A DISSOCIATION BETWEEN VERBAL AND PICTORIAL IMPLICIT MEMORY IN AN ELDERLY POPULATION

by

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Abstract

Current research indicates that, although older people show impaired performance, relative to young people, on standard tasks of explicit memory, i.e. recognition, cued recall and free recall, they perform as well as young people on tasks of implicit memory. In this study, performance of old and young subjects was compared on an explicit free recall task and on two implicit memory tasks; word fragment completion and picture fragment completion. As expected, on the free recall task performance of old subjects was impaired relative to young subjects for pictures and words. In addition, there were no age related decrements in performance on the implicit verbal task. In contrast, on the implicit pictorial task clear age related differences emerged with the older subjects performing more poorly than the young subjects. Further, manipulations of frequency and familiarity had no differential effect on performance for either group on the implicit tasks. In addition, there was a significant correlation for old, but not young, subjects between the picture completion task and a standard visual perceptual task.

These findings suggest that, at least some components of implicit memory and specifically pictorial memory, may show an age related decline. The results are discussed in terms of a material specific, component processing approach to memory function.

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DEDICATION

To my best
friend
and
kindred spirit
Eleanor

I. INTRODUCTION

It has long been known that patients with organic memory loss, despite a severe anterograde amnesia, are capable of some new learning (Korsakoff, 1889). Korsakoff observed that his patients were able to learn their way about the hospital wards, although if questioned they would deny that they had been in the hospital before.

A classic example of this memory without awareness was demonstrated by Claparede in 1911 (cited in Barbizet, 1970). He noted that a female patient, who had been pricked by a concealed pin when he shook her hand, was unwilling to shake his hand on subsequent meetings. However, this patient seemed to have no conscious awareness of the previous aversive experience.

In 1912, Schneider (cited in Parkin, 1982) reported evidence of perceptual learning in amnesics. He used "Heilbronner's Method" which involved asking the patient to identify fragmented pictures of familiar objects. If the patient was unable to recognize the object, less fragmented versions were shown until identification was made. Following the initial trials, subjects were retested with the fragmented pictures at one to four week intervals. Schneider found evidence of improvements in performance (savings) in reidentifying the fragmented drawings for all three patients, although they denied any conscious awareness of having seen the pictures before.

Since these early accounts, considerable evidence has accumulated to indicate that amnesics can learn and retain new information. Typically, studies that have demonstrated memory without awareness have involved situations in which the instructions focussed on the performance of a perceptual or motor task rather than on explicit instructions to remember. Generally, a normal level of savings is shown in objective performance although the amnesic patient has no subjective sense of having done the task (Jacoby & Witherspoon, 1982). Until recently, much of the experimental work with amnesics had focussed on delineating their memory deficits as opposed to examining their residual memory abilities (Parkin, 1982). As a rule, tasks on which amnesics have shown good performance have been viewed with less interest (Warrington & Weiskrantz, 1979). However, by examining the preserved memory abilities in amnesic patients we may be able to further our understanding of the functional organization of the intact memory system in normals (Parkin, 1982).

A large body of knowledge demonstrating residual learning abilities in amnesics has come from neuropsychological research and single case studies and is now available for a variety of different tasks including: classical conditioning (Gantt & Muncie, 1942; Linskii, 1954; Luria, 1976); mirror drawing (Milner, 1966); pursuit rotor (Cermak, Lewis, Butters & Goodglass, 1973); learning melodies on a piano (Starr & Phillips (1970); and perceptual learning (Milner, Corkin & Teuber, 1968; Warrington & Weiskrantz, 1968).

Numerous classification schemes have been suggested to characterize the kinds of memory (or processes) that are impaired versus the kinds of memory (or processes) that are spared including: memory with awareness/memory without awareness (Jacoby & Witherspoon, 1982), knowing that/knowing how (Cohen & Squire, 1980), declarative knowledge/procedural knowledge (Cohen, 1984), and explicit memory/implicit memory (Graf & Schacter, 1985). It is not clear, at present, which of these dichotomies best describes the phenomena under investigation. For the purposes of this paper the nomenclature used by each researcher will be retained when their research is being discussed. However, for this study the terms "implicit memory" and "explict memory" are used in a purely descriptive sense, that is, implicit memory is that which is measured when the task instructions do not require reference to a prior episode, whereas, explicit memory is that which is measured when the task instructions include reference to a specific prior episode. This definition is similar to what other researchers refer to as indirect, and direct, memory measures, respectively (Johnson & Hasher, 1987; Richardson-Klavehn & Bjork, 1988). No claims are made as to whether conscious or unconscious awareness are involved.

In this section, research that demonstrates implicit memory with amnesics will be reviewed, followed by evidence of a dissociation between implicit and explicit memory in normal young people, and finally, the more recent research on implicit memory in the elderly will be examined.

Studies that have demonstrated intact perceptual learning are of particular importance for the present research. Warrington and Weiskrantz (1968) examined the performance of Korsakoff amnesic patients using a technique similar to Heilbronner's method. Either fragmented words or fragmented pictures of common objects were shown to the subjects. More complete versions were shown successively until the word or object was correctly recognized. Five rials were administered on three successive days and error scores were obtained. The results of testing on subsequent days indicated that the amnesic patients showed considerable savings. For both fragmented pictures and words, the amnesic subjects showed improved performance; the scores obtained on day 2 were better than those on day 1, and those obtained on day 3 were better than on day 2.

Milner, Corkin and Teuber (1968) used a task similar to that of Warrington and Weiskrantz (1968) with their amnesic patient H.M. and a control group. The procedure involved showing 20 fragmented pictures to the subjects and encouraging them to verbalize what they thought the drawing might represent. Successively more complete drawings were shown until all of the items were correctly recognized. After a one hour interval and without prior warning the entire test was repeated. The results showed that H.M.'s performance on the original test was actually above the average of the control subjects. On retesting after a one hour delay both H.M. and the control group made fewer errors, however H.M's performance did not remain as good as that of the controls.

