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Priming in Episodic and Semantic Memory

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Priming between newly learned paired associates was examined in two experimental procedures, lexical decision and item recognition. In lexical decision, the priming effect, shown by decrease in response time, was as large between newly learned associates (e.g., "city grass") as between semantic associates (e.g., "green grass"). This result shows that episodic information has an effect on semantic (lexical) decisions. In item recognition, priming with semantic associates affected error probability, showing the effect of semantic information on an episodic decision. These results argue against a functional separation of the semantic and episodic memory systems. In the discussion, the utility of the semantic–episodic distinction is examined in some detail.

Many recent experiments have been interpreted in the light of the distinction between semantic and episodic memory. Semantic memory is defined as a mental thesaurus, the organized knowledge a person possesses about words and other verbal symbols, about meanings and referents and the relations among them, and about rules, formulae, and algorithms for the manipulation of these symbols, concepts, and relations. Episodic memory is conceived as receiving and storing information about personal experiences, temporally dated episodes or events, and temporal–spatial relations among these events (Tulving, 1972, pp. 385–386). When Tulving introduced the distinction between semantic and episodic memory to cognitive psychologists (see Hintzman, 1978, p. 367), he presented a case only for the possible heuristic usefulness of a taxonomic distinction (Tulving, 1972, p. 401). However, some authors have since gone further and argued for the structural or functional separation of the two memory systems (Atkinson, Herrmann, & Wescourt, 1974; Kintsch, 1975; Lockhart, Craik, & Jacoby, 1976; Tulving, 1976; Watkins & Tulving, 1975). If indeed the two systems are structurally or functionally separate, then information in the two systems should be independently accessible. In this paper, we use a prototypical semantic memory task, the lexical decision task, to examine whether semantic information can be accessed independently of episodic information.

In a lexical decision experiment, a subject is presented with a string of letters and he must decide whether or not the string is a word. Typically, error rate is low and the dependent measure of interest is response time. Meyer and Schvaneveldt (1976) have found consistently that, if a test word is immediately preceded in the test list by a closely related word, then response time is faster than if it

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is immediately preceded by some unrelated word. This effect has been labeled "priming," and the amount of priming is given by the difference in average latency between responses for which the test word is not related to the preceding word and responses for which the test word is related to the preceding word.

It has been assumed that a lexical decision is based on lexical or semantic information; that is, a letter string is a word if it has associated with it in memory information about its meaning (including its syntactic and pragmatic uses). The kinds of relations between words that have been studied using the lexical decision task have been preexperimentally well-learned semantic relations or associations; for example, "green" will prime "grass" and "doctor" will prime "nurse." In the present experiments, we examine whether newly learned associates will prime each other. Subjects are taught pairs of words in which the words are not highly associated semantically, that is, they are not preexperimentally associated (e.g., "city grass"). Then the amount of priming between the words of a pair is examined in a lexical decision test.

If the semantic and episodic memory systems are structurally or functionally independent, then there should be experimental tasks in which the two kinds of information are accessed independently. Lexical decision is an obvious candidate for such a task; if semantic information can ever be accessed independently of episodic information, then it should be in a lexical decision. Thus, in lexical decision there should be no effect of episodic information; the words of a newly learned pair such as "city grass" should not prime each other.

An experiment by Fischler (1977) gives some support to this position. He found that semantic similarity is more important than semantic association in determining the size of priming effects. If semantic association plays little or no role in priming, then neither should newly learned association. If newly learned association were not to play a role in priming, then semantic similarity giving rise to priming would be a characteristic of semantic memory and not of episodic memory, and so form one of the distinguishing features of the two systems.

The opposite prediction, namely, that the words of a newly learned pair should prime each other, would be made by an alternative view of the episodic–semantic distinction. This view is that both semantic and episodic information are stored in the same memory system; the two kinds of information are not independently accessible (Anderson, 1976; Baddeley, 1976; Lindsay & Norman, 1977; Wickelgren, 1977).

