RICE UNIVERSITY

RECOGNITION WITHOUT RECOLLECTION

by

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Abstract

Four experiments were conducted to explore the effects of prior exposure to word stimuli on a) identification of the words under perceptually impoverished conditions, and b) recognition of the words as having been previously presented. In Experiment 1, distributing a two-second study duration between two one-second or four ½-second presentations as opposed to concentrating it into a single two-second presentation was found to enhance perceptual identification but have no reliable effect on recognition. Experiment 2 showed that changing modalities between study and test presentations (i.e. from visual to auditory or auditory to visual) reduces but does not eliminate the effect study presentation has on perceptual identification. Experiments 3 and 4 demonstrated that identification both of word-fragment cues and of tachistoscopic stimuli declines sharply over very brief study-to-test intervals but then stabilizes for intervals of at least 24 hours.

Acknowledgments

I would like to express my gratitude to the members of my committee, John Brelsford and Randi Martin, and to Michael J. Watkins whose wisdom, patience, and steady hand allowed me to bring this thesis to completion. I am reminded of Dante's painful pleasure when he meets his master on the journey through Hell,

> .....For I keep with me still,
> Stamped on my mind, and now stabbing my heart,
> The dear, benign, paternal image of you,
> You living, you hourly teaching me the art
> By which men grow immortal.....

And for my husband Bill, whose sense of humor and unending support and encouragement kept me sane and relatively productive, I have these words,

> "When we're dead we shall have the sensation of having enjoyed life altogether, whatever has happened to us. Even if we've been murdered, what a pleasure to have been capable of it." (Charles Williams)

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Experimental research on recognition memory typically involves the presentation of a study list of items, such as randomly selected words, followed by a test in which subjects indicate which items in the test material were members of the original study list. There are numerous versions of this test and inherent in each version is the assumption that when a subject makes a positive recognition judgment he is acknowledging that he remembers the item as having been a member of the study list. Although this assumption is perhaps not unreasonable, the ease with which it is made may have precluded researchers from examining recognition memory more fully. One purpose of this thesis is to show that by utilizing only these standard recognition paradigms, researchers have restricted our understanding of recognition memory.

Standard laboratory procedures have overlooked the fact that recognition can occur without reference to a particular context. This fact is apparent from everyday experience. Imagine you are standing in a grocery store line waiting to be checked out and a person several aisles away has caught your eye. You find yourself staring as you attempt to remember where and when you have seen this person before. You might even try to generate possibilities -- at work? at school? at the local gym? It is not improbable that later, perhaps hours or even days later, you will remember who that person is and how you came to know him. Ah!...you met him at your neighbor's house last Saturday! This not unusual experience illustrates recognition without the

retrieval of the particular episode or context in which the event occurred. The phenomenon will be referred to as recognition without recollection and it is the object of this thesis to investigate how the phenomenon relates to the kind of recognition studied in conventional laboratory experiments.

Perhaps the first clear demonstration of recognition without recollection emerged from investigations of clinical amnesia. Although an amnesic person is, by definition, someone who has inordinate difficulty reflecting upon memories for prior experiences, the literature is replete with instances of amnesics showing evidence of recognition memory of some sort (Warrington & Weiskrantz, 1974; Huppert & Piercy, 1976; Cohen & Squire, 1980). That this recognition is clearly not the kind studied in conventional laboratory experiments is revealed by the fact that in all of these instances the amnesic is unable to recollect the previous experiences involved. While the amnesic is able to demonstrate normal levels of learning over a series of trials with a wide variety of tasks, he may be unable to remember ever having engaged in the task. Any satisfactory account of amnesia will clearly require that the product of a learning episode be distinguished from memory for the episode itself.

Huppert and Piercy (1976) make such a distinction when they suggest that an amnesic can perform more or less normally on a recognition test as long as the test is of a kind that does not call for direct, conscious recollection of a particular episode or episodes. This conclusion was reached on the basis of the findings of two experiments. The first concerned memory for pictorial material. Amnesic

patients were presented with 80 complex pictures for study, and after a one-week interval they were given a yes/no recognition test on the original pictures together with as many new ones. The results indicated that their memory for the pictures was quite good: 80% of their responses were correct. Since this proportion was only slightly less than that for normal controls, the authors concluded that the amnesic subjects were probably not remembering the particular episode of picture presentation but, rather, were responding on the basis of item familiarity. A second experiment was designed to test this possibility.

In the second experiment, amnesic and normal subjects were presented with 80 pictures which were designated the "familiar set." On Day 2, the subjects were presented with one half the familiar set (40 pictures) and 40 new pictures which together comprised the target set. After a 10 minute retention interval subjects were given a yes/no recognition test on the 80 target pictures, the remaining 40 from the Day 1 familiar set, and 40 new pictures. The results showed that the amnesic subjects did disproportionately worse than normal subjects on the familiar pictures. The tendency was for the amnesic subjects to make positive responses to any picture previously seen regardless of the context -- that is, whether or not it had been designated a target picture. Thus in this study, where successful performance was dependent upon recollecting the item within the episode or context of its presentation, the amnesics' performance was severely impaired.

Until recently the dissociation between ability to make recognition judgments and the recollection of the specific prior episode was not an issue in orthodox psychological theorizing, for the phenomenon

was thought to be restricted to the area of amnesia. Research during the last decade or so, however, has begun to change this view. In fact, the possibility of recognition without recollection in normal subjects might have been anticipated from a consideration of the relationship between free-choice and forced-choice recognition. In free-choice recognition tests, the subject may respond positively, and likewise negatively, to any number of the test items. In forced-choice recognition tests, on the other hand, the subject is required to give a specified number of positive recognition responses. The test material may be presented in pairs or small sets and the subject is asked to choose the one item from each set most likely to have been in the study list, or the subject may be given all of the test items and asked to designate a particular number as study items (e.g. 24 out of 48 test items).

Forced-choice recognition tests are often used because they produce a higher percentage of correct judgments than do free-choice recognition tests. Consider why this may be so. It does not seem unlikely that subjects in a free-choice situation assume they must actually recollect the occurrence of that item in the presentation context in order to say that they recognize it, or, put another way, their response is marked by a high degree of confidence. On the other hand, the forced-choice recognition test forces the subject to give at least some responses that are characterized by lower levels of confidence however accurate they might be. Perhaps normal subjects in making responses characterized by less confidence are (like the amnesic subjects) not really recollecting the appearance of the item in the study list but instead are responding to the greater "familiarity" of one item over another -- just as one does

when one recognizes a person in a store but cannot place him.

Recent research has provided more direct evidence for the possibility of recognition without recollection in normal subjects. In 1974 Murrell and Morton demonstrated that the effects of memory can be revealed in a person's performance on a perceptual task. Specifically, subjects' ability to identify briefly presented words was enhanced by exposure to those words in preceding study lists. This effect on perceptual identification performance is obviously produced by the subject's memory for the items in some sense. Subsequently, Jacoby and Dallas (1981) explored the relation between the more aware form of memory that is expressed in standard recognition memory and the less aware form that apparently can be expressed in perceptual learning.

When the effects of study on perceptual identification and recognition memory performance were examined, two distinct classes of variables were revealed. Changes in such study variables as the level of processing, study time, task difficulty, and retention interval produced effects in recognition memory but not in perceptual identification performance. Under these circumstances, the effect of study on perceptual identification performance remained the same regardless of the level of recognition memory. For example, increasing study time improves recognition memory but not perceptual identification performance (Jacoby & Dallas, 1981, Experiment 3). On the other hand, number and spacing of repetitions, frequency of the item in the language, and perceptual similarity produced parallel effects on the two measures. For example, increasing word presentation from one to several spaced presentations increases both recognition memory and perceptual

identification performance. Given that performance on the perceptual identification test reflects memory which is not always related to the direct, conscious recollection of recognition memory, such performance is strikingly suggestive of the recognition without recollection frequently occurring in everyday experience.

More evidence for the dissociation between standard recognition memory and recognition without recollection is found in research reported by Tulving, Schacter, and Stark (1982). Using a task previously developed in research with amnesics, this research was designed to study "priming effects" (the facilatory effects of having had previous exposure to the test material) in a word-fragment completion task and to compare the effect of test delay on performance in a word-fragment completion test with that in a conventional recognition memory test. In such word-fragment completion tests, subjects are provided with graphemic word fragments such as "_ y s _ e r" under the instructions to replace the blanks with letters so as to create a meaningful word. The results of the study showed performance on the fragment completion task to be independent of standard recognition memory in two ways. First, over a seven day retention interval recognition memory performance declined substantially while the priming effect in perceptual identification performance remained unchanged. Second, the priming effect on perceptual identification performance was as great for words incorrectly identified as "new" in the immediately preceding recognition memory test as for words correctly identified as "old". Hence, performance on the word-fragment completion test also appears to demonstrate an effect of previous exposure without recall of this

exposure-- that is, recognition without recollection.

Although these various lines of research are very suggestive, a great deal more evidence is needed to clearly specify the relation between standard recognition memory and recognition without recollection. The research reported here takes a small step towards this goal. In a series of four experiments, several variables are manipulated in such a manner as to address certain questions left unanswered by previous research. First, consider presenting study items once for, say, two seconds versus presenting them for the same total but distributed over two or more shorter presentations. Although Jacoby and Dallas (1981, Experiments 4a & 4b) examined the effects of both study time and repetition on standard recognition memory and perceptual identification performance, they confounded study time with number of repetitions. However, since increased study time was shown not to increase perceptual identification performance while additional repetitions did, perceptual identification performance still might be expected to increase across one presentation to several when study time is held constant. In the case of recognition memory, however, both repetition and study time increased performance (Jacoby & Dallas, 1981). If, as has been suggested by Jacoby and Dallas (1981), increased study time (and "deeper" levels of processing) improve recognition memory by allowing more time for elaborative processing, recognition memory might be expected to decrease as the number of repetitions increased but the length of each decreased. Experiment 1 was designed to address this question.

Second, research concerned with the effect of perceptual similarity on perceptual identification performance has shown that changing the

modality of the material between study and test can virtually eliminate the facilatory effect of a prior presentation. In the past, however, research has used only visual perceptual identification tests; visual presentation was used to achieve a modality consistent condition and auditory presentation was used for the modality inconsistent condition. Auditory versions of perceptual identification tests were apparently deemed unnecessary or too difficult to construct. Consider however, that perhaps the dependence of the facilatory effects of study on the consistency of modality from study to test is true only for visually presented material. Indeed, even if enhanced performance for auditorily presented material is dependent on an auditory test, the net effect of study over time for auditorily and visually presented material may be different. To evaluate these possibilities, both visually and auditorily presented material was tested by both visual and auditory forms of the perceptual identification test in Experiment 2.

