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On the Relationship Between Autobiographical Memory and Perceptual Learning

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SUMMARY

Although the majority of research on human memory has concentrated on a person's ability to recall or recognize items as having been presented in a particular situation, the effects of memory are also revealed in a person's performance of a perceptual task. Prior experience with material can make that material more easily identified or comprehended in perceptually difficult situations. Unlike with standard retention tests, effects of prior experience on a perceptual task do not logically require that a person be aware that he or she is remembering. Indeed, amnesic patients purportedly show effects of practice in their subsequent performance of a perceptual or motor task even though they profess that they do not remember having engaged in that prior experience. The experiments that are reported were designed to explore the relationship between the more aware autobiographical form of memory that is measured by a recognition memory test and the less aware form of memory that is expressed in perceptual learning. Comparisons of effects on perceptual learning and recognition memory reveal two classes of variables. Variables such as the level of processing of words during study influenced recognition memory, although they had no effect on subsequent perceptual recognition. A study presentation of a word had as large an effect on its later perceptual recognition when recognition memory performance was very poor as it did when recognition memory performance was near perfect. In contrast, variables such as the number and the spacing of repetitions produced parallel effects on perceptual recognition and recognition memory. Following Mandler and others, it is suggested that there are two bases for recognition memory. If an item is readily perceived so that it seems to "jump out" from the page, a person is likely to judge that he or she has previously seen the item in the experimental situation. Variables that influence ease of perceptual recognition, then, can also have an effect on recognition memory, so parallel effects are found. The second basis for recognition memory involves elaboration of a word's study context and depends on such factors as level of processing during study—factors that are not important for perceptual recognition of isolated words. Comparisons of perceptual recognition and recognition memory are shown to be useful for determining how a variable has its effect. Effects of study on perceptual recognition appear to be totally due to memory for physical or graphemic information. Results reported are also relevant to theories of perceptual learning. A single presentation of an item is shown to have large and long-lasting effects on its later perceptual recognition. At least partially, effects of study on perceptual recognition depend on the same variables as do effects on more standard memory tests.

Most studies of human memory have concentrated on factors that influence a person's ability to recall or recognize items as having been presented in a particular situation. Memory as measured in these experiments is autobiographical in that people are being asked to judge whether they remember experiencing a particular event. The effects of memory, however, can also be revealed in a person's performance of a perceptual task. Prior experience with material can result in perceptual learning so that the material is more easily identified in perceptually difficult situations. For example, when perceptual recognition is tested by asking people to report briefly presented words, prior exposure to those words in the experimental situation enhances subsequent perceptual recognition performance (e.g., Murrell & Morton, 1974). Typically, investigations of perceptual learning and those of autobiographical memory have been conducted by investigators working within different traditions, and, consequently, little has been done to relate these two effects of prior experience. The experiments reported in this article explored the relationship between autobiographical memory and perceptual learning by comparing the effects of traditionally important variables on recognition memory and perceptual recognition. One class of variables is shown to influence recognition memory but not perceptual recognition; another class of variables is shown to influence performance on both forms of test. On the basis of these results, it is argued that there is one process or type of information that is shared by autobiographical memory and perceptual learning, and another process or type of information that is involved only when autobiographical memory is tested. That is, there are two forms of recognition memory: one that has a basis common to that of perceptual learning and a second that is based on information that is irrelevant to perceptual learning.

Several theorists have suggested that perceptual learning and autobiographical memory reflect the operation of different memory systems. Among the first to claim that two memory systems are involved was Bergson (1913). According to Bergson, the past survives in two forms: in the adjustment of perceptual or motor mechanisms to a set of circumstances and in independent recollections. Bergson described the reading of a lesson, for example, both as contributing to the habit or the adaptation of actions necessary to recite that lesson and as setting up an independent representation of the individual reading of the lesson. He described the adaptation of action to circumstances as being gained gradually through repetition. Recollection, in contrast, cannot benefit from repetition, since it is memory for a particular episode and an episode cannot be truly repeated. Recollection was further described as requiring reflection and consequently attention, whereas the expression of memory in actions adapted to the circumstances was described as automatic.

To justify postulating two forms of memory, Bergson cited instances of brain damage that apparently resulted in a dissociation of autobiographical memory and memory as expressed in action or perception. The amnesic patients described expressed memory of prior experience in a situation through their actions even although they professed to not recognize the situation as being one they had previously encountered. Tulving's (1972) more recent distinction between episodic and semantic memory is similar to the distinction drawn by Bergson. Semantic memory can be likened to the adaptation of actions or perception to circumstances; it is semantic memory that would be held responsible for perceptual learning. Episodic memory, in turn, corresponds to recollection, memory for a particular episode. In this same vein, dissociations of the form cited by Bergson have recently been described by others. For example, prior presentation of a picture makes it more likely that an amnesic patient can report what is depicted when a fragmented version of the same picture is shown later; however, the patient will often not recognize the picture as one that was presented earlier. A parallel set of experiments with word fragments has yielded results similar to those found with picture fragments (e.g., Warrington & Weiskrantz, 1968, 1973, 1978).

Although there may be two separate memory systems, performance of a particular task might reflect the operation of both forms of memory. By making the distinction between forms of memory, one might expect

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that recognition memory of an item as having appeared in a particular situation would always involve recollection or retrieval of the episode in which the item occurred. However, Mandler and his colleagues (e.g., Mandler, 1979, 1980; Rabinowitz, Mandler, & Patterson, 1977) as well as others (Atkinson & Juola, 1974) have argued that there is also a second basis for recognition memory. According to Mandler, recognition memory can be based on a judgment of familiarity as well as on retrieval. The phenomenal experience of familarity is said to reflect the integration of an item; integration, in turn, depends on factors such as number of repetitions. The bases of recognition memory that we propose are in general agreement with those postulated by Mandler. However, we are interested in further exploring the basis of the phenomenal experience of familiarity by examining the relationship between recognition memory and the effect of prior study on perceptual recognition. A possibility we entertain is that the feeling of familiarity results from the enhanced perceptual recognition of an item that comes from having studied the item in the experimental situation. That is, the type of information that serves as one basis for recognition memory may be the same as that involved in perceptual learning, since the feeling of familiarity may depend on enhanced perceptual recognition.

We argue that the judgment of reoccurrence, recognition memory, can be based on two types of information: relative perceptual fluency and elaboration. Subjects can judge that they have seen an item before because the processing of the item seems relatively fluent, a situation that we might expect to be influenced by frequency of prior experience with the item in the experimental context and by similarity of perceptual characteristics between study and test presentations. As an example, subjects in recognition memory experiments often report that "old" items seem to jump out from the page. The notion is that subjects become aware of their more fluent perceptual processing of some items on the test, and correctly attribute their fluency to prior experience with those items in the experimental setting. That is, differences in judged fluency are used as a basis for recognition memory. Using the second basis of recognition, subjects might judge an item to be a reoccurrence because they can recover the unique context and elaboration given that item on its first occurrence. This more elaborative form of recognition might be expected to depend on the extent and the meaningfulness of prior processing. The dissociation between recognition memory and perceptual identification observed with amnesics would be explained if people have a bias toward judging reoccurrence on the basis of elaboration. This, in fact, might be a more conservative or reliable basis of recognition memory, since perceptual fluency may be influenced by several factors aside from experience with an item in the experimental situation. Further, if an item is recognized on the basis of relative perceptual fluency alone, all that the subjects would be able to say is that the item seems familiar; they would be unable to justify their recognition memory decision by providing details about the context in which the item previously occurred.

The experiments reported in this article were also designed to address other theoretical issues. For perception, investigations of the effects of study may help to specify the means by which variables such as frequency in the language operate and to reveal information about the factors controlling perceptual learning. For memory, comparisons of perceptual performance and memory performance help to specify the means by which such manipulations as level of processing have their effect. As is discussed later, investigations of perceptual identification may also help to produce an index of memory that differs from those typically used and that will be useful for applied purposes.

The experiments in this article were designed to explore the relationship between perceptual recognition and recognition memory. Each experiment compared the effects of variables on recognition memory with the effects of those variables on perceptual recognition. The first two experiments investigated the effects of elaboration during study. These experiments used incidental learning procedures and varied the meaningfulness (Experiment 1) and the extent (Experiments 2a and 2b) of processing required to answer a question about words presented during the study phase. The next two experiments used intentional learning procedures to investigate the effects of frequency in the language and study time (Experiment 3) as well as the effects of repetition and the spacing of repetitions during study (Experiments 4a and 4b). The last two experiments were designed to investigate the effect of retention interval (Experiment 5) and the effect of perceptual similarity between the study and test versions of a word (Experiment 6). Differences in the effects of variables in perceptual recognition and recognition memory are treated as evidence that the two forms of test can use different types of information. Similarity of effects, in contrast, is treated as being consistent with the claim that recognition memory and perceptual learning can have a common basis.

General Method

Since one basic paradigm is used throughout the series of studies, the method will be described in detail at this point. Variations in the general method will be indicated as each study is described.

The subjects were volunteers from an introductory psychology course at McMaster University, Ontario. Subjects were randomly assigned to conditions and tested individually.

Each experiment included a study phase and a test phase. During the test phase, words that had been studied and "new" words were intermixed and tested by means of a perceptual recognition test or recognition memory test. Stimuli were presented by means of a PDP-8A computer. The video screen of this system measures 26.5 cm × 18.5 cm. The screen was covered by a black construction paper mask that contained a centered window that was 8.5 cm long and 1 cm tall; words were presented in this window. Character size was approximately 2.8 mm × 5.1 mm; words were presented in all capital letters. Subjects were seated such that their viewing distance was approximately 60 cm.

For a recognition memory test, subjects made their responses by pressing the "yes" or "no" button mounted in a box they held on their laps. During the presentation of test items, subjects sat with their right thumb resting on one button and their left thumb resting on the other button. For half the subjects the right-hand button was assigned to the yes response, and for the other half of the subjects the left-hand button was assigned to the yes response. Subjects were instructed to respond yes if a test item had been presented during the study phase of the experiment. Subjects also used this button arrangement for responding during the question (study) phase of experiments, which used incidental learning procedures.

Subjects who received a perceptual recognition test were informed that words would be flashed on the screen and that they were to report each word immediately after its presentation. Further, they were informed that a portion of the words that would be presented had previously been presented during the study phase of the experiment. The sequence of events accompanying presentation of a word was as follows: First the message "Press when ready" appeared on the screen. The arrangement of buttons was the same as described earlier for recognition memory. When the subject pressed one of the buttons, the original message was replaced for 500 msec by a set of markers (two short horizontal lines) surrounding the location in which the word would be presented. Immediately after presentation of the word, a mask (a series of ampersands) appeared in the same location the word had been presented and remained on the screen for 2 sec. This sequence of events then repeated with presentation of the next word until the entire test list had been presented. For the main list of test items, words were presented for 35 msec prior to being replaced by the mask. Before presenting the main test list, a practice list was presented to "shape" perceptual recognition performance. This practice list contained 10 words that did not appear in either the study phase of the experiment or in the main test list. The first of these 10 words was presented for 135 msec, a duration that allowed nearly all subjects to report the presented word. The presentation duration of each successive word in the practive list was then decreased by 10 msec so that the last word appeared for 45 msec, a duration near that for which items in the main test list were presented.

Effects of Elaborative Processing

Experiment 1

A recurring theme in the memory literature is that retention performance reflects the degree to which meaning has been processed. One viewpoint that has stressed the importance of meaning is the levels-of-processing framework proposed by Craik and Lockhart (1972). This framework has led to several experiments in which the processing of study material is controlled by means of an orienting task, and a test of incidental retention is given. The typical finding is that subsequent retention performance is higher when the orienting task involves the meaning rather than the pronunciation or physical appearance of presented words (e.g., Craik & Tulving, 1975). However, the level-of-processing framework has recently been attacked for its failure to provide a satisfactory specification of what constitutes a meaningful analysis (e.g., Baddeley, 1978). Although there are currently a large number of experiments showing effects of manipulating an orienting task, there is no generally accepted framework that incorporates the results of those experiments.

Comparisons of perceptual recognition and recognition memory may help to clarify the means by which the level-of-processing manipulation has its effect. One account of the levels effect implies differences in perceptual processing (e.g., Morris, Bransford, & Franks, 1977) and can be used to predict parallel effects of level of processing on recognition memory and perceptual recognition performance. If a person is asked to search through a word for a particular letter, for instance, the person may accomplish the task without perceiving the word as a unit or fully identifying all the letters in the word. For semantic analysis of a word, however, dealing with the word as a unit is probably required. It seems reasonable to assume that effects on both subsequent recognition memory and perceptual recognition performance depend on a word having been processed as a unit. For recognition memory, a person is asked to recognize the *word* that was presented earlier, and is unlikely to be able to do so if earlier he or she identified only a few letters of the word. Similarly, identifying only a few letters of a word should do little to enhance subsequent perceptual recognition of that word. For both forms of test, then, effects of level of processing may reflect differences in the extent to which a word was processed as a unit during study. Differences in "trace strength" provide a second basis for predicting parallel effects of level of processing in recognition memory and perceptual recognition performance. Perhaps the memory trace that results from a semantic analysis is stronger or decays at a slower rate than does a trace that results from an analysis of the physical characteristics of a word. Assuming that trace strength determines both recognition memory and the probability of perceptual recognition, one would expect to find parallel effects of level of processing with the two forms of test.