Priming between newly learned associates was examined in the first three experiments of this paper. A study–test procedure was used; subjects were presented with a series of trials, where each trial was a study list followed by a test list. A study list consisted of pairs of words that subjects were required to learn for a later cued recall test. A test list consisted of letter strings; for each string, the subject had to decide whether or not it was a word. In the first experiment, priming was examined between words that were newly learned associates (that is, not preexperimentally associated) and this priming was compared to priming between words highly related preexperimentally (that is, semantically related). The second and third experiments provided certain control conditions that were not present in the first experiment. The fourth experiment investigated the converse of Experiment 1, that is, whether well-known semantic information affects a decision that should, logically, be based only on newly learned (episodic) information. The decision examined was item recognition in a study–test procedure.

Experiment 1

The study list for each trial was made up of pairs of words that were highly associated preexperimentally (e.g., "green grass") and pairs of words that were not highly associated preexperimentally (e.g., "city grass"). In the test list, priming effects were examined between words that were presented as a pair in the study list and were highly associated preexperimentally, between words that were not presented as a pair in the study list but were highly associated preexperimentally, and between words that were presented as a pair in the study list and were not highly associated preexperimentally.

Method

Subjects. Sixteen right-handed undergraduates at the University of Toronto participated in the experiment for course credit.

Materials. One hundred and twenty-eight triples of words were formed (see Appendix 1). Two words of each triple (e.g., "green grass") were chosen so as to be highly associated preexperimentally; according to published norms, the second target word (e.g., "grass") was either the first or second most frequent response to the first word (e.g., "green"). The third word of each triple, not associated preexperimentally to either of the first two according to published norms, was chosen so as to form an easily learned pair with the target word (e.g., "city grass"). The fact that these pairs were chosen to be easily learned means that some association could be made between the two words. However, preexperimental association between them was not high enough to produce priming (see Experiment 3). In addition to the 128 triples, the materials included a set of common words, to be used as fillers in the test list and in the first and last positions of the study list, and a set of nonwords. A nonword was formed from one of the words of the triples or the fillers by replacing vowels with randomly chosen vowels and consonants with randomly chosen consonants.

Procedure. A sample trial is shown in Table 1. Each subject received 32 such trials, preceded by 2 practice trials. Study list presentation, test item presentation, randomization, and response recording were all controlled by a PDP-12A laboratory computer.

TABLE 1
EXAMPLE OF A TRIAL IN EXPERIMENT 1

red	lamp
green	grass
plainly	see
widow	child
tree	table
happy	runner
* * * * * *	
krua	
runner	
blue	
sky	
bopre	
tree	
child	
palip	
.	
.	
.	

A study list consisted of six pairs of words, displayed one at a time for 3 sec each. After presentation of a study list, a row of asterisks signalled the beginning of a test list. There were 22 items in each list, 13 words and 9 nonwords. Each item was presented individually and remained in view until the subject made a response (right index finger on one button for "yes" or "word" responses and left index finger on another button for "no" or "nonword" responses). Subjects were instructed to make the lexical decisions as fast as possible while maintaining high accuracy. Following a response, there was a 250-msec delay before presentation of the next test item. After the last test item, a new study list was presented.

Subjects were instructed to learn the pairs in the study list for a later cued recall test. They were informed that the cue on the recall test would always be the left-hand member of a pair. A cued recall test was given after every eight trials.

Design. The eight experimental conditions are shown by example in Table 2. For each

triple of words, a subject studied the pair that was highly associated preexperimentally (Conditions 1 and 2), the pair that was not associated preexperimentally (Conditions 3, 4, 5, and 6), or did not study any words of the triple at all (Conditions 7 and 8). In the immediately following test list, the target word of the triple was immediately preceded by the preexperimentally associated word (Conditions 1, 5, and 7), the word that was not preexperimentally associated but was paired with the target in the study list (Condition 3), or by some other word from the study list (Conditions 2, 4, 6, and 8). Note that in half the test conditions (Conditions 2, 4, 6, and 8), the target is not preceded by a word associated either in the study list or preexperimentally, and, in the other half of the conditions, the target is preceded by an associated word; this is the reason for the two identical conditions, 4 and 6.

The 128 triples of words were divided into eight groups of 16 triples each; these eight groups were combined with the eight experimental conditions and eight groups of subjects (two subjects per group) in a Latin-square design. Thus, every triple and every subject appeared in every experimental condition. No subject saw the same test word more than once in the experiment. Order of presentation of study and test materials was rerandomized for every subject.