Third, the Jacoby and Dallas (1981, Experiment 5) study showed priming effects in perceptual identification to remain virtually unchanged over retention intervals as long as 24 hours. Tulving, Schacter, and Stark (1982) found priming effects in word-fragment completion performance undiminished after seven days. In both cases, however, recognition memory declined during these retention intervals. Consequently, the third and fourth experiments reported here were designed to examine more closely the effect of the length of retention interval on perceptual identification and word-fragment completion performance. Would the effect of study persist for long periods with word-fragment completion as it does with perceptual identification?

These experiments are relevant to the question of whether, as suggested by research with amnesics, word completion performance can involve recognition without recollection.

Experiment 1

Jacoby and Dallas (1981) have shown that while recognition memory for target items presented for two seconds is greater than for items presented for only one second, perceptual identification of those target items is not affected. On the other hand, when the list presented for study contained items presented once, items presented twice back to back, and items presented twice but separated by fifteen other items, the probability of identifying an item in the perceptual identification test and the probability of item recognition both increased from the once- through the twice-massed to the twice-spaced condition.

The results from another experiment by Jacoby and Dallas (1981) suggest a reason why the effect of the length of study time on recognition memory and perceptual identification performance is dissimilar while the effect of the number of repetitions is similar. Finding that meaningful elaboration had no effect on perceptual identification performance (Jacoby & Dallas, 1981, Experiment 1), Jacoby and Dallas hypothesized that increased study time might enhance recognition memory but not perceptual identification performance by allowing for further elaboration on the meaning of the word. The effects of repetition, on the other hand, must depend on factors other than shades of meaning and may have a strengthening effect, through the reprocessing of the item, and thus enhance both recognition memory and perceptual identification

performance. In line with this possibility, the effect of repetition was found to depend on spacing. Massed repetition, like changes in study time, had little effect on perceptual identification performance.

Experiment 1 explored this hypothesis a little further. The number of times an item is repeated was varied while holding total study time constant. In the Jacoby and Dallas (1981, Experiments 4a & 4b) study, presentation time was not independent of the number of repetitions: as the number of repetitions increased so did the total amount of time for that item. Perhaps perceptual identification performance would increase with the number of presentations into which a given presentation time is split. Since recognition memory, on the other hand, is affected by both manipulations of study time and number of presentations, the decline in the length of each presentation may be offset by the increase in memory strength which results from the repetition of processing. Kirsner (1973) has presented evidence relevant to this issue. In line with the possibility that memory for physical attributes becomes increasingly less important as information about meaning is accrued, his study showed that a change in typecase between study and test has a larger effect on the recognition of nonsense words than on that of real words.

Method

Materials and Design. The materials consisted of 576 6-letter words. These were randomly allocated to six 96-word sets, and within each of these sets a randomly selected subset of 48 formed a study list and the remaining 48 served as nonpresented words in the test lists. Each test list comprising 48 presented and 48 nonpresented words was

then subdivided into two subsets each comprising 24 presented and 24 nonpresented words.

Each subject was given both a perceptual identification (Pi) and a recognition memory (Rn) test on the items of both subsets. For one of the subsets, the tests were given in a recognition memory, perceptual identification order (Rn,Pi); for the other subset, the order of test presentation was perceptual identification, recognition memory (Pi,Rn). However, the two tests for a given subset were never presented back to back; every other test referred to words from the same subset. For example, if the two subsets are referred to as a and b, the order of testing was Rn(a),Pi(b),Pi(a),Rn(b) for three of the six study lists, and Pi(a),Rn(b),Rn(a),Pi(b) for the other three lists. In this manner, both recognition memory and perceptual identification performance could be assessed in the absence of test induced priming; in other words, for the test sequence Rn(a),Pi)b),Pi(a),Rn(b), Rn(a) and Pi(b) are free of the effects of previous tests on the same study words, while performance of Pi(a) and Rn(b) is confounded by exposure of the target items in the preceding test.

In addition to the two types of test, the distribution of an item's exposure was varied. The total time for which each word was presented was always two seconds, but it was spent in a single (2-second) presentation, in two (1-second) presentations, or four (0.5-second) presentations. Presentation rate was blocked within each list: 16 of the 48 words of a list were presented once for two seconds each; a second block of 16 words was presented twice (once through and then again in the same order) at a 1-second presentation rate; the third block of

16 words was presented for four cycles at a 0.5-second presentation rate. To simplify expression, these three presentation conditions will be referred to hereafter as the 1-p, 2-p, and 4-p conditions, respectively. Since for the 2-p and 4-p conditions, the block of items was repeated with the same ordering of items, each repetition was separated by 15 other word presentations. There were no physical or temporal indicators between blocks.

Three orderings of the blocks within a study list were used: 1-p, 2-p, 4-p; 2-p, 4-p, 1-p; and 4-p, 1-p, 2-p. Since each subject was presented with six study lists, each order was represented twice. In addition, between-subject balancing procedures assured that the blocks within each study list were presented in the three orders equally often. The ordering of items in each block was the same for all subjects. Finally, like the study lists, the tests following each list presentation were also blocked. Each successive block of six items included one word from each of the three study conditions (1-p, 2-p, 4-p) and three distractor words. Within these blocks, however, placement was random.

Thus, the design of Experiment 1 was a 2x2x2x3 factorial design with all independent variables (old versus new test item; test type; test order; and number of presentations) being manipulated within subjects. All words were rotated through the conditions such that, across subjects, each served equally often as an old and new test word, and when as an old test word it served equally often in each combination of the three study condition blocks, two test types, and two test orders.

Subjects and Procedure. Twenty-four Rice University undergraduates served as subjects in one two hour experimental session for either course

credit or pay. It was necessary for subjects to be tested individually, for item exposure duration in the perceptual identification tests required individual calibration. Thus the procedure began by determining the exposure duration for which the subject was able to identify approximately 50% of the words. The practice trials during which the exposure duration was chosen took place prior to the onset of the actual experiment. The exposure durations were varied in 60ths of a second, and ranged from 1/60th of a second to 6/60ths, with mean and median durations of 3/60ths of a second.

For the experiment proper, subjects were instructed to study each word as it was presented. All words were presented in the center of a Radio Shack Model I microcomputer display screen. Following the study list, two perceptual identification and two recognition memory tests were given. Subjects were told that the first and third tests involved the same random half of the study words plus as many new words, and that the second and fourth tests were made up of the other half of the study words plus as many new words. Although subjects had been familiarized with both test formats, they did not know which test would immediately follow list presentation.

Both the recognition memory tests and the perceptual identification tests were paced. As for list presentation, all test items were presented in the center of the microcomputer display screen. Each item in the perceptual identification tests was preceded by a string of asterisks lasting ½ second to alert the subject to the upcoming test item. Subjects were given four seconds per test item to give either an identification or a recognition response, depending on the test

condition. For the recognition tests, the test items were exposed for the entire four seconds. In addition, the recognition responses included a confidence rating. Specifically, subjects were instructed to add a 1, 2 or 3 to their yes/no response: a 3 if they were "certain" of that response, a 2 if only "fairly certain", and a 1 if they were "uncertain". Responses were reported orally for both tests; the experimenter recorded all responses, correct or incorrect. If during the perceptual identification tests a subject neared 100% accuracy, the experimenter blurred the test items to a predetermined degree to make the test more difficult. So as not to change the difficulty of the test within study conditions, adjustments of this sort were made only between blocks of six items. (Remember that each block of six test items contains three items from each of the study conditions plus three distractors). The same procedure was repeated for all six lists, with a short rest allowed before the third and fifth list presentations. The entire procedure lasted approximately two hours.

Results

As noted in the design section, use of both test sequences, Rn,Pi and Pi,Rn, allows assessment of the effects of study on each of the tests without the confounding effects of a preceding test. Since the primary purpose of this experiment is to test the effect of study condition (1-p, 2-p, 4-p) on perceptual identification and recognition memory performance only the data from the Pi,Rn test sequence was used to assess perceptual identification performance and only the data from the Rn,Pi test sequence was used to assess recognition memory. The data from the other test sequence in each instance is confounded by

by what essentially amounts to another study exposure in that the words have already appeared in the previous test.

Table 1 shows the probability of recognition memory for each of the three study conditions for the test sequences Rn,Pi. (See Tables A1 and A2 in Appendix for complete data). Although examination of the data suggests a trend towards increased recognition memory across one presentation to four, the difference between the 1-p and 4-p conditions was not statistically significant, $t(23)=1.37$.

Table 1

Probability of Recognition Memory as a Function of Study Condition for Test Sequences Rn,Pi and Pi,Rn

	Study Condition			
Test Sequence	1-p	2-p	4-p	Nonpresented
Rn,Pi	.78	.81	.80	.27
Pi,Rn	.73	.75	.76	.40

Table 2 shows the probability of perceptual identification of the test words for each of the three study conditions for the test sequences Pi,Rn. Note in particular that, in the Pi,Rn sequences, items that had been presented were much more likely to be identified than were items that had not been presented, $t(23)=12.41$, $p<.01$. In addition, the trend was for increasingly more items to be identified as the number of presentations increased from one to two to four. Indeed, an analysis of study conditions revealed that items in the 4-p condition were identified significantly more often than were items in the 1-p condition, $t(23)=3.53$, $p<.01$.

Table 2

Probability of Recognition Memory as a Function of Study Condition for Test Sequences Pi,Rn and Rn,Pi

	Study Condition			
Test Sequence	1-p	2-p	4-p	Nonpresented
Pi,Rn	.55	.58	.63	.34
Rn,Pi	.53	.53	.56	.48

Consider now the other half of the data, the recognition data from the Pi,Rn test sequences and the perceptual identification data from the Rn,Pi test sequences. Table 1 gives the recognition data for the Pi,Rn test sequences, and Table 2 gives the perceptual identification data for the Rn,Pi test sequences. Note that test sequence made very little difference in the probability of recognizing and perceptually identifying target items. When recognition performance for the Pi,Rn sequence is conditionalized on perceptual identification performance, items that had been identified were recognized more often (.82) than were items that had not been identified (.64). Also, the mean confidence rating on the recognition test was significantly higher (i.e. closer to the "certain" or yes-3 end of the rating range) than for nonidentified targets, $t(23)=10.01$, $p< .001$. In addition, subjects were more likely to respond at the highest confidence level (yes-3) if the item had been identified in the perceptual identification test, $t(23)=10.92$, $p< .001$. To analyze confidence ratings, each rating, yes-3 through no-3, was weighted.

