the delayed recall condition there was again observed a reduction in the overall number of words recalled with age. The classic theory of spontaneous decay in memory (Ebbinghaus, 1913) has been replaced with interference theory, both retroactive interference and proactive interference (Wingfield & Barnes, 1981). Wilson, Bacon, Fox & Kaszniak (1983) showed evidence of greater deficits in LTM than in STM, which is supported in the present study by the small proportion of experimental list words recalled in the delayed condition. The elderly group recalled less than the young but more than the AD groups, as hypothesized, and is consistent with the theory of a reduced storage capacity with age, a very rapid rate of forgetting frequently reported for even mildly impaired AD subjects, and increased concentration deficits with age and AD (Bruning et al., 1975; Hart et al., 1988; Salmon et al., 1989; Waugh et al., 1978).

Since the delayed recall of concrete words was significantly greater than delayed recall of abstract words for all groups in both experiments, words which are high in concreteness and imagery ratings may possibly be less susceptible than abstract words to interference from either previous or subsequent items. Using a 24-hour delay, Sebrechts et al. (1989) found a long-term semantic benefit in a delayed recall task for young subjects, suggesting that elaboration provided by greater associations for concrete words proved to be more helpful at longer delays. In the present study, there was a much shorter delay than reported by Sebrechts et al. (1989), although the delay was filled with considerable interference from alternate tasks. Semantic encoding may use relatively more resources to process words, thus contributing to long-term retention and easier retrieval.

These results also appear to be consistent with Rissenberg and Glanzer (1987) since our AD group may have been exhibiting a greater deficit in retrieval of abstract words from LTM. However, the question still remains whether those abstract list words were encoded in LTM yet remained difficult to retrieve, or whether fewer abstract words were actually encoded into a long term memory store.

For AD subjects, the very severe drop in the total number of words recalled in the delayed condition of both experiments, compared to their immediate recall performance, is consistent with the rapid forgetting exhibited by AD subjects. Hart et al. (1988) found the AD subjects demonstrated rapid forgetting in the first 10 minutes after learning line drawings of common objects. This would suggest that consolidation of stored information into long term memory, rather than the initial encoding process in immediate memory, leads to many of the observed memory deficits in AD patients.

Delayed Recognition

Recall tasks have been shown to require more processing resources than recognition tasks (Craik & McDowd, 1987), so the strong recall performance for young subjects in the present study would most likely have been translated into near ceiling performance in the recognition task. Furthermore, Craik and McDowd (1987) reported that age differences found in recall were minimized in recognition tasks when comparing young and elderly subjects.

In a study differentiating age-related memory decline and dementia using free recall and recognition accuracy, Rohling, Ellis, and Scogin (1991) reported no difference between their young and elderly group on either recall or recognition, but reported significant deficits for the demented subjects on these measures when compared to both young and normal elderly subjects. However, the tasks Rohling et al. (1991) tested constituted automatic processing, which appears to be unaffected by age or practice, as opposed to effortful processing (Hasher & Zacks, 1979).

Regardless of method of assessment, however, recognition memory performance has been consistently shown to be age dependent on tests associated with episodic memory (Crook & Larrabee, 1992; Hultsch, et al., 1991; Salthouse, 1988), since older individuals have a smaller pool of processing resources available. However, the present relatively weak recognition performance evidenced in the elderly subjects does not appear to be totally consistent with traditional observations that recognition involves less effortful processing than does recall (Craik & McDowd, 1987; Hasher & Zacks, 1979). The low percentage of correct words recognized for both our elderly and AD subjects may be due to an unidentified bias in the present subject population. Perhaps both elderly and AD subjects were displaying a failure to inhibit anterograde interference from previously presented sequences, leading to a more liberal bias due to confusion or uncertainty. Our initial large pool of concrete and abstract words was added to in the delayed recall task with words the subjects guessed were part of the experimental words, which may have led to poorer performance because of confusion. However, our results do appear consistent with those of Abbenhuis, Raaijmakers, Raaijmakers, & van Woerden (1990) who reported poorer recognition memory for AD compared to elderly subjects, and elderly compared to young subjects in a word identification task.

Results of the confidence ratings reported earlier indicated that age- and dementia-associated differences in metamemory may primarily be a function of false alarm rates (Bartlett, Strater, & Fulton, 1991). However, results of the recognition task suggest that differences between elderly and AD subjects in recognition memory may more likely be a function of hit rates and independent measures of sensitivity. In this recognition task, hit rates, as well as the sensitivity measure of P_r, proved to be the best discriminating measures between elderly and mild AD subjects. This may very well have been a result of the small sample size for each group, but may also suggest that mild AD subjects, like elderly subjects, similarly benefitted from a task demanding less resource processing.

Conclusions and Future Directions

In conclusion, results of the present study add support to both a reduced storage hypothesis with age and mild AD, and the hypothesis that a processing deficit contributes to certain decrements in memory observed with age under conditions requiring greater effort. In addition to age-related changes regarding storing and processing capacities, patients with mild AD have shown relative retention of certain aspects of memory and loss in others, supporting evidence that the brain distributes cognition and language processing over various areas which are differentially affected by dementia, resulting in disproportionate and inconsistent performance.

The present findings are also consistent with the communication hypothesis of Rissenberg and Glanzer (1987) since there appears to be reduced activation of information stores based on a breakdown of the information network underlying memory and cognitive processing to a limited degree for the elderly and to a much greater degree for the AD group, although the mild AD subjects are not so impaired as to cause a total breakdown of lexical or semantic associations (Salmon et al., 1988). Furthermore, the elderly exhibited no deficit in inhibiting irrelevant information, while the AD subjects did have great difficulty with response inhibition, consistent with evidence of an abnormal reduction in attentional capacities and a greater susceptibility to interference with AD (Fuld, 1983a; Ober et al., 1986).

The present findings also strongly support the utility of delayed recall in discriminating elderly from mild AD subjects (Welsh et al., 1991). The pattern of deficits in the AD group support observations of substantial qualitative differences (Morris & Baddeley, 1988) when compared to young and elderly subjects: There is a comparatively unimpaired recency effect in free recall, moderate decline in memory span, and a distinct impairment in retention following distraction, either from a suffix or from a delay interval.

The comparison of strict serial recall and free recall suggest that the application of a lenient scoring method in strict serial recall may provide results which are comparable to free recall when other conditions and variables are consistent, although these are different and distinct paradigms.