However, the level-of-processing manipulation may influence recognition memory, although it has no effect on perceptual recognition performance. If, across different levels of processing, previously presenting a word has a uniformly large effect on perceptual recognition, it can be argued that the word was perceived as a unit upon its prior presentation regardless of the orienting task. The levels effect on recognition memory could then not be attributed to differences in the extent to which a word was processed as a unit during study. Rather, it could be concluded that the manipulation of level of processing must have its effect through a form of information that is important for recognition memory but not useful for perceptual recognition.

Method

Subjects. Forty-eight volunteers from an introductory psychology class served in a 1-hr. session for course credit.

Design and materials. In the first experiment, subjects answered a different question about each word in a long list. Retention of these words was then assessed by means of either a test of recognition memory or a test of perceptual recognition. During presentation of the list, three types of questions were used: questions about the constituent letters of words (e.g., contains the letter L?), rhyme question (e.g., rhymes with train?), and question about the meaning of words (e.g., is the center of the nervous system?). Sixty questions were presented during the first phase—10 questions that required a yes answer and 10 questions that required a no answer for each of the three question types. For each of the two types of retention test, 80 words were presented—the 60 words that had been presented during the first phase plus 20 new words. Different subjects received the test of perceptual recognition and the test of recognition memory; 24 subjects were randomly assigned to each of the two forms of test.

All words were five-letter nouns. Three questions, one of each of the three types, were prepared for each word; each of these questions required a yes answer. Questions requiring a no answer were formed by repairing words and questions. Within a list of questions and words, no question was repeated. Across lists, questions about the constituent letters of a word used all the letters in the alphabet except X and Z. From this pool of words and questions, eight question formats were constructed. Across six of these formats, any particular word was associated with two questions of each of the three question types; one of these two questions required a yes answer; the other required a no answer. In the remaining two formats, the word was not presented in the first phase but appeared as a "new" item on the retention test. Four random orderings of the 80-word test list were used. The same question formats and test orders were used for subjects receiving a test of recognition memory and subjects receiving a test of perceptual recognition. Within each test condition, each question format and test order was used equally often. Each of the 24 subjects in a test condition received a different combination of question format and test order.

Procedure. During the first phase of the experiment, a question was presented for 1 sec and then replaced on the screen by a target word. The target word remained in view until the subject made a yes or no response to the combination of target word and question. For the recognition memory test, subjects were instructed that they were to respond yes to words that had been presented along with questions in the first phase of the experiment and no to words that had not been presented. For the recognition test, words were presented at a 2-sec rate. Subjects who received a perceptual recognition test were informed that words would be flashed on the screen and that they were to report each word immediately after its presentation.

Analyses. First, analysis of the data from the common "question" phase of the experiment will be reported. Next, separate analyses will be reported for recognition memory and for perceptual recognition performance. For recognition memory, the primary data that were analyzed were the reaction time and the probability of responding yes to a word that did occur in the first phase of the experiment (hits). Question type was varied within subjects so there is no basis for expecting differential bias when subjects made recognition memory decisions for words that were accompanied by the different question types. For perceptual recognition, the number of words correctly reported provides the primary data for analyses. A brief description of errors is also reported. Discussion of some details of the errors is deferred until after other experiments have been reported, then those details that are common across experiments are discussed jointly. The significance level for all tests was set at $p < .05$.

Results

Question phase. In the first phase of the experiment, the probability of correctly answering a question that required a no answer (.98) was significantly higher than that of correctly answering a question that required a yes answer (.96), $F(1, 39) = 6.14$, $MS_e = .005$. There was no effect of type of question (physical, rhyme, or semantic) on the probability of a correct response. However, this variable did influence the speed of responding. Mean reaction times are presented in Table 1 for each of the three question types, separated for questions requiring a yes response and those requiring a no response.

Table 1
Reaction Times as a Function of Type of Question in Phase 1 of Experiment 1

Item	Physical Yes	Physical No	Rhyme Yes	Rhyme No	Semantic Yes	Semantic No
Reaction time (msec)	1,023	1,105	1,038	1,060	1,160	1,314

Analyses of the reaction time data revealed a significant effect of question type, $F(2, 78) = 27.04$, $MS_e = 32{,}286$, and response type (yes vs. no), $F(1, 39) = 28.37$, $MS_e = 15{,}783$, and a significant interaction of these two variables, $F(2, 78) = 6.59$, $MS_e = 13{,}217$. As shown in Table 1, questions about the meaning of an item took longer to answer than did questions about the presence or absence of a constituent letter or questions about a rhyme relationship. Further, questions that required a no response required longer to answer than those requiring a yes response. This latter effect was larger when the question was about the meaning of an item (cf. Craik & Tulving, 1975).

Recognition memory. The recognition memory results are summarized in Table 2. Analyses of these results revealed a significant effect of question type on subsequent recognition both in the probability of a hit, $F(2, 30) = 29.20$, $MS_e = .03$, and in the re-

Table 2
Effects of Level of Processing on Recognition Memory and Perceptual Recognition

Form of memory	Physical Yes	Physical No	Rhyme Yes	Rhyme No	Semantic Yes	Semantic No	New words
Recognition memory							
Probability of hit	.51	.49	.72	.54	.95	.78	—
Reaction time (msec)	924	957	855	901	749	880	—
Perceptual recognition							
Probability of hit	.78	.81	.82	.80	.80	.83	.65

action time of those decisions, $F(2, 30) = 5.5$, $MS_e = 32{,}254$. Further, questions that required a yes response during the first phase of the experiment produced a higher probability of subsequent correct recognition, $F(1, 15) = 11.05$, $MS_e = .03$, and faster correct recognition, $F(1, 15) = 17.0$, $MS_e = 16{,}740$, than did questions that required a no response. The probability of correctly rejecting items that were not presented in the first phase of the experiment was .85; the mean reaction time for a decision of this type was 919 msec.

The recognition memory results served to validate the materials and procedures used in the present experiment. The results show an effect of level of processing that is of the same form as that found in other experiments (e.g., Craik & Tulving, 1975). The size of the levels effect, however, is noteworthy; recognition performance after a semantic question that required a yes answer was nearly twice as high as that after a question about constituent letters that required a no answer.

Perceptual recognition. The perceptual recognition results are summarized in Table 2. Although question type had large effects on recognition memory, that manipulation had no effect on perceptual recognition, $F(2, 46) = .41$, $MS_e = .015$. Further, for subsequent perceptual recognition, it did not matter whether a question had required an answer of yes or an answer of no, $F(1, 23)$, = .30, $MS_e = .016$. Although there was no effect of level of processing, presentation of a word in the first phase did enhance its subsequent perceptual recognition. A t test assessing the difference between perceptual recognition of presented items (collapsed across question type) and items that were not presented during the first phase revealed a highly significant effect, $t(23) = 8.15$, $MS_e = .095$. This advantage of previously presented words in perceptual recognition was shown by every subject.

In light of comments by Clark (1973), the consistency of effects across items is of importance. For each item in the list, the probability of the item being recognized when it was presented (collapsed across question type) and when it was not presented in the first phase were computed across subjects. Of the 80 items, 47 showed an advantage of previously presented over not presented, 21 showed a tie for the two conditions, and 12 showed a reversal of the effect of prior presentation. One potential basis for differences in perceptual recognition between items is the effect of frequency of occurrence of items in the natural language. Perhaps the effect of presenting an item in the first phase is restricted to items that occur with a low frequency in the natural language. To see if this was the case, items were broken into three groups on the basis of their frequency of occurrence as recorded by Thorndike and Lorge (1944). Although the effect of presenting a word on subsequent perceptual recognition was a bit higher for words that occur infrequently in the language, there was a substantial effect of prior presentation even for high-frequency words. The effects of frequency in the language will be reexamined when reporting Experiment 3, in which frequency was explicitly manipulated.

Across all conditions (presented and nonpresented items), the probability of an error in perceptual recognition was .23. Within these errors, the probability of an omission error was .27. Intrusion of words that did not appear in either the first phase of the experiment or in the test list (extralist intrusions) comprised .46 of the errors, whereas words that were presented (intralist intrusions) accounted for the remaining .27 of the errors. As with the probability of correct perceptual recognition, there was no consistent effect of question type on the probability of an intrusion error. As an example, 14 intrusion errors originated from questions about constituent letters that had required a no response, whereas 10 intrusion errors originated from semantic questions that required a yes response. In contrast, it will be remembered that these two conditions produced a substantial difference, in the opposite direction, in recognition memory performance. Intrusion errors tended to be words that looked like the word they replaced (cf. Morton, 1964). That this was the case is most easily demonstrated by considering the intralist intrusion errors. Inadvertently, the pool of 80 words that was used included three pairs of words that differed only in their initial letter (e.g., hound, wound). Words from these three pairs accounted for .36 of the intralist intrusions.

Discussion

Although the variation in processing produced by asking different types of questions doubled the probability of recognition memory in some instances, manipulations of processing had no effect on later perceptual recognition. The effect of a prior presentation on perceptual recognition was as large when recognition memory was very poor as it was when recognition memory was near perfect. It seems that recognition memory and perceptual recognition, at least partially, use different types of information. Further experiments by the first author in collaboration with Gordon Hayman have revealed a similar dissociation of perceptual recognition and recognition memory in other situations. As in the present experiment, the first phase of those other experiments embodied the level-of-processing manipulation. In the second phase of those experiments, subjects either solved anagrams or judged whether a presented item was a word (lexical decision task). Anagrams were solved faster when their solution words had been presented in the first phase of the experiment; however, the level of processing of the solution word in the first phase did not influence the speed of solving an anagram of that word. Similarly, lexical decisions were faster when the word being judged had been presented in the first phase of the experiment; again, level of processing of the word in the first phase did not influence the speed of the lexical decision for the word in the second phase. Thus, across experiments the level-of-processing manipulation that has a large effect on recognition memory did not influence performance on tasks that require access to memory of a word but do not require subjects to judge whether that word was presented previously. This dissociation of recognition memory and other tasks requiring memory has implications for both theories of perception and of memory.

One striking result in the present experiment was the effect of study on perceptual recognition. The general feeling among those investigating perceptual recognition seems to be that a subject must engage in substantial study before evidence of that study will be found in perceptual recognition performance. Previous perceptual recognition experiments that show effects of study on tachistoscopic recognition have allowed subjects a relatively long period of time to study a short list of words. Murrell and Morton (1974), for example, allowed subjects 3 min. to study a list of 12 words. Further, subjects were encouraged to keep the list of words in mind during the tachistoscopic recognition phase of the experiment. In contrast to expectations evidenced by these experiments, the results of the present experiment revealed that a single brief presentation of a word in a long list was sufficient to produce a large effect on its later perceptual recognition.

To account for the effects of a word's frequency of occurrence in the language on its perceptual recognition, some have suggested that subjects are more likely to correctly guess a presented high-frequency word than a low-frequency word. Similarly, prior presentation of a word may make it more likely that a subject will correctly guess the word when it is later presented for perceptual recognition. To account for the effects of study observed in the present experiment, however, increases in the probability of guessing a word would have to be independent of the subject's recognition of that word as being one that was presented previously. Given the long list of words that was used, the effect of presenting an item on its subsequent perceptual recognition also seems much too large to be accounted for by guessing alone. Further, intrusion errors were not random; words that were given as an intrusion error shared letters with the words they replaced. Information gained from the visual array must combine by some means with information preserved from the prior presentation of a word to influence perceptual recognition. Broadbent and Broadbent (1975) rejected the guessing explanation of the effect of frequency in the language and argued that biases reflecting frequency in the language combine multiplicatively with information gained from the visual presentation of a word to determine perceptual recognition performance. It seems that a similar account is required to explain the effect of a prior presentation of a word on its later perceptual recognition.

Turning to memory, a strong interpretation of the levels-of-processing view proposed by Craik and Lockhart (1972) would suggest that an orienting task can be used to totally control processing and that physical information about a presented word is lost very rapidly. Results from the present experiment conflict with both of these claims. When asked to judge whether a word contained a particular letter, subjects were not instructed to read the word as a whole; however, effects on perceptual recognition were as large in that condition as in the condition that did require subjects to deal with the word as a unit. It seems that a word was perceived as a unit regardless of the orienting task. Although the results may change with extended practice at searching for constituent letters, responding to a word as a unit appears to be initially automatic (e.g., Shiffrin & Schneider, 1977), occurring regardless of the orienting task. Others have used more traditional measures of memory and also provided evidence that an orienting task does not fully control processing (e.g., D. L. Nelson, 1979). The recognition memory effects of level of processing obtained in the present experiment, then, cannot be attributed to differences in the extent to which a word was processed as a unit during study. With regard to the decay of physical information, it was apparently information about the physical appearance of a word that was preserved and that influenced its later perceptual recognition; intralist intrusion errors were based on physical similarity, and requiring semantic processing did not further enhance perceptual recognition performance. Experiments reported later in this article provide further evidence that physical information is retained over the long term. An account of the levels effect in terms of differences in elaboration or distinctiveness of encoding is offered after reporting Experiments 2a and 2b.