A more complex form of perceptual learning, using the McGill Picture Anomalies test, was reported by Warrington and Weiskrantz (1978). This test is comprised of a series of line drawings depicting a scene that has one anomalous feature; for example, a lifejacket lying on the ocean floor. The subject is shown each drawing and the time taken to detect the anomaly is recorded. In Warrington and Weiskrantz's study of a mixed group of amnesics, subsequent testing with the same pictures showed a clear reduction in the time taken to detect the anomaly. In a somewhat similar study by Meudell and Mayes (1981) a group of Korsakoff amnesics and a normal control group were given pictures of cartoons with a hidden object in each. Search times were recorded at initial testing and again after a seven week interval. The results showed that savings in search time was similar for both the amnesic and control groups. When shown previously unseen cartoons on retest, both groups required longer search times, suggesting that improved performance was due to memory for specific item information rather than to a generalized practice effect. Moreover, at retest, the amnesics could not discriminate the cartoons they had seen before from those that were presented for the first time. (For more comprehensive reviews of residual learning in amnesia see: Butters, 1984; Hirst, 1982; Parkin, 1982; Stern, 1981; and Squire & Butters, 1984.)

The hallmark of much of this research is the dissociation between the amnesics' objective performance, which utilizes some prior learning, and their ability to consciously recollect specific information from that revious learning situation. This apparent dissociation between memory and awareness has more recently been explored in normal subjects using a variety of procedures and paradigms.

Kolers (1976) recorded the speed at which subjects read transformed text. A year later the same subjects were asked to read some of the old sentences as well as some from the same original source they had not seen before. The results revealed a low correlation between recognition memory for, and memory as measured by faster reading speed of, the repeated sentences. Kolers interpreted these findings as evidence of independence between the subject's more rapid reading speed of repeated sentences and the ability to recognize the sentence as one that had been read a year earlier.

Using a lexical decision task in which subjects had to decide whether a string of presented letters was a word or a nonword, Scarborough, Cortese and Scarborough (1977) found a repetition-priming effect regardless of the time lag (ie. number of intervening words) between initial and subsequent presentation of the item. In contrast, a longer time lag resulted in poorer recognition memory. Some researchers (Jacoby & Dallas, 1981) have suggested that although repetition priming effects on later perceptual identification probably do not require conscious awareness, recognition memory does require awareness on the part of the subject.

Further evidence of a distinction between explicit memory as measured by yes/no recognition and implicit memory as measured by a repetition priming effect was provided by Moscovitch (1982). Using a lexical decision task similar to that of Scarborough et al. (1977) he found that the repetition-priming effect was equally as good for old and young subjects as well as those suspected of being in the early stages of Alzheimer's Disease. However, on the recognition portion of the test when subjects were required to decide whether they had seen a word before, performance of the old and young subjects was equally affected by lag. In contrast to his predictions, Moscovitch did not find an age by lag interaction on the recognition task. That is, both old and young subjects showed longer reaction times to make a decision about whether they had seen a word before as the lag increased. The suspected Alzheimer's patients however performed at chance levels on the recognition test. These findings clearly support the notion that recognition and repetition priming are probably mediated by different mnemonic processes (Moscovitch, 1982).

Jacoby and Witherspoon (1982) provide additional evidence of independence between recognition memory and perceptual identification. The procedure used was composed of three phases. Initially, the subjects were asked to study a visually presented list of both high and low frequency words (Thorndike & Lorge, 1944). Next, a test of recognition memory was given either immediately or after a 20 minute delay. For the recognition part of the test, words were presented on a computer screen, on a typed sheet of paper, or were read to the subjects. Finally, a test of perceptual identification which included old as well as new words was given. These words were flashed for 35 msec. followed by a mask. The results revealed that a single presentation of a word enhanced later perceptual identification of that word. More importantly, in all conditions the enhancement of perceptual identification did not depend on being able to recognize the old word.

Jacoby and Witherspoon (1982) also conducted an experiment that examined the effects of priming on the spelling of homophones in normals and Korsakoff amnesic patients. The procedure involved three parts. In part one, the interpretation of a homophone was biased by asking the subject a question which included the least frequently used interpretation of that homophone (e.g. Name a musical instrument that uses a reed.) In part two, the subject was required to spell some words including the homophones which were primed in part one. The notion here was that, if the prior presentation was remembered, the probability of the subject spelling the low frequency version of the homophones, which were biased by previous presentation, would be greater than for spelling the high frequency version of the homophones that were not previously presented. The third part of this experiment involved a test of recognition memory. The results showed a large effect for patients and controls of prior presentation of a homophone on its later spelling. In fact, the probability of a Korsakoff amnesic patient using the interpretation of a word which had been previously introduced was greater than for normal control subjects (.63 vs. .49 respectively). It should be noted that this part of the study was introduced as a spelling test, not as a memory test. For the recognition test, however, when subjects were required to be aware of what was to be remembered the Korsakoff patients performed very poorly. The interesting result of this research, however, is that the dissociation of memory and awareness was also evident for the normal subjects.

Using a somewhat similar approach Howard, (1986) compared young and old subjects on a homophone spelling test in which the less popular interpretation of the homophone was previously biased. She found that for the immediate implicit memory task performance between the groups did not significantly differ, whereas, on the explicit cued recall task the old group performed more poorly relative to the young group. After a 48 hour delay however, the old, but not the young, group showed a decay in spelling bias.

Tulving, Schacter and Stark (1982) used a word-fragment completion task to show that priming effects on word-fragment completion are independent of recognition memory. Subjects were visually presented a long list of words (96) and were tested either one hour or seven days later. Testing was comprised of a recognition memory test as well as a graphemic, word-fragment completion task (e.g., _E_D_L_M for PENDULUM). Consistent with the results of Jacoby and Witherspoon (1982) they found that performance on the word-fragment completion test was facilitated by the presentation of the fragmented word in the previous study list. In addition, these priming effects were independent of recognition memory. Although performance on the recognition test deteriorated over the seven day interval, the priming effects did not. Moreover, for subjects who received the recognition memory test prior to the fragment completion test, priming effects were as great for words incorrectly identified as "new" as they were for words correctly identified as "old".