In free recall, it would be expected that subjects would put their responses in the first space on the left of the response sheet and proceed to fill each space, since placing the word in its position of presentation would not be required. Indeed, in Experiment 2 the instructions to the subjects specified this free recall procedure. Every young subject was able to follow these instructions. The few blank spaces left were always at the end of the sequence. All but four of the elderly subjects likewise placed their responses in the first line at the left of the response sheet and wrote their answers across the row without leaving spaces in between response items. Of those four who did leave spaces (one left a single space, two left two spaces and one subjects left four spaces), it seems reasonable to suggest that rather than disregarding the initial free recall instructions, they may have skipped a space or two as a strategy to facilitate recall. Perhaps for those four subjects, ordering the words was easier than randomly recalling them.

Of particular interest is that 50% (8 subjects) of the AD group in the free recall experiment left at least one, but as many as 17, spaces between words in the four conditions, indicating a considerable deficit in attending to the instructions to "begin writing in the first space on the left and continue to fill each space to the right for as many words as you can recall in that sequence."

In serial recall, the reverse may be expected. Since instructions for Experiment 1 directed subjects to write the words "in the order and correct serial position in which they were spoken", intervening spaces would be appropriate when a word could not be recalled. Not surprisingly, all of the young subjects, with one exception, left intervening spaces in their attempts to place words in the correct serial positions. The one exception in this group was a subject who indeed attended to the directions, but who left no spaces at all. Although words may have been misplaced or intruded, this subject wrote six words for each sequence in each of the four conditions.

The elderly subjects exhibited a similar pattern, with all but two subjects leaving intervening spaces on the response sheet. The two exceptions left spaces at the end of some sequences, indicating that they did consider their responses to be in the correct positions. They were, therefore, like the young subjects, consistently adhering to the serial recall procedures.

The response pattern for the AD subjects, however, resembled the pattern seen for that group in free recall. Fifty-six percent (9 subjects) of the AD group left intervening spaces, suggesting an appropriate attempt to place words in the correct serial position. However, the fact that almost half of this group left no intervening spaces (only spaces at the ends of most sequences) again highlights the major attention deficit for this mildly demented group, in spite of frequent reminders of the correct response procedure throughout the experiment.

The results of the present study provide interesting suggestions for future research. A more definitive measure of subtle changes in memory processing and consolidation, as well as in the concreteness effect, could be evaluated to ascertain whether words recalled in a delayed condition were primarily the words which were originally among the first words presented for immediate recall, and whether concrete words were more likely than abstract words to be recalled when they were in these positions. In the present study, word order was transformed, and presentation of control and suffix conditions varied so that no subject within a group received the same word order or condition. However, teasing apart the first and final words presented to each subject on an individual basis and comparing their responses could provide further information regarding the facilitation of encoding and retention based on presentation order, and will be pursued as a future project.

Further research is warranted, to create a serial position curve for delayed recall and determine the impact of primacy and recency, found so strongly in all groups in immediate recall, on delayed recall and recognition. Do the words which maintain distinctiveness as the first or final words presented retain that distinctiveness after varying delay intervals? Can the quantitative and qualitative findings for the AD subjects reported here be modified to distinguish level of severity of AD, or to distinguish AD from other dementing illnesses? Could the discriminating indices between aging and mild AD be more finely adapted as an early marker of incipient dementia (e.g., in a group of borderline, GDS 3, subjects)? Can the definitive response inhibition reported for the AD group be correlated with other attentional deficits previously noted in this population?

Certain aspects of the present study, such as the type of suffix or the severity and etiology of the demented group, could be adapted to answer these and more questions regarding normal and abnormal processes of immediate memory which may be age-associated and dementia-dependent.

APPENDIX A: ASSESSMENT INSTRUMENTS

ASSESSMENT PROCEDURES USED AT THE NYU-ADRC

A. Cognitive Evaluations

1. Clinical

Global Deterioration Scale (GDS) (Reisberg, Ferris, de Leon, & Crook, 1982). The results of this evaluation are scored by a clinician, and based upon information about subjective complaints of memory deficit, objective observation of deficit on careful clinical interview, and an assessment of the ability of the patient to function in a community setting and to survive with or without assistance. The global status of the patient is rated on a seven-point scale. The following broad criteria are used: (GDS 1) no subjective complaints or objective clinical evidence of a memory deficit; (GDS 2) subjective complaints about, but no objective evidence of, a memory disorder; (GDS 3) first objective evidence of a memory deficit (patient may show decreased job functioning detectable by a co-worker or have experienced difficulty in traveling to a new location); (GDS 4) marked cognitive deficit (patient typically manifests decreased knowledge of recent events, concentration deficit on serial subtraction tasks, and diminished ability to handle personal finances); (GDS 5) patient can no longer survive without some assistance (patient is unable to recall a major aspect of his or her current life such as home address or name of close family members; patient requires assistance in choosing proper clothing); (GDS 6) very severe cognitive impairment, slightly functional with supervision (patient is largely unaware of all recent events and personal experiences, has difficulty putting on clothing properly and may become incontinent); (GDS 7) profound cognitive impairment with need for constant supervision and assistance (patient loses all verbal abilities and basic motor skills).

The GDS was designed to provide as precise a brief clinical description as possible of the clinically observable deficits accompanying brain aging and progressive Alzheimer's disease. It has been very useful in providing clinicians and scientists with a basic overview of the nature and course of these conditions and the GDS scale has been widely employed in research and clinical practice. The scale has been reproduced in large part or entirety in many current medical and scientific texts (e.g. Grebb, 1989; Kolb & Whishaw, 1990; Jenike, 1985; Group for the Advancement of Psychiatry, 1988; Gallo, Reichal & Andersen, 1988). Previous studies have demonstrated strong, significant relationships between GDS assessments and independent behavioral assessments of subjects with both normal aging and AD (Reisberg, Ferris, de Leon & Crook, 1982; Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988). The interrater reliability of the GDS at our own center is .92, as determined by dual evaluations of 38 patients (Reisberg, Ferris, Steinberg, Shulman, de Leon & Sinaiko, 1989). In addition, at least three other separate reliability studies in diverse settings and in diverse subject populations have been published (Gottlieb, Gur & Gur, 1988; Foster, Sclan, Welkowitz, Boksay & Seeland, 1988; Dura, Haywood-Niler & Kiecolt-Glaser, 1990). All of these studies have demonstrated excellent interrater and test/retest reliability of the GDS. Those studies which have compared the reliability of the GDS with other assessment modalities, including mental status and psychometric assessments, have found the GDS to be at least as reliable as these other measures.