Experiment 2a

Recent experiments have shown that increasing task difficulty enhances incidental retention performance, even when orienting tasks do not obviously differ in the extent to which they require the processing of meaning. As an example, Jacoby, Craik, and Begg (1979) found that retention performance was enhanced when subjects corrected the spelling of a word rather than recognized and copied a correctly spelled word, two tasks that appear to involve meaning equally. To account for results of this type, some have suggested that processing effort or arousal as well as level of processing is an important determinant of retention (Tyler, Hertel, McCallum, & Ellis, 1979). One means by which effort could operate to influence retention would be by strengthening the memory trace of a presented item. Increasing effort or arousal may act in a manner that is similar to increasing the number of repetitions of an item. Alternatively, task difficulty may have its effect by increasing the effective duration of the study exposure of a word. More difficult tasks take longer to complete than do easier ones, and this difference in study time may be responsible for effects on retention. Again, the effect would presumably operate through differences in strength of the memory trace and be similar to that of increasing the number of repetitions of an item.

In the first phase of the second experiment, subjects either read a word or solved an anagram that required that word as a solution. Retention was tested by means of a test of perceptual recognition and then a test of recognition memory. On the basis of prior research, it was expected that producing a word as a solution to an anagram would result in higher recognition memory performance than would simply reading the word. The purpose of the experiment was to determine whether this effect of task difficulty operated in a manner similar to that of the level-of-processing manipulation. If the two manipulations produce their effects in a similar manner, one would expect to find an effect of task difficulty on recognition memory but no effect on perceptual recognition. Alternatively, the manipulation of task difficulty may have its effect through differences in the strength of the resultant memory. Assuming that perceptual recognition performance reflects differences in strength, one would expect an effect of task difficulty on both perceptual recognition and on recognition memory.

Method

Subjects. Twenty-four students in an introductory psychology course were each paid $2 for serving in a 1-hr. session.

Design and materials. In the first phase of the experiment, subjects worked through a list containing 30 words that were to be read and 30 anagrams that were to be solved. Next, a test of perceptual recognition was given. This test included the words that had been previously read, the solution words for the anagrams, and 30 new words that had not been presented previously. After the test of perceptual recognition, a test of recognition memory was given.

A pool of 90 five-letter nouns was used to construct the list presented in the first phase and the test of perceptual recognition. The letters of each of these words could be rearranged to form an anagram with only one solution. From this pool of words, six formats were constructed such that across formats all words were read, required as a solution word for an anagram, and encountered as a new word in the test of perceptual recognition an equal number of times. Five different rules were used to rearrange the letters of words to form anagrams, each used equally often in each list. Within each of these lists, words and anagrams were intermixed so that their presentation order was random. The test of perceptual recognition used four random orders of items. Each of the 24 subjects received a different combination of list format and test order.

The test of recognition memory contained the 90 words that had been presented for perceptual recognition plus 180 new five-letter words. These words were arranged in a random order and typed on a sheet of paper to be provided as a test of recognition memory.

Procedure. The display device and viewing conditions used in the second experiment were as described for Experiment 1.

At the outset of the experiment, subjects were told that we were interested in how long it took them to solve anagrams. The words that were to be read were explained as providing a measure of the time it takes to read a word, which could be subtracted from that of solving the anagrams to give a better measure of solution time. When an item was presented, subjects were to read it aloud if it was a word or say the solution aloud if it was an anagram. Simultaneously, a subject was to push a button to record reaction time. If an anagram was not solved within 1 min. the experimenter told the subject the solution word, and the subject then pressed the button. The arrangement of buttons was the same as described for Experiment 1. When a button was pushed, the item on the screen was erased and the screen remained blank for 2 sec; the next item was then presented.

The procedure for the test of perceptual recognition was the same as described earlier. For the test of recognition memory, subjects were instructed to circle items on a test sheet that had either been read or given as a solution word for an anagram in the first phase of the experiment.

Results and Discussion

The probability of solving an anagram in the first phase of the experiment was .67. It took substantially longer to solve an anagram ($\bar{X}$ = 11.48 sec) than to read a word aloud ($\bar{X}$ = 1.08 sec).

Perceptual recognition and recognition memory results are summarized in Table 3. In the test of recognition memory, words that had been encountered as anagrams in the first phase were more likely to be recognized than were words that had been read in the first phase of the experiment, $F(1, 23) = 31.25$, $MS_e = .006$. Words that had been presented only on the perceptual recognition test (new items) were rather likely to be falsely recognized as having occurred in the first phase of the experiment (.37). The probability of a false recognition response to items that occurred only in the recognition memory test was .05. For a second analysis of recognition memory, the probability of correct recognition was conditionalized on identifying and failing to identify words during the perceptual recognition test. The results of this analysis showed that the probability of correct recognition was higher for words that had been identified during the perceptual recognition test than for those that had not been identified (.75 vs. .50). However, the effect of study condition on recognition memory was consistent across these two classes of items. For items that were not identified during perceptual recognition, words that had been presented as anagrams were more likely to be correctly recognized than were words that had only been read (.59 vs. .41).

Table 3
Effects of Task Difficulty on Probability of Recognition Memory and Perceptual Recognition

Form of memory	Item type: Read	Anagram	New
Recognition memory	.62	.75	.37
Perceptual recognition	.79	.74	.62

In perceptual recognition, words that had been read in the first phase of the experiment were much more likely to be correctly identified than were new words, $F(1, 23) = 24.84$, $MS_e = .04$. In contrast to the recognition memory results, however, previously producing a word as a solution for an anagram did not result in higher perceptual recognition performance than did simply having read the word. Although the difference is not significant, the anagram condition produced poorer perceptual recognition performance than did the condition that only required that words be read.

The effect of encountering a word in the first phase of the experiment on its later perceptual recognition was consistent across items. When words were presented as anagrams in the first phase, 56 of the 80 words benefited from presentation, 13 words were equally likely to be perceptually recognized when they had and had not been presented in the first phase, and 21 words showed a reverse effect of prior presentation; they were more likely to be perceptually recognized when they had not been presented in the first phase. For items read in the first phase of the experiment, 63 words benefited, 20 items showed no effect of prior reading, and only 7 items showed a reverse effect.

As in the first experiment, intralist intrusion errors were similar to the words they replaced. Intralist intrusion errors accounted for .14 of the total errors, and shared an average of 2.95 letters with the words they replaced.

Experiment 2b

In the anagram condition of Experiment 2a, subjects did not see words with their letters in the appropriate order prior to the test of perceptual recognition of those words. Perhaps a disadvantage due to not seeing the words in the first phase counteracted, in perceptual recognition, some advantage that seeing the solution word would have otherwise held over reading the word. To check on the importance of reading a word for subsequent perceptual recognition, an additional experiment was conducted. This experiment was identical to Experiment 2 with the exception that the presentation of each anagram was followed by the presentation of its solution word. If the subjects were able to solve an anagram, the solution word replaced the anagram on the screen immediately after the subject had pressed the button and said the solution word; subjects were told that this procedure was to allow them to check their answers. If subjects were not able to solve an anagram within 1 min. they were instructed to push the button to see the solution word.

After testing 11 subjects, means were compared and the experiment was discontinued. The results were nearly identical to those obtained in the prior experiment. Perceptual recognition performance for previously presented words (.75) was higher than that for new words (.54), $F(1, 10) = 22.36$, $MS_e = .026$. More important, producing a word as a solution for an anagram still resulted in slightly lower perceptual recognition performance than did reading the word (.74 vs. .76).

Discussion of Experiments 1, 2a, and 2b

Effects in perceptual recognition can be largely independent of the level of recognition memory performance. Although task difficulty and level of processing have large effects on recognition memory, neither of the two manipulations influences perceptual recognition. The similar pattern of results produced by the two manipulations supports the suggestion that task difficulty and level of processing have their effects on recognition memory by a similar means. Further, the lack of effects on perceptual recognition rule out differences in memory for words per se as being responsible for effects observed in recognition memory performance.

It has been suggested elsewhere (e.g., Jacoby & Craik, 1979) that recognition memory and recall performance reflect the distinctiveness of an encoding. The notion is that processing results in what is essentially a description of a presented stimulus, and that the memory trace can be regarded as the record of that description. The more meaningful or difficult the initial task, the richer, more elaborate, and more precise the resulting description of an item. In turn, precise descriptive records are likely to be highly discriminable from other memory traces produced by occurrences of the particular word in other contexts or by the occurrence of similar words. By this view, effects in recognition memory of task difficulty and level of processing are due to a record of the additional processing required by a task being preserved to produce a more distinctive memory trace.

An account based on distinctiveness also provides an explanation for the observed lack of effects of level of processing on perceptual recognition performance. The additional detail included in a more precise descriptive record is only potentially retrievable, being dependent on the cues provided at the time of test and the utilization of those cues. For a perceptual recognition test of individual words presented out of context, a richer memory trace is of no benefit, since the cues provided by the visual array are only relevant to the word per se. Further, information other than the visual pattern and name of the word is not required by the perceptual recognition test, and may be accessed only after the presented word has been perceived, too late to influence perceptual recognition performance. However, if study context were reprovided at the time of test by presenting the question that had been asked about an item during study, one might well find an effect of level of processing in perceptual recognition performance. One point to be made here is that an effect of meaningful elaboration during study depends on the cues provided at the time of test and task demands. Perceptual recognition and recognition memory differ in their reliance on elaboration or the distinctiveness of the encoding of an item.

Effects of Repetition and Study Time

In an earlier article (Jacoby, Bartz, & Evans, 1978), it was suggested that there are two classes of variables that influence memory performance. One class of variables was identified with meaning or organization; the other class of variables has traditionally been identified with the "strength" of a memory and includes manipulations such as number of repetitions and study time. It was suggested that, although these two classes of variables operate in different ways, a variable from either class can be manipulated to influence overall memory performance. That is, an event can be well remembered either because it is meaningful or because it has been repeated a large number of times. Similarly, Mandler (1979) suggested that integration and elaboration are two dimensions of memory for an event; integration is said to reflect the number of repetitions of an event, whereas elaboration reflects the meaning or organization of an event with other events. Mandler goes on to argue that an item can be recognized in a test of recognition memory either on the basis of its familiarity, which depends on integration, or on the basis of its retrieval, which depends on the elaboration of the item.

The first two experiments manipulated variables related to the elaboration or the meaning of presented words and found effects in recognition memory but no effects in perceptual recognition. Thus it appears that elaboration affects recognition memory but has no affect on perceptual recognition. In the experiments that follow, variables such as study time and number of repetitions that might influence the strength or integration of the memory for a word were manipulated. Manipulations of these variables were expected to produce parallel effects on perceptual recognition and recognition memory.

Experiment 3

Variables manipulated in the third experiment were study time and the frequency in the language of words presented for study and recognition. Again, both a test of perceptual recognition and a test of recognition memory were given.

Although solving an anagram took substantially longer than did reading a word in Experiment 2, this difference was not reflected in perceptual recognition performance. However, the additional time could not be spent studying the *word* that would later be presented for perceptual recognition; a great deal more time was required to arrive at the word when it was presented as an anagram but, once obtained, the time allowed for study of the word did not exceed that provided for items that were simply read. Perhaps only study time for a word is important for later perceptual recognition of that word. In order to check this possibility, subjects studied a long list of words at a rate of either 1 sec per word or 2 sec per word, then received a test of perceptual recognition or of recognition memory. In contrast to the effect of solving anagrams, the manipulation of study time may produce parallel results in the two forms of test.

One of the most important variables influencing perceptual recognition is frequency in the language of the word that is to be recognized. Words that occur frequently are identified much more readily than words that occur infrequently (e.g., Morton, 1969). A question addressed by the present experiment is, How easily can effects of frequency in the language be diminished or eliminated? The post hoc analysis of items in Experiment 1 showed that low-frequency items benefit slightly more from a prior presentation than do high-frequency items. In the present experiment, items were selected from much more discrepant levels of frequency so as to further investigate the interaction of frequency in the language with study presentation. Frequency in the language has also been shown to influence recognition memory performance (e.g., Gregg, 1976). Here, the effect of frequency that is typically reported is opposite to that found in perceptual recognition; low-frequency words are more readily recognized as having been presented previously than are high-frequency words. However, the effects of frequency in the language on perceptual recognition and recognition memory have not been investigated using the same words within the confines of a single experiment.