For the Rn,Pi test sequence, items that had been recognized were more likely to be identified (.56) than words that had not been

recognized (.47). Perceptually identified targets had been characterized by significantly higher confidence responses on the recognition test than were nonidentified targets, $t(23)=3.43$, $p < .01$. Moreover, the difference between the level of confidence accompanying the recognition response for perceptually identified and for nonidentified targets was significantly greater in the Pi,Rn test sequences than in the Rn,Pi test sequences, $t(23)=6.06$, $p < .01$. However, in the Pi,Rn test sequences only those words perceptually identified received additional exposure. It is not unlikely then that a subject encountering words on the recognition test that he or she had been able to identify would be inclined to say that they recognized them and to do so with greater confidence.

The results of Experiment 1 reveal that priming effects are greater in perceptual identification performance when allotted study time is broken up into several exposures than when the total time is kept intact. On the other hand, recognition memory did not change as a function of study condition indicating that the only significant variable in affecting recognition memory is the total amount of study time given the items. Contrary to previously published findings, perceptual identification performance and recognition memory were positively associated: performance on one test was an effective predictor of performance on the other.

Experiment 2

Ever since Craik and Lockhart (1972) formulated the levels of processing framework for conceptualizing human memory, there has been much research on the idea that the processing of meaning is the primary means of enhancing retention. On the other hand, other recent research has shown that recognition memory can depend to a large extent on memory for featural or graphic aspects of an item, in that recognition performance declines with a study-to-test change in modality (Jacoby & Dallas, 1981; Kirsner, 1974), orientation (Kolers, 1973) or voice of speaker (Geiselman & Bjork, 1981). More recently, Jacoby and Dallas (1981, Experiment 6) found that having heard a word prior to a visual perceptual identification test produced none of the facilatory effects found when the study presentation is visual. This conclusion is qualified by the finding that when subjects spell auditorily presented words prior to a test of perceptual identification, performance is enhanced to nearly the same extent as when the items had been read (Jacoby & Witherspoon, 1982).

In all this research, there has been no examination of the effects of visual presentation on subsequent auditory identification performance. Experiment 2 was designed to do just this. To round out its design, auditory and visual study presentations were factorially combined with auditory and visual forms of the perceptual identification test.

Method

Subjects were presented with two study lists. Each list consisted of alternating blocks of visually and auditorily presented words. For each subject, one study list was followed by a visual perceptual identification test and the other study list by an auditory perceptual identification test. An equal number of nonpresented words was included in both tests.

Materials and Design. A total of 384 six-letter words were randomly allocated to four 96-word sets. For any given subject, two sets were presented as study lists and the other two provided the "new" test items for the perceptual identification tests that followed each list presentation. The sets were rotated between subjects such that overall each item served as a presented and as a nonpresented item equally often.

Each set of 96 words was divided into six blocks of 16. Presentation modality alternated between successive visual and auditory blocks to create mixed visual-auditory study lists. Specifically, for one half of the subjects, the first 16-word block of both study lists was presented visually, the second block auditorily, the third block visually, and so on until all six blocks had been presented. For the other half of the subjects, the two study lists each began with an auditory block followed by a visual block and so on in the same fashion. Following the first study list presentation, half of the subjects who had received the auditory,visual sequence and half who had received the visual,auditory sequence were given a visual perceptual identification test, which included all 96 study words plus as many nonpresented words. The other subjects were given the auditory version of the perceptual

identification test. Following presentation of the second study list, subjects for whom the first test had been visual received the auditory version and vice versa. In the perceptual identification tests, the 96 target words occurred in reverse order relative to that of their study presentation, although this time they were mixed in with nonpresented words. In this fashion, the first words presented were the last ones tested and the last words presented were the first words tested. This aspect of the design allowed examination of the study-to-test interval for its effect on perceptual identification performance.

Subjects and procedure. The subjects were 16 Rice University undergraduates who participated for either course credit or pay. They were randomly assigned to one of four combinations of study and test conditions and were tested individually. Prior to the onset of the actual experiment, subjects were familiarized with both the visual and auditory forms of the perceptual identification tests. As in Experiment 1, the exposure duration for the items in the visual perceptual identification test was determined separately for each subject during these practice trials. The experimenter attempted to find the exposure duration which enabled the subject to identify approximately 50% of the words. Starting exposure durations for the individual subjects ranged from 1/60th to 6/60ths of a second, with most subjects being given 3/60ths of a second.

Lists were presented for study at a rate of one word every two seconds. In the visually presented blocks, words were shown in the center of a Radio Shack Model I microcomputer display screen; in the auditorily presented blocks, they were presented over both channels of an Akai Model II reel-to-reel taperecorder.

The presentation formats of the auditory and visual test items were, of course, quite different. As with list presentation, test items in the visual perceptual identification test were presented in the center of the computer screen. Since attention to the computer screen was so crucial to the visual identification test, each word was preceded on the screen by a string of asterisks lasting one half second which alerted the subject to the upcoming test word. The screen then went blank for another half second before the test item appeared for the length of time determined in the practice trials. After the test item had been presented it was immediately masked by a series of dollar signs (one for each of the six letters in the word). The screen then went blank for four seconds during which time the subject was to make a response. This procedure was repeated throughout the entire test list.

For the auditory test condition, both study and nonpresented words were presented from a tape recorder. The test words were presented over one channel and pink noise was presented simultaneously over another. Test words were presented every five seconds and the stream of pink noise was heard continuously. The subjects' task was to identify by reporting aloud those words that could be detected through the noise. If the task proved too easy, the volume of the noise was increased slightly. Subjects were told to make only one response to each word but if they quickly changed their response (as they were often inclined to do), credit was given if the new response was correct. For both tests the experimenter recorded whether the response was correct or incorrect. Failures to respond were, of course, counted as misses. Finally, because of the high degree of concentration demanded by these tests, subjects

were allowed short breaks after 64 and 128 words.

Results

The mean number of words identified in each of the four experimental conditions plus the control (no presentation) condition is shown in Table 3. (See Table A3 in Appendix for complete data). No effect of presentation modality was observed, $F(1,15)=1.73$, although a reliable effect of test modality in favor of the visual test was found, $F(1,15=17.57$, $p < .001$. More important was the reliable interaction between presentation modality and test modality, $F(2,30)=29.27$, $p < .001$. When test presentation was visual, visually presented study words were identified more often than auditorily presented words; when test presentation was auditory, auditorily presented words were identified more often.

Table 3

Mean Number of Words Identified out of 48 as a Function of Presentation and Test Modality

Presentation Modality	Test Modality	
	Auditory	Visual
Auditory	27.8	23.6
Visual	26.9	33.4
Nonpresented	20.3	23.0

Comparisons of the modality consistent conditions with the modality inconsistent conditions, however, revealed that the difference between visually presented words tested visually and those tested auditorily is greater than the difference between auditorily presented words tested auditorily and those tested visually, $t(15)=4.19$, $p < .001$. Also, there is evidence for cross modality priming when performance in the

inconsistent conditions is compared to performance on nonpresented words. Performance was greater for words that had been presented in one modality and tested in another than it was for words not previously presented, $t(15)=3.68$, $p < .01$.

To examine the effect of retention interval, target words were grouped into three equal sets. The first third presented comprised the long retention interval items, and the second and third thirds the median and short retention interval items respectively. The effect of retention interval turned out not to be reliable, $F(2,30)=1.94$. Although Table 4 suggests that the length of the retention interval was perhaps a significant factor in performance for the modality consistent study and test conditions, when considering only the difference between the shortest and the longest retention intervals, the interaction between retention interval and the modality consistent and inconsistent conditions proved non-significant, $t(1,15)=1.23$.

Table 4

Mean Number of Words Identified out of 16 as a Function of Retention Interval, Presentation and Test Modality

	Presentation and Test Modality			
Retention Interval	Auditory, Auditory	Auditory, Visual	Visual, Visual	Visual Auditory
Short	10.1	9.0	12.2	7.9
Median	9.1	8.8	10.2	7.8
Long	8.6	9.1	11.1	8.0

These results, like those of Jacoby and Dallas (1981), indicate that perceptual identification performance is diminished by a change in

modality between study and test. This was true for words presented auditorily and tested visually as well as for words presented visually and tested auditorily. However, unlike previous findings (Jacoby & Dallas, 1981), evidence was found for cross-modality priming. Although not as powerful as same modality priming, words tested in the modality other than the presentation modality maintained an advantage over nonpresented words.

The findings from the manipulation of retention interval shed little light on the question of the persistence of priming effects. Although the length of the retention interval ranged from just several seconds to approximately 20 minutes, perhaps no decline in priming effects occurs over this relatively short period of time. In other words, perhaps our manipulation was not sensitive or broad enough to detect any differences that may exist. Experiment 3 was designed to explore in greater depth the relationship between priming effects and the length of the retention interval.

Experiment 3

The length of the retention intervals in Experiment 2 ranged from just 30 seconds to almost 20 minutes. Over this range, no decline in priming effects was observed. Experiment 3 was designed to extend this range at the longer end. As noted in the introduction, previous research has shown the effect of study to remain remarkably unchanged over intervals of at least 24 hours in the case of perceptual identification (Jacoby & Dallas, 1981) and at least seven days in the case of word-fragment completion performance (Tulving, Schacter, & Stark, 1982) while recognition memory declined substantially. For Experiment 3, a 24 hour retention interval was chosen because it was substantially longer than the 20 minute interval in Experiment 2 and because a lack of a decline in priming effect over this length of time would certainly provide information concerning the persistence of memory involved in performing these two tasks.

The results of Experiment 2 also hinted at an interaction between retention interval and the consistency of modality conditions at study and test. Although both tests in Experiment 3 are visual, both visual and auditory presentation conditions were included to check for this interaction.

Method

Materials and Design. The items consisted of 384 six-letter words chosen from the Crossword Puzzlers Handbook (developed and

published by D.R. Corron, 4231 N. Bearclaw Way, Tuscon, Arizona 85715). Each word was unique in that it allowed for a two-letter fragment that had only one solution. Twelve sets of 32 words were constructed by random assignment. Sixteen words from each set were presented in study lists and the remaining sixteen served as the nonpresented items in the subsequent memory tests. Between subjects, each item served as a presented and as a nonpresented item equally often.

The modality of the words in the study lists was varied within lists. One half of the subjects were presented the twelve study lists in the following order: visual,visual,auditory,auditory,visual,auditory, auditory,visual,auditory,visual,auditory,visual. The remaining half of the subjects received the lists in the opposite order: auditory,auditory, visual,visual,auditory,visual,visual,auditory,visual,auditory,visual, auditory. The two list modality orders were crossed with two testing formats to create four conditions of study and test. The two complementary testing formats were as follows (Wf for word-fragment completion and Pi for perceptual identification): Wf,Pi,Pi,Wf,Wf,Pi,Wf, Pi,Pi,Wf,Wf,Pi; and Pi,Wf,Wf,Pi,Pi,Wf,Pi,Wf,Wf,Pi,Pi,Wf. Although the two test formats include six word-fragment completion tests and six perceptual identification tests, the pseudo-random order of the tests prevented subjects from anticipating type of test prior to the completion of list presentation.