The GDS is capable of assisting in the clinical discrimination of ostensibly normal aged subjects with, and without, subjective complaints of cognitive impairment (i.e., GDS stages 1 and 2). Also, the GDS can identify a subject population who are manifesting subtle but evident clinical deficit, but whose mental status scores are generally insufficient for a diagnosis of dementia (i.e., GDS stage 3 subjects). At the other end of the clinical spectrum, the GDS can discriminate a subject clinical severity group, which almost invariably achieves only bottom scores on diverse psychometric and mental status modalities (i.e., GDS stage 7 subjects). The GDS differs from other clinical severity staging instruments which have also come into usage (e.g., the Clinical Dementia Rating Scale of Hughes et al., 1982), in part in that the GDS distinguishes more clinical gradations. The GDS correlates well with other dementia scales (e.g., with the Mini Mental State, $r = -.89$, $p < .001$, $n = 154$ (Reisberg, Ferris, et al., 1988).

Brief Cognitive Rating Scale (BCRS). This scale consists of separate clinical ratings, on a 7-point scale, of 10 axes (5 "major" and 5 "minor") designed to be maximally concordant with each other and with the GDS at each cognitive functioning level (Reisberg, Schneck, Ferris, Schwartz & de Leon, 1983; Reisberg, London, Ferris, Borenstein, Scheier & de Leon, 1983; Reisberg & Ferris, 1988). This instrument provides another global assessment that may prove useful as a sensitive instrument for measuring cognitive deficit and change over time, especially since it yields scores that are potentially more continuous than the GDS but, like the GDS, gives meaningful scores for the more severely demented AD patients. The relevant global score is the average of the five major axes, including ratings of concentration, recent memory, remote memory, orientation, and functioning and self-care. This averaged score, although correlating highly with the GDS, has the advantage of providing scores that have intermediate values between the whole-number steps provided by the GDS. The inter-rater reliability of the average BCRS score is high ($r = .96$, $p < .001$, $n = 38$) (Reisberg, Ferris, Steinberg, Shulman, de Leon & Sinaiko, 1989).

The BCRS has been found to be useful by other investigators in examining the course of AD (e.g., Tinklenberg, Brooks et al., 1990), in the investigation of putative treatments for AD (e.g., Ala, Romero, Knight, Feldt & Frey, 1990), and in the assessment of nursing home patients with dementia (e.g., Cohen-Mansfield, Marx & Rosenthal, 1989; Werner, Cohen-Mansfield, Braun & Marx, 1989; Cohen-Mansfield, Werner & Marx, 1990).

Functional Assessment of AD (FAST). We have expanded a 7-item ordinal functional assessment measure which is an axis of the Brief Cognitive Rating Scale (Reisberg, Schneck, Ferris, Schwartz & de Leon, 1983) into a new 16-item assessment called Functional Assessment Staging (Reisberg, Ferris & Franssen, 1985; Reisberg, Ferris, Anand, de Leon, Schneck & Buttinger, 1984; Reisberg, 1988). Using this measure, approximately 11 stages of AD progression can be identified beyond the point at which most conventional test measures produce bottom scores and approximately 6 to 8 stages in AD progression can be identified beyond the point at which AD patients commonly score zero on the MMSE.

Recently, we completed a reliability study in 16 subjects using the FAST (Sclan & Reisberg, 1992). Two intraclass reliability coefficients (ICC) were computed: (1) rater consistency was 0.86 ($p < .01$), and (2) rater agreement was 0.87 ($p < .01$). In addition to statistical significance, the ICC can also be interpreted in terms of clinical significance (Cicchetti and Sparrow, 1981). Using this criterion, both the ICC reliability models for the FAST demonstrated "excellent" clinical significance (i.e., "excellent" chance-corrected interrater agreement). This study has demonstrated that the FAST fulfills the Guttman criteria for an ordinal scale. Concurrent reliability data are now available with cognitive measures for the FAST throughout the range of the scale. The correlation with the MMSE is ~ 0.81 (Reisberg, Ferris, Anand, de Leon, Schneck & Buttinger, 1984) and for late stage AD patients, the correlation with the modified Uzgiris-Hunt Ordinal Scales of Psychological Development (Sclan, Foster, Reisberg, Franssen & Welkowitz, 1990) is 0.8 (Sclan & Reisberg, 1992).

Mini-Mental State Exam (MMSE). Administered by a clinician. Includes a series of short tests designed to elicit information about orientation to time and place, comprehension, attention and calculation abilities, recall and copying (praxis) ability (Folstein, Folstein & McHugh, 1975). This is a widely used dementia screening instrument. The relationship between MMSE scores and GDS levels in our baseline sample of subjects free of cerebrovascular disease has been published (Reisberg et al., 1988).

Blessed Dementia Scale. This commonly used instrument comprehensively evaluates memory, information, concentration, functioning and emotional status (Blessed et al. 1968). This scale has been validated neuropathologically. The relationship between these measures and GDS levels has been published (Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988).

B. Psychometric Evaluations

1. Psychometric Screening Battery. Administered by an assistant psychologist. The battery includes the Guild Memory Test, consisting of immediate and delayed recall of paragraphs and word pairs and recall of designs (Gilbert, Levee & Catalano, 1968; Crook, Gilbert & Ferris, 1980). The battery also includes the MSQ (Kahn, Goldfarb, Pollack & Peck, 1960) and the Vocabulary, Digit Span and Digit Symbol Substitution subtests of the WAIS. Relationships between scores on these measures and GDS scores in our baseline sample of subjects with aging and dementia free of vascular concomitants have been published (Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988).

2. Psychometric Deterioration Score (PDS). The PDS represents a combined score derived from an equal weighting of six tests that are included in the psychometric screening battery. Tests 1-3 are taken from the Guild Memory Test (Gilbert, Levee & Catalano, 1968; Crook, 1983) and test 4-6 are taken from the WAIS (Wechsler, 1981). The PDS is calculated by taking the sum of the per cent correct performances for the (1) immediate recall and delayed recall of paragraphs, (2) immediate recall and delayed recall of paired associates, (3) recall of designs, (4) WAIS vocabulary, (5) digit symbol substitution test, and (6) digits forward and backward; the obtained sum is then divided by the total number of tests. This score is then converted into a continuous scale with low absolute scores representing relatively little deterioration and high scores denoting very deteriorated psychometric test performance. Although the PDS correlates well with GDS (r = 0.85, $p < .001$, N = 328), it is obtained independently and the PDS has the advantage of having a continuous rather than an ordinal scale of scores and, thus, may allow for a more sensitive and precise measure for assessing behavioral differences or change over relatively short, between-assessment intervals. The inter-rater reliability for the PDS is quite high (r = .94, $p < .001$, N = 25). The proportion of patients that get a zero score (i.e., PDS = 8) having a GDS of a, 2, 3, 4, 5, 6, and 7 is 0%, 0%, 1.2%, 1.7%, 24.2%, and 100%, respectively. More information on the relationships between PDS scores and GDS levels in our aging and dementia sample has been published (Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988).