Method

Subjects. Forty-eight students enrolled in an introductory psychology course participated in a 1-hr. session for course credit.

Design and materials. A list of 60 words was presented for study at a rate of either 1 sec per word or 2 sec per word; half were high-frequency words, the others were low-frequency words. After presentation of the study list, different groups of subjects were given a test of perceptual recognition or a test of recognition memory; 12 subjects were randomly assigned to each of the four combinations of study rate and test condition. Each of the two forms of test used the same list of words. Half of the words in a test list had been presented during study; the remaining half were new in that they appeared only in the test list. Old and new words were matched with regard to their frequency in the language.

A pool of 120 words was selected from the Thorndike-Lorge (1944) word book; 60 of the selected words were low frequency (1 to 5 per million), whereas the remaining 60 words were high frequency (A and AA) as scaled by Thorndike and Lorge. From this pool of words, two list formats were constructed such that words presented for study in one format were presented only as new words in the test list in the other format. In addition, there were three random orders of items in the test list. The combination of list format and test order resulted in six different test lists. Each of these test lists was used twice in conjunction with each of the four combinations of test condition and study rate.

Procedure. Subjects were instructed to read the words aloud as they were presented during the study phase of the experiment. Details of the study presentation and of the recognition memory and perceptual recognition tests were as described for earlier experiments.

Results

Recognition memory. Only data from correct responses (hits and correct rejections) were analyzed. These data are summarized in Table 4.

The analysis of the probability of a correct recognition memory response revealed a significant effect of study time, $F(1, 22) = 7.91$, $MS_e = .01$; the probability of a correct response was higher when items were presented for study at a 2-sec rate than at a 1-sec rate. Words that occur less often in the natural language were more likely to be correctly recognized than words that occur more often, $F(1, 22) = 46.11$, $MS_e = .008$. Details of the results provide evidence that the latter effect was primarily due to an influence of frequency in the language on the probability of correctly recognizing an old item rather than on the probability of correctly rejecting a new item. Overall, the probability of a correct yes response to an old word was lower than that of a correct no response to a new word, $F(1, 22) = 16.61$, $MS_e = .02$. Further, type of test item (old vs. new) interacted with frequency in the language so that the effect of frequency was substantial only for the old items, $F(1, 22) = 12.54$, $MS_e = .01$. Analyses of reaction times revealed that recognition responses were substantially faster for low-frequency than

Table 4
Effects of Frequency in the Language and Study Rate on Recognition Memory

Study rate	Hits: High frequency	Hits: Low frequency	Correct rejections: High frequency	Correct rejections: Low frequency
1 sec				
Probability	.63	.88	.91	.92
Reaction time (msec)	856	814	985	891
2 sec				
Probability	.78	.93	.89	.97
Reaction time (msec)	798	750	860	864

for high-frequency words, $F(1, 22) = 12.35$, $MS_e = 3{,}964$. Further, correctly rejecting a new item (no response) required more time than did correctly recognizing an old item (yes response), $F(1, 22) = 16.92$, $MS_e = 12{,}890$. Although increasing study time produced slightly faster correct responses, neither the main effect of study time nor any interaction with study time was significant in the analyses of reaction times.

In general, the recognition memory results confirm those of earlier experiments (e.g., Gregg, 1976). Low-frequency words were recognized more readily as having been presented previously than were high-frequency words, and increasing study time enhanced recognition memory performance.

Perceptual recognition. The perceptual recognition results are summarized in Table 5. Analysis of these results showed that old items, those that had previously been presented for study, were much more likely to be correctly recognized than were new items, $F(1, 22) = 140.98$, $MS_e = .012$. In opposition to results found in recognition memory, words that occur more often in the language were more likely to be correctly recognized in the test of perceptual recognition than were words that occur less often, $F(1, 22) = 165.68$, $MS_e = .007$. The interaction of prior study with frequency was also significant, $F(1, 22) = 12.44$, $MS_e = .017$. Study presentation had a larger effect on the subsequent perceptual recognition of low-frequency words than on that of high-frequency words; however, even the effect with high-frequency words was substantial. In contrast to the recognition memory results, study time had no effect on perceptual recognition; the difference between perceptual recognition of presented and nonpresented items is approximately the same at the two presentation rates.

Analyses of the individual words revealed that among the 40 high-frequency words, 28 words were more likely to be correctly reported in the test of perceptual recognition if they had been previously presented for study; 7 words were uninfluenced by prior study (ties); and 5 words were more likely to be recognized if they had not been presented for study (reversals). Among the 40 low-frequency words, 39 words were more likely to be correctly reported if they had

Table 5
Probability of Perceptual Recognition as a Function of Study Time and Frequency in the Language

Study rate	Presented: High frequency	Presented: Low frequency	Nonpresented: High frequency	Nonpresented: Low frequency
1 sec	.84	.73	.68	.37
2 sec	.82	.63	.62	.30

been previously studied, and only 1 word showed a reverse effect.

Overall, there were 82 intralist intrusion errors. Inspection of these errors shows that a high-frequency word was more likely to be given as an intrusion error (58 errors) than a low-frequency word (24 errors). Further, an item that had been presented for study was more likely to occur as an intrusion (60 errors) than was a word that appeared only in the test of perceptual recognition (22 errors). As in the earlier studies, words that intruded were physically similar to those they replaced; intralist intrusion errors shared an average of 3.41 letters with the words they replaced.

Discussion

The results of the present experiment revealed that the effects of frequency in the language of a word on its perceptual recognition can be greatly diminished by a single prior presentation of the word. A similar result using a different task was found by Scarborough, Cortese, and Scarborough (1977). In their experiments, subjects judged whether a presented item was a word; the effects of frequency in the language were greatly diminished when words were repeated within a list. The effects of presenting a word on its later perceptual recognition can be described within current models of perceptual recognition (e.g., Morton, Note 1). However, it is surprising within the context of those models that a single study presentation has such a large effect, doing so much to override the effects of frequency in the language.

Increasing frequency has opposite effects in perceptual recognition and recognition memory. High-frequency words are more likely to be perceptually recognized but are less likely to be recognized as having been presented in the study context. However, parallel effects are found if one considers *change* in performance produced by prior study rather than absolute level of performance. The perceptual recognition of low-frequency words benefits more from prior study, and low-frequency words are also more likely to be recognized as having been presented previously. It is argued later that relative perceptual fluency can serve as one basis for recognition memory. The notion is that the change in ease of perceptual recognition that results from prior study can serve as one basis for recognition memory. Similarly, Mandler (1980) claimed that a larger relative increment in familiarity is responsible for the recognition memory advantage of low-frequency words. As indicated earlier, we want to identify familiarity with ease of perceptual recognition. For judgments of relative perceptual fluency, different baselines must be used for high- and low-frequency words. Others have reported evidence to show that people are very sensitive to differences in the baseline frequency of words and to changes in frequency (e.g., Hintzman, 1976; Kinsbourne & George, 1974). The assumption that the effect of word frequency on recognition memory is closely related to that effect on perceptual recognition is shown to be useful for interpreting data reported later in this article.

The experiments reported next investigated the effects of repetition of a word on subsequent perceptual recognition and recognition memory. Results of the present experiment showed no effect of study time on perceptual recognition. However, increasing the number of prior presentations of a word may operate differently than increasing the length of a single presentation. When the presentation duration of a word is increased during study, subjects may use the additional time to deal with the meaning of the word or to elaborate its encoding, activities that are useful for later recognition memory but that do not aid later perceptual recognition. Increasing the number of presentations of a word, however, may enhance both later perceptual recognition and recognition memory. Frequency of presentation in the laboratory may act like frequency in the language to influence perceptual recognition.

Experiment 4a

Experiments 4a and 4b were designed to investigate the effect of repetition and the effect of spacing repetitions. That the spacing of repetitions is important for recognition memory is well established (Hintzman, 1974); recognition memory performance is higher when repetitions of an event are separated by the presentation of other events rather than being massed. The underlying basis of the effect of spacing repetitions, however, is not clear. Some (e.g., Madigan, 1969) have argued that the spacing of repetitions has its effect by influencing the meaning of the repeated item; when repetitions are spaced, more meanings or senses of the repeated word are said to be encoded, thereby increasing the number of access routes to the item in memory. It is in the light of these notions that the effect of spacing of repetitions in perceptual recognition is of particular interest. Our previous experiments showed that perceptual recognition is not influenced by differences in meaningfulness or elaboration of processing. Consequently, if an effect of spacing repetitions is found in perceptual recognition, that effect must have some basis other than differences in the encoding of meaning. That an effect of spacing repetitions will be found in perceptual recognition seems likely. Increasing the number of massed presentations of a word appears to be similar to increasing the duration of a single presentation, and Experiment 3 showed that the duration of a study presentation does not influence perceptual recognition. Increasing the number of spaced repetitions of a word, however, might act like frequency in the language and influence perceptual recognition.

Experiments 4a and 4b differed only in minor details. The words used in Experiment 4a were of a middle level of frequency of occurrence in the language, whereas those used in Experiment 4b were of a low level of frequency of occurrence. Along with this difference in frequency in the language, a shorter presentation duration for the test of perceptual recognition was used in Experiment 4a. A condition that received a test of recognition memory was included only in Experiment 4b.

Method

Subjects. Subjects for both Experiment 4a and Experiment 4b were volunteers from an introductory psychology course who each served in a 1-hr. session for course credit. Sixteen subjects participated in Experiment 4a; 32 subjects participated in Experiment 4b.

Design and materials. In the first phase of each of the two experiments, a list containing 60 different words was presented for study. Twenty of these appeared once in the study list, 20 were presented twice with their repetitions massed, and the remaining 20 were presented twice with their repetitions separated by the presentation of other words. Subjects were instructed that during presentation of the study list they were to read each word aloud as it was presented and remember the words for a later test; the nature of the test of memory was not specified. After presentation of the study list a test of perceptual recognition was given to 16 subjects in each of the two experiments. In Experiment 4b, a separate group of 16 subjects received a test of recognition memory.

Each of the two experiments used a pool of 80 words to construct study and test lists. For Experiment 4a, words had a frequency of 37 to 49 occurrences per million (Thorndike & Lorge, 1944). Words selected for Experiment 4b had a frequency of occurrence of 1 to 5 occurrences per million. For both experiments, all words were five-letter nouns. The method of constructing lists was identical for the two experiments. Each study list was 100 items long and contained 60 different words; 20 words presented once, 20 massed repetitions, and 20 spaced repetitions. Repetitions that were spaced were separated by the presentation of 15 other words. Items representing the different repetition conditions were spread evenly through the list by using the restriction that the list must contain N words representing each condition before it could contain $N + 1$ words representing any condition. Two study orders that conformed to this restriction were constructed. Each test list contained 80 words: the 60 words that had been presented for study plus 20 new words. Two random orders of test words were used. In addition, four list formats were constructed such that across formats all words represented each of the three presentation conditions and served as new words in the test list equally often. In both experiments, each subject in a particular test condition received a different one of the 16 possible combinations of list format, study order, and test order. The recognition test in Experiment 4b used the same lists that were used for the test of perceptual recognition.

Procedure. The study list was presented at a rate of 1 sec per word. Subjects were instructed to read each word aloud as it was presented, and to remember the words for a later test. For the test of perceptual recognition, the exposure duration of words was 30 msec in Experiment 4a and 35 msec in Experiment 4b. Other details of the perceptual recognition test and of the recognition memory test used in Experiment 4b were the same as described for earlier experiments.

Results

Recognition memory. The recognition memory results from Experiment 4b are summarized in Table 6. The probability of correctly recognizing a word as having been presented previously increased across once-presented words to spaced repetitions, $F(2, 30) = 28.75$, $MS_e = .01$. The analysis of reaction time for correct recognition memory responses also showed a significant effect of repetition and the spacing of repetitions, $F(2, 30) = 9.28$, $MS_e = 3740$. The recognition memory results replicate those of prior experiments (see Hintzman, 1974, for a review).

Perceptual recognition. The perceptual recognition results from Experiment 4a and Experiment 4b are summarized in Table 7. In both experiments, words were more likely to be correctly reported in the test of perceptual recognition if they had been presented once during study rather than being new words on the test list, $F(1, 15) = 10.62$, $MS_e = .013$, and $F(1, 15) = 142.98$, $MS_e = .005$, respectively. This effect of study on perceptual recognition was consistent across items. In Experiment 4a, 35 items were more likely to be correctly reported in the test of perceptual recognition if they had been presented for study once rather than being new; 25 items showed no effect of study presentation; and 20 items showed a reverse effect. For Experiment 4b, the corresponding numbers were 48, 21, and 11, respectively.

In Experiment 4a, repetition of a word and the spacing of repetitions influenced perceptual recognition performance. Perceptual recognition of a word was more likely if repetitions of the word were spaced during study rather than being massed, $F(1, 15) = 5.86$, $MS_e = .076$. A similar pattern of results was evident in Experiment 4b; however, the effects of repetition were not statistically significant in that experiment.