The test involved three levels of cue for each item. In the case of the perceptual identification test, each item was presented three consecutive times: the first for 1/60th of a second, the second for 2/60th, and the third for 3/60th. Although the slight increases in the length of item exposure were rarely noticed by subjects, the differences

were enough to substantially increase performance. For the word-fragment completion test, the number of letters omitted in each fragment decreased from the first presentation to the third: the first fragment comprised only two of the six letters, the second fragment comprised three letters, and the third comprised four letters. Once a letter had been exposed it remained through any subsequent exposures.

The within-subject manipulation of retention interval necessitated the construction of two sets of test lists. The sixteen words from each study list were divided between an immediate test and a delayed test so that each test involved eight presented items. Eight nonpresented items were also assigned to each test condition. In addition, type of test for each list was the same from Day 1 to Day 2 such that if List 1 had been tested by word-fragment completion on Day 1, the remaining portion of the list was also tested by word-fragment completion on Day 2. Between subjects, each word served as a presented and as a nonpresented items and in the immediate and delayed test conditions equally often.

Subjects and Procedure. Thirty-two undergraduate students at Rice University participated for course credit or for pay. Subjects were randomly assigned to one of the four combinations of study and test conditions. All testing was done on an individual-subject basis.

List words were presented at a rate of one per second. Each subject was instructed to study the words for a later test. When the study condition called for visual list presentation, subjects viewed the words in the center of a Radio Shack Model I microcomputer display screen. When the study condition called for auditory list presentation, subjects were instructed to look away from the display screen while the

experimenter read the list words aloud. Immediately after each list presentation subjects were given the appropriate test.

For both types of test condition, each test item was presented in the center of the computer display screen. A string of asterisks lasting one half second preceded the cuing of each item. If the test was one of word-fragment completion, a two letter graphemic fragment of the target word was presented for three seconds with the missing letters marked by blanks (e.g. _ x _ g _ _). The subject was instructed to produce the target word as quickly as possible. If the subject could not or did not provide the correct word within the allotted time (three seconds), a third letter appeared in place of one of the blanks (e.g. _ x _ g _ n). This three-letter fragment remained exposed for another three second period. If the subject was still unable to complete the fragment a fourth letter replaced yet another of the blanks to form a 4-letter fragment which remained in view for another three seconds (e.g. _ x _ g e n). If the subject was still unable to provide the target word, no additonal letters were provided. The display screen went blank and a string of asterisks appeared to signal that a new word was about to be cued. If the test following list presentation was one of perceptual identification, the test items were presented intact but the exposures were very brief. The first exposure was the briefest, the second and third each slightly longer than the previous one. Immediately following each exposure, the item was masked for one half second by a series of dollar signs and then the screen went completely blank for three seconds, during which time the subject could report the word. After the third exposure, regardless of whether the subject had been able to identify the word, a series of asterisks

appeared to signal that a new word was about to be cued.

During both tests, the experimenter recorded the level of cuing (two, three, or four letters, or the first, second, or third exposure), if any, at which the subject first gave the correct response. Subjects were not told if their responses were correct but were encouraged to respond repeatedly or to change their response as they felt inclined. Although the experimenter recorded all correct responses, some incorrect responses were recorded as well so that subjects could not use the recording of their response as an indication of performance. Regardless of whether the subject identified the word at the first or second level of cuing, all three levels were presented.

When all twelve lists had been presented and tested, subjects were reminded to return to complete the experiment at the same time on the following day. When the subjects returned they received only the series of twelve tests containing the remaining study words from Day 1 and as many nonpresented words. This series of tests was presented in the same order as the immediate tests, the only difference being the lack of intervening study lists.

Results

Performance was measured according to three criteria. The first criterion was the number of successful fragment completions at the first level of cuing, that is at the 1/60th of a second exposure or the two-letter fragment; the second criterion was the number of successful fragment completions after both the first and second levels of cuing; the third criterion was the number of successful fragment completions after all three levels of cuing. Collecting performance data at each

of these levels allowed a choice of criterion to be used for inferential analyses that was most sensitive to each individual subject's performance. For both perceptual identification and word-fragment completion, the data included in the analysis coresponded to the criterion at which performance, for each subject considered individually, was closest to 50% accuracy across all conditions except type of test. In this way, one subject might contribute data to the analysis from the first cue level and another subject, who needed more informative cues to achieve 50% accuracy, might contribute data from the second or third cue level. (See Tables A4 and A5 in Appendix for complete data).

Preliminary analysis indicated that for both modalities of presentation and for both types of test, words that had been presented were reliably more likely to be identified than were those that had not. This finding was hardly surprising, and of little interest here. More important were the analyses of the data for just the presented items. These will be considered first for the perceptual identification test and then for the fragment completion test.

Perceptual identification. The data on perceptual identification performance are summarized in Table 5. Across retention intervals, there was a strong effect of presentation modality: performance was greater when the study words were presented visually (and so matched the test modality) than when they had been presented auditorily, $F(1,15)=26.53$, $p < .001$. A decline in priming effect over the 24 hour retention interval was observed as well; items tested immediately after list presentation were more likely to be identified than items tested after the 24 hour retention interval, $F(1,15)=6.99$, $p < .02$. Finally,

Although the interaction between modality of presentation and retention interval was not reliable, $F(1,15)=3.33$, the difference between visually presented items and auditorily presented items tended to be greater in the immediate condition than in the delayed test condition. In the immediate test condition, the probability of identifying visually presented words was .77 compared to .59 for auditorily presented words; in the delayed condition, the probability was .59 for visually presented and .52 for auditorily presented.

Table 5

Mean Number of Words Identified out of 24 on Perceptual Identification Tests as a Function of Presentation Modality and Retention Interval

	Presentation Modality		
Retention Modality	Auditory	Visual	Nonpresented
Immediate test	14.2	18.4	8.3
Delayed test	12.5	14.2	10.3

Word-fragment completion. The data on word-fragment completion performance are summarized in Table 6. There was a strong effect of presentation modality, $F(1,31)=12.25$, $p < .01$, in favor of visual presentation. There was also a clear effect of retention interval, $F(1,15)=59.40$, $p < .001$, in favor of the immediate test. There was no reliable interaction between retention interval and modality of presentation, $F(1,15)=.42$.

In short, the results of this experiment indicate that the effects of modality and retention interval on tests of perceptual

Table 6

Mean Number of Fragments Completed out of 24 on Word-Fragment Completion Tests as a Function of Presentation Modality and Retention Interval

Retention Interval	Presentation Modality		
	Auditory	Visual	Nonpresented
Immediate test	17.1	19.3	9.9
Delayed test	13.4	14.7	10.3

identification and word-fragment completion are quite similar. The decline in the effect of priming after 24 hours observed for both test types is not, however, supported by previous research (Jacoby & Dallas, 1981; Tulving, Schacter, and Stark, 1982), and requires further investigation.

Experiment 4

Experiment 3 demonstrated that while the facilatory effects of study on perceptual identification and word-fragment completion performance still exist after a 24 hour retention interval, they are substantially less than those found immediately after list presentation. This finding contrasts with results reported by Jacoby and Dallas (1981, Experiment 5) which revealed that not only were the effects of study on perceptual identification and word-fragment completion long lasting but that they remained entirely undiminished after rather lengthy retention intervals.

A possible explanation for the discrepancy between Jacoby and Dallas' results and those reported in Experiment 3 is the difference in the number of words which come between an item's occurrence in the study list and its occurrence in the initial test. Although in both cases the initial tests immediately followed list presentation, the testing of a specific word did not immediately follow its study presentation: except for the last study item in Experiment 3, additional items were presented and other items were tested before that specific word appeared in the test. Thus, the average interval between presentation and immediate (first) test would depend on list length. In Jacoby and Dallas' experiment, list length was sixty words; in Experiment 3 it was only 16 words. Thus, the interval between any given item's presentation and

and its occurrence at test was on average substantially shorter in Experiment 3. Perhaps, then, the effect of study on perceptual identification and word-fragment completion performance is greatest for a very short period after item presentation, declines relatively quickly and then stabilizes.

The purpose of Experiment 4 was to test this hypothesis by using a series of list lengths ranging from 16 to 192 words. By examining a wide range of intervals it was hoped to obtain a more complete picture of the effect of the length of retention interval on priming effects. In addition, since the results of Experiments 2 and 3 suggested an interaction between study and test modalities and retention interval, both modality consistent (visual presentation and visual test) and modality inconsistent (auditory presentation and visual test) conditions were included.

Method

Materials and Design. The items consisted of 386 6-letter words and corresponding graphemic fragments. Each of these words allowed for one 3-letter fragment that had only one solution (based on all words in the Crossword Puzzlers Handbook). Twenty-four 16-word sets were created by random assignment. Twelve sets served as study lists and the words in the remaining 12 sets served as "new" items in the word-fragment completion tests. Assignment of sets to conditions was rotated across subjects so that each item served as a presented item and a nonpresented item equally often.

One half of the study lists was presented visually and one half auditorily with order determined randomly within the constraint that

consecutive sets of four lists included two in each modality. Specifically, for half of the subjects the order of presentation for the 12 lists was auditory,visual,visual,auditory,visual,auditory, auditory,visual,auditory,visual,auditory,visual; and visual,auditory, auditory,visual,auditory,visual,visual,auditory,visual,auditory,visual, auditory for the other half of the subjects.

There were four study-to-test delays. One test was given after every presentation of a list of 16 words and consisted of the graphemic fragments of four list words and four "new" words. Second, tests were presented after List 4, List 8, and List 12. They involved cuing for 16 study-list words, four from each of the four immediately preceding lists, and 16 new words. Each test was therefore, in effect, for items presented within a 64-word list.

Following the presentation of all 12 study lists, together with the 12 short 8-word and 3 32-word tests, a comprehensive 96-word test was given. The words cued in this test comprised 4 from each list (for a total of 48) and 48 that had not been presented. The test was thus for a functional list length of 192 words (12 lists of 16 words). The remaining four words from each list were reserved for the final 96-word test which was similar in all respects except in the length of the retention interval; it was presented after a 24-hour delay. It is important to note that for all tests involving words from the earliest list (together with an equal number of new words) first, then, from the next presented list and so on so that the interval between study and test could be more accurately controlled.