3. Cognitive Assessment Battery. In order to provide a profile of cognitive and neuropsychological function for research use, a comprehensive neuropsychological test battery is administered. This battery evaluates various aspects of memory, language, attention, spatial, and psychomotor processes. A list of several of the components of our psychometric battery appears below. Some characteristics at baseline of our subjects without vascular concomitants on many of these psychometric variables have been published (Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988). The list below of our comprehensive battery includes the measures referred to above.

Immediate Memory
(i) Digit Span (Wechsler, 1981)

Recent Memory
Verbal Recall:
(i) Paragraph Recall (Gilbert, Levee & Catalano, 1968)
(ii) Shopping List Task (McCarthy, Ferris, Clark & Crook, 1981)
Visuospatial Recall:
(i) Delayed Spatial Recall Task (Flicker, Bartus, Crook & Ferris, 1984)
(ii) Misplaced Objects Task (Crook, Ferris & McCarthy, 1979)
Visual Recognition Memory:
(i) Visual Recognition Span (Flicker, Ferris, Crook & Bartus, 1987)

(ii) Facial Recognition Task (Flicker, Ferris, Crook & Bartus, 1989)

Remote Memory
(i) Remote Memory Questionnaire (Flicker, Ferris, Crook & Bartus, 1987)

Language
(i) Vocabulary (Wechsler, 1981)
(ii) Category Retrieval (Battig & Montague, 1969)
(iii) Object Naming (Flicker, Ferris, Crook & Bartus, 1987)
(iv) Object Function Recognition (Flicker, Ferris, Crook & Bartus, 1987)
(v) Object Identification (Flicker, Ferris, Crook & Bartus, 1987)

Concept Formation
(i) Object Sorting Task (Flicker, Ferris, Crook & Bartus, 1987)

Visuospatial Praxis
(i) Block Construction (Wechsler, 1981)
(ii) Digit Symbol (Wechsler, 1981)

Visuoperceptual Function
(i) Judgment of Line Orientation (Benton, Hamsher, Varney & Spreen, 1983)
(ii) Face Matching (Benton, Hamsher, Varney & Spreen, 1983)
(iii) Road Map Test (Money, Alexander & Walker, 1965)

Psychomotor Speed
(i) Finger Tapping (Lehman & Ban, 1970)
(ii) Driving Test (Flicker, Serby & Ferris, 1990)

4. Cognitive assessment of late-stage AD. We have embarked upon an exploration of the hypothesis that mental function in late-stage AD patients can be assessed using measures of the earliest stage of cognitive development as hypothesized by Piaget (Piaget, 1952). The test employed is the Ordinal Scales of Psychological Development (OSPD), designed to assess an infant's level of sensorimotor development based upon Piaget's models (Uzgiris & Hunt, 1975). Current data indicate that these OSPD and similar measures are useful in the cognitive assessment of even the most severely impaired AD patients (Sclan, Foster, Reisberg, Franssen & Welkowitz, 1990; Sclan & Reisberg, 1992).

C. Behavioral Evaluations

1. The Hamilton Psychiatric Rating Scale for Depression (Hamilton, 1960). Administered by a clinician. Used primarily to rule out symptoms of depression as the primary cause of disability.

2. Behavioral Pathology in Alzheimer's Disease Rating Scale (BEHAVE-AD). This rating scale is designed to assess the presence and magnitude of suspiciousness, agitation, affective and other behavioral symptoms that have been identified as being associated with AD (Reisberg, Borenstein, Franssen, Salob, Steinberg & Shulman, 1987). The instrument is scored based upon information obtained from caregivers. Reliability, validity, specificity, and sensitivity data have all been published for this instrument. Patterson, Schnell, Martin, Mendez, Smyth & Whitehouse, 1990, found that agreement on ratings of AD patients was "good to excellent" for 20 of the 25 BEHAVE-AD items. A study at our Center, (Sclan, Reisberg, Franssen, Torossian & Ferris, 1990) found that "the rater consistency coefficient for BEHAVE-AD total score was 0.96 and the rater agreement coefficient for BEHAVE-AD total score was also 0.96." Consequently, there appears to be good agreement on the reliability of this instrument.

The BEHAVE-AD was specifically designed to assess commonly occurring potentially remediable behavioral symptoms in AD (Reisberg, Borenstein, Franssen, Shulman, Steinberg & Ferris, 1986). A recent study found that 12 of the 25 items assessed occurred in 40% or more of AD patients at some stage and that 8 of the remaining 13 items occurred in 15% to 40% of AD patients at some stage of their illness (Reisberg, Franssen, Sclan, Kluger & Ferris, 1989). Consequently, the BEHAVE-AD appears to be valid in that it assesses broadly, commonly occurring behavioral symptoms in AD.

In contrast to the common occurrence of BEHAVE-AD symptoms in AD patients, a study of 15 control subjects found no symptoms in the controls on 15 of the 25 items. Of the remaining 10 items, symptoms were manifest in less than 25% of controls on 8 of the 10 items. Up to one out of three controls manifested tearfulness and "other anxieties". Patterson, Schnell, Martin, Mendez, Smyth & Whitehouse, 1990, also noted "that controls rarely reported any of these symptoms, other than tearfulness [7 of 17], diurnal rhythm disturbances [4 of 17], fear of being alone [2 of 17], and unspecified anxieties [1 of 17]." Consequently, there is excellent agreement regarding the specificity of these symptoms in AD.

The BEHAVE-AD was designed to assess pharmacologically responsive symptoms and preliminary data indicated that the symptoms were pharmacologically responsive (Reisberg, Borenstein, Salob, Ferris, Franssen & Georgotas, 1987). More recent data (Dysken, Johnson, Holden, Vatassery, Nygren & Jelinsky, 1990) indicates that at the end of two weeks of neuroleptic intervention, 10 of 15 participants with AD had improved rates of $\geq$ 30% on the BEHAVE-AD. Consequently, the instrument appears to have excellent pharmacologic sensitivity.