TABLE 2
EXPERIMENTAL CONDITIONS OF EXPERIMENT 1

	Study list		Test list	
Condition	Associate	Target	Preceding word	Target
1	green	grass	green	grass
2	green	grass	x	grass
3	city	grass	city	grass
4	city	grass	x	grass
5	city	grass	green	grass
6	city	grass	x	grass
7	—	—	green	grass
8	—	—	x	grass

Note. "x" is some word from the study list, but not "city" or "green."

The words to be presented in each trial were chosen in the following way: the eight experimental conditions were divided into four sets, Conditions 1 and 2, conditions 3 and 4, Conditions 5 and 6, and Conditions 7 and 8. For each trial, one condition was chosen from each set; which of the two conditions was decided randomly with the restriction that each of the two conditions be represented in 16 of the 32 trials. For each condition chosen for a trial, one of the 16 triples assigned to that condition was chosen randomly without replacement. The appropriate pair of words for that triple and condition was then assigned randomly to one of the four middle positions of the study list (the first and last positions were occupied by filler words). For Conditions 7 and 8, in which none of the words of the triple were studied, filler words were inserted in the study list.

The test list was constructed in the following way: the target words of each of the four triples assigned to the trial were placed in random positions (but not in positions 1 or 2) in the test list, and each target was immediately preceded in the test list by the word appropriate to its condition. Then five other words from the study list were placed in random positions in the test list, with the restriction that, if any of these words belonged to the triple of one of the targets, it could not precede the target by fewer than four test items. Nonwords filled the remaining positions in the test list. Note that all words in the test list were presented in the study list, except for the words of triples in Conditions 7 and 8 and the word preceding the target in Condition 5.

Results

Average performance in the cued recall tests was 92% recall for words that were highly associated preexperimentally and 80% recall for words that were not highly associated preexperimentally.

TABLE 3
MEAN RESPONSE TIMES WITH STANDARD ERRORS AND ACCURACY IN EXPERIMENT 1

Condition[a]	Type of associative information contributing to priming	RT (msec ± *SE*)
1	Semantic and episodic	533 ± 12 (0)[b]
3	Episodic	539 ± 13 (1)
5	Semantic	530 ± 12 (0)
2, 4, and 6 combined	Unprimed	579 ± 8 (2)
7	Semantic	555 ± 13 (2)
8	Unprimed	617 ± 24 (3)

[a] The conditions are defined in Table 2.
[b] The error (%) is given in parentheses.

The mean lexical decision response time for each subject in each condition was calculated; means of these means are displayed in Table 3. Only correct responses preceded by correct responses were included in the means and the analyses to ensure that both the targets and the words that immediately preceded them in the test list were in memory.

Response times for Conditions 2, 4, and 6 were combined because they did not differ significantly (the means were all within one standard deviation of each other). In these conditions, the target word of a triple was preceded by a word that was not associated to it, that is, the target was not primed. In Condition 1, a target word was preceded by a word associated both preexperimentally and by pairing in the study list; the priming effect was 46 msec. A priming effect almost as large (40 msec) was obtained in Condition 3, where the association between the target and the preceding word was due only to pairing in the study list. In Condition 5, where the association tested was due only to preexperimental association, the priming effect was 49 msec.

The important finding in this experiment is that newly learned associative information led to priming in lexical decision, a task that might be thought to involve only preexperimentally learned (semantic) information. This priming effect was shown to be significant by analysis of variance comparing Condition 3 response times to the combined Condition 2, 4, and 6 response times, $F(1, 14) = 7.68$, $p < .05$.

Another priming effect due to newly learned information was that response times for words that were presented in the study list were 38 msec faster on the average than words that were not presented in the study list (when the words were not primed in the test list). Words that were not presented in the study list also showed a larger priming effect, 62 msec.

Discussion

The main result of this experiment is the finding that there is priming in lexical decision between newly learned paired associates, that is, between words that are not preexperimentally associated. In terms of a distinction between episodic and semantic memories, newly learned associations are episodic associations, and so this finding is evidence for the interaction of episodic and semantic information in a prototypical semantic memory task. Such an interaction would not be expected if it were assumed that the episodic and semantic memory systems were independently accessible, because, logically, only semantic (lexical) information is necessary for a word–nonword decision.

The size of the priming effect was about the same, whether priming was between the words of a newly learned pair, between preexperimentally associated words that were not presented as a pair in the study list, or between preexperimentally associated words that were presented as a pair in the study list. This indicates that the priming effect has about the same magnitude irrespective of the source, newly learned association, well-known association, or both.