In short, the design of the experiment was a 2x2x4 with study

modality (visual vs. auditory), type of test item (old vs. new), and retention interval (16 words, 64 words, 192 words, and 192 words plus 24 hour delay) as within-subject variables. Counterbalancing measures ensured that each word served in each of the 16 experimental conditions equally often.

Subjects and Procedure. Thirty-two Rice University undergraduate students participated as subjects for either course credit or pay. They were tested in small groups of two to four persons. Testing took place in the same room on both days.

Study words were presented at the rate of one every two seconds. Subjects were instructed to study each item as it was presented. All study words were printed two inches in height on 10x15 cm index cards. When list presentation was visual, the experimenter turned the cards up one at a time so that all subjects could read the word printed on each card. When list presentation was auditory, the experimenter turned the cards up out of the subjects' view and reach each aloud. After a 16-word list had been presented subjects were given a short 8-item test. Subjects had been instructed to attempt to complete each word-fragment with a meaningful word by replacing the blanks with appropriate letters. The three letter graphemic fragments were typed on small sheets of paper; fragments of presented and nonpresented words were intermixed. In addition, subjects were told that some of the solutions to the fragments were words from the study list but that others were not. Immediately after the 8-item test for the fourth, eighth, and twelfth lists, subjects were given a 64-item test. Following the final 64-item test, subjects were given the first 96-word test and then reminded to return

the following day at the same time to complete the experiment.

All of the word-fragment completion tests were paced. Subjects were told that they had 8 seconds to work on each fragment and a beeper was used to indicate when subjects were to move on to the next fragment. A small white index card with a slit cut to expose only one word at a time prevented subjects from previewing other fragments. Subjects moved the card to the next fragment when they heard the beeper regardless of whether they had completed the current fragment.

Results

The number of successfully completed word-fragments for both visually, auditorily, and nonpresented words is shown in Table 7. (See Table A6 in Appendix for complete data). Note that the fragments of words that had been presented in either modality were more likely to have been completed than were the fragments of nonpresented words. This finding is hardly surprising and of little interest. More important is the effect of presentation modality and retention interval on the presented words.

Table 7

Mean Number of Correct Fragment Completions out of 24 as a Function of Presentation Modality and Retention Interval

Retention Interval	Presentation Modality		
	Auditory	Visual	Nonpresented
16 words	13.3	17.6	5.3
64 words	9.1	11.5	5.2
192 words	8.1	10.6	5.6
192 words, 24 hour delay	8.8	9.6	6.5

Collapsing across retention interval, the fragments of words presented visually were completed reliably more often than the fragments of words presented auditorily, $F(1,15)=34.17$, $p < .001$. Also, the longer the interval between list presentation and test, the less likely the fragment of a word was to be completed, $F(3,45)=76.53$, $p < .001$. Moreover, a reliable interaction between presentation modality and retention interval revealed that the effect of retention interval was greater when the fragment was that of a visually presented word, $F(3,45)=6.53$, $p < .01$.

To examine more closely the effect of retention interval, the test data corresponding to the four study-to-test intervals was collapsed across presentation modality and subjected to pair-wise analyses. Table 7 shows the number of fragments completed for each of the four study-to-test intervals. Note that the number of fragments completed after the 16-word intervals was substantially greater than the number completed after any of the other three intervals. The number of fragments completed after the 64-word intervals was not, however, reliably greater than the number completed after the 192-word interval, $F(1,15)=2.78$, although it was greater than the number completed after the 192-word plus 24 hour delay interval, $F(1,15)=6.53$, $p < .05$. A reliable presentation modality by retention interval interaction in this instance, $F(1,15)=5.66$, $p < .05$, reveals that the difference was between the 64-word and the 192-word plus 24-hour delay interval when presentation modality was visual.

The number of fragments completed after the 192-word interval did not differ reliably from the number completed after the additional 24 hour delay, $F(1,15)=0.17$. However, the presentation modality by

retention interval interaction proved marginally significant, $F(1,15)=4.86$, $p < .05$, and reflects the slight decline in the number of fragments completed after the 192-word plus 24 hour delay when presentation modality was visual.

The results from this experiment indicate that the effect of study-to-test delay is localized at very short delays. The apparent discrepancy between the findings of Experiment 3 and those of Jacoby and Dallas (1981, Experiment 5) is cleared up by the finding that the facilatory effect of study drops off rapidly immediately after study and then levels off. It appears likely that because list length in the Jacoby and Dallas study was a good bit longer (thus having the effect of lengthening the study-to-test delay) than in the present study, the rapid drop off immediately after study went undetected.

General Discussion

The four experiments reported here concerned the effect of certain study variables on tests of perceptual identification, word-fragment completion, and standard recognition memory. Previous research has demonstrated that prior exposure to an item, such as a word, not only can produce recognition memory but can also be sufficient to influence perceptual identification and word-fragment completion performance (Jacoby & Dallas, 1981; Tulving, Schacter, & Stark, 1982). The curious aspect of this research, and the impetus for the present four experiments, was that performance on these tests was often unrelated to the kind of recognition studied in conventional laboratory experiments. Thus performance on perceptual identification and word-fragment completion tests demonstrate a kind of recognition where the retrieval of the particular episode or context, which so characterizes standard tests of recognition memory, may be absent.

In the present study, the effects of distribution of study time, study and test modality, and retention interval were examined in order to further explore the relation between standard recognition memory and the phenomenon of recognition without recollection. Experiment 1 demonstrated that when a constant amount of study time is split up among several presentations of an item, the facilatory effect of that study on perceptual identification performance is greater than when the total study time is allotted to a single presentation.

Recognition memory, on the other hand, did not differentially benefit from any particular distribution of the allotted study time. Despite this difference, performance on the two tests was related: subjects were more likely to recognize an item if it had recently been perceptually identified, and likewise, were more likely to identify an item if it had been previously recognized.

Experiment 2 showed that, although performance on a perceptual identification test was greatest when the modality of an item was the same at study and at test, perceptual identification of an item presented on one modality and tested in another was greater than for items that had not been presented for study at all. Also, retention interval did not prove a reliable factor in perceptual identification performance despite the suggestion of a difference in favor of words tested after the shorter intervals in the modality-consistent conditions.

Like Experiment 2, Experiment 3 showed that when an item's modality is the same at study and at test, performance on perceptual identification and word-fragment completion tests is enhanced over the inconsistent conditions. In this experiment, in which the final performance measure was delayed 24 hours, the length of the retention interval was a significant factor in performance. The likelihood of a correct response was less after the 24 hour delay than at the initial, immediate test.

Finally, Experiment 4, which examined the effect of retention interval on word-fragment completion more closely, showed that the facilatory effect of visual study dropped off rather dramatically shortly

after item presentation and then leveled off to where differences in the length of the retention interval produced very little difference in performance.

Two major aspects of these results distinguish this study from previous studies. First, performance on perceptual identification and word-fragment completion tests was found to be less independent of performance on standard recognition memory tests than previous research, most notably that of Jacoby and Dallas (1982), has suggested. Second, although performance was reliably greater when test modality was the same as presentation modality, performance was not entirely modality specific as has been demonstrated previously (Jacoby & Dallas, 1981, Experiment 6).

At a more general level, a result that is consistent with previous research is that of one-trial learning of graphemic and featural aspects of items. The discovery of a long-lasting memory for the featural aspects of an item that is relatively independent of episodic memory has led to claims of a dissociation between memory and awareness in persons with "normal" memories that is in some respects of the same form as that found with certain kinds of amnesics. The distinction between memory and awareness revolves around the notion of "perceptual familiarity." Consider the conclusion Huppert and Piercy (1976) drew from their study. Amnesic subjects who were unable to recollect past episodes were said to be responding on the basis of item familiarity: when the set of familiar items (in this case, items previously seen) was exactly the same as the set of target items, performance was at near normal levels; however, when the set of target

pictures was made to overlap but not be entirely comprised of the set of target pictures, the number of false positives increased dramatically. If amnesic subjects could not recollect the particular episode involving the presentation of a picture, how then were the pictures familiar to them?

Mandler (1980) has suggested a theory of recognition based on the types of information upon which recognition judgments can be made. The primary hypothesis is that an item can be recognized not only through accessing the meaning and context of the item but in terms of the ease with which the item is perceived. That is, the hypothesis assumes that with each exposure to an item not only is the item's meaning and context encoded, but also the item's structural attributes, and that the encoding of these attributes leads to facilitation of the encoding processes upon subsequent exposure to the item. At the subjective level, this ease of processing translates to feelings of familiarity with the item. Thus, not only can recognition memory occur on the basis of the recollection of the item's occurrence in a particular context, as generally assumed in standard recognition memory paradigms, but it can occur on the basis of the phenomenal experience of familiarity which depends upon the encoding of the item's structural attributes. Applying the notion of familiarity to performance on perceptual identification tests, the effect of a previous exposure is to ease and facilitate the processing at subsequent exposures such that when subsequent exposures are degraded in some fashion, as by a very brief or incomplete exposure, performance will favor items previously presented.

Jacoby and Dallas (1981) employ this hypothesis to explain the dissociation found between effects on perceptual identification and recognition memory performance produced by such variables as study time and level of processing. These variables, the authors contend, emphasize elaborative encoding; that is, an item's meaning and context are stressed. At test, recognition is likely to occur on the basis of the meaningfulness and distinctiveness of the study encoding. Alternatively, variables such as the number of repetitions and frequency of the word in the language produce parallel effects on recognition memory and perceptual identification because the recognition judgements are being made on the basis of the subjects' relative perceptual fluency with the word. In other words, when elaborative encoding is restricted due to the parameters of the study situation, performance on the two tests will depend upon the encoding of the item's structural attributes.

The hypothesis that perceptual identification has its basis in memory for the featural aspects of an item and recognition memory in either the featural aspects or the meaning and context of an item implies certain outcomes with respect to two of the variables examined in the present studies: number and duration of presentations and modality of study and test presentation. The findings of the present studies offer only qualified support for the hypothesis.

Consider first the effect of number of presentations, which was varied in Experiment 1. Mandler's (1980) hypothesis predicts perceptual identification performance to increase from the 1-p through the 2-p to the 4-p condition, and the data supports this prediction.

The hypothesis gains no clear support, however, from the recognition memory data. Thus, although total time of item presentation is the issue for all these conditions, the opportunity for elaborative processing might be reasonably expected to be greater with a single 2-second presentation than with briefer multiple presentations, in which case recognition memory should have been greatest in the 1-p condition and poorest in the 4-p condition. No such trend occurred; what trend did occur was in the other direction, albeit not reliably so.