Light, Singh, and Capps (1986) used a similar paradigm to explore the relationship between priming in word-fragment completion and recognition memory for both old (mean age = 69 years) and young (mean age = 23 years) subjects. Their procedure involved the visual presentation of a list of 40 words for study. Subjects were then tested immediately and after a one week retention interval for recognition memory as well as for their ability to complete word fragments. "New" and "old" words were included in both the recognition and fragment completion tasks. The results showed that older adults performed as well as younger adults on fragment completion but not on recognition. Moreover, performance on fragment completion was independent of whether words were recognized as "old". Light et al. (1986) found that performance on both recognition and fragment completion declined across the seven day retention interval. On the recognition task, the older group showed a steeper decline than the younger group, whereas on fragment completion both groups showed a comparable decline. These results led Light et al. to suggest that, like amnesic patients, older adults may be impaired on tasks that require them to consciously recall information to memory (explicit memory), whereas, memory that does not require awareness (implicit memory) is not related to age. The key to finding these positive results on tests of implicit memory for both amnesics and older subjects seems to be related to the structure of the task at hand. Thus when instructions to remember prior information are given, performance is typically quite poor. In contrast, when the instructions do not refer to the use of some previously learned information, even though the subject requires this information to perform the task correctly, performance of older subjects is as good as for normal young subjects.

These findings were confirmed in a subsequent series of experiments (Light & Singh, 1987), which used repetition priming in word fragment completion (experiments 1 & 2) and erceptual identification of visually degraded words (experiment 3). In all 3 experiments no age diferences were found on the implicit memory tasks, and clear age differences were obtained on the explicit tasks (cued recall, free recall and recognition). The authors noted, however, that although the age differences on the implicit memory tests were not statistically significant, the overall pattern of performance was consistent in that the young subjects performed better than the old subjects in all 3 experiments. Light and Singh (1987) acknowledged that the power to detect age differences in experiment 1 and 2 was quite low (.30 & .16 respectively). However, power was higher for the perceptual identification task in experiment 3 (.82). From these results they concluded that there may be real, albeit small, age differences on word completion tasks (though not on perceptual identification tasks), but their study was not powerful enough to find them.

This conclusion is corroborated by more recent evidence from Chiarello and Hoyer (1988). These researchers compared performance of young and elderly subjects on word stem completion or cued recall at three delay conditions following semantic or graphemic orienting tasks. They found that the old performed more poorly than the young on implicit and explicit tasks at all three delay conditions. This is the first demonstration of a significant age effect in implicit verbal memory.

Other converging evidence (Read, 1988) indicates that there may be age differences in at least some implicit pictorial memory tasks. Read (1988) investigated age-related changes in explicit and implicit memory abilities on a visual closure task. Four age groups of normal elderly volunteers were tested: 50-59; 60-69; 70-79; and 80 or older. Although all age groups showed some savings over both a 15 minute and one year delay, there were some clear age-related differences. Over both the short- and long-term retention intervals the oldest group showed significantly less savings than the two middle age groups and, in addition, the two middle age groups showed smaller savings than the younger group. These findings contrast with those of Light et al. (1986; 1987) who found no age related differences in performance on tasks of implicit verbal memory.

There is some question, however, about the validity of the percent savings measure used by Read (1988). This measure is sensitive to different baselines in performance between the age groups. The old subjects have a higher baseline error rate than the young subjects and thus their difference score is divided by a larger amount leading to a smaller percent savings score. If one examines the mean difference error scores on part 1 from 1984 to 1985 (Table 2) for the four age groups there appears to be a negligible age effect. Thus, Read's results may be an artifact of the measure he used rather than any real age-related differences in implicit pictorial memory. It may be that percent avings is not a useful measure when there are differences in baseline performance between the age groups. Nevertheless, the issue of age-related differences on implicit tasks of pictorial memory remains a valid one and should be explored further.

Assuming that Read's (1988) results are not artifactual, there are several other possible reasons for the conflicting results of these studies. One is that different paradigms produce variable results. That is, Light et al. (1986) tested their subjects immediately and after a one week delay, whereas, Read tested his subjects both after a 15 minute delay and again, after a one year delay. Alternatively, it may be that Read's study measured a different component of implicit memory. That is, whereas Light et al. (1986) used primarily a verbal task (graphemically-fragmented words), Read used primarily a visual task (fragmented line drawings). This suggests that within the domain of implicit memory there may be material-specific differences between verbal and pictorial memory abilities in the elderly that are not found with younger subjects.

An alternative explanation concerns the issue of word frequency. Many of the implicit verbal memory studies employed moderate to low frequency words, whereas the visual closure task used high frequency (familiar) items. This raises the possibility that on word-fragment completion tasks, older subjects may be more fluent than younger subjects at generating low versus high frequency words, thus enabling improved performance. In contrast, tasks that use high frequency items may not allow the same compensatory advantage to older subjects, resulting in overall poorer performance.

These issues were addressed directly in the present research. Young and old subjects were exposed to 40 high and low frequency words and 40 familiar and unfamiliar pictures and asked to make a living/non-living decision about each item. Immediately following the orienting task subjects were given two implicit tasks: (1) an old and new word fragment completion task, and (2) an old and new picture fragment identification task. In addition, an explicit task involving free recall of words and pictures from the target list, was given.

If the material-specific hypothesis is true then age differences favoring the young subjects should emerge on the implicit picture task but either be less robust or not occur on the implicit word task, regardless of item frequency. However, if the compensatory hypothesis is true we expect to find age differences favoring young subjects with high, but not low, frequency items for pictures and words on the implicit task. On the explicit (free recall) task we expect to find the often reported superior performance for young subjects.

II. METHOD

Subjects

A total of 96 volunteer subjects participated in the study. The young subjects were volunteers from undergraduate courses at the University of Victoria (20 males & 28 females) ranging in age from 18 to 38 years (mean = 26 years). The elderly subjects were healthy, community dwelling, persons (15 males & 33 females) who had participated in a previous study in the department of psychology. They ranged in age from 58 to 79 years (mean = 67 years). Young subjects had a mean of 15 years of education, whereas old subjects had a mean of 14 years. All subjects, by self report, were in good health and not depressed. Vision and hearing were normal or corrected to normal. Any subjects with a prior history of brain injury or illness such as cerebrovascular accident, coronary bypass, tumor, head injury, or epilepsy etc. were excluded from the study. Subjects were tested individually or in pairs. An opportunity for debriefing was provided following the test session.

Materials

Three main tests were employed in the study: a word fragment completion task (WFC), a pictorial fragment completion task (PFC), and a free recall test (FR).