EXPERIMENT 2

While we would like to interpret the results of Experiment 1 as evidence for the interaction of semantic and episodic information in a task that should logically involve only semantic information, there is an alternative explanation of the results that would be compatible with the independence of the two memory systems. Suppose that subjects had adopted the strategy of responding "word" either if the letter string matched a representation in semantic memory or if the letter string matched a representation in episodic memory. The only study items in episodic memory were words, so that a match with an item in episodic memory (independent of any word–nonword judgment) would have been sufficient for a correct response. Furthermore, suppose that the events encoded into episodic memory during presentation of the study list were pairs of words, not single words. Then matching a test word against the episodic representation of that word could have been facilitated by immediately previous testing of the other word of the pair, assuming some activation remaining from the test of the first word. In Experiment 2, conditions for the successful use of this strategy were removed by placing nonwords in the study list. Thus, whether or not a test letter string was a word was no longer correlated with whether the string had been presented in the study list.

There were also several other differences between this experiment and Experiment 1. First, a different set of word pairs was used to ensure that the priming effect for newly learned associates would generalize across materials. Second, words not presented in the study list were included in the test list. This, like the inclusion of nonwords in the study list, decreases the probability that matching test letter strings against episodic representations will lead to a correct lexical decision. Finally, no words that were highly associated preexperimentally were presented as pairs in either the study or test lists.

Method

Subjects. Thirty-two right-handed undergraduates at Scarborough College participated in the experiment for course credit.

Materials. The experimental materials included 96 pairs of words different from the pairs of Experiment 1 (see Appendix 2). The two words of a pair were not associated preexperimentally, according to published norms. The experimental materials also included 96 pairs of nonwords. Filler items included additional nonwords and the same filler words as were used in Experiment 1. All nonwords were pronounceable.

Procedure. A study–test procedure like that of Experiment 1 was used. Each subject received 48 trials, preceded by two practice trials. All experimental materials were displayed on a Digital Equipment Corporation Decscope, model VT52, controlled by a PDP-11 computer. The procedure was the same as in Experiment 1, with the following differences.

There were seven pairs in each study list, including word–word pairs, nonword–nonword pairs, word–nonword pairs, and nonword–word pairs. The pairs were presented one at a time for 4 sec each. Each test list consisted of 22 items, 11 words and 11 nonwords, 12 items that had been presented in the study list and 10 items that had not been presented in the study list. Following a response, there was a 150-msec delay before presentation of the next test item. As in Experiment 1, a cued recall test was given after every eight trials.

Design. The target word of a pair was tested either primed (preceded in the test list by its associate) or not primed (preceded in the test list by some other word from the study list). This variable was combined with two sets of materials (48 pairs per set) and two groups of subjects (16 per group) in a Latin-square design. The same two experimental conditions, primed and not primed, applied to the nonword pairs and were also combined in a Latin square with sets of materials and groups of subjects. Thus, for both words and nonwords, every subject and every pair was tested in both experimental conditions. Order of presentation of study and test materials was rerandomized for every four subjects.

For each trial, one pair of words from the set of pairs assigned to the primed condition and one pair from the unprimed set were chosen randomly. Two pairs of nonwords were chosen in a similar manner. From the filler words and nonwords, either a nonword–word or a word–nonword pair was chosen. These five pairs were placed in the middle five positions of the study list in random order. In the first and last positions of the study list were filler items, either word–word, nonword–nonword, word–nonword, or nonword–word pairs.

The test list was constructed in the following manner: First, the two target words and the two target nonwords from the study list pairs were placed in randomly chosen positions in the test list (but not in positions 1 or 2), and the appropriate items were placed in the immediately preceding positions in the test list. Then, two of the other words and two of the other nonwords of the study list were placed in random positions in the test list, except that the paired associate of a target could not precede that target by fewer than four items. Finally, five words and five nonwords that had not been in the study list were placed randomly in the remaining positions of the test list.

Results

A mean lexical decision reaction time was calculated for each subject in each condition and all analyses were performed on these means. Only correct responses preceded by correct responses of the same answer ("yes" or "no") were included in the means and analyses.