One way of reconciling the finding that recognition memory did not decrease with number of presentations is to assume that it was based on a combination of genuine recollection and familiarity such that recollection played the biggest role in the 1-p condition and smallest in the 4-p condition. If this was the case, however, the association between the individual item's probability of being recognized or of being identified in the perception task should be least in the 1-p condition and greatest in the 4-p condition; there is, in fact, evidence that memory for physical attributes becomes increasingly less important as information about meaning is accrued (Kirsner, 1973). This was not the case, however, in Experiment 1. The association between recognition memory and perceptual identification existed both when items had been presented four times for 1/2 second and when they had been presented once for two seconds.

No less problematic for Mandler's (1980) hypothesis are the confidence data from the recognition memory test. High confidence positive responses presumably indicate distinct recollection of item occur-

rence, whereas low confidence positive responses presumably indicate a greater dependence on a feeling of familiarity, which in turn should signal a greater association with perceptual identification. This prediction was not borne out: target items characterized by a highly confident recognition response were more likely to be identified (regardless of which order the recognition and perceptual identification tests were given in) than were items marked by low confidence recognition responses.

Consider now the findings concerning the relation between study and test modalities. Mandler (1981) and Jacoby and Dallas (1981) have stated that priming effects in perceptual identification and, more generally, repetition effects, depend on the form of the item at initial presentation being identical to the form of its presentation at test, or for repetition effects, from one exposure to the next. Indeed, Jacoby and Dallas (1981, Experiment 6) found the effects of prior study on perceptual identification performance could be completely eliminated by changing the modality between initial presentation and test. The results of Experiment 2 and 3 of the present study, however, showed that the presentation of an item in one modality and testing of that item in another modality enhances performance over nonpresented items tested in the same modality.

Perhaps the solution to the discrepancy between our finding and those reported by Jacoby and Dallas (1981, Experiment 6) can be found in the type of words that were used. Although there is a dearth of research involving perceptual identification tests, research involving recognition memory has demonstrated that the encodings of sensory

attributes affects the likelihood of recognizing rare as opposed to common words. For example, Schulman (1967), using auditory presentation and a visual test, found that increasing the number of syllables in target words enhanced subsequent recognition of low frequency words but not of high frequency words. Although some researchers have argued that the structural aspects of a word are encoded with its meaning during study and retained with the word meaning in long term storage (Kolers, 1976; Nelson, Wheeler, Borden, & Brooks, 1974), Lee, Tzeng, Garro, and Hung (1978) have suggested that access to the structural aspects of a word is contingent upon access to the meaning of the word originally encoded. In the present Experiments 2 and 3, each word was cued with a 2-letter fragment that was unique to that word. These target words tended to be rare, unusual words as rare words tend to share fewer graphemic characteristics with other words than do common words (Landauer & Streeter, 1973). Jacoby and Dallas (1981), on the other hand, state only that "all words were 5-letter nouns," although each word in their first experiment was associated with one of each of three question types: questions about constituent letters, rhyme questions, and questions about word meanings. Their words, then, may well have been considerably more common than those used in the present study, and therefore it is possible that word frequency was at the root of the difference between the present findings and those of previous research. In short, word frequency may control whether perceptual priming occurs across modalities.

Finally, we turn to the question of the effects of retention interval, which appears to be comparatively straightforward. In Experiment

3, a priming effect in perceptual identification was found to diminish, although by no means disappear, over a 24-hour period. By contrast, previous research (Jacoby & Dallas, 1981, Experiment 5) has failed to reveal any such change. This apparent discrepancy was resolved in Experiment 4, in which the effect of study-to-test delay was found to be localized at very short delays.

All other issues aside, it remains to be answered why memory for the structural aspects of an episode should be more persistent than memory for the meaning and context of an episode. One approach to resolving this problem is by way of Jacoby and Witherspoon's (1982) distinction between memory and awareness. As Jacoby and Witherspoon suggest, recognition without recollection may operate in an early passive phase of processing. A subsequent and more active phase of processing is assumed to underlie a more analytic processing that leads to genuine recollection. It may be this more active phase of processing that is subject to any detrimental effects due to the passage of time. In addition, it may be a deficiency in the active phase of processing that underlies the amnesic syndrome. As Jacoby and Witherspoon (1982) point out, this distinction cuts across interpretations in terms of storage and retrieval (Warrington & Weiskrantz, 1970; Woods & Piercy, 1974) in that a deficiency in more active processing has consquences for both.

Whatever the outcome of the investigation of the relationship between memory and awareness and, more specifically, recognition with and recognition without recollection, the findings reported here seem to suggest that memory research has too long neglected the less aware

forms of recognition and the relationship between recognition and perception.

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APPENDIX

Table A1

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no)						Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no)					
		Y3	Y2	Y1	N1	N2	N3	Y3	Y2	Y1	N1	N2	N3
1	4-p	9	11	3	2	2	0	0	9	4	5	3	0
	2-p	10	6	4	1	0	0	5	2	9	8	3	0
	1-p	3	9	3	3	0	0	5	4	6	6	6	3
	not-p*	3	17	11	6	4	0	3	9	21	31	33	6
2	4-p	3	8	1	1	8	3	3	8	3	3	4	3
	2-p	4	4	1	2	9	3	1	4	4	6	5	5
	1-p	3	4	3	1	1	6	3	2	6	5	10	4
	not-p	3	7	7	7	16	5	1	6	12	17	30	33
3	4-p	23	3	0	0	1	1	8	3	0	0	6	3
	2-p	19	2	1	0	2	0	16	4	1	0	2	1
	1-p	24	2	0	0	0	0	9	9	2	1	0	1
	not-p	23	5	1	1	6	1	12	22	7	6	38	22
4	4-p	22	4	2	1	1	3	4	6	1	1	3	0
	2-p	19	5	0	0	1	1	11	4	2	0	4	1
	1-p	16	4	0	0	3	0	6	10	2	2	5	0
	not-p	17	17	3	1	1	5	10	21	9	9	35	16

* All nonpresented figures (not-p) are out of 144 responses.

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
5	4-p	20	13	1	0	2	0	7	1	2	0	2	0
	2-p	31	3	1	0	1	3	2	2	1	0	4	0
	1-p	16	5	1	0	4	1	5	3	3	0	8	2
	not-p	7	20	8	4	10	2	7	9	12	10	34	21
6	4-p	11	6	4	3	3	0	5	2	2	8	4	0
	2-p	15	5	4	2	3	0	5	5	2	4	2	1
	1-p	10	4	2	5	1	2	9	4	1	6	3	1
	not-p	11	8	12	11	10	4	2	8	13	21	15	29
7	4-p	15	4	1	2	2	0	8	7	3	4	1	1
	2-p	16	4	3	1	0	1	6	6	2	3	5	1
	1-p	17	2	0	0	3	0	10	11	1	0	2	2
	not-p	23	9	5	1	1	0	16	16	22	16	17	18
8	4-p	9	2	1	5	0	1	11	5	4	2	4	4
	2-p	17	4	2	1	2	1	1	6	5	2	3	4
	1-p	14	1	2	0	3	2	5	6	2	5	2	6
	not-p	12	12	4	3	2	5	8	8	12	24	25	29

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
9	4-p	11	6	11	2	0	1	3	6	6	1	1	0
	2-p	9	8	4	3	5	0	1	12	3	0	3	0
	1-p	13	8	5	1	3	0	5	7	4	2	0	0
	not-p	6	8	12	3	6	2	6	16	13	17	41	4
10	4-p	18	4	6	1	0	0	8	4	3	3	0	1
	2-p	16	2	2	6	1	0	6	3	8	1	3	0
	1-p	14	5	7	2	0	0	8	4	1	2	4	1
	not-p	7	15	4	13	5	4	0	4	9	23	31	29
11	4-p	18	7	1	1	2	0	6	3	2	1	5	2
	2-p	11	5	5	1	1	1	9	7	1	1	6	0
	1-p	14	5	2	1	1	1	7	0	1	5	6	5
	not-p	25	8	5	3	3	4	9	17	21	4	25	20
12	4-p	16	10	4	3	0	1	2	5	3	2	1	1
	2-p	13	11	4	2	1	0	2	5	2	3	3	2
	1-p	13	8	7	4	2	1	0	3	2	0	7	1
	not-p	9	15	12	15	4	2	0	3	8	8	35	33

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
13	4-p	17	6	0	1	2	1	4	4	2	1	5	5
	2-p	18	8	1	0	0	1	5	5	1	1	6	2
	1-p	19	8	0	2	2	0	10	3	0	0	2	2
	not-p	34	7	4	0	3	2	3	12	3	7	26	43
14	4-p	15	9	1	3	7	2	3	2	1	1	2	2
	2-p	10	7	4	1	4	3	8	4	0	1	2	4
	1-p	12	4	3	1	4	1	5	2	1	4	5	6
	not-p	6	18	6	2	17	15	2	6	2	7	22	41
15	4-p	14	14	2	1	4	0	4	6	1	1	1	0
	2-p	14	9	5	0	5	1	10	2	0	0	2	0
	1-p	15	2	1	1	2	0	11	7	3	5	1	0
	not-p	9	12	11	8	3	1	2	19	11	14	50	4
16	4-p	24	1	1	1	4	3	5	0	0	2	1	6
	2-p	24	0	1	0	1	2	10	3	0	1	0	6
	1-p	32	0	1	1	1	1	10	0	0	0	1	1
	not-p	3	2	0	2	6	25	1	4	10	9	31	51

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no)						Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no)					
		Y3	Y2	Y1	N1	N2	N3	Y3	Y2	Y1	N1	N2	N3
17	4-p	22	6	1	1	0	1	8	4	2	1	2	0
	2-p	21	2	2	1	4	0	8	3	2	3	2	0
	1-p	17	6	3	3	1	0	8	2	0	4	4	0
	not-p	3	5	13	11	15	7	0	4	15	18	27	26
18	4-p	17	7	6	1	1	1	2	2	4	1	4	2
	2-p	11	7	5	3	3	0	1	5	7	3	2	1
	1-p	8	7	8	4	1	0	6	3	6	0	3	2
	not-p	14	16	8	7	8	3	5	15	16	12	12	28
19	4-p	13	12	4	3	3	1	0	1	5	2	4	0
	2-p	18	8	6	2	2	0	3	4	2	1	2	0
	1-p	15	8	5	2	2	0	2	3	3	6	0	2
	not-p	5	18	16	7	5	2	0	3	13	24	26	25
20	4-p	14	2	6	3	5	1	6	2	1	3	5	0
	2-p	14	1	1	9	0	3	9	1	2	3	3	2
	1-p	14	1	2	3	2	1	6	1	4	5	4	5
	not-p	19	3	6	16	7	10	11	3	9	15	23	22