Word Fragment Completion Task: The slide materials for this task were taken primarily from the 260 items normed by Vanderwart and Snodgrass (1980). All of the 80 words chosen were common nouns that varied in length from 4 to 11 letters. The words were matched for frequency and randomly assigned to one of two target sets (A or B). Each target set therefore contained 20 high frequency words and 20 low frequency words (Kucera-Francis frequency count from 30 - 897, and 0 - 27 respectively; Kucera & Francis, 1967). Word fragments were obtained for each item using pilot subjects such that previously unseen words could be correctly produced 20 to 40% of the time. The response sheet contained 80 word fragments half of which were previously seen in the target set (old) and half of which were previously unseen items (new). See Appendix A for samples of word fragments.

Pictorial Fragment Completion Task: The materials for this task consisted of 80 slides of simple line drawings also taken from the Snodgrass and Vanderwart norms (1980). The pictures were divided into two sets (A or B). Each set contained 20 familiar items and 20 unfamiliar items (3.5 - 5 and 1 - 2.3 respectively, Snodgrass and Vanderwart, 1980). In addition, each drawing had a corresponding fragmented version drawn in black ink on a white 5 by 8 inch card. Picture fragments were produced by removing lines from the original pictures until pilot subjects could correctly name the items 20 to 40% of the time. See Appendix A for samples of picture fragments.

Two slide trays were prepared, tray A consisted of 80 items, 40 words (20 high & 20 low in frequency) and 40 pictures (20 familiar and 20 unfamiliar) randomly mixed. Tray B included the remaining 80 items.

Procedure

Initially, subjects were randomly assigned to one of four counterbalanced conditions according to target set and test order:

1) Target set A, Picture Fragment Completion, Word Fragment Completion (APW).

2) Target set A, Word Fragment Completion, Picture Fragment Completion (AWP).
3) Target set B, Picture Fragment Completion, Word Fragment Completion (BPW).
4) Target set B, Word Fragment Completion, Picture Fragment-Completion (BWP).

Following a short introduction, subjects were shown a series of 80 slides (target set A or B) of both pictures and words at a rate of one slide every 5 seconds. They were asked to make a decision as to whether the item shown was of a living or non-living thing and to circle either L (for living) or N (for non-living) on the response sheet. Two sample slides were shown, one of a living (i.e. leopard) and one of an non-living (i.e. cloud) item.

Immediately following the orienting task subjects were given either the Word, or Picture Fragment Completion task, according to their assigned condition. Instructions for the Word Fragment Completion task were as follows: "Here is a list of 80 words with some of the letters missing. All of the words are common nouns and there are no proper nouns (i.e. There are no names of people, places or products). Try to fill in the missing letters so that you make a word.

Don't spend too much time on any one item, if you don't complete it in about 20 seconds please go on to the next word. Some of these fragments are very difficult and most people don't get all of them."

For the Picture Fragment Completion task subjects were told: "Here is a deck of 80 cards, each card has a line drawing on it with some of the lines missing. Look at each item carefully and write down what you think it might be. If you're not sure, try to guess. I don't want you to spend too much time on any one item, so after about 20 seconds go on to the next card. Some of these items are very hard and most people don't get all of them." Subjects were allowed approximately 20 minutes to complete each of the tasks.

Following the completion tasks a Free Recall test was given. Instructions to the subjects were: "Do you remember looking at a series of slides of pictures and words a while ago? Now I would like you to write down as many of those items as you can remember." Most people required 3 to 5 minutes to complete this task.

In addition to the three main tests described above, standard vocabulary and visuo-perceptual tests from the

Multidimensional Aptitude Battery (MAB, Jackson, 1984) were administered. The vocabulary test consisted of 46 items for which subjects had to choose the one word from a list of five that was closest in meaning to the given word. The perceptual test consisted of 35 items and subjects had to decide what was the most important part missing from the picture. A maximum of 7 minutes was allowed for each test.

Finally, a brief questionaire with questions regarding the subjects' health status and mood (Geriatric Depression Scale, Yesavage, et al., 1983) was administered. During the debriefing session subjects were given the rationale for the study as well as an opportunity for feedback. Anecdotally, it is interesting to note that many subjects were surprised to learn that the word and picture fragments were from the slides they had seen before.

III. RESULTS

Separate analyses of variance (ANOVA) were conducted for the explicit memory (free recall) task and the two implicit memory tasks (word fragment completion & picture fragment completion). Subsequent to any higher order interactions post hoc ANOVAS were carried out to explore the simple main effects as suggested by Kirk (1982). Following these, additional ANOVAS were conducted to determine whether there were age differences on the standard vocabulary and visuo-perceptual tasks. Then, a series of ANCOVAS were carried out on the implicit verbal and pictorial tasks to determine whether differences on the covariates (vocabulary and visuo-perceptual tasks) were related to age differences. As this study used naturally occurring and not randomly assigned groups one will need to use some caution in interpreting the results of the ANCOVAS. To investigate whether there were age differences in the relationship between the explicit and implicit memory tasks a series of correlational analyses were computed. Finally, it was of interest to compute the power of the statistical tests for the free recall and word fragment completion tasks.

To protect the family wise error rate the alpha level for the preplanned comparisons was set at the .05 level of significance. The effects of major interest were age, frequency and age by frequency interactions; all remaining comparisons that involve the counterbalancing variables were tested using the more conservative Bonferroni Inequality correction (Howell, 1987).

Free Recall Task

For the free recall task the mean proportion of old and new items recalled for young and old subjects can be seen in Table 1. In this task old items were those items that appeared in the target set and were previously viewed by the subject, whereas, new items were considered to be interlist intrusions. These interlist intrusions were not viewed in the target set but were seen as new items in either the word, or picture, fragment completion tasks. An overall multivariate test was not required as specific comparisons were preplanned for each task. The major effects of interest were a main effect for age, a main effect for frequency and an age by frequency interaction. Four separate ANOVAS were carried out using a mixed design with age (old, young), target set (A, B), and test order (picture/word, word/picture), as between group factors and

Table 1.

Mean proportion of target (old) items and interlist intrusions (new items) on the free recall task for each age group.