In addition to fulfilling all of the above criteria, the BEHAVE-AD also appears to fulfill the additional criterion of wide acceptance. It is presently being used in the U.K., Germany, and France as well as the U.S.

3. Instrumental Activities of Daily Living Scale (IADL). Elicits information from the caregiver concerning the patient's present and previous levels of social functioning and behavior (Lawton & Brody, 1969).

D. Medical Evaluations

The function of the medical and neurological evaluation is to (1) identify patients with active pathology or a history of pathology which would exclude or confound a diagnosis of AD; (2) aid in the differential diagnosis of senile dementia (particularly between AD and vascular or other dementias); and (3) to identify the usage of concurrent medications which might confound some of the cognitive evaluations. These medical and neurological evaluations are outlined below:

1. Health and History Questionnaire. Filled out by the patient or relative and returned by mail prior to scheduling of the screening visit. Includes information about family history of dementia, clinical and behavioral symptoms, functional abilities, whether the onset of symptoms was sudden or gradual, whether the symptoms are persistent or intermittent. Also includes a comprehensive checklist of past medical, neurological and psychiatric problems and all surgical procedures and hospitalizations. Current medications are recorded.

2. Modified Ischemia Scale. Administered by a clinician to determine the extent to which cerebrovascular factors might account for the cognitive symptoms (Hachinski, 1983; Hachinski, Lassen & Marshall, 1974; Rosen, Terry, Fuld, Katzman & Peck, 1980).

3. Laboratory Tests.

i. Blood and serum analyses (SMA-18, corpuscular blood count with differential and platelet count, T3 and T4, TSH, folic acid and B12).

ii. Urinalysis.

iii. EKG.

4. Quantitative Medical Evaluation (QME). The QME is a form filled out by the clinician which provides objective information about relevant medical problems, with particular emphasis on cerebrovascular risk factors. A history of stroke is sufficient evidence for a diagnosis of vascular dementia or vascular normal. This history can be either a clinical history or evidence from information on the CT scan.

5. Complete physical examination and vital signs. All patients have a complete and extensive physical exam. A detailed medical history is obtained. Special attention is paid to abnormalities in blood pressure (hypertension, hypotension, orthostatic hypotension) which is recorded on repeated occasions in supine and erect position.

Special attention is also paid to any abnormalities of the cardiovascular system. Results of an electrocardiogram are reviewed, as are the results of a laboratory exam which includes a complete blood count and differential, SMA 18, serum vitamin B12 and folate levels, and serum thyroxine, T3 uptake and TSH levels.

6. Complete neurological exam. This comprehensive exam is documented on a detailed, quantitative neurological form. Patients with focal neurological signs indicating cerebrovascular disease or intracranial space occupying lesions are excluded. Patients with clinical evidence of neurodegenerative diseases, other than Alzheimer's disease or vascular dementia, are also excluded. This includes patients with infectious diseases of the brain, as well as patients with evidence of central nervous system trauma or toxic-metabolic disorders of the CNS including significant history of alcohol abuse.

The neurological exam also includes evaluation of the cranial nerves, the motor system, the sensory system, deep tendon reflexes, coordination, gait and station, speech, language and praxis. Presence of pathological reflexes and extrapyramidal signs are documented. In addition, special attention is paid to the presence of neurological signs that are commonly associated with diffuse cerebral dysfunction, in particular the so-called developmental reflexes or frontal release phenomena. In particular, the following signs are looked for; conjugate gaze and visual tracking abnormalities, persistence of glabellar blink, snout reflex, suck reflex and rooting (visual and tactile), blepharospasm, startle reflex, nuchocephalic reflex, force biting, grasp reflex, palmomental reflex, plantar grasp, paratonia or gegenhalten, perseveration, impersistence, abnormal face-hand stimulation test and oculocephalic reflex. The occurrence of hallucinations, delusions, Kluver Bucy syndrome and Capgrass syndrome are also documented.

Since it is not clear whether Alzheimer's disease always diffusely affects the cortex of both hemispheres simultaneously or whether there exists asymmetry, we carefully look for subtle asymmetries in the neurological exam. This issue is also of direct relevance in the study of extrapyramidal symptoms.

The neurological signs are graded on a scale of increasing severity from 1 to 7. Relevant groups of neurological signs are determined and analyses are underway in order to examine the appearance and course of the signs in relation to the stage of cognitive decline. A publication describing in detail the results of one of these analyses, i.e., of non-cognitive neurologic reflex changes in aging and AD, has recently appeared (Franssen, Reisberg, Kluger, Sinaiko & Boja, 1991). The overall results of this exam are categorized as (1) normal; (2) abnormal, nonfocal; (3) abnormal, focal; (4) other. A classification of (1) or (2) is required for an AD diagnosis.

7. Computerized Tomography (CT) and Magnetic Resonance Imaging (MRI). The results of the CT and/or MRI scans are classified as (1) diffuse atrophy (including "normal" scans); (2) focal vascular disease; or (3) other. A classification of (1) is required for an AD or "normal" diagnosis. A classification of (2) is sufficient for a diagnosis of vascular dementia or vascular normal. In addition, a classification of "lucency" is assigned to CT or MRI studies for any diagnostic groups which show white matter lucencies (leukoencephalopathy).

8. Quantitative Brain Imaging Information. In addition to diagnostic classification, comprehensive quantitative CT and MRI measures (regional atrophy, ventricular volume, etc.) are obtained on each subject. The relationship between many of these assessments and the GDS levels in our subject sample have been published (Reisberg, Ferris, de Leon, Sinaiko, Franssen, Kluger & Mir, 1988).

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APPENDIX B: GLOBAL DETERIORATION SCALE (GDS)

Global Deterioration Scale (GDS) for Age-Associated Cognitive Decline and Alzheimer's Disease.