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	Ni	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
21	4-p	18	9	4	1	3	0	5	3	4	0	1	0
	2-p	19	6	1	1	3	0	5	3	4	2	4	0
	1-p	18	5	3	3	2	0	6	3	1	3	3	1
	not-p	4	12	10	12	16	0	2	8	9	23	41	7
22	4-p	9	9	4	3	1	0	6	4	5	2	4	1
	2-p	14	4	1	0	2	2	12	6	4	0	2	1
	1-p	13	7	4	2	1	0	4	7	4	1	3	2
	not-p	0	14	17	9	9	1	1	5	14	18	42	14
23	4-p	6	11	3	3	4	0	2	6	6	4	3	0
	2-p	10	0	7	4	3	0	4	4	4	5	6	1
	1-p	13	8	0	3	4	1	2	10	1	3	2	1
	not-p	14	19	13	10	5	1	4	24	19	9	23	3
24	4-p	6	12	6	2	4	1	7	4	0	1	5	0
	2-p	11	5	3	1	7	1	5	5	2	2	4	2
	1-p	13	7	2	1	5	0	6	2	3	5	4	0
	not-p	2	13	14	3	8	2	1	5	12	10	47	27

Table A1 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Pi,Rn (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
Means	4-p	14.6	7.3	3.0	1.8	2.5	0.9	4.9	4.0	2.7	2.0	3.0	1.3
for all	2-p	15.2	4.8	2.8	1.7	2.5	1.0	6.0	4.4	2.8	2.1	3.3	1.4
24	1-p	14.4	5.0	2.7	1.8	2.0	0.7	6.2	4.4	2.4	2.9	3.5	2.0
subjects	not-p	10.8	12.1	8.4	6.5	7.1	4.3	4.4	10.3	12.2	14.7	30.4	23.0

Table A2

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

		Perceptual Identification											
		Identified						Not Identified					
		Recognition Response (Y-yes; N-no)											
Subject Number	Study Condition	Y3	Y2	Y1	N1	N2	N3	Y3	Y2	Y1	N1	N2	N3
1	4-p	4	8	3	4	2	1	5	5	7	5	4	0
	2-p	7	2	3	2	1	1	8	8	6	6	3	1
	1-p	5	2	3	4	1	0	8	7	4	6	6	2
	not-p*	1	5	5	15	7	5	3	7	19	27	39	11
2	4-p	11	6	7	0	3	1	3	3	3	2	9	0
	2-p	5	10	3	0	6	1	5	7	4	2	0	5
	1-p	7	1	4	1	2	0	6	8	5	4	8	2
	not-p	1	11	5	2	18	13	2	5	11	14	29	33
3	4-p	21	4	1	0	0	1	9	8	1	0	2	1
	2-p	15	2	0	1	3	0	13	7	1	1	5	0
	1-p	20	5	0	0	1	0	12	6	1	0	1	2
	not-p	11	10	1	5	22	13	11	13	2	6	27	23
4	4-p	12	5	0	0	2	5	18	4	0	0	2	0
	2-p	12	4	1	1	2	2	15	4	1	1	4	1
	1-p	11	7	0	1	2	3	14	3	3	0	4	0
	not-p	9	12	8	5	12	13	15	15	7	5	24	19

* All nonpresented figures (not-p) are out of 144 responses.

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Non Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
5	4-p	21	7	0	1	4	0	7	2	3	2	1	0
	2-p	23	6	4	0	2	0	5	3	2	1	1	1
	1-p	15	7	2	2	7	2	5	2	0	2	4	0
	not-p	2	10	5	3	36	30	0	5	1	5	19	28
6	4-p	14	3	4	3	0	1	8	8	2	4	1	0
	2-p	16	2	2	3	0	2	8	4	4	6	1	2
	1-p	15	3	0	2	1	2	14	5	2	2	2	0
	not-p	3	7	9	18	13	8	2	10	12	18	13	31
7	4-p	21	7	2	2	3	0	6	5	0	2	0	0
	2-p	21	3	0	2	1	0	16	2	1	1	1	0
	1-p	14	4	5	0	0	0	11	9	2	3	0	0
	not-p	9	5	4	10	17	18	9	7	13	11	18	23
8	4-p	15	5	4	2	1	0	10	4	2	2	0	3
	2-p	11	2	1	0	1	1	13	12	3	2	2	0
	1-p	16	4	4	2	2	2	10	1	2	2	2	1
	not-p	3	11	15	16	12	12	6	9	12	17	17	14

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
9	4-p	12	12	4	0	3	0	5	5	7	0	0	0
	2-p	16	9	5	2	2	0	7	4	1	1	1	0
	1-p	13	12	3	2	2	0	11	4	1	0	0	0
	not-p	3	19	9	12	29	7	0	12	9	7	23	14
10	4-p	18	3	1	1	1	0	13	3	5	1	2	0
	2-p	14	3	1	3	0	1	12	9	2	1	2	0
	1-p	14	2	1	4	1	1	12	3	4	4	2	0
	not-p	0	5	6	20	15	14	0	4	7	17	30	26
11	4-p	16	7	2	1	3	0	6	5	2	4	1	1
	2-p	12	4	6	2	2	0	11	3	2	2	2	2
	1-p	12	6	2	1	3	0	11	3	3	3	4	0
	not-p	4	12	14	6	21	13	1	10	12	13	24	14
12	4-p	9	6	3	2	3	0	9	3	6	2	5	0
	2-p	8	9	1	1	7	0	6	6	3	2	5	0
	1-p	7	14	5	1	4	0	5	3	3	1	5	0
	not-p	3	4	8	4	19	35	1	1	4	8	23	34

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
13	4-p	16	4	1	2	6	2	6	3	1	2	4	1
	2-p	17	4	0	2	1	2	10	5	1	1	4	1
	1-p	12	5	2	0	4	5	11	2	0	2	4	1
	not-p	6	16	6	4	18	21	4	10	5	8	17	29
14	4-p	13	4	2	1	5	0	14	2	2	1	3	1
	2-p	8	4	4	1	5	1	17	2	2	2	1	1
	1-p	11	4	3	3	5	2	7	6	1	3	2	1
	not-p	1	7	1	9	21	36	2	6	7	4	21	29
15	4-p	9	5	2	1	2	0	15	8	1	0	5	0
	2-p	16	5	1	1	1	0	12	5	2	2	3	0
	1-p	21	2	1	1	2	0	9	4	5	1	2	0
	not-p	1	10	6	7	33	8	2	7	8	12	39	11
16	4-p	21	1	1	1	4	0	8	2	2	2	5	1
	2-p	25	1	0	0	0	2	13	1	0	1	3	2
	1-p	21	0	0	0	1	5	17	1	0	0	2	1
	not-p	6	9	7	6	15	37	1	5	4	7	15	32

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3	Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no) Y3	Y2	Y1	N1	N2	N3
17	4-p	21	1	0	4	1	1	14	4	0	2	0	0
	2-p	25	1	2	3	2	1	7	4	2	0	0	1
	1-p	23	0	3	0	2	1	11	3	3	2	0	0
	not-p	4	6	9	9	27	18	1	4	10	17	22	17
18	4-p	9	11	4	0	2	1	7	6	4	2	1	1
	2-p	10	7	2	2	1	2	12	4	2	3	2	1
	1-p	8	7	5	0	3	1	6	5	5	2	4	2
	not-p	3	10	14	12	15	15	2	7	10	8	24	24
19	4-p	12	8	4	3	1	1	5	3	3	5	3	0
	2-p	20	2	2	5	0	0	9	2	4	1	3	0
	1-p	10	5	7	3	3	0	9	4	3	1	3	0
	not-p	4	4	13	19	29	18	0	3	7	13	19	15
20	4-p	18	3	3	3	1	0	12	2	2	3	1	0
	2-p	15	3	3	3	1	1	11	0	2	3	4	2
	1-p	15	0	3	2	1	2	14	0	3	3	4	1
	not-p	11	6	3	17	17	26	7	2	4	23	16	12

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

Subject Number	Study Condition	Perceptual Identification: Identified — Recognition Response (Y-yes; N-no)						Perceptual Identification: Not Identified — Recognition Response (Y-yes; N-no)					
		Y3	Y2	Y1	N1	N2	N3	Y3	Y2	Y1	N1	N2	N3
21	4-p	14	9	2	0	1	0	13	5	0	1	3	0
	2-p	12	7	3	2	1	0	11	10	1	0	1	0
	1-p	17	5	1	1	4	0	8	3	3	2	4	0
	not-p	2	9	7	24	32	9	5	11	9	10	25	1
22	4-p	15	1	3	2	7	0	9	4	0	3	4	0
	2-p	15	3	5	1	0	0	15	5	1	2	1	0
	1-p	17	5	1	1	1	0	14	4	1	2	2	0
	not-p	0	3	8	12	38	11	1	5	8	9	39	10
23	4-p	7	10	4	3	1	0	9	4	7	1	2	0
	2-p	11	6	5	1	4	1	10	2	4	1	2	1
	1-p	14	2	2	3	3	0	7	6	4	6	0	1
	not-p	3	14	15	10	20	3	2	19	12	19	21	6
24	4-p	15	2	6	3	1	0	11	3	4	2	1	0
	2-p	12	5	3	2	2	1	10	2	3	4	4	0
	1-p	15	4	3	1	3	1	9	6	1	1	4	0
	not-p	0	4	6	6	42	17	0	5	9	4	35	16

Table A2 (continued)

Number of Correct Responses out of 48 on Perceptual Identification and Recognition Memory Tests for Test Sequence Rn,Pi (Experiment 1)

		Perceptual Identification											
		Identified						Not Identified					
		Recognition Response (Y-yes; N-no)											
Subject Number	Study Condition	Y3	Y2	Y1	N1	N2	N3	Y3	Y2	Y1	N1	N2	N3
Means for all 24 subjects	4-p	14.3	5.5	2.6	1.6	2.4	0.6	9.3	4.2	2.7	2.0	2.5	0.4
	2-p	14.4	4.3	2.5	1.5	2.0	0.7	10.7	4.6	2.3	1.9	2.3	0.9
	1-p	13.9	4.4	2.5	1.5	2.4	1.1	10.0	4.1	2.5	2.2	2.9	0.6
	not-p	3.8	8.7	7.7	10.5	22.0	16.7	3.2	7.6	8.4	11.8	24.1	19.7

Table A3

Number of Correct Responses out of 48 on Visual and Auditory Perceptual Identification Test (Experiment 2)

	Visual Test							Auditory Test						
	Retention Interval and Presentation Modality (1st-short; 2nd-median; 3rd-long; Np-nonpresented, out of 96)													
Subject Number*	Visual			Auditory			NP	Visual			Auditory			NP
	1st	2nd	3rd	1st	2nd	3rd		1st	2nd	3rd	1st	2nd	3rd	
1	12	8	8	5	9	10	52	12	6	5	8	12	7	40
2	9	9	8	7	12	12	50	8	7	8	11	8	8	45
3	15	10	9	5	8	8	48	11	8	11	11	7	10	47
4	14	6	11	6	9	12	56	7	9	7	11	6	7	37
5	12	12	10	6	11	8	47	12	6	3	8	7	10	32
6	16	12	13	13	12	12	40	8	9	8	6	8	9	35
7	12	10	12	8	6	8	35	8	8	7	8	12	9	36
8	11	9	9	6	7	11	25	9	12	8	7	7	11	37
9	8	11	10	10	8	9	49	8	6	8	14	9	11	49
10	11	11	14	11	11	7	57	8	8	7	7	10	6	56
11	12	12	11	12	8	6	57	12	8	7	12	8	4	39
12	10	8	14	12	7	7	48	6	5	12	10	6	11	39
13	14	11	10	13	9	7	39	5	9	7	12	9	6	39
14	14	10	12	12	10	12	44	3	9	11	11	12	10	40
15	13	12	14	11	7	10	44	6	6	10	13	12	11	40
16	12	12	12	7	8	6	46	3	9	9	12	13	8	40
Mean	12.2	10.2	11.1	9.0	8.8	9.1	46.1	7.9	7.8	8.0	10.1	9.1	8.6	40.7

* Subjects 1-8 began list sequence with auditory block; subjects 9-16 began sequence with visual block.