Mean Proportion Recalled

	Young			Old		
Free recall Task	High Freq	Low Freq	Mean	High Freq	Low Freq	Mean
Words						
targets	.12	.16	.14	.09	.08	.09
intrusions	.01	.02	.02	.01	.00	.01
	Fam	Unfam	Mean	Fam	Unfam	Mean
Pictures						
targets	.28	.17	.23	.13	.09	.11
intrusions	.04	.02	.03	.02	.01	.02

frequency (high, low, for words; familiar, unfamiliar, for pictures) as the within group factor. The dependent variable was proportion of items recalled and it varied for each ANOVA as follows; 1) old words (targets), 2) new words (interlist intrusions), 3) old pictures (targets), and

4) new pictures (interlist intrusions).

Word Recall

The results of the ANOVA on proportion of old words recalled showed a main effect for age with young subjects recalling more target items than old subjects (F(1,88)=16.30, MSe=.008, eta2=9.1%). Although there was no main effect for frequency (F(1,88)=2.91, MSe=.005), there was a frequency X age (F(1,88)=4.1, MSe=.005) interaction indicating that for young subjects low frequency words were recalled more than high frequency words. However, this pattern did not hold for older subjects.

Word Intrusions

ANOVA on the proportion of new words (interlist intrusions) recalled showed that, although there was no significant main effect for age (F(1,88)=3.49, MSe=.001, eta2=11.3%), it did approach significance (p=.07). That is, the young subjects tended to report more intrusions than the old subjects. There were no significant interactions.

Picture Recall

The results of the ANOVA on proportion of old pictures recalled indicated that there was a main effect for age ($F(1,88)=32.75$, $MSe=.019$, $eta2=18.5\%$) with the young subjects recalling more items than the old subjects. Further, there was a main effect for familiarity showing that familiar pictures were recalled more than unfamiliar ($F(1,88)=34.84$, $MSe=.007$) and a familiarity X age interaction ($F(1,88)=8.34$, $MSe=.007$). This interaction ndicated that for young subjects high familiar pictures were recalled more than low familiar pictures. Moreover, this effect was weaker for older subjects.

Picture Intrusions

The ANOVA for proportion of new pictures (interlist intrusions) recalled indicated a main effect for age ($F(1,88)=12.17$, $MSe=.002$, $eta2=6.2\%$) with young subjects reporting more interlist intrusions than old subjects. A significant main effect for familiarity showed that familiar items were recalled more than unfamiliar items.

Extra List Intrusions

An additional ANOVA was conducted using number of extra list intrusions as the dependent variable. These intrusions were items reported at recall that did not appear in either target set. It was found that the two groups did not differ significantly with respect to external intrusions, with means of 1.27 for the young group and .94 for the old group.

Free Recall Summary

To summarize the results from the explicit memory free recall task, the young group recalled significantly more items from the target set, (whether pictures or words) than the older group. This is consistent with the large body of literature that shows a decrease in free recall scores across the lifespan (Burke & Light, 1981; Salthouse, 1982). In addition, an age by frequency interaction indicated that the age difference, in favor of young subjects, was greater for low frequency, than high frequency, words. A low frequency advantage for words is consistent with the findings of other researchers (May, Cuddy & Norton, 1979; Gregg & Tryk, 1980) when mixed frequency lists are employed.

That effect, however, did not appear for the older subjects. An age by picture familiarity interaction suggests that, although young subjects recalled more target pictures than old subjects, the difference in performance was greater in the familiar, than in the unfamiliar, condition. With regard to interlist intrusions, the older group was less likely than the young group to produce intrusions of pictures or words and thus appeared more conservative.

Word Fragment Completion Task

For the word fragment completion task the data were arrayed as a 2x2x2x2 mixed design with age (old, young), target set (A, B), and test order (picture/word, word/picture) as between group factors; and frequency (high, low) as the within group factor. The dependent variable was a difference score, determined by subtracting the proportion correct of new items (baseline) from the proportion correct of old items (targets). Rather than using difference scores, a percent change measure could have been used. However, there is a problem with using percent change when the groups differ on baseline performance. For example, if baseline performance is better among young subjects, results viewed in terms of items correct would reduce age effects, whereas, percent change viewed in terms of errors would enhance age ffects. Difference scores were preferred because they would be the same whether performance was expressed in terms of proportion correct or proportion of errors.

Table 2 shows the mean proportion correct of old and new items and the difference scores on the word fragment completion task. An analysis of variance to determine whether the young and old groups differed on the implicit word fragment completion task revealed no main effect for the two variables of most interest; age ($F<1$, $MSe=.023$) and frequency ($F=1.66$, $MSe=.020$). However, the pattern of findings was consistent with that of other researchers (Light & Singh, 1987) with the young subjects performing slightly, but not significantly better than old subjects. The only other significant findings, using the Bonferroni correction, were a main effect for target favoring set B, ($F(1,88)=14.78$, $MSe=.023$), and a frequency X target interaction ($F(1,88)=16.54$, $MSe=.020$).

Table 2.

Mean proportion of items correct on word, and picture, fragment completion tasks for each age group.

Mean Proportion Correct

	Young	Old
Task Word Fragment Comp.		
Target	.487	.440
Baseline	.351	.327
Difference	.136	.114
Picture Fragment Comp		
Target	.521	.367
Baseline	.372	.264
Difference	.149	.103

Further analysis of this interaction indicated no significant difference in frequency levels for target set A ($F(1,44)=2.93$, $MSe=.025$), but for target set B, performance on low frequency items was reliably better than on high frequency items ($F(1,44)=20.97$, $MSe=.026$). These counterbalancing effects appear to be due to the chance assignment of more difficult word fragments to target set A than to target set B.

To summarize the findings on the implicit verbal memory ask, the elderly subjects showed no significant deficit relative to the younger subjects on the word fragment ompletion task. These results are consistent with the literature which shows preserved implicit memory for word fragment completion tasks across the lifespan (Light et al, 1986; Light & Singh, 1987; Light & Burke, in press). As noted by Light and her colleagues, however, the overall pattern of performance suggests slightly, but not significantly, better implicit memory for young versus old subjects.