Analyses of intrusion errors show evidence of repetition effects in both experiments. As in earlier experiments, words that were given as intrusion errors were similar to the words they replaced. In Experiment 4a, there were 56 intralist intrusion errors, comprising .10 of the total errors in perceptual recognition. Across these intralist intrusion errors, words that intruded had a mean of 2.46 letters in common with the words they replaced. In Experiment 4b, there were 79 intralist intrusion errors, comprising .18 of the total errors in perceptual recognition; words that occurred as intralist intrusion errors had a mean of 2.7 letters in common with the words they replaced. Other details of the intralist intrusion errors show that either number of presentations of a word or recency of presentation is important for perceptual recognition. A word that occurred as an intrusion error almost always appeared in the test list prior to the word that it replaced. This was true of .86 of the errors in Experiment 4a and .87 of the errors in Experiment 4b. A similar pattern of results was observed in earlier experiments. The probabilities of a word preceding the one it replaced in the test list in Experiments 1–3 were .68, .70, and .72, respectively. If neither repetition nor recency of presentation had any effect, the probability of a word that occurred as an intrusion error being presented in the test list prior to the word that it replaced would, of course, be .50.

The intrusion errors provide further evidence that number of repetitions and spacing of repetitions is important for perceptual recognition. Words given as intralist intrusions were most often words that had been repeated with those repetitions being spaced in the study list. Of the 56 intralist intrusion errors in Experiment 4a, 29 of the words given in error had appeared as spaced repetitions in the study list, 16 had appeared as massed repetitions, 6 had been presented only once in the study list, and the remaining

Table 6
Measures of Recognition Memory as a Function of Repetition and Spacing

Measure	Single	Repeated massed	Repeated spaced
Probability of hit	.66	.78	.92
Reaction time (msec)	762	712	669

Table 7
Probability of Perceptual Recognition as a Function of Number and Spacing of Study Presentations

	Presentation			
Experiment	New	Single	Repeated massed	Repeated spaced
4a	.41	.54	.58	.65
4b	.45	.73	.71	.76

5 had appeared only in the test list. Of the 79 intralist intrusions in Experiment 4b, the corresponding numbers were 36, 20, 19, and 4, respectively. In general, a word that appeared as an intrusion error was physically similar to the word it replaced, appeared in the test list prior to the word it replaced, and had been repeated during study with its repetitions being spaced.

Discussion

In contrast to the effect of study time, increasing the number of repetitions of a word had parallel effects on recognition memory and perceptual recognition performance. This difference in the effects of study time and number of repetitions may simply reflect a difference in the sensitivity of the experimental designs used to manipulate the two variables; study time was manipulated between subjects, whereas number of repetitions was manipulated within subjects. Alternatively, increasing study time may result in further elaboration of the encoding of a word, and thereby benefit only recognition memory, whereas repetition may have a strengthening effect and enhance both recognition memory and perceptual recognition performance. In line with the second alternative, the effect of repetitions was found to depend on their spacing. Massed repetition, like increased study time, had little influence on perceptual recognition performance.

Prior experiments have found effects of spacing repetitions in free recall, cued recall, recognition memory, and frequency judgments (Hintzman, 1974). At the least, the present experiments add perceptual recognition performance to the list of memory tests that show spacing effects. More important, the present experiments provide constraints for interpreting the spacing effect. Others have argued that the effect of spacing repetitions is due to different meanings or "senses" of a word being encoded for each presentation when repetitions of a word are spaced; this increase in the variability of encoding is said to enhance recall by increasing the number of access routes to the memory representation of the word. For perceptual recognition, in contrast, experiments reported earlier showed no effect of meaningful elaboration, so one would also expect no effect of variation in the encoding of meaning. If there is a common basis across form of test, the effect of spacing repetitions must depend on factors in addition to differences in the meanings that are given to repetitions of a word.

A recent account of the spacing effect (Jacoby, 1978) can be used to explain the effect found in perceptual recognition as well as that found in recognition memory and recall. By this account, the effect of spacing repetitions is due to an influence on the processing of repeated items. It is argued that repetition of an item does not necessarily entail a repetition of the processing that was previously required to interpret or encode that item. For example, when repetitions of a word are massed, the perceptual operations involved in reading the word on its second presentation are likely to be less extensive than were those required to read the word on its first presentation; in part, the person remembers his or her prior interpretation of the visual pattern rather than fully rereading the word. As repetitions of a word are spaced, more complete repetition of processing is likely to be necessary. This repetition of processing will "strengthen" the memory record of the processing that is repeated. When repetitions are massed, however, much of the processing is not repeated, so there is less strengthening effect. This view implies that the magnitude of the spacing effect should vary across tests. For perceptual recognition, it is the memory record of the operations involved in reading the previous presentation of the word that is likely to be important and that is influenced by the spacing of repetitions. For recognition memory, operations involved in meaningful elaboration as well as those involved in reading the word are likely to be important and may be largely bypassed when repetitions of a word are massed. The larger spacing effect observed in recognition memory may be due to more of the operations that are bypassed when repetitions are massed being especially relevant to the later test of memory.

It seems likely that the magnitude of repetition effects obtained in perceptual recognition performance depends critically on the physical similarity among words in a list.

In the present experiment, intralist intrusions were almost always in error by only one or two letters and had been previously presented a larger number of times than the word they replaced. The importance of physical similarity is understandable within the framework of current theories of perceptual recognition (Morton, 1969; Treisman, 1978). The information derived from a brief tachistoscopic presentation of a word may be insufficient to uniquely specify the presented word, but it may serve to specify a set of words that are consistent with the derived information. Selection from this set would then be influenced by the frequency of occurrences of the alternative words, both in the language and in the experimental situation. Presentation of a word in the experimental situation would be effective only if that presentation acts to overturn an advantage that would otherwise be held by a competing word. High physical similarity among words in a list may cause competition among words and provide an occasion for repetition effects to be shown.

Although not surprising, the importance of physical similarity is of interest in the light of experiments designed to identify the features of a word that are used for its recognition. Those experiments have looked for a facilitative effect of studying a word on later perceptual recognition of a similar word. On the basis of facilitative effects of prior study, Murrell and Morton (1974) concluded that morphemes rather than individual letters act as units for word perception. Consistent with the claim that individual letters are not used, Ross, Yarczower, and Williams (1956) failed to find a monotonic relation between degree of facilitation and level of visual similarity between studied words and test words. The present experiments, however, found interference among words in the form of intrusion errors that appeared to be on the basis of common letters. These data could be taken as evidence that individual letters are used in word perception. A potentially important difference between experiments is that earlier experiments allowed extensive study of words prior to the test of perceptual recognition, whereas in the present experiments a word was presented a maximum of two times. It seems likely that degree of learning is important for transfer among words in perceptual recognition just as it is for transfer in other situations. In paired-associate learning, for example, one can obtain either positive or negative transfer, depending on the degree of learning of the first list (e.g., Martin, 1965). Similar mechanisms may operate in word perception.

Effects of Retention Interval and Perceptual Similarity

A single presentation of a word is sufficient to produce a large effect in perceptual recognition as well as producing recognition memory for the presented word. Further, repetition and the spacing of repetitions have parallel effects in recognition memory and perceptual recognition. Results such as these make it plausible that recognition memory and perceptual recognition use the same form of information. Manipulations of meaningfulness or extensiveness of processing, in contrast, influence recognition memory but do not influence perceptual recognition performance. One way of reconciling these two sets of results is to postulate two bases for recognition memory—one that is closely related to perceptual recognition and a second that uses different information than does perceptual recognition. Before concluding that there are two forms of recognition memory, however, it seems necessary to more clearly establish that perceptual recognition and recognition memory can have a common basis.

The experiments reported in this section sought further parallels between effects in recognition memory and effects in perceptual recognition. A single presentation of an item is often sufficient to produce recognition memory even when a long delay intervenes between study and test. In contrast, it might be expected that the perceptual effects of prior study are short-term. Effects in perceptual recognition may rely on memory for "low-level" physical information, and many have argued that information of this form is lost very rapidly (e.g., Craik & Lockhart, 1972). The effects of retention interval were investigated in Experiment 5 to determine if the persistence of the influence of prior study on perceptual recognition is comparable to that found for recognition memory.

The effects of perceptual similarity were investigated in Experiment 6; the modality of presentation (auditory vs. visual) was either held constant or changed between study and test. If it is physical information that is remembered and that influences perceptual recognition, prior study of a word should have a larger effect when the modality of presentation is the same in study and test. The results of Experiment 6 are also useful for interpreting the effect of frequency in the language. In the discussion of Experiment 3, we argued that the effects of frequency in the language in recognition memory parallel those in perceptual recognition; low-frequency words benefit more from study in later perceptual recognition and are also more likely to be recognized as having been previously presented. For both forms of test, it may be memory for physical or graphemic information that produces different effects for high- and low-frequency words. If so, the manipulation of perceptual similarity should interact with frequency in the language, regardless of the form of test. The larger effect of prior study for low-frequency words may depend on modality of presentation being preserved between study and test.

Experiment 5

Method

Design and subjects. Besides investigating the effects of retention interval, Experiment 5 provided a further check on the effects of repetition and of frequency in the language. Words presented for study occurred either frequently or infrequently in the language and were presented either once or twice. A test of perceptual recognition was given immediately after presentation of the study list, 15 min. after, or 24 hr. after. A test of recognition memory followed that of perceptual recognition. Frequency in the language and repetition were manipulated within subjects, and retention interval was manipulated between subjects.

The subjects were 36 students enrolled in an introductory psychology course who served for course credit; 12 subjects were randomly assigned to each of the three conditions created by the manipulation of retention interval.

Materials. Study and perceptual recognition test lists were constructed from a pool of 90 words selected from the Thorndike-Lorge (1944) word book. Of these words, 45 occurred frequently in written material, A and AA words, and 45 occurred infrequently, one to five times per million as recorded by Thorndike and Lorge. All words were five letters in length.

The 45 words from each level of frequency in the language were broken into 3 groups of 15 words each. Within a study list, words from one group were presented twice, words from a second group were presented once, and words from the third group did not appear in the study list but served as new items for the perceptual recognition test. That is, a study list contained 90 words; 15 high- and 15 low-frequency words presented once each. Repetitions within a study list were separated by a minimum of 12 and a maximum of 20 intervening words. An attempt was made to spread words that differed in frequency in the language or number of presentations evenly throughout the study list so that no particular class of words would benefit from any serial position effects. Three list formats were constructed by "rotating" words through conditions such that across formats each word did not appear, appeared once, and appeared twice equally often in study lists.

As in earlier experiments, a perceptual recognition test began with a practice list of 10 words. The main perceptual recognition test list included 90 words; the 30 new words, the 30 words that had been presented once, and the 30 words that had been presented twice during study. There were four random orders of the test list. Each subject in a particular retention interval condition received a different one of the 12 combinations of study format and test list order.

A recognition memory test list contained 120 words; the 90 words that had appeared in the main portion of the perceptual recognition test plus 30 new words that served as distractors. The 30 new words were five letters in length but were selected without regard to their frequency of occurrence in the language. Words were arranged in a random order and typed on a sheet of paper to produce the recognition memory test list.

Procedure. Lists were presented for study at a rate of 1 sec per item. Subjects were told that we were interested in reading speed and that they were to say each word aloud as rapidly as they could when it was presented. They were informed that some words in the study list would be repeated. Subjects were not informed that a test of retention would be given. After presentation of the study list, subjects in the immediate test condition were given the perceptual recognition test. In the 15-min. retention interval condition, subjects were informed that it was necessary to score the data from the first part of the experiment before the experiment could be completed. These subjects left the experimental room to wait in a waiting area until called by the experimenter after a 15-min. delay; the test of perceptual recognition was then given. Subjects in the 24-hr. retention interval condition were also told that the experiment must be interrupted to allow scoring of their data, but they were instructed to return the next day at the same time to complete the experiment. For all subjects, the recognition memory test was given immediately after that of perceptual recognition. Subjects were instructed to circle words that had appeared either during study or during the perceptual recognition test. Other details of the procedure were the same as described for earlier experiments.

Results

Recognition memory. Recognition memory was conditionalized on perceptual recognition performance by computing the probability of recognition memory separately for words that were identified and those that were not identified on the perceptual recognition test. This procedure was necessary, since appearance on the perceptual recognition test essentially served as an additional study presentation for words that were identified. Further, the perceptual recognition test immediately preceded that of recognition memory regardless of the retention interval between study and test; consequently, one might expect an effect of retention interval on recognition memory only for those items that were not identified on the perceptual recognition test. In a few instances, it was impossible to compute a conditionalized recognition memory score for a subject, since perceptual recognition performance was either perfect or zero for a particular combination of conditions. This problem arose infrequently. The combination of subjects with experimental conditions gives rise to 216 possible recognition memory scores conditionalized on successful perceptual recognition; only 2 of these scores could not be computed for a subject because no items were perceptually recognized for a particular combination of conditions. Similarly, there were 216 possible recognition memory scores conditionalized on failure of perceptual recognition; only 9 of these scores could not be computed. When a recognition memory score could not be computed, the corresponding group mean was inserted for purposes of analysis.