Table A4

Number of Correct Responses out of 48 for Immediate and Delayed Perceptual Identification Tests. Critical Level underlined for each subject (Experiment 3)

Subject Number	Test	Visual Presentation Cue Level 1st	2nd	3rd	Auditory Presentation Cue Level 1st	2nd	3rd	Nonpresented Cue Level 1st	2nd	3rd
1	Immed.	1	7	15	1	8	9	0	3	13
	Del.	0	5	10	1	2	6	0	10	16
2	Immed.	2	15	20	1	12	15	0	4	18
	Del.	0	0	10	0	0	15	0	0	23
3	Immed.	11	22	22	7	17	19	3	13	25
	Del.	7	17	21	8	16	20	10	24	32
4	Immed.	8	18	21	8	14	20	2	13	24
	Del.	7	16	20	4	15	20	10	25	34
5	Immed.	16	17	19	9	13	15	7	12	22
	Del.	8	13	15	4	7	10	3	10	18
6	Immed.	4	16	19	0	5	14	0	1	10
	Del	0	5	13	0	4	7	0	3	11
7	Immed.	0	5	7	2	4	8	1	4	9
	Del.	4	9	15	0	2	5	4	8	11
8	Immed.	1	9	21	0	2	17	0	0	28
	Del.	0	7	17	3	9	21	1	6	30

Table A4 (continued)

Number of Correct Responses out of 48 for Immediate and Delayed Perceptual Identification Tests. Critical Level underlined for each subject (Experiment 3)

Subject Number	Test	Visual Presentation Cue Level 1st	2nd	3rd	Auditory Presentation Cue Level 1st	2nd	3rd	Nonpresented Cue Level 1st	2nd	3rd
9	Immed.	20	23	23	14	18	22	24	32	35
	Del.	20	20	23	19	23	23	29	29	31
10	Immed.	2	10	16	1	8	13	0	5	19
	Del.	0	9	13	0	4	10	0	9	18
11	Immed.	13	20	23	12	14	19	0	9	20
	Del.	7	20	23	4	13	19	8	17	36
12	Immed.	20	21	23	16	21	23	17	28	34
	Del.	11	17	16	15	18	20	21	31	37
13	Immed.	15	23	23	14	20	22	6	27	42
	Del.	18	22	23	17	22	23	30	41	39
14	Immed.	21	24	24	10	22	23	12	27	37
	Del.	8	19	24	7	13	16	14	32	37
15	Immed.	23	24	24	16	23	23	36	41	42
	Del.	18	21	23	19	22	22	31	39	44
16	Immed.	15	19	22	13	21	24	4	15	38
	Del.	2	6	23	1	5	23	0	10	41
Mean	Immed.	10.7	17.1	20.1	7.9	13.9	17.9	7.0	14.6	26.0
	Del.	6.9	12.9	18.1	6.4	10.9	16.3	10.1	18.4	28.6

Table A5

Number of Correct Responses out of 48 for Immediate and Delayed Word-Fragment Completion Tests. Critical level underlined for each subject (Experiment 3)

Subject Number	Test	Visual Presentation			Auditory Presentation			Nonpresented		
		Cue Level			Cue Level			Cue Level		
		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
1	Immed.	5	9	<u>19</u>	4	8	<u>19</u>	1	5	<u>25</u>
	Del.	0	8	<u>16</u>	0	3	<u>14</u>	1	7	<u>28</u>
2	Immed.	3	8	<u>19</u>	7	12	<u>22</u>	0	3	<u>27</u>
	Del.	0	4	<u>18</u>	0	3	<u>17</u>	0	7	<u>31</u>
3	Immed.	5	10	<u>18</u>	2	7	<u>17</u>	1	5	<u>23</u>
	Del.	0	4	<u>15</u>	2	8	<u>16</u>	1	5	<u>22</u>
4	Immed.	4	13	<u>19</u>	1	7	<u>19</u>	0	6	<u>22</u>
	Del.	2	6	<u>18</u>	0	0	<u>11</u>	0	1	<u>24</u>
5	Immed.	9	15	<u>19</u>	2	8	<u>19</u>	3	6	<u>31</u>
	Del.	5	6	<u>17</u>	0	3	<u>18</u>	1	7	<u>17</u>
6	Immed.	3	12	<u>19</u>	3	8	<u>18</u>	0	4	<u>23</u>
	Del.	0	8	<u>20</u>	1	4	<u>16</u>	0	12	<u>28</u>
7	Immed.	11	13	<u>18</u>	3	12	<u>18</u>	0	2	<u>23</u>
	Del.	3	6	<u>16</u>	0	1	<u>6</u>	0	2	<u>14</u>
8	Immed.	3	9	<u>22</u>	0	3	<u>14</u>	0	2	<u>23</u>
	Del.	0	1	<u>11</u>	0	4	<u>12</u>	0	3	<u>14</u>

Table A5 (continued)

Number of Correct Responses out of 48 for Immediate and Delayed Word-Fragment Completion Tests. Critical level underlined for each subject (Experiment 3)

Subject Number	Test	Visual Presentation Cue Level 1st	2nd	3rd	Auditory Presentation Cue Level 1st	2nd	3rd	Nonpresented Cue Level 1st	2nd	3rd
9	Immed.	13	<u>18</u>	20	9	<u>15</u>	20	0	<u>8</u>	28
	Del.	6	<u>12</u>	20	3	<u>9</u>	16	2	<u>8</u>	23
10	Immed.	4	11	<u>18</u>	1	5	<u>13</u>	0	7	<u>19</u>
	Del.	0	5	<u>13</u>	0	5	<u>13</u>	0	2	<u>23</u>
11	Immed.	7	13	<u>21</u>	5	12	<u>20</u>	0	1	<u>20</u>
	Del.	4	9	<u>16</u>	3	7	<u>20</u>	2	9	<u>31</u>
12	Immed.	9	15	<u>19</u>	6	8	<u>18</u>	1	1	<u>16</u>
	Del.	1	6	<u>16</u>	3	6	<u>15</u>	1	10	<u>22</u>
13	Immed.	9	<u>19</u>	23	11	<u>14</u>	21	3	<u>9</u>	30
	Del.	3	<u>10</u>	18	2	<u>7</u>	16	2	<u>10</u>	31
14	Immed.	11	<u>17</u>	21	4	<u>11</u>	16	0	<u>8</u>	28
	Del.	2	<u>6</u>	17	1	<u>11</u>	20	1	<u>9</u>	33
15	Immed.	12	17	<u>22</u>	4	11	<u>17</u>	1	5	<u>20</u>
	Del.	0	6	<u>17</u>	0	5	<u>14</u>	4	9	<u>25</u>
16	Immed.	6	12	<u>21</u>	2	6	<u>19</u>	0	1	<u>20</u>
	Del.	0	4	<u>14</u>	0	2	<u>15</u>	0	2	<u>23</u>
Mean	Immed.	7.1	13.2	19.9	4.0	9.2	18.1	0.6	4.6	23.6
	Del.	1.6	6.3	16.4	0.9	4.9	14.9	0.9	6.4	24.3

Table A6

Number of Correct Responses out of 48 on Word-Fragment Completion Tests (Experiment 4)

	Presentation Modality and Retention Interval							
	Visual				Auditory			
Subject Number*	16 Words	64 Words	192 Words	192 words, 24 hours	16 Words	64 Words	192 Words	192 words, 24 hours
1	19	11	14	13	16	11	15	10
2	18	15	15	10	13	10	12	8
3	19	13	16	18	20	13	13	15
4	21	19	12	13	13	11	11	10
5	16	10	12	4	7	7	2	6
6	15	13	10	10	14	10	8	5
7	23	14	11	13	16	10	7	11
8	20	14	12	11	14	11	16	11
9	15	8	4	4	10	2	3	7
10	19	12	7	10	13	4	5	7
11	22	11	13	8	13	8	9	7
12	19	11	8	8	10	4	8	4
13	21	14	20	16	22	17	15	13
14	13	9	6	10	13	7	7	7
15	18	13	6	9	11	10	7	7
16	18	11	9	9	13	7	8	7

* Subjects 1-16 began list sequence with a visual list; subjects 17-32 (next page) began with an auditory list.

Table A6 (continued)

Number of Correct Responses out of 48 on Word-Fragment Completion Tests (Experiment 4)

	Presentation Modality and Retention Interval							
	Visual				Auditory			
Subject Number	16 Words	64 Words	192 Words	192 words, 24 hours	16 Words	64 Words	192 Words	192 words, 24 hours
17	17	11	16	10	14	8	8	11
18	14	11	9	7	11	7	5	8
19	16	8	11	8	15	10	6	7
20	12	14	8	8	13	11	9	11
21	12	6	6	3	8	7	2	5
22	15	10	11	12	9	13	7	15
23	18	13	13	6	15	8	9	6
24	19	8	17	13	17	8	11	8
25	20	13	11	9	17	16	7	10
26	17	8	9	10	15	7	11	11
27	17	12	7	14	18	7	11	10
28	3	6	7	5	6	10	5	6
29	17	13	10	7	11	9	5	11
30	17	10	11	12	12	7	6	10
31	18	11	3	7	14	11	5	8
32	16	10	8	9	13	10	7	9
Mean	17.0	11.3	10.4	9.3	13.3	9.1	8.1	8.8