Whenever small but nonsignificant group differences emerge the power of the study to detect these differences becomes an issue. To calculate power we need an estimate of effect size. One estimate that we have readily available is that from the explicit free recall task (.56). Further, it would be reasonable to use this effect size as we know that it was large enough to show a significant age effect. Thus using the effect size from the free recall task (.56) as an estimate of the effect size for the implicit word fragment completion task we find that the power for the implicit task would be about .81. On the other hand, if we use a smaller estimate of effect size such as the observed effect size on the implicit task (.14) then the power would be quite low (.17). Thus, one can be reasonably confident that the word fragment completion task had the power to detect age differences of the magnitude observed in the explicit free recall task. Since the observed effect was not significant it could be concluded that the actual effect size for implicit memory for word fragments is smaller than .56. Moreover, if age differences exist on the implicit verbal task they are probably quite small.

Picture Fragment Completion Task

The design used for the picture fragment completion task was similar to the one used for the word fragment completion task except that familiarity (familiar, unfamiliar) was used as the within group factor rather than frequency. For the purposes of this study, familiarity on the picture completion task is considered analagous to frequency on the verbal fragment completion task (Snodgrass & Vanderwart, 1980). Table 2 shows the mean proportion correct of old and new items and difference scores for each age group on the picture fragment completion task. A separate ANOVA was carried out to determine whether the groups differed on the implicit picture completion task. In contrast to the findings on the implicit verbal task, these results indicate a main effect for age (F(1,88)=5.04, MSe=.020, eta2=2.4%) favoring the younger group. In addition, after using the Bonferroni correction the only other significant finding was a main effect for target set, favoring set A (F(1,88)=42.02, MSe=.020).

In sum, there were clear age related differences on the implicit pictorial task, with the young subjects showing stronger implicit memory effects than the older subjects.

Vocabulary and Visuo-perceptual Tasks

To explore these findings further it was of interest to look at performance between the groups on the vocabulary and visuo-perceptual tasks, and then to determine whether erformance on these tests was correlated with performance on the word, or picture, fragment completion tasks. On the vocabulary test, as is often the case (Kausler, 1982), old subjects scored reliably higher than young subjects with means of 37.58 and 33.6 respectively (F(1,94)=6.68, MSe=.006, eta2=6.6%). The correlation between the word fragment completion task and the vocabulary test was nonsignificant (r=-.07). Since there was no significant relationship between performance on these two tests ANCOVA was not computed.

In contrast, on the visuo-perceptual test the young subjects scored significantly higher than the older subjects with means of 26.04 and 22.06 respectively (F(1,94)=16.91, MSe=.002, eta2=15.2%). In addition, the correlation between the picture fragment completion task and the visuo-perceptual test was significant (r=.29, p<.01). ANCOVA was carried out to determine whether this relationship could account for the age effect on the picture fragment completion task. The results of the ANCOVA of scores on the picture fragment completion task with the visuo-perceptual test scores as the covariate failed to produce a significant age effect (F<1).

Correlations between Explicit and Implicit Memory

Additional correlations were calculated between performance on the verbal explicit free recall task and the word fragment completion task for the young ($r=.51$, $p<.01$), and the old ($r=.32, p<.05$), subjects; as well as, between performance on the pictorial free recall task and the picture fragment completion task for the young ($r=.32$, $p<.05$), and the old ($r=.36$, $p<.05$) subjects. Although all of these correlations were significant, they do not support the notion that young, but not old, subjects use explicit strategies to improve their performance on the implicit tasks.

IV. DISCUSSION

To highlight the major results of interest in this study, we found a dissociation in performance on two similar measures of implicit memory; on a verbal task there were no age related differences, whereas, on a pictorial task the old subjects were impaired relative to the young subjects. In addition, when the standard visuo-perceptual task was used as a covariate the age-related difference on the pictorial task disappeared. These findings support a material-specific hypothesis and suggest a deterioration in performance on at least some kinds of implicit memory tasks across the lifespan. Little support was found for the compensatory hypothesis which suggested superior performance for young subjects on high, but not low, frequency items on the implicit tasks. These findings and their implications will be discussed in more detail in the following sections.

Explicit Free Recall Task

The results of this study are consistent with the prevailing literature on explicit memory tasks (Craik, 1977; Light & Burke, in press; Light, Singh & Capps, 1986) which suggest that old people are impaired, relative to young people, on explicit verbal memory tasks. Furthermore, these findings can also be extended to include a similar age discrepancy in performance on explicit (free recall) pictorial tasks. In addition, manipulation of word frequency showed that for the young, but not old, subjects free recall of low frequency words was significantly better than for high frequency words. Other researchers have found similar results with young subjects on free recall tasks which used mixed lists of high and low frequency words (Gregg, Montgomery, & Castano, 1980; May, Cuddy, & Norton, 1979). Manipulation of picture familiarity showed a main effect indicating that familiar pictures were recalled more than unfamiliar pictures. In addition, a familiarity by age interaction suggested that the familiarity effect was stronger for the young than the old subjects. I know of no other studies that used high and low familiarity pictures in a free recall task and so it is not clear how these findings should be interpreted.

Implicit Verbal Task

Similarly, on the implicit verbal task the present data are consistent with most of the current research. That is, when given word fragments to complete, without reference to remembering a prior episode, young and old subjects perform slightly, but not significantly, different (Light et al., 1986; Light & Singh, 1987; Moscovitch, 1982). As noted earlier, however, the young subjects generally tend to perform better than the old subjects. To date, there is only one study that reports significant age differences on an implicit verbal task (Chiarello & Hoyer, 1988). These researchers suggested that they found significant effects ecause they had a larger sample size and more statistical power to detect age differences than previous studies. The related issues of effect size and statistical power are important for research on implicit memory as it now appears that age differences may be quite small and therefore difficult to detect without sufficient power.

The current study not only had more subjects per group than Chiarello and Hoyer (1988), but it also had good power to detect an effect size as large as that obtained in their study. The underlying difference between the current study and that of Chiarello and Hoyer is not one of power or sample size, but one of effect size.

It is interesting to examine the effect size (gamma) for each of the three studies discussed above. Light and Singh (1987) and Chiarello and Hoyer (1988) expressed age effects in terms of difference scores rather than effect size, however, gamma takes variability into account and expresses effect size in terms of standard deviation units. This makes for more meaningful comparisons between studies that may have different standard deviations. In order to facilitate comparisons between the three studies, gamma was computed for each of them. The effect size for the implicit verbal tasks were computed to be: .14 for the current study, .34 for Light and Singh (1987, experiment 2) and .64 for Chiarello and Hoyer, (1988).