GDS Stage	Clinical Characteristics	Diagnosis
1 No cognitive decline	No subjective complaints of memory deficit. No memory deficit evident on clinical interview.	Normal
2 Very mild cognitive decline	Subjective complaints of memory deficit, most frequently in following areas: (a) forgetting where one has placed familiar objects; (b) forgetting names one formerly knew well. No objective evidence of memory deficit on clinical interview. No objective deficit in employment or social situations. Appropriate concern with respect to symptomatology.	Normal Aging
3 Mild cognitive decline	Earliest clear-cut deficits. Manifestations in more than one of the following areas: (a) patient may have gotten lost when travelling to an unfamiliar location. (b) co-workers become aware of patient's relatively poor performance. (c) word and name finding deficit become evident to intimates. (d) patient may read a passage or book and retain relatively little material. (e) patient may demonstrate decreased facility remembering names upon introduction to new people. (f) patient may have lost or misplaced an object of value. (g) concentration deficit may be evident on clinical testing. Objective evidence of memory deficit obtained only with an intensive interview. Decreased performance in demanding employment and social settings. Denial begins to become manifest in patient. Mild to moderate anxiety frequently accompanies symptoms.	Mild Neurocognitive Disorder
4 Moderate cognitive decline	Clear-cut deficit on careful clinical interview. Deficit manifest in following areas: (a) decreased knowledge of current and recent events. (b) may exhibit some deficit in memory of one's personal history. (c) concentration deficit elicited on serial subtractions. (d) decreased ability to travel, handle finances, etc. Frequently no deficit in following areas: (a) orientation to time and place. (b) recognition of familiar persons and faces. (c) ability to travel to familiar locations. Inability to perform complex tasks. Denial is dominant defense mechanism. Flattening of affect and withdrawal from challenging situations occur.	Mild Alzheimer's Disease
5 Moderatly severe decline	Patient can no longer survive without some assistance. Patient is unable during interview to recall a major relevant aspect of their current life, e.g.: (a) their address or telephone number for many years. (b) the names of close members of their family (such as grandchildren). (c) the name of the high school or college from which they graduated.	Moderate Alzheimer's Disease

GDS: Continued

	Frequently some disorientation to time (date, day of the week, season, etc.) or to place. An educated person may have difficulty counting back from 40 by 4s or from 20 by 2s. Persons at this stage retain knowledge of many major facts regarding themselves and others. They invariably know their own names and generally know their spouse's and children's names. They require no assistance with toileting or eating, but may have difficulty choosing the proper clothing to wear.	
6 Severe cognitive decline	May occasionally forget the name of the spouse upon whom they are entirely dependent for survival. Will be largely unaware of all recent events and experiences in their lives. Retain some knowledge of their surroundings; the year, the season, etc. May have difficulty counting by 1s from 10, both backward and sometimes forward. Will require some assistance with activities of daily living: (a) may become incontinent. (b) will require travel assistance but occasionally will be able to travel to familiar locations. Diurnal rhythm frequently disturbed. Almost always recall their own name. Frequently continue to be able to distinguish familiar from unfamiliar persons in their environment. Personality and emotional changes occur. These are quite variable and include: (a) delusional behavior, e.g., patients may accuse their spouse of being an imposter; may talk to imaginary figures in the environment, or to their own reflection in the mirror. (b) obsessive symptoms, e.g., person may continually repeat simple cleaning activities. (c) anxiety symptoms, agitation, and even previously non-existent violent behavior may occur. (d) cognitive abulia, e.g., loss of willpower because an individual cannot carry a thought long enough to determine a purposeful course of action.	Moderately severe Alzheimer's Disease
7 Very severe cognitive decline	All verbal abilities are lost over the course of this stage. Early in this stage words and phrases are spoken but speech is very circumscribed. Later there is no speech at all - only grunting. Incontinent of urine; requires assistance toileting and feeding. Basic psychomotor skills (e.g. ability to walk) are lost with the progression of this stage. The brain appears to no longer be able to tell the body what to do. Generalized and cortical neurologic signs and symptoms are frequently present.	Severe Alzheimer's Disease

Source: B. Reisberg,et al., "The Global Deterioration Scale for Assessment of Primary Degenerative Dementia." *American Journal of Psychiatry*, 139 (1982).

APPENDIX C: IMAGERY, CONCRETENESS AND FREQUENCY RATINGS: Stimulus and Practice Words

IMAGERY, CONCRETENESS AND FREQUENCY RATINGS:
Stimulus and Practice Words

HIGH IMAGERY WORDS

	I	C	F	M I/C
APPLE	6.76	7.00	A	6.88
ARMY	6.53	6.96	AA	6.75
BABY	6.70	6.90	AA	6.80
BIRD	6.67	6.96	AA	6.82
BOTTLE	6.57	6.94	A	6.76
BOY	6.57	6.93	AA	6.75
BREAST	6.77	6.80	A	6.79
BUTTER	6.57	6.96	AA	6.77
CAMP	6.57	6.56	AA	6.57
CAR	6.87	7.00	AA	6.94
CATTLE	6.40	6.79	A	6.60
CHAIR	6.63	7.00	AA	6.82
CHILD	6.50	6.87	AA	6.69
CHURCH	6.63	6.59	AA	6.61
CLOCK	6.50	6.94	A	6.72
COFFEE	6.73	6.89	A	6.81
COIN	6.50	6.90	A	6.70
DIAMOND	6.67	6.94	A	6.81
DOLLAR	6.50	6.62	AA	6.56
DOOR	6.60	7.00	AA	6.80
FIRE	6.70	6.66	AA	6.68
FLAG	6.60	6.94	A	6.77
FLOWER	6.57	6.96	AA	6.77
FOREST	6.63	6.69	AA	6.66
GIRL	6.87	6.83	AA	6.85
HOTEL	6.40	6.80	A	6.60
KISS	6.80	6.13	AA	6.47
MEAT	6.63	6.93	AA	6.78
MOTHER	6.67	6.52	AA	6.60
NAIL	6.50	6.96	A	6.73
PALACE	6.50	6.73	A	6.64
RIVER	6.63	6.83	AA	6.73
SHIP	6.67	6.93	AA	6.80
STREET	6.57	6.62	AA	6.60
TOWER	6.53	6.96	A	6.75
VILLAGE	6.50	6.69	AA	6.60

LOW IMAGERY WORDS

	I	C	F	M I/C
ADVICE	3.13	2.08	A	2.61
AIR	3.17	5.67	AA	4.42
AMOUNT	2.73	3.62	AA	3.18
ANSWER	2.77	4.49	AA	3.63
CHANCE	2.50	1.51	AA	2.01
COST	3.57	3.41	AA	3.49
CUSTOM	3.43	2.99	A	3.21
DEED	3.63	4.19	A	3.91
DUTY	3.17	2.32	AA	2.75
EFFORT	3.33	2.22	AA	2.78
EVENT	2.90	3.72	A	3.31
EXCUSE	2.77	3.05	A	2.91
FACT	2.20	3.31	AA	2.76
FATE	2.37	1.46	A	1.92
FAULT	2.83	2.87	A	2.85
HIDE	3.80	5.45	A	4.63
HONOR	3.50	1.75	AA	2.63
HOPE	3.83	1.18	AA	2.51
HOUR	3.60	2.93	AA	3.27
IDEA	2.20	1.41	AA	1.81
JUSTICE	3.69	2.18	A	2.94
LAW	3.73	3.23	AA	3.48
LENGTH	3.73	3.75	AA	3.74
LIFE	4.07	2.96	AA	3.52
METHOD	2.63	2.20	AA	2.42
MIND	3.03	2.60	AA	2.82
MOMENT	2.50	2.52	AA	2.51
MORAL	3.17	1.39	A	2.28
SOUL	2.13	1.87	AA	2.00
SPIRIT	3.43	1.86	AA	2.65
STYLE	3.83	3.18	A	3.51
THEORY	2.57	1.90	A	2.24
TIME	4.13	2.47	AA	3.30
TROUBLE	3.53	2.25	AA	2.89
TRUTH	2.73	1.69	AA	2.21
VIRTUE	3.33	1.46	A	2.40