Newly learned associations led to priming in this experiment just as they did in Experiment 1. The mean primed response time for words was 518 msec (1% errors) and the mean unprimed response time for words was 548 msec (2% errors); the difference was significant, $F(1,31)=10.86$, $p<.01$. The effect of priming on nonwords was to slow response times; the primed mean was 660 msec (6% errors) and the unprimed mean was 634 msec (8% errors). This difference was also significant, $F(1,31)=5.15$, $p<.05$. Average standard error for word responses was 10 msec, and for nonword responses, 17 msec.

As in Experiment 1, responses to filler words that had been presented in the study list were faster than responses to words not presented in the study list; the respective means were 545 msec (3% errors) and 592 msec (7% errors). An analysis of variance was performed on response times to filler items; the factors were whether an item was a word, whether it had been presented in the study list, and subjects. Orthogonal comparisons showed the difference in response times between presented words and not-presented words to be significant, $F(1,31)=4.17$, $p<.05$. Responses to filler nonwords that were presented in the study list were slower than responses to filler nonwords that were not presented in the study list, 645 msec (8% errors) versus 608 msec (5% errors). Orthogonal comparisons showed that this difference was significant, $F(1,31)=9.69$, $p<.01$. Average standard error of the means for filler items was 13 msec.

The subjects recalled 62% of the target words on the cued recall tests and 3% of the target nonwords.

Discussion

As in Experiment 1, there was a significant priming effect due to newly learned association; mean reaction time to a word presented in the study list was faster if it was preceded by its paired associate than if it was preceded by some other word from the study list. In Experiment 1, this effect could have been made compatible with the assumption of independently accessible episodic and semantic memory systems by supposing that subjects adopted the strategy of responding "word" when either the test letter string matched a word in semantic memory or the test letter string matched a letter string in episodic memory. In Experiment 2, nonwords were presented in the study list, rendering the episodic matching strategy unworkable. The episodic priming effect was still obtained.

Another result of Experiment 2, which also shows the interaction of episodic and semantic information in lexical decision, was the inhibitory rather than facilitory effect of priming on nonwords. Apparently, the association between the nonwords of a pair biased subjects toward a "yes" ("word") response, or, equivalently, inhibited a "no" ("nonword") response. This inhibitory effect contradicts explanations of priming that account for the facilitation solely by assuming a decrease in encoding time (Meyer & Schvaneveldt, 1976), because this explanation predicts that nonwords should be facilitated just as much as words (see also Sanford, Garrod, & Boyle, 1977).

EXPERIMENT 3

There is a potential confound in Experiments 1 and 2; perhaps the pairs of words assumed not to be associated preexperimentally (e.g., "city grass") were in fact weakly associated preexperimentally. Such a weak association might have been strong enough to result in the priming obtained in Experiments 1 and 2. Experiment 3 was designed to investigate this possible confound. There were two study conditions: A test pair was presented either in the same paired associate in the study list or in a different paired associate. For example, the test pair "city grass" was presented in the study list either as the paired associate "city grass" or as two paired associates, "x grass" and "city y," where x and y are some other words. Preexperimental association must be the same for the two study conditions; only the newly learned association can vary. Thus, if the priming effect obtained in Experiments 1 and 2 resulted from weak preexperimental associations and not from newly learned associations, there should be no difference in the amount of priming obtained in the two study conditions. If, on the other hand, the priming effect was due to newly learned association, then the effect should be larger in the condition in which the words of the test pairs are learned as paired associates.

Method

Subjects. Sixteen right-handed Dartmouth undergraduates served as subjects for course credit.

Materials. The materials were the 128 unassociated pairs of the triples used in Experiment 1 (e.g., "city grass"). The same nonwords as in Experiment 2 and the same filler words as in Experiment 1 were used.

Procedure. Stimuli were presented on a Datamedia Elite 1520 video terminal controlled by Dartmouth's time-sharing system. Response times were recorded by a Polytronics Universal Response timer.

The study–test procedure differed slightly from that of Experiments 1 and 2. There were six pairs in each study list (all words); the pairs were shown one at a time for 4 sec each. A test list consisted of eight pairs. A pair was signalled by a row of asterisks. After 300 msec, the asterisks were replaced by the first member of the pair, always a word. Subjects were instructed to read it but to make no response. the word was displayed for 300 msec and then was immediately replaced on the CRT screen by the second member of the pair. Half of the second members were words and half were nonwords. Subjects were instructed to respond "word" or "nonword" as quickly and accurately as possible. After the eighth pair, a new study list began. Each subject received 32 trials preceded by 2 practice trials. There was a cued recall test after every eight trials.