Clearly, Chiarello and Hoyer have a much larger effect size than either of the other two studies. One wonders why they obtained such a large effect size. It is generally accepted that young people perform better than old people on tasks of explicit memory (Howard, 1986; Jacoby & Witherspoon, 1982; Moscovitch, 1982). One possibility considered by Chiarello and Hoyer is that young subjects may have used explicit memory strategies that are not available to old subjects to increase their performance on the implicit task. The procedure used by Chiarello and Hoyer may have contributed to the use of explicit memory strategies. For example, during the orienting task, each stimulus word was presented twice and each subject was tested 3 times at different delay intervals (0, 13, and 46 minutes). It is possible that some subjects may have realized that some of the word stems were from the target list. This unsolicited form of remembering has been referred to as "involuntary explicit memory" by Schacter (1987). According to Schacter (1987; Ross, 1984) involuntary explicit memory occurs when the implicit cue (i.e., word stem) causes an unintentional but explicit memory about the prior occurrence. The probability of this occurring may be higher when the task is repeated as it was in Chiarello and Hoyer's study.

Furthermore, the word stem task that Chiarello and Hoyer (1988) used was constrained by the number of dditional letters that could be added to make a word. It could be argued that limiting word length in this way would make the task more difficult than stem completion tasks used by others and thus encourage the use of explicit strategies Chiarello & Hoyer, 1988; Squire, Shimamura & Graf, 1987).

In addition, there may be a relationship between effect size and the mean difference between target and baseline performance. If we look at the effect size and the mean difference for the three studies of interest, the effect size increases as the mean difference increases. The effect sizes are .14, .34, and .64; whereas the mean difference scores for old subjects on the verbal implicit memory tasks are .113, .200, and .320 for the present study, Light and Singh (1987), and Chiarello and Hoyer (1988), respectively. Larger difference scores may mean that explicit memory is having a larger effect on performance. Similarly, small difference scores may mean that memory is playing a smaller role and therefore age effects may be smaller. The positive correlation between age effect size and memory difference scores suggests that explicit memory may be involved. If explicit memory is operating one would expect a larger age effect size as older subjects are impaired relative to younger subjects on explicit tasks.

Implicit Pictorial Memory Task

In contrast to the results on the implicit verbal task, significant age related differences were obtained on the implicit pictorial task with young subjects performing better than old subjects. Taken together with the results of the implicit verbal task, these findings are consistent with a material-specific hypothesis. That is, although old subjects perform as well as young subjects on implicit verbal tasks, they seem to perform worse than young subjects on implicit pictorial tasks. These tasks may be tapping into different processes or components of implicit memory.

Why might old subjects perform more poorly on an implicit pictorial task? Some might argue that the pictorial task was more difficult than the verbal task resulting in older subjucts just giving up. This is unlikely, however, as there are other tasks, such as perceptual identification (Light & Singh; 1987, experiment 3), that are as or more difficult than the picture completion task that show no age-related differences in performance.

It is generally accepted that visuo-perceptual abilities decline faster than verbal abilities with aging (Kausler, 1982) and thus it may be that pictorial memory also declines at a faster rate than verbal memory. Danziger and Salthouse (1978) would argue that old subjects show decreased performance in identifying incomplete pictures because they are less efficient at utilizing partial cues. Further support for this position comes from the finding that old subjects not only obtained lower scores than young subjects on the standard visuo-perceptual task but also these scores were significantly correlated with their performance on the picture completion task. A reduced ability to use partial cues in the elderly may account for their lower baseline performance. Nevertheless, age differences persist after taking the baseline performance nto account suggesting that something else was involved.That is, along with a deterioration in perceptual performance per se there may be an additional and parallel deterioration in some component of implicit pictorial processing.

Taken together, the poorer performance on the picture fragment completion task and the standardized visuo-perceptual task, along with the positive correlation between the two, suggests that there may be some process shared by both tasks that changes with age. The disappearance of the age effect when the visuo-perceptual task was used as a covariate strongly suggests that this process may be concerned with the application of operations during encoding of pictorial details.

It may be that when young subjects perform encoding tasks, similar to the orienting task used in this experiment, they engage in adequate amounts of data driven processing and are able to reapply these processing operations later when given the picture fragment completion task. Perhaps older subjects do not apply appropriate data driven operations while encoding the pictures and therefore are disadvantaged later while performing the picture fragment completion task.

Alternatively, one might argue that the superior performance by young subjects on the picture fragment completion task may reflect the fact that young subjects were able to utilize explicit memory strategies or processes to improve their performance. Old subjects, in contrast, may have been unable or less efficient in applying these processes. However, if young subjects used explicit memory to improve performance on the pictorial task then one might expect them to use the same strategies on the word fragment completion task thereby producing a significant age difference on this task. This hypothesis is improbable as there was no significant age difference on the verbal test. In addition, the correlation between the explicit and implicit pictorial tasks, although significant, was not stronger for the younger subjects.

Theoretical Considerations

Although several different theoretical views have been postulated to explain dissociations between explicit and implicit memory, no single theory to date provides an adequate explanatory framework. Three of the more popular theoretical approaches as outlined by Schacter (1987) and Richardson-Klavehn and Bjork (1988) will be discussed briefly; activation and elaboration (Graf, Squire & Mandler,1984; Mandler, 1980), multiple-memory systems (Kinsbourne & Wood, 1985; Tulving, 1972) and component processes (Jacoby, 1983).

Graf, Squire and Mandler (1984) posit two processes, activation and elaboration, that provide a framework from which to understand the residual learning abilities and deficits in amnesic patients. Mandler (1980) suggests that when a word is presented to a subject for study its features are activated automatically. Consequently, once the schema representing the word is activated in memory, the vailability of the word temporarily increases and subsequent production of the word to a partial stimulus cue is facilitated. It is this automatic activation process that is thought to be spared in amnesia. In addition, this process could be used to explain the effects of priming and perceptual recognition (Scarborough, Cortese, & Scarborough, 1977).

The process of elaboration, on the other hand, requires cognitive effort and involves the integration of context and other information in memory. Elaboration, according to Graf et al. (1984), is the process that is impaired in amnesic patients.