MIXED PRACTICE WORDS

	I	C	F	M I/C
ARROW	6.57	7.00	37	6.79
BANNER	5.93	6.58	23	6.23
BLOOM	5.63	5.82	35	5.73
BOSS	5.73	6.53	23	6.04
CANDY	6.63	6.56	32	6.60
CHARM	4.70	2.17	A	3.44
DRAMA	4.90	3.66	23	4.28
ELBOW	6.30	6.94	26	6.62
FABRIC	5.60	6.55	21	6.08
GHOST	5.37	2.97	32	4.17
GIFT	5.77	5.95	A	2.96
HOUSE	6.67	6.93	AA	6.80
LEADER	5.13	5,83	AA	5.48
LECTURE	5.57	4.50	28	4.79
LINK	4.80	5.38	24	5.09
MEADOW	6.43	6.69	47	6.56
ODOR	5.13	5.83	27	5.48
PRAYER	5.17	3.60	A	4.39
SKY	6.73	6.18	AA	6.46
STAR	6.70	6.73	AA	6.72
TOOL	5.77	6.80	40	6.29
TRIBUTE	3.57	3.12	22	3.35
VAPOR	4.80	5.93	27	5.37
VISION	4.73	4.00	45	4.37

APPENDIX D: TEST MATERIALS

1. Serial Recall and Free Recall Instructions
2. Response Sheet
3. Digit Span
4. Mini Mental Status Examination
5. Recognition Task

EXPERIMENT 1 - SERIAL RECALL

Instructions - Control Condition

You will be presented with lists of words which you will be asked to recall. After each sequence of six words, you will hear a tap. That is your signal to write down the six words in the list in the order and correct serial position in which they were spoken. You do not need to write the entire word. The first two or three letters are enough. Once you start writing, do not go back to add or change any word. You are then to rate each word as to whether you believe you answered correctly or incorrectly. Under each word is a box. Put either a "C" for correct if you believe your answer is correct, or an "I" for incorrect if you believe you answered incorrectly. There will be 40 seconds between sequences for you to write your answers and ratings. If you are not sure of a word, you may guess. If at any time you are not sure of what to do, please let me know and I will be glad to repeat the instructions.

Do you have any questions?

We will first have a practice trial.

EXPERIMENT 1 - SERIAL RECALL

Instructions - Suffix Condition

You will be presented with lists of words which you will be asked to recall. After each sequence of six words, you will hear the word "CODE". That is your signal to write down the six words in the list in the order and correct serial position in which they were spoken. Do not write the word "CODE". It is just your signal to begin recalling and writing the list words. You do not need to write the entire word. The first two or three letters are enough. Once you start writing, do not go back to add or change any word. You are then to rate each word as to whether you believe you answered correctly or incorrectly. Under each word is a box. Put either a "C" for correct if you believe your answer is correct, or an "I" for incorrect if you believe you answered incorrectly. There will be 40 seconds between sequences for you to write your answers and ratings. If you are not sure of a word, you may guess. If at any time you are not sure of what to do, please let me know and I will be glad to repeat the instructions.

Do you have any questions?

We will first have a practice trial.

EXPERIMENT 2 - FREE RECALL

Instructions - Control Condition

You will be presented with lists of words which you will be asked to recall. After each sequence of six words, you will hear a tap. That is your signal to write down the six words in the list in any order you recall them. They need not be in the order in which they were spoken, but do begin writing in the first space on the left and continue to fill each space to the right for as many words as you can recall in that sequence. You do not need to write the entire word. The first two or three letters are enough. Once you start writing, do not go back to add or change any word. You are then to rate each word as to whether you believe you answered correctly or incorrectly. Under each word is a box. Put either a "C" for correct if you believe your answer is correct, or an "I" for incorrect if you believe you answered incorrectly. There will be 40 seconds between sequences for you to write your answers and ratings. If you are not sure of a word, you may guess. If at any time you are not sure of what to do, please let me know and I will be glad to repeat the instructions.

Do you have any questions?

We will first have a practice trial.