The primary analysis of the recognition memory data examined the effect of experimental manipulations on the probability of recognizing previously studied items (hits). This analysis revealed a large effect of an item having been identified on the perceptual recognition test, $F(1, 33) = 118.07$, $MS_e = .081$. Items that had been identified were much more likely to be recognized as having appeared previously (.84) than were items that had not been identified (.48). The effects of frequency in the language, $F(1, 33) = 50.68$, $MS_e = .046$, and of repetition during study, $F(1, 33) = 5.79$, $MS_e = .037$, were also significant. Low-frequency words were more likely to be recognized (.75) than were high-frequency words (.57); words that had been presented twice during study were more likely to be recognized (.69) than were words that had been presented only once (.63). The effects of frequency in the language and of repetition were consistent across items that had been identified and those that had not been identified on the perceptual recognition test. However, the interaction of identification on the perceptual recognition test with retention interval did approach significance, $F(2, 33) = 3.02$, $p < .06$, $MS_e = .081$. The probability of recognition memory for items that had not been identified on the perceptual recognition test declined as the interval separating study and test increased from an immediate test (.54) to a 15-min. delay (.51) to a 24-hr. delay (.37). For items that were identified on the perceptual recognition test, there was no consistent effect of retention interval; the study presentation gained by identifying an item on the perceptual recognition test was apparently sufficient to offset the effects of any forgetting over the retention interval. A separate analysis examined the effect of retention interval on the probability of incorrectly responding old to items that appeared for the first time on the test of recognition memory (false alarms). The probability of a false alarm (.09) was found to be consistent across retention intervals, $F < 1$.

Perceptual recognition. Neither the effect of retention interval nor any interaction involving retention interval approached significance in the analysis of perceptual recognition performance. However, inspection of the data reveals a small decline in the probability of perceptual recognition as retention interval is increased from an immediate test (.73) to a 15-min. delay (.72) to a 24-hr. delay (.67) between study and test. The perceptual recognition results, collapsed across the manipulation of retention interval, are displayed in Table 8.

The effect of prior study that is evident in the results displayed in Table 8 was highly significant, $F(2, 66) = 86.40$, $MS_e = .012$. The effect of frequency in the language, $F(1, 33) = 56.88$, $MS_e = .023$, and the interaction

Table 8
Probability of Perceptual Recognition as a Function of Frequency in the Language and Repetition

	Presentation		
Frequency	New	Single	Repeated
High	.66	.72	.77
Low	.34	.65	.70

of frequency in the language with prior study, $F(2, 66) = 27.99$, $MS_e = .015$, were also significant. As in experiments reported earlier, high-frequency words were more readily perceptually recognized. The effects of frequency in the language on perceptual recognition were substantially diminished by prior study; low-frequency words benefited more from study. A further analysis included only the perceptual recognition of words that had been presented for study. The results of this analysis revealed that items that had been presented twice were more likely to be perceptually recognized than were items that had been presented only once, $F(1, 33) = 7.38$, $MS_e = .012$. However, the effect of frequency in the language on perceptual recognition was not further diminished by increasing study from one to two presentations of an item. That is, the interaction of frequency in the language with study did not approach significance, $F < 1$, when items that were not presented for study (new items) were removed from the analysis.

Experiment 6

The results of the preceding experiment revealed that study of a word influences its later perceptual recognition even when a 24-hr. period intervenes between study and test. This result is surprising, since earlier experiments indicated that it is memory for physical or graphemic information that is responsible for the influence of prior study on perceptual recognition, and others have suggested that information of this form is lost very rapidly (e.g., Craik & Lockhart, 1972). The lack of an effect of level-of-processing manipulations and the presence of intrusion errors that were physically similar to the words they replaced were offered earlier as evidence that memory for physical or graphemic information mediates the effects of prior study. Experiment 6 was designed to provide more direct evidence of the importance of physical information by manipulating the modality of presentation between study and the perceptual recognition test. Words were presented for study by means of either the auditory or the visual modality, then a test of visual perceptual recognition was given. The loss of modality-specific information was investigated by giving the test of perceptual recognition either immediately after presentation of the study list or after a 15-min. delay. In contrast to that in Experiment 5, the manipulation of retention interval was within subjects in Experiment 6. The within-subject design may be sensitive enough to reveal some forgetting even though no evidence of forgetting was found in Experiment 5.

The effects of frequency in the language were also investigated further in Experiment 6. Others have suggested that the advantage low-frequency words have in recognition memory is due to differences in meaning. Recognition memory effects have been attributed to the lower associative value of low-frequency words (e.g., Underwood & Freund, 1970), to greater stability in the encoding or fewer meanings of low-frequency words (Glanzer & Bowles, 1976; Gregg, 1976), and to the greater distinctiveness or precision of the meaning of low-frequency as compared with high-frequency words (Jacoby et al., 1979). If differences in meaning are responsible, the effect of frequency in the language should not be diminished by changing modality of presentation between study and the recognition memory test. In contrast, it is shown that effects of frequency in the language in recognition memory are similar to the effects of study in perceptual recognition in that both depend on the modality of presentation being preserved. Memory for physical or graphemic information appears to be at least partially responsible for mediating both effects.

Method

Subjects. The subjects were 32 volunteers from an introductory psychology class who served for course credit; 16 subjects were randomly assigned to each of the two of modalities of study presentation.

Materials. The study lists and perceptual recognition test lists were constructed from 120 words selected from the Thorndike–Lorge (1944) word book. Of these words, 60 were high frequency, A and AA; the remaining 60 were low frequency, occurring one to five times per million as tabulated by Thorndike and Lorge. A study list contained 60 words: 30 high frequency and 30 low frequency. Within a study list, high- and low-frequency words were distributed evenly so that neither class of words could benefit from any serial position effects. With this restriction, two random orders were formed of words in a list. Crossed with these study orders were two list formats. Formats were constructed such that across formats each word appeared and did not appear equally often in study lists. That is, across formats the same words served as study items and as new items for the perceptual recognition tests.

The within-subject manipulation of retention interval necessitated construction of two sets of test lists. Lists used for the immediate test began with 10 practice items, as in earlier experiments. Next, 5 items were presented for further practice followed by 60 test items; 15 old and 15 new test items from each of the two levels of frequency in the language. Test lists used for the delayed test began with 5 additional practice items followed by the remaining 15 old and 15 new items from each of the two levels of frequency in the language. With the restriction that items from a particular class be distributed evenly throughout a list, two random orders of words in each test list were used. Further, two test list formats were constructed such that those words that appeared on the immediate test in one format appeared on the delayed test in the other format, and vice versa. Each subject within a modality condition received a different one of the 16 possible combinations of study format, study order, test format, and test order.

A recognition memory test list contained the 120 words from the study and perceptual recognition phases of the experiment plus 30 distractors. Of these distractors, 15 were high frequency and 15 were low frequency. The 150 words comprising a test list were typed in a random order for visual presentation to subjects.

Procedure. Words were tape-recorded at a rate of 1 sec per word for auditiory presentation. For visual presentation, words were presented at the same rate on the television screen, as in earlier experiments. During the first phase of the experiment, subjects were instructed to study the words as they were presented and to remember those words for a later test. Immediately after presentation of the study list, the first perceptual recognition test was given. Subjects were then informed that it was necessary to interrupt the experiment to allow the experimenter to score their data and that they were to be seated in a nearby waiting area. After a 15-min. delay, the subject was brought back to the experimental room and given the delayed test of perceptual recognition. The details of the perceptual recognition tests were as described for earlier experiments. After the delayed perceptual recognition test, the recognition memory test was administered. Subjects were instructed to circle items that had been presented during study or that had appeared on either of the perceptual recognition tests. They were given as much time as they needed to complete the recognition memory test.

Results

Recognition memory. As in Experiment 5, recognition memory was conditionalized on perceptual recognition performance by computing the probability of recognition memory separately for words that were identified and those that were not identified on the perceptual recognition test. The combination of subjects with experimental conditions gives rise to 256 possible recognition memory scores conditionalized on failure of perceptual recognition; in only 7 instances could a score not be computed because perceptual recognition performance was perfect for a particular combination of subject and experimental conditions. Similarly, there were 256 possible recognition memory scores conditionalized on successful perceptual recognition; only 5 of these could not be computed. When a recognition memory score could not be computed, the mean for the corresponding condition was inserted for purposes of analysis.

A first analysis examined the effect of experimental manipulations on the probability of responding yes to old items (hits). The results of this analysis revealed a significant effect of retention interval on recognition memory, $F(1, 30) = 14.19$, $MS_e = .051$. Items that had appeared on the delayed test of perceptual recognition were more likely to be recognized as having been presented previously (.62) than were items that had appeared on the immediate test (.51). Since the test of recognition memory followed the delayed test of perceptual recognition, the retention interval was shorter for items that appeared on the delayed rather than the immediate test of perceptual recognition. None of the interactions of retention interval with other factors was significant. The recognition memory data, collapsed across the manipulation of retention interval, are displayed in Table 9.

In addition to the effect of retention interval, the analysis of hits revealed significant effects of a word being identified on the test of perceptual recognition, $F(1, 30) =$

Table 9
Probability of Recognition Memory as a Function of Frequency in the Language, Study Modality, and Identification During Perceptual Recognition

	Auditory		Visual	
Perceptual recognition	High frequency	Low frequency	High frequency	Low frequency
Identified				
Probability of hit	.76	.81	.70	.92
Corrected	.06	.05	.15	.30
Not identified				
Probability of hit	.25	.34	.27	.50
Corrected	.09	.08	.18	.37

291.86, $MS_e = .045$, and of frequency in the language, $F(1, 30) = 17.40$, $MS_e = .079$. Recognition memory was more probable for items that had been identified on the test of perceptual recognition; presentation on the perceptual recognition test essentially constituted an additional study trial for items that were identified on that test. Low-frequency words were more likely to be recognized as having been presented previously than were high-frequency words. Of greatest interest was the significant interaction of frequency in the language with modality of presentation, $F(1, 30) = 4.48$, $MS_e = .079$. As shown in Table 10, the advantage of low-frequency words over high-frequency words in recognition memory was substantial only when modality of presentation was held constant between study and test; that is, when items were read during study.

A second analysis of recognition memory used the difference in the probability of recognition between items presented both for study and on the perceptual recognition test and those presented only on the perceptual recognition test. This measure essentially subtracts recognition resulting from an item's appearance on the perceptual recognition test from recognition resulting from study, so as to give a more pure measure of the effect of presenting items during study on recognition memory. With these corrected recognition memory scores, neither the effect of retention interval nor that of identifying an item during perceptual recognition was significant. The earlier reported significant effects of these factors on the probability of a hit apparently reflected the influence of presenting items for perceptual recognition on later recognition memory. However, there was a highly significant effect of modality of presentation, $F(1, 30) = 35.45$, $MS_e = .050$, and of frequency in the language, $F(1, 30) = 6.43$, $MS_e = .079$, in the analysis of corrected recognition memory scores. As in the analysis of hits, the interaction of frequency in the language with modality of presentation was significant, $F(1, 30) = 4.63$, $MS_e = .079$. Again, as shown in Table 10, low-frequency words were substantially more likely to be recognized than were high-frequency words only when modality of presentation was held constant between study and test. Items heard during study held little advantage over items that appeared only on the test of perceptual recognition, regardless of frequency in the language.

A further analysis examined the probability of responding old to items that appeared for the first time on the test of recognition memory. It revealed a significant effect of modality of study, $F(1, 30) = 8.37$, $MS_e = .009$. Subjects that had listened to the study list were more likely to call one of these new items old (.12) than were subjects who had read the study list (.05). The effect of frequency in the language on the probability of a false alarm did not approach significance.

Perceptual recognition. The perceptual recognition data are displayed in Table 10. Several effects evident in those data confirm results of experiments reported earlier. Items that had been presented for study were much more likely to be identified than were items that were new on the perceptual recognition test, $F(1, 30) = 99.69$, $MS_e = .012$. High-frequency words were more likely to be perceptually recognized than were low-frequency words, $F(1, 30) = 147.39$, $MS_e = .035$. Frequency in the language interacted with study such that the effect of frequency in the language was diminished by prior study of the items that were presented for perceptual recognition, $F(1, 30) = 9.82$, $MS_e = .015$. That is, low-frequency words benefited more from prior study than did high-frequency words. As in Experiment 5, neither the effect of retention interval nor any interactions involving retention interval approached significance. There was no evidence of forgetting over the 15-min. retention interval.