Design. There were four experimental conditions: A target and its associate were either paired or not paired in the study list and the target was either primed (preceded by its associate) or not primed (preceded by some other word from the study list) in the test list (see Table 4). These four conditions were combined with four groups of subjects (four per group) and four sets of materials (32 pairs per set) in a Latin-square design, as in Experiments 1 and 2. Order of presentation of study and test materials was rerandomized after every two subjects.

For each trial, one of the pairs assigned to each of the experimental conditions was chosen randomly without replacement. These four pairs were placed in random order in the middle four positions of the study list in the appropriate manner, two paired and two not paired (that is, two for which the targets and associates were switched). In the first and last positions were filler words.

The test list was constructed in the following way: First, the four targets of the experimental pairs in the study list were assigned to randomly chosen positions (except position 1); these targets were always the second members of the test list pairs. Then the first members of these pairs were chosen; the primed targets were preceded by their associates from the study list, the unprimed targets by some other word from the study list. The remaining four positions of the test list were filled with word–nonword pairs, where the word was chosen randomly without replacement from the words of the study list not already used in the test list. The one restriction was that an associate could not precede its unprimed target by fewer than three pairs. On eight randomly chosen trials, the first test list pair was a word–word pair rather than a word–nonword pair; the extra word was a filler word not presented in the study list.

Results

Subjects recalled 51% of the target words on the cued recall tests.

A mean response time was calculated for each subject in each condition. the means of these means are shown in Table 4. Only correct responses were included in the means and in the analyses. Analysis of variance showed a significant difference among the means, $F(3,36)=5.225$, $p<.01$. Newman–Keuls tests ($p=.05$) showed that the first condition, the test pair paired in the study list and the target primed in the test list, was significantly different from the other three conditions, and that these three did not differ among themselves. Thus, the priming effect due to newly learned association that was found in Experiments 1 and 2 is replicated in this experiment.

TABLE 4
MEAN RESPONSE TIMES WITH STANDARD ERRORS AND ACCURACY IN EXPERIMENT 3

Condition		
Study list	Test list	RT (msec ± *SE*)
Paired (city grass)	Primed (city grass)	688 ± 14 (3)[a]
Paired (city grass)	Unprimed (z grass)	784 ± 17 (4)
Not paired (x grass) (city y)	Primed (city grass)	772 ± 18 (4)
Not paired (x grass) (city y)	Unprimed (z grass)	758 ± 17 (3)

Note. x, y, and z are some words in the study list, but not "city."

[a] The error (%) is given in parentheses.

Discussion

The result of this experiment is quite clear: If two words were paired in the study list, then one primed the other in the test list. If the same two words were not paired in the study list, then there was no priming between them. Because the same pairs appeared in both conditions in this experiment (paired in the study list and not paired in the study list), preexperimental association was controlled. Thus the hypothesis that the priming obtained in Experiments 1 and 2 was due to preexperimental association can be ruled out.

The size of the priming effect for newly learned associates was somewhat greater (80 msec) than that found in Experiments 1 and 2 (40 and 30 msec, respectively). This difference can be attributed to the change in experimental procedure between Experiments 1 and 2 and Experiment 3. In Experiments 1 and 2, both the primer and the primed items required responses (they were tested as individual items in the test list), while in Experiment 3, the primer item was displayed for 300 msec and did not require a response.

EXPERIMENT 4

In terms of an episodic–semantic distinction, the first three experiments have all been concerned with the effect of episodic information in a semantic task. Experiment 4 investigated the effect of semantic information in an episodic task, item recognition. The design of Experiment 4 was similar to the design of Experiment 1 in that a study–test procedure was used. However, in the test lists, subjects had to decide whether tested items were in the study list rather than whether tested items were words. For this item recognition experiment, distractor items were words that had not appeared in the study list rather than nonwords.

Method

Subjects. Sixteen right-handed undergraduates at the University of Toronto served as subjects for $3.00 for a 1-hr session.