EXPERIMENT 2 - FREE RECALL

Instructions - Suffix Condition

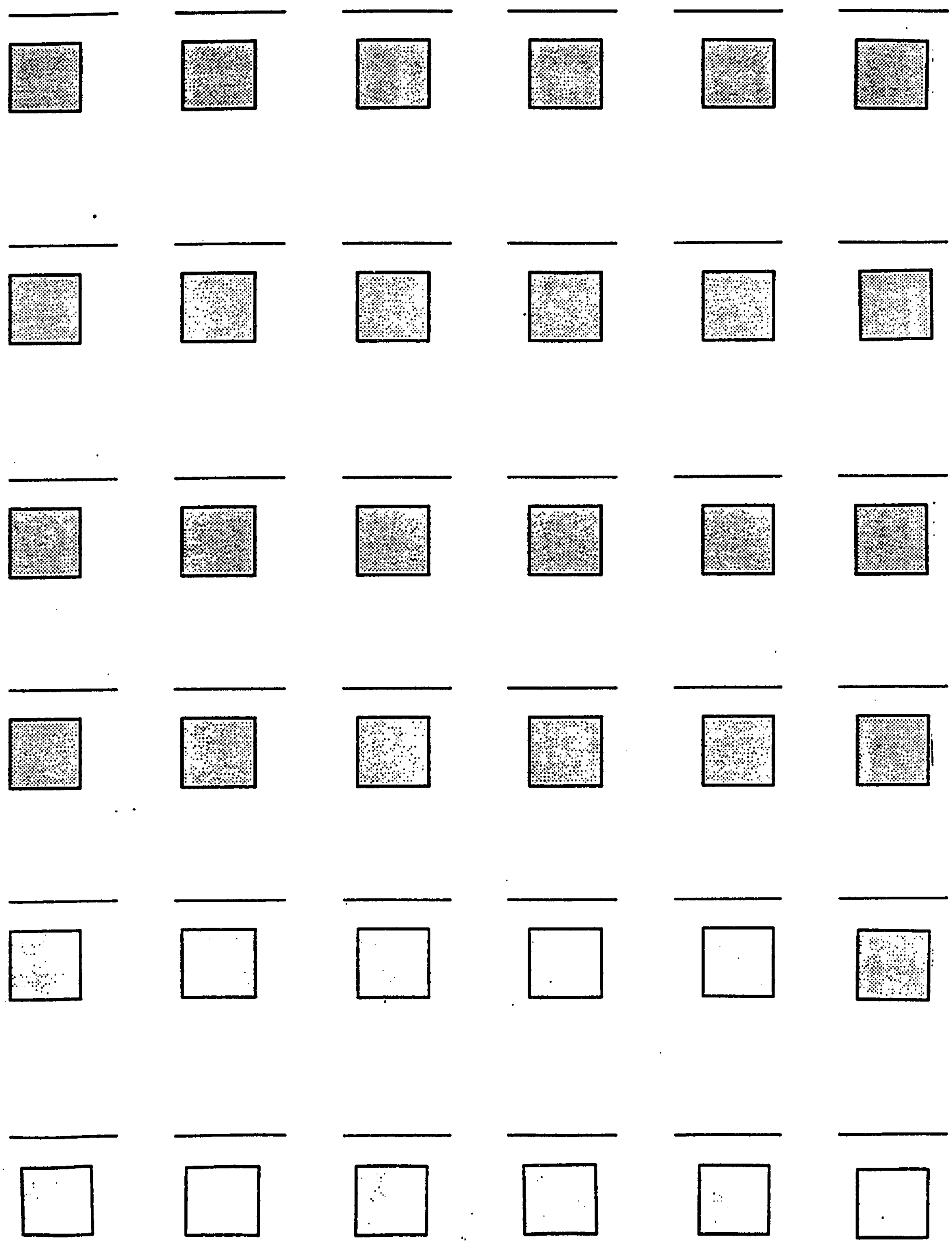
You will be presented with lists of words which you will be asked to recall. After each sequence of six words, you will hear the word "CODE". That is your signal to write down the six words in the list in any order in which you remember them. They need not be in the order in which they were spoken, but do begin writing in the first space on the left of the page and continue to fill each space to the right for as many words as you can recall in that sequence. Do not write the word "CODE". It is just your signal to begin recalling and writing the list words. You do not need to write the entire word. The first two or three letters are enough. Once you start writing, do not go back to add or change any word. You are then to rate each word as to whether you believe you answered correctly or incorrectly. Under each word is a box. Put either a "C" for correct if you believe your answer is correct, or an "I" for incorrect if you believe you answered incorrectly. There will be 40 seconds between sequences for you to write your answers and ratings. If you are not sure of a word, you may guess. If at any time you are not sure of what to do, please let me know and I will be glad to repeat the instructions.

Do you have any questions?

We will first have a practice trial.

SUBJECT #: ____________ TRIAL: ____________

SEQUENCE: ____________



NAME: ____________________ ID#: __________ DATE: ___/___/___ PERIOD: ____

DIGIT SPAN
Forward

(Discontinue after failure on both trials of any item. Administer both trials even if the first trial is passed.)

DIGITS FORWARD

Item	Trial I	Pass Fail	Trial II	Pass Fail	WAIS Score Max correct for item	WMS-R Score 2, 1, or 0
1.	6-2-9		3-7-5			
2.	5-4-1-7		8-3-9-6			
3.	3-6-9-2-5		6-9-4-7-1			
4.	9-1-8-4-2-7		6-3-5-4-8-2			
5.	1-2-8-5-3-4-6		2-8-1-4-9-7-5			
6.	3-8-2-9-5-1-7-4		5-9-1-8-2-6-4-7			
			WMS-R Total Forward		Max=12	

If patient completes either trial of item # 6 then go on to item # 7.

Include scoring of item # 7 for WAIS digit span only.

Item	Trial I	Pass Fail	Trial II	Pass Fail	WAIS Score Max=9
7.	2-7-5-8-6-2-5-8-4		7-1-3-9-4-2-5-6-8		

NAME: ____________________ ID#: __________ DATE: ___/___/___ PERIOD: _____

MINI MENTAL STATE

(MMS)

Orientation	Score
What is the (year) (season) (month) (day) (date) (5 points)	( )
Where are we? (state) (county) (town) (hospital) (floor) (5 points)	( )
Registration	
Name 3 objects from list: Apple, Telephone, River, Book, Horse, Chair. 1 second to say each. Then ask the patient to repeat all three after you have said them. 1 point for each correct. (3 points)	( )
Attention and Calculation	
Serial 7s. 1 point for each correct. Stop at 5 answers. Or spell "world" backwards. (Number correct equals letters before first mistake- i.e., dlorw = 2 correct). (5 points)	( )
Recall	
Ask for the objects above. 1 point for each correct. (3 points)	( )
Language Tests	
Name- pencil, watch (2 points)	( )
Repeat- no ifs, ands or buts (1 point)	( )
Follow a 3 stage command: "Take the paper in your right hand, fold it in half, and put it on the floor." (3 points)	( )
Read and obey the following:	
CLOSE YOUR EYES. (*Show statement printed on prior page.*) (1 point)	( )
Write a sentence spontaneously on the next page. (1 point)	( )
Copy the design on the next page. (1 point)	( )
TOTAL (30 POINTS)	( )

TESTER: ______________ COMMENTS: ______________________________

____

NAME: ____________________ ID#: ________ DATE: ___/___/___ PERIOD: ______

WRITE A SENTENCE BELOW

____

____

____

____

COPY THIS BELOW

#______

Recognition Task

SPIRIT	CABIN	KING	GLORY
APPLE	PATENT	SILENCE	OCEAN
MERCY	EARTH	UNIT	FATE
CAT	MOMENT	ROCK	FOREST
ADVICE	GARDEN	CHURCH	STREET
DOOR	LIFE	ORIGIN	KISS
EGO	CHANCE	JUDGE	BELIEF
TRUTH	IRONY	CAMP	FIRE
DRESS	BOTTLE	STONE	HONOR
EXCUSE	FOLLY	PALACE	DUTY

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