Of primary interest was the effect of modality of presentation during study on later perceptual recognition. The interaction of prior study with modality of presentation was highly significant, $F(1, 30) = 48.90$, $MS_e = .012$. As shown in Table 10, prior study had a substantial effect on perceptual recognition only when words were read during study so that modality of presentation was held constant between study and test. Further, the pattern of results obtained for perceptual recognition was identical to that obtained for recognition memory. For both forms of test, the larger effect of prior study for low-frequency than for high-frequency words appears to depend on modality of presentation being preserved between study and test. An analysis of perceptual recognition performance included only items that had been presented for study so as to parallel the earlier reported analysis of recognition memory performance. Although the interaction of frequency in the language with modality of presentation was significant in the earlier analysis of recognition memory, the interaction of these variables only approached significance in the corresponding analysis of perceptual recognition, $F(1, 30) = 3.11$, $p < .09$, $MS_e = .029$.

Discussion

Although a great deal of recent theorizing has served to emphasize the importance of processing meaning to enhance retention, a number of experiments have shown very good retention of the physical or graphemic properties of words presented for study. Recognition memory performance depends on the perceptual similarity of the study and test versions of an item. A change in modality (Kirsner, 1974), orientation (Kolers, 1973), voice of speakers (Geiselman & Bjork, 1980), or the case of the letters comprising a word (Kirsner, 1973) between study and test will lower recognition memory performance. Other experiments have also demonstrated that a change in modality of presentation between study and test largely eliminates the effects of prior study on perceptual recognition performance. In those experiments, words were either read or given as a name for a presented picture, then tested by means of a visual test of perceptual recognition (Morton, Note 1) or presented visually within the context of a lexical decision task (Scarborough, Gerard, & Cortese, 1979). For both forms of test, the effects of prior study were greater when words were read during the first phase of the experiment so that modality of presentation was held constant between study and test.

In the present experiment, words were presented for study by means of either the

Table 10
Probability of Perceptual Recognition as a Function of Frequency in the Language and Study Modality

Presentation	Auditory: High frequency	Auditory: Low frequency	Visual: High frequency	Visual: Low frequency
Presented	.65	.36	.74	.56
Nonpresented	.64	.30	.58	.25

auditory or the visual modality, and then visual tests of perceptual recognition and recognition memory were given. Both recognition memory performance and the effects of prior study on perceptual recognition were greatly diminished by a change in modality between study and test. Further, the effects of frequency in the language appear to depend on modality of presentation. Low-frequency words held a substantial advantage over high-frequency words in recognition memory and in the extent that they benefited from prior study in perceptual recognition only when the modality of presentation was preserved between study and test. This pattern of results supports the suggestion that memory for physical or graphemic information is at least partially responsible for the influence of frequency in the language on recognition memory (e.g., Zechmeister, 1972) and that it is information of this form that mediates the effects of prior study on perceptual recognition. It seems unlikely, however, that differences in memory for physical information are fully responsible for the influence of frequency in the language on recognition memory. Rather, both differences in meaning and differences in physical or graphemic properties are likely to be involved.

Lee, Tzeng, Garro, and Hung (1978) also investigated the dependence of the frequency effect in recognition memory on the maintenance of modality of presentation between study and test. In agreement with the results of the present experiment, they found that frequency in the language had its largest effect when items were studied and tested in the visual modality. However, Lee et al. found that some effect of frequency in the language remained even when modality of presentation was changed between study and test. A potentially important difference between their experiment and our own is that Lee et al. presented items for study at a slower rate than we did (2 sec per word vs. 1 sec per word). Their slower rate may have resulted in subjects further processing the meaning of presented words. As more information about meaning is accrued, differences in memory for physical characteristics of words may become relatively less important. In line with this possibility, Kirsner (1973) has shown that a change in typecase between study and test has a larger effect on the recognition memory of nonsense words than on that of real words. Similarly, Geiselman and Bjork (1980) found that, in the auditory modality, changing the voice of the speaker between study and test has a larger effect if subjects have engaged in rote rehearsal than if they have dealt with the meanings of presented words.

Morton (Note 1) suggested that it is not a literal copy of a studied item that is remembered, but rather a more abstract modality-specific representation. To support this argument, Morton demonstrated that prior study has little effect on perceptual recognition when items are studied in a handwritten format and tested in a printed format, rather than studied and tested in the same format. However, in Morton's experiments substantial study was allowed prior to the test of perceptual recognition. When less study is allowed for words in a longer list, effects in perceptual recognition of within-modality changes between study and test may be similar to those found in recognition memory; type font or orientation, for example, may be important. In any case, the results of the present experiment provide further evidence of parallel effects of variables on perceptual recognition and recognition memory; for both forms of test, memory for physical or graphemic information plays an important role.

General Discussion

The results of the experiments reported reveal a dissociation for perceptual recognition and recognition memory that is of the same form found with Korsakoff patients. The Korsakoff patient is more likely to be able to fill in the missing letters of a word fragment to produce the complete word if the word is one that was studied earlier; however, he or she will often not recognize the word as being one already studied. The present experiments produced similar results for normals by showing that different variables can influence perceptual recognition and recognition memory. Effects of study on perceptual recognition were as large when the probability of recognition memory was low as when recognition memory was near perfect. In Experiment 1, semantic processing produced much higher recognition memory performance than did searching through a word for a specified target letter; however, the effects in perceptual recognition of the two types of processing were identical. Similarly, in Experiment 2 the more difficult task of solving an anagram produced higher recognition memory of the solution word than did the easier task of simply reading the solution word; however, this manipulation of task difficulty did not influence later perceptual recognition performance.

Other experiments, however, revealed several parallels between effects in perceptual recognition and effects in recognition memory. A single brief study presentation of a word can be sufficient to produce recognition memory and to influence later perceptual recognition of the word. This is true even when 24 hr. intervene between study and test (Experiment 5); perceptual recognition performance is much more sensitive to the effects of study and those effects are more long lasting than seems to have been previously believed. Repetition of a word during study enhances both recognition memory and later perceptual recognition (Experiments 4a, 4b, and 5) as does increasing the spacing of repetitions. Low-frequency words are more likely to be recognized as having been presented previously, and benefit more from prior study in perceptual recognition, than do high-frequency words (Experiments 3, 5, and 6). Further, it seems that both recognition memory and effects of study on perceptual recognition depend on memory for graphemic or physical information. Switching the modality of presentation between study and test essentially eliminates the effects of prior study on perceptual recognition and also reduces recognition memory performance (Experiment 6). In addition, interactions of study with frequency in the language are largely removed when modality is switched. When words are presented auditorially for study and then tested visually, low-frequency words hold almost no advantage in recognition memory and benefit little more in perceptual recognition from prior study than do high-frequency words. The different effects of study for high- and low-frequency words is at least partially due to memory for graphemic or physical information, regardless of whether memory is tested by means of a recognition memory or a perceptual recognition test.

Two Bases for Recognition Memory

Others have used statistical means in an attempt to separate the contribution of different bases for recognition memory (e.g., Atkinson & Juola, 1974; Mandler, 1980). If the feeling of familiarity that is said to serve as one basis for recognition memory reflects memory for physical information, however, comparisons with perceptual recognition performance provide a more direct means of separating bases for recognition. The effects of study on perceptual recognition of words presented out of context appears to depend totally on memory for physical or graphemic information. Consequently, comparisons of effects in perceptual recognition with those in recognition memory are useful for separating the different bases of recognition memory and for determining how different variables have their effect. Effects in recognition memory in the absence of effects in perceptual recognition, as found for the level-of-processing manipulation, can be taken as evidence that the variable has had its effect through elaborative processing or memory for meaning rather than through memory for the perceptual characteristics of the presented items. Parallel effects in the two forms of test, in contrast, can be interpreted as showing that perceptual recognition and recognition memory can be based on the same type of information, memory for physical or graphemic information. The bases for recognition memory on which we propose to interpret these results are in general agreement with those postulated by others. However, we are interested in further specifying the two bases for recognition memory and in exploring the possibility that the phenomenal experience of familiarity relies on enhanced perceptual recognition.

The relationship between effects in perceptual recognition and those in recognition memory may be profitably viewed from the larger context of questions about the relationship between performance and introspective reports. Nisbett and Wilson (1977) describe a number of instances in which there is a dissociation between effects of manipulations on performance and subjects' introspections concerning the causes of those effects. Subjects were often unable to report events that were responsible for effects in their performance of a subsequent task. Turning to memory, when subjects say they recognize an item as having been presented before or as being familiar, they are essentially giving a report based on introspection. As with other such reports, a question arises concerning the correlation between the subjects' ability to report a particular event and the influence of that event on their performance. The dissociation of perceptual recognition and recognition memory represents an extreme instance of the type described by Nisbett and Wilson; subjects show effects in perceptual recognition that are partially independent of recognition memory, which is a more phenomenal measure. Nisbett and Wilson stressed subjects' failures to correctly report factors that control their behaviour. From these failures, one might conclude that introspective reports are not important. However, this would be ignoring the fact that we often act upon the information reflected in those reports. In the case of memory, both recognition memory and effects in performance are of interest. There are instances in which it is important whether one thinks they have seen a person or event in a particular context.

Questions about the basis of the phenomenal feeling of familiarity remain. How does a person know he or she is remembering? In discussing the basis of introspections, Nisbett and Wilson (1977) denied that introspection can provide direct access to knowledge about factors controlling performance. Rather, they argued that we interpret our own performance in the same way we interpret that of others. Generalizing their arguments to recognition memory, we hypothesize that subjects may base their recognition memory decision on judgments of the relative fluency of their own performance of a task. If someone else easily performs a task that appears to be a normally difficult one, we conclude that they have practiced the task. Similarly, relative fluency in our own performance of a task may give rise to a feeling of familiarity and serve as a basis for recognition memory. Others have emphasized the influence of manipulations of study on the performance of a subsequent task (Kirsner, 1972; Kolers, 1973). The "memory for operations" approach taken by these investigators, however, neglects the question of how subjects are able to judge that they are remembering a particular event. The use of relative fluency that we propose as a basis for recognition memory is similar to the availability heuristic described by Kahneman and Tversky (1973). Those authors showed that judgments of the relative probability of two classes of events can depend on the comparative ease of bringing an event from each class to mind. The class of events of which the person can most readily think of an example is judged to be more probable. Similarly, we propose that judgments of relative perceptual fluency can be used as a basis for recognition memory. As is true of the use of availability to judge probability, the use of relative perceptual fluency as a basis for recognition memory is a heuristic and can, consequently, result in error. The retrieval of study context serves as a second more reliable basis for recognition memory.

For recognition on the basis of perceptual fluency, the judgment might be of the relative fluency of performing acts that are judged to be immediate and ordinary; that is, acts such as discrimination and naming that are immediately performed in many different situations. Due to its prior exposure, an item appears to jump out from the page. Because of this fluent processing, the item seems familiar and is judged to be old. Perceptual fluency and the form of recognition memory based on fluency are seen as depending on factors such as the number and spacing of repetitions during study and on the perceptual similarity of study and test versions of an item. Note that it is relative perceptual fluency rather than absolute fluency that is postulated as a basis for recognition memory. The assumption that relative fluency is important is useful for interpreting effects of frequency in the language reported earlier. For both perceptual identification and recognition memory, low-frequency words benefit more from study presentation than do high-frequency words, so the relative effects of study are the same for the two types of task. Others have also found it useful to describe effects involving frequency in terms of relative changes rather than absolute levels and have shown that subjects are very sensitive to differences in baseline frequency and changes in frequency (e.g., Hintzman, 1976; Mandler, 1980). In any case, logical considerations favor the importance of relative rather than absolute perceptual fluency. More complex tasks are typically more difficult to complete than are simpler ones, and this difference in difficulty is not fully removed by prior experience with the tasks. To serve as a valid basis for recognition memory, judgments of fluency must be relative to difficulty of the task.

Retrieval of study context provides a second, more conservative basis for recognition memory. Relative perceptual fluency can only provide a basis for recognizing an item as being familiar. Further evidence to support the recognition memory decision is not made available by information about fluency. An example can serve to clarify this point. If a telephone number has been learned through repetition alone, the only basis for confidence that we are remembering the correct number is the ease with which the number comes to mind. If challenged, all we can say is that the number seems right or familiar. The use of a mnemonic device for memorizing a telephone number, on the other hand, can provide additional criteria for judging the correctness of the number we have recalled. Similarly, retrieving study context can provide a more conservative basis for recognition memory. It is this form of recognition memory that is thought to be influenced by the "level" or difficulty of processing items during study. A more distinctive encoding of an item during study can be used to provide more evidence for the validity of a later recognition memory decision.