Memory deficits in the normal aging process can also be understood using this framework. Light, Singh, and Capps (1986) found evidence of a memory deficit in normal older subjects when retention was measured by recognition, but not by a fragment completion task. They argued that good performance on the fragment completion task could be explained by intact, automatic activation processes with no need to invoke context retrieval (elaboration) mechanisms.

In contrast, poorer performance on the yes/no recognition task could be due to impaired context retrieval mechanisms which require that effortful and elaborative mechanisms be invoked. Although this approach readily accounts for the dissociation between implicit and explicit verbal memory, it does not easily account for the observed deficit in implicit pictorial memory found in the elderly in this study.

Multiple memory system approaches seek to understand the differences in implicit and explicit memory by hypothesizing the existence of distinct memory systems, one of which is spared in amnesic patients and one of which is impaired. These include the semantic/episodic distinction (Kinsbourne & Wood, 1975; Tulving, 1972); procedural/declarative knowledge (Cohen & Squire, 1980); and item/context memory (Huppert & Piercy, 1976). To explain the current findings according to this view one would have to postulate a new memory system for mediating implicit pictorial memory.

It may not be necessary, however, to postulate two or more distinct memory systems in order to understand either the differences between implicit and explicit memory, or dissociations between different types of implicit memory. A more parsimonious view suggests a unitary memory system with varying component processes (Jacoby, 1983b; Kolers & Roediger, 1984; Masson, in press). In this view, specific operations applied at encoding can be reapplied in remembering. The fluency in performing the memory task is determined by the degree of similarity between the processes applied at encoding and at retrieval. When retrieval cues such as word or picture fragments invoke a fluent reapplication of the same procedures then memory performance will be enhanced. In contrast, when the retrieval cues do not recruit reapplication of the same procedures then memory performance will be impaired.

Process views can be described by using the distinction between data driven and conceptually driven processes (Jacoby, 1983b; Roediger & Blaxton, 1987). Data driven processes are concerned with sensory and perceptual analyses of the stimuli and are determined by the information or materials provided. Conceptually driven processes, in contrast, are more concerned with semantic-associative processes (such as elaborating & organizing) and tend to be initiated by the subject (Schacter, 1987). Although implicit and explicit tasks may involve both kinds of processes, it is generally accepted that certain explicit tasks emphasize conceptually driven components, whereas certain implicit tasks emphasize data driven components (Schacter, 1987). Differences between implicit and explicit memory are thus accounted for by differences in the task demands. Using this framework, the free recall task employed in this study invoked conceptually driven processes, whereas the two implicit tasks emphasized data driven processes.

The current findings can be understood in terms of a component processing approach to memory function. Old subjects demonstrated decreased performance, relative to young subjects, on a standard visuo-perceptual task and on a pictorial implicit memory task. Both of these tasks emphasized data driven processes. It may be that some of the elderly subjects engaged in less data driven processing than others during the orienting task. The positive correlation, therefore, could be accounted for by suggesting that those elderly subjects who showed impaired data driven processing on the standardized visuo-perceptual task, would also be more likely to apply inadequate data driven operations during the orienting task. This would result in overall poorer performance, relative to young subjects, on the implicit pictorial memory task.

This conclusion appears to be in contrast to current claims about age-related differences in explicit memory that support the view that older subjects are less likely to engage in conceptually driven processing (Craik, 1983; Light & Singh, 1987). However, these two views are not necessarily inconsistent. Studies that emphasize conceptual processing deficits in the elderly have been largely confined to explicit memory tasks. There may be an additional age-related deficit for data driven operations on implicit tasks.

The results of the ANCOVA could be interpreted as equating young and old subjects on data driven visuo-perceptual processing ability; resulting in the disappearance of an age-related deficit.

It is clear from this study, as well as others (Chiarello & Hoyer, 1988; Light & Singh, 1987) that we can no longer refer to implicit and explicit memory as being spared or impaired in different pathological disease states (amnesia, dementia) or in normal aging. The pattern of findings suggest that a more complex explanatory framework is needed. At present a material-specific component rocessing approach offers the most viable theory for understanding memory function in older adults.

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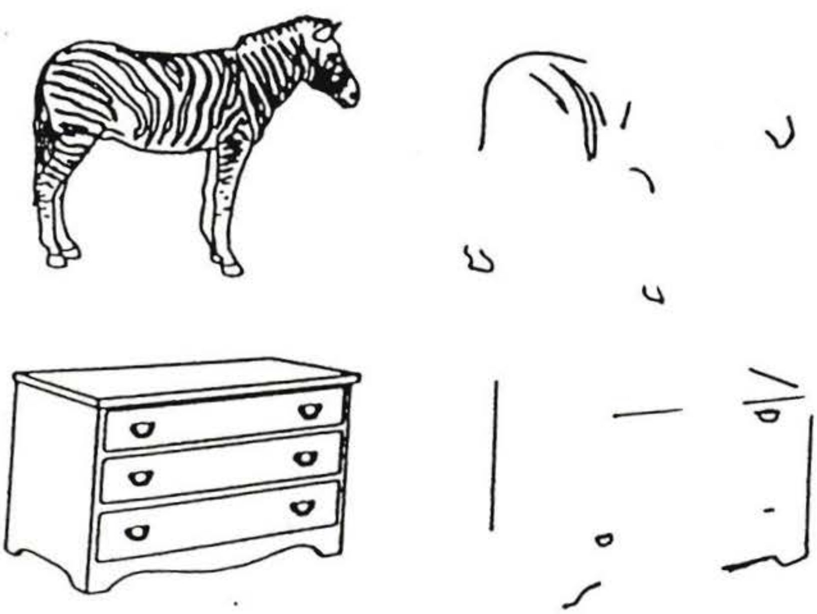
VI. Appendix A

Examples of Word Fragment-Completion Task

ROOSTER RO _ _ TE _

SCISSORS SCI _ _ O _ S

Examples of Picture Fragment-Completion Task



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Title of Dissertation

A DISSOCIATION BETWEEN VERBAL AND PICTORIAL IMPLICIT MEMORY IN AN ELDERLY POPULATION

Author C. Deidre O'Sullivan

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Date January 31, 1989.