Materials. The experimental materials were the 128 triples used in Experiment 1. Filler words for the study lists and distractor words for the test lists were the same as those used in Experiment 1.

Procedure. A study–test procedure was used, similar to that used in Experiments 1 and 2. Study list presentation, test item presentation, randomization, and response recording were all controlled by a PDP-12A laboratory computer.

A study list consisted of six pairs of words, presented individually at 3 sec per pair. Following the study list, a row of asterisks signalled the beginning of the test list. A test list contained 22 words, 13 that had appeared in the study list and 9 that had not appeared in the study list. Each test word was presented individually, remaining in view until the subject responded. Subjects were instructed to respond as quickly as possible while maintaining high accuracy. Then, after a 250-msec delay, the next item appeared. After the last test word, the next study list began.

Subjects were instructed to learn the pairs of the study lists for a later cued recall test. Each subject received 32 study–test trials preceded by 2 practice trials. There was a cued recall test after every eight trials.

Design. In the study list, a target word was paired with either the word highly related preexperimentally (e.g., "green grass") or the word not associated preexperimentally (e.g., "city grass"). In the test list, a target was primed by (immediately preceded in the test list by) the word preexperimentally associated, primed by the word not preexperimentally associated, or unprimed (preceded by either a word from the study list or a word not from the study list). The experimental conditions are shown in Table 5. Note that, in the study list, a target was paired with its preexperimentally associated word in half the conditions and paired with the word not preexperimentally associated in the other half of the conditions. This is the reason for the identical conditions 2, 3, and 4, and 6 and 8.

TABLE 5
EXPERIMENTAL CONDITIONS OF EXPERIMENT 4

	Study list		Test list	
Condition	Associate	Target	Preceding word	Target
1	green	grass	green	grass
2, 3, and 4	green	grass	x	grass
5	city	grass	city	grass
6	city	grass	x	grass
7	city	grass	green	grass
8	city	grass	x	grass

Note. x is some word that is not "city" or "green."

The eight experimental conditions were combined with eight groups of subjects (two per group) and eight sets of triples (16 per set) in a Latin-square design. Order of presentation of study and test materials was rerandomized for each subject.

The eight experimental conditions were divided into four sets of two: Conditions 1 and 2, Conditions 3 and 4, Conditions 5 and 6, and Conditions 7 and 8. For each trial, one of the conditions of each set was chosen randomly, with the restriction that each condition be assigned to 16 trials. Then, for each condition, 1 triple was chosen randomly without replacement from the 16 triples assigned to that condition. The four pairs of words representing the chosen triples were placed in random order in the middle four positions of the study list. The first and last positions of the study list were occupied by filler words.

To construct the test list, the four target words of the triples assigned to the trial were placed in random positions in the test list (except positions 1 and 2). If the target was to be primed (determined by the condition to which it was assigned), the priming word was placed in the test list position immediately preceding the target. If the target was not to be primed, it was preceded by either a word from the study list or a word not from the study list, which was decided randomly. Then the remainder of the test list positions were filled with words from the study list and words not from the study list, in random order, with the restrictions that the total number of words from the study list was 13 and that an unprimed target could not be preceded by its associate by fewer than four positions.

Results

A mean response time was computed for each subject in each condition; means of these means are shown in Table 6. Only correct responses preceded by correct responses were included in the means and analyses.

TABLE 6
MEAN RESPONSE TIMES WITH STANDARD ERRORS AND ACCURACY WITH STANDARD ERRORS IN EXPERIMENT 4

Condition[a]	Type of associative information contributing to priming	Correct response to preceding test item	RT (msec ± *SE*)
1	Semantic and episodic	Yes	568 ± 13 (3 ± 1)[b]
5	Episodic	Yes	624 ± 14 (6 ± 2)
7	Semantic	No	738 ± 16 (20 ± 3)
2, 3, 4, 6, and 8 combined	Unprimed	Yes	782 ± 11 (10 ± 1)
2, 3, 4, 6, and 8 combined	Unprimed	No	743 ± 7 (14 ± 1)

[a] The conditions are defined in Table 5.
[b] The error (% ± *SE*) is given in parentheses.