Returning to the dissociation of perceptual recognition and recognition memory, there are two means by which prior study can have an effect in perceptual recognition performance without producing recognition memory (Jacoby, in press). If relative perceptual fluency is used as a basis for recognition memory, effects on performance may sometimes be too subtle for the subject to detect. Like judgments of sensory dimensions, the precision of judgments of relative perceptual fluency would be expected to vary across subjects and situations. Differences in performance that can be detected by the experimenter through the use of specialized instruments may not always be detected by the subject. A failure to retrieve study context serves as a second and probably more common basis for the dissociation between perceptual recognition and recognition memory. Often we are asked to justify our memory claims by providing information about the context in which a particular event occurred. As described earlier, judgments of relative perceptual fluency cannot provide information of this type. If subjects adopt the more stringent criterion of saying that they recognize an item only if they can retrieve information about study context, effects on perceptual performance in the absence of recognition memory should be common. The possibility of retrieving study context depends on the distinctiveness of the original encoding of the item and on retrieval operations used at the time of test. Effects on perceptual recognition of words presented in isolation, in contrast, do not appear to depend on factors such as meaning or distinctiveness.

Generality of the Two Bases for Recognition

The two bases for recognition memory may exemplify two more general modes of responding. The judgment of relative perceptual fluency may correspond to the fast automatic mode of responding that is typically attributed to guessing or intuition whereas the retrieval of study context corresponds to a more careful analytic form of responding that is mediated by consciousness. The postulation of these general modes of responding is useful for interpreting effects in several different tasks. The lexical decision tasks serve as a first example. Several effects in perceptual recognition described earlier parallel effects found by Scarborough and his colleagues (Scarborough et al., 1977; Scarborough et al., 1979) in a lexical decision task. Consequently, one might conclude that perceptual recognition of a briefly exposed word and a decision about the lexical status of that word involve similar processes. Lexical decisions may be based on judgments of relative perceptual fluency or the familiarity of presented items. In line with this possibility, some pilot data from our laboratory as well as data reported by others (McKoon & Ratcliff, 1979) show that repeated exposure of a nonword can increase the probability of a subject mistakenly accepting that item as being a word or increase the reaction time of correctly rejecting the item. As is true for recognition memory, however, there may be two bases for making a lexical decision. Rather than using familiarity, a person may sometimes make a decision about the lexical status of an item on more conservative grounds that involve meaning. If there are two bases for lexical recognition that are similar to the two bases for recognition memory, one should be able to find variables related to meaning that influence performance in a lexical decision task but that do not influence perceptual recognition. James (1975) discussed the possibility of various forms of information being used to make a lexical decision and demonstrated that lexical recognition can involve meaning by showing that lexical decisions can be made more rapidly for concrete than for abstract words. In contrast to this effect of meaning in a lexical decision task, Paivio and O'Neill (1970) showed that the concreteness of the referent of a word does not influence perceptual recognition of that word. As indicated earlier, we have found that the level of processing of a word does not influence the speed of a subsequent decision about its lexical status. Duchek and Neely (Note 2), however, have found an influence of level of processing on subsequent lexical decisions. It might be possible to explain the conflict between our results and those of Duchek and Neely in terms of the two bases for a lexical decision. The involvement of meaning in a lexical decision and, consequently, the effect of level of processing may depend on the details of the experimental procedures.

Judging the truth value of a statement serves as a second example of a task that may involve two bases for responding. Recent experiments (e.g., Bacon, 1979) have demonstrated that subjects are more likely to accept a statement as being true if that statement has been presented in the experimental situation. It appears, then, that familiarity can serve as a basis for judging the truth value of a statement. However, familiarity is obviously not the only basis for judging truth; if it were, progress in an enterprise such as science would be impossible. As an alternative to judging familiarity, one can test the truth value of a statement by assessing the consistency of the statement with other knowledge or by testing implications of the statement. In general, two bases for responding similar to those described for recognition memory seem to cut across several tasks. Comparisons with effects in perceptual recognition performance similar to those used for recognition memory may be useful for analyzing tasks such as the lexical decision task and that of judging the truth value of statements.

Semantic Versus Episodic Memory

The results of the experiments reported earlier can be described in terms of the semantic vs. episodic memory distinction proposed by Tulving (1972). Presentation of an item during study may activate the semantic memory representation of a word without a new episodic trace being formed. Recognition memory, an episodic memory task, may depend on the formation of an episodic trace, whereas perceptual recognition, a semantic memory task, depends only on the level of activation of the semantic representation of the tested item. Variables such as level of processing, then, can be described as influencing the probability of an episodic trace being formed, thereby having an effect on recognition memory but not perceptual recognition. Parallel effects in recognition memory and perceptual recognition may simply show that differences in semantic memory can influence performance of an episodic memory task.

Although the above interpretation seems to fit our results, some questions about the distinction between semantic and episodic memory are raised. First, in line with Bergson (1913), it seems reasonable to think of semantic memory as developing through repetition and as representing something like a habitual mode of responding to a set of circumstances along with general knowledge. In this light, it is surprising that a single presentation of an item has such large and long lasting effects on its later perceptual recognition. Even low-frequency words have been read thousands of times by most university students, so one additional reading of the word in the laboratory should add little. The influence of study on perceptual recognition is more similar to what one would expect to find in an episodic memory task than a semantic memory task. Further, the specificity of the effects of prior study has yet to be determined for perceptual recognition performance. Rather than being due to the activation of a general representation of a word, the effects of prior study on perceptual recognition may be specific in that they reflect memory for the particular presentation of an item. For recognition memory, context and perceptual factors such as modality of presentation or type font are important, so it is concluded that the memory being tested is of a particular presentation. McKoon and Ratcliff (1979) found similar effects of providing context in a recognition memory task and in a lexical decision task, a task that is generally regarded as involving semantic memory. Effects specific to the study presentation of an item similar to those found for recognition memory may also be found for perceptual recognition. In any case, differences in memory similar to those described by Bergson appear within the confines of what are generally agreed to be episodic memory tasks. As described by Bergson for memory of a lesson, repetition of a word in a study list enhances recall and recognition memory of that word as well as establishing a separate memory for each of its occurrences (Hintzman, 1976). Hintzman described these results as favoring a multiple-trace theory over a strength theory of repetition effects. Implications of the two theories are paralleled by those of episodic and semantic memory. Semantic memory, like a strength theory of repetition effects, does not allow for the representation of individual occurrences of an item. The question in both instances is, How is memory for specific occurrences of an item related to more general memory of that item? In investigations of concept formation, this question takes the form of a question about the relationship between memory for individual instances of a concept and memory for the concept. By suggesting that concept formation is based on memory for individual instances, Brooks (1978) took a position similar to that taken by Hintzman to describe the effects of repetition. Effects that are attributed to semantic memory may reflect memory for individual episodes.

Further studies of perceptual recognition are likely to clarify the relationship between episodic and semantic memory. Effects of prior study in perceptual recognition may be confined by memory for particular occurrences of an item in the same way as recognition memory. If so, the distinction between episodic and semantic memory is of limited use in distinguishing between the two tasks. However, we are also concerned with another aspect of the distinction between episodic and semantic memory. Is an amnesic patient who correctly recalls words from a previously studied list but claims to not remember studying the list and to be only guessing showing evidence of episodic memory? From the examples that are commonly given, episodic memory involves not only the influence of a prior episode on later performance but also the subject's awareness that he or she is remembering the prior episode. It is this awareness of remembering that we consider to be important and have described by the term *autobiographical memory*.

Measures of Memory

Recognition memory, recall, and relearning have served as the traditional measures of memory. Of these measures, relearning is most similar to the measure obtained by using a perceptual recognition task. Neither relearning nor perceptual recognition logically requires that subjects be aware they are remembering in order to show effects of prior study. Use of the relearning measure also sometimes reveals memory and perceptual recognition; relearning sometimes provides evidence of memory even when the subject does not recognize the study material as having been presented previously. T. O. Nelson (1978) selected pairs from a paired-associate list that subjects had failed to recognize as having been presented earlier and found evidence of memory for those pairs by using the relearning measure. Kolers (1976) used a measure of memory similar to that of perceptual recognition. In a study of reading transformed text, Kolers found a very low correlation between memory as measured by the increase in the speed of reading a repeated sentence and memory as measured by a test of recognition memory. Sentences that had been read a *year* earlier were read more rapidly than were new sentences taken from the same source. This increase in reading speed was largely independent of the subjects' recognizing the sentence as being one they had read earlier.

T. O. Nelson (1978) attempted to account for differences between recognition memory and relearning in terms of differences in the sensitivity of the two forms of test. Nelson suggested that the relearning measure was more sensitive, having a lower "threshold." However, if relearning is similar to perceptual recognition, an account based on differences in sensitivity is inadequate. As described earlier, perceptual recognition and recognition memory performance can be influenced by different variables, so they do not differ only in threshold. The problem of comparing perceptual recognition and recognition memory is similar to that of comparing recognition memory and recall performance; many of the arguments and procedures developed to show independence of recognition memory and recall (e.g., Flexser & Tulving, 1978) are applicable. Comparisons involving perceptual recognition or relearning, however, add an extra dimension to earlier comparisons between tests of memory. Again, perceptual recognition and relearning differ from other tests of memory in that it is not necessary that subjects know they are remembering to show effects of prior study. By comparisons with perceptual recognition and relearning, we may obtain information about how awareness is gained and what role it serves.

There is no reason comparisons among tests must be restricted to memory for individual words. One can speak as readily of recognition of patterns as recognition of words. That experience can influence the perception of patterns is supported by studies of expertise. In DeGroot's (1966) study of chess players, the major difference between the expert and the novice seems to be perceptual in nature; the expert sees patterns that the novice does not. Again, the question arises as to the possible dissociation between what a person can say about his or her prior experience and the effect of that prior experience on performance of a perceptual task (Ericsson & Simon, 1980). One might find little difference between an expert and a novice when the two are asked to talk about strategies, facts concerning the subject matter, and so forth. However, differences are apparent in a more perceptual task. We are currently attempting to use these notions to test the expertise of medical students. With multiple-choice tests of the type that are often used to assess performance, the final year medical student typically scores higher than does a physician who has been practicing successfully for several years. Consequently, one must question whether these tests are a good measure of expertise. We have devised a more perceptual task, upon which the performance of the practicing physician far surpasses that of the student. Similar to the expert chess player, the practicing physician sees patterns among symptoms that the novice does not. In designing tests for an educational setting one encounters many of the same issues as were encountered when examining the relationship between perceptual recognition and recognition memory of individual words.

Summary and Conclusions

Variables such as level of processing have a large effect on recognition memory but have no effect on perceptual recognition. Given these data, one can conclude that perceptual recognition and recognition memory can be based on different kinds of information. However, other experiments revealed parallel effects of variables in perceptual recognition and recognition memory performance. It appears that there are two bases for recognition memory. A person can become aware that he or she is remembering because of the fluency of his or her performance of a task (relative perceptual fluency). This form of recognition memory would result in parallel effects of variables on recognition memory and perceptual recognition. Alternatively, an item's study context can be elaborated to produce evidence that the item was encountered during study. This second form of recognition memory depends on the meaningfulness or distinctiveness of encoding during study and involves more elaborative retrieval at the time of test.

The comparison of effects in perceptual recognition with those in recognition memory has proved useful for determining how variables have their effect. Earlier accounts have attributed the effects of level of processing to differences in attention or to the rapid forgetting of physical or graphemic information. In contrast to these accounts, perceptual recognition data provide evidence that an item can be perceived as a word regardless of differences in attention produced by manipulating orienting tasks. Manipulation of orienting tasks did not influence perceptual recognition performance although there were large effects in recognition memory. Further, the perceptual recognition data provide evidence that physical or graphemic information is incredibly well remembered over long intervals of time, rather than quickly forgotten. The effects of level of processing must be due to differences in elaboration or distinctiveness of encoding rather than differences in the registration or rate of decay of memory for a word per se. The effects of frequency in the language, in contrast, are at least partially due to differences in memory for physical or graphemic information. Effects of frequency in the language can be largely eliminated by changing modality of presentation between study and test.

In this article, we have emphasized the importance of comparisons of perceptual recognition and recognition memory for theories of memory. However, comparisons of this sort are equally important for theories of perception. The results that have been reported have implications for perceptual learning, such as is involved in learning to read. The laws that govern learning of these tasks are at least in part the same as those that operate in other memory tasks. For example, spaced repetitions are more effective for producing perceptual recognition than are massed repetitions. Further investigations of perceptual recognition within a memory framework are also likely to be useful in specifying the cues that are used to identify a word and specifying how those cues change across situations. A great deal of research has shown that recognition memory and recall are dependent upon context; similar effects of context may be found for perceptual recognition. Perhaps the most interesting questions concern the relationship between awareness and eventual effects in perceptual recognition performance. Here the question is similar to that raised by people investigating the role of metamemory (e.g., Brown, 1975): How does awareness of the operation of memory influence subsequent performance of a perceptual task? In any case, the experiments reported have demonstrated that perceptual recognition performance is easily influenced, and that there are some parallels as well as differences between the effects of variables in perceptual recognition and recognition memory.

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