Condition 5 shows a large priming effect, 158 msec, reflecting the association between the target and its newly learned associate; this priming effect is based on episodic information and so would be expected in a task requiring episodic information. There is an even larger priming effect in Condition 1 (214 msec), where the target is primed by a word that is both preexperimentally associated to the target and paired in the study list with the target. It could be that this result shows the effect of the preexperimental association on the decision process, but it could also be an effect on learning and not on the item recognition decision (highly associated pairs such as "green grass" may be better learned). However, the effect of preexperimental association on the decision process is clearly shown by Condition 7, where preexperimental association did not significantly affect response time but significantly increased error rate ($z = 1.897$, $p < .05$, one-tailed), compared to conditions where the target was not primed and was preceded by a correct "no" response.

Subjects recalled 94% of the targets of the preexperimentally associated pairs and 82% of the targets of the pairs that were not preexperimentally associated.

Discussion

The results of this experiment show that preexperimental association has a significant effect on performance in an item recognition task, a task that, if episodic and semantic information are independently accessible, should require only episodic information. Similar effects have been observed by, for example, Perlmutter, Harsip, & Myers (1976), Herrmann & McLaughlin (1973), Gossman & Meyer (Note 1), and Lewis & Anderson (1976).

The priming effect obtained in this experiment is much larger than the priming effect found in the lexical decision task. It has been argued that the lexical decision priming effect is the result of a speedup in the encoding process (Meyer & Schvaneveldt, 1976). If the priming effect in item recognition were also due to a speedup in encoding, then the time required for the encoding stage would have to be on the order of 250 msec; the priming effect in item recognition is 214 msec, and encoding must take longer than that. But Reed (1976), using a response signal method with item recognition, has shown that the sum of the times required for encoding, response, and other processes not including decision is about 220 msec. So, while some of the priming effect in lexical decision may be due to speedup in encoding, probably most of the speedup comes from the decision stage, unless encoding processes very different from lexical decision are postulated for item recognition (see Ratcliff & McKoon, 1978; Sanford et al., 1977).

General Discussion

The experiments presented in this paper argue that newly learned information and well-known information, that is, what would be called episodic information and semantic information, are not processed independently in a task that logically requires only episodic information (item recognition) or in a task that logically requires only semantic information (lexical decision). Experiment 4 showed the effect of semantic information in item recognition and Experiments 1, 2, and 3 showed the effect of episodic information in lexical decision.

In Experiments 1, 2, and 3, priming was obtained between the words of a newly learned paired associate. Experiment 1 showed that the facilitation between the words of a newly learned pair was about the same size as the facilitation between words that were well-known semantic associates, when the primer and primed words were presented as a pair in the study list. The size of the semantic priming was larger for words not presented in the study list, and words that were not presented in the study list had slower response times than words that were presented in the study list. Thus, the effect of presentation in the study list appears to be the inverse of the effect of stimulus degradation in the lexical decision task (Sanford et al., 1977).

The results of Experiment 1 could have been interpreted in a way consistent with a dichotomy between episodic and semantic memory systems. The only study items stored episodically were words (only words were presented in the study lists). Thus subjects could have responded correctly in the lexical decision task by matching test letter strings against episodic letter strings, and this strategy might have been responsible for the priming between newly learned associates. This interpretation was ruled out by Experiment 2, where the strategy could not work because the study lists contained nonwords as well as words. Another possible explanation of the priming between newly learned associates was that the words supposed to be preexperimentally unassociated were actually preexperimentally associated enough to produce the observed priming. This explanation was ruled out by Experiment 3, where one word primed another only when the two words were presented in the study list as a pair, and not when the two words were presented separately.

The fourth experiment demonstrated an effect of preexperimental association (semantic relatedness) on performance in item recognition. There was a large priming effect between words studied as a pair, much larger than that in lexical decision, 160 msec for preexperimentally unassociated words, 210 msec for preexperimentally associated words. The effect of preexperimental association on the item recognition decision was shown by an increase in error responses when a word was preceded by a word that was not in the study list but was highly associated preexperimentally.

The main point of these results is that in tasks for which we might expect to find a functional separation of well-known semantic information and newly learned episodic information, we find instead evidence for the interaction of the two kinds of information. This interaction is consistent with the class of models that assumes no dichotomy between semantic and episodic memory systems (Anderson, 1976; Anderson & Bower, 1973). Models of this class could predict the interaction of newly learned and well-known information because both kinds of information are stored in a single memory system. The interaction is not consistent with a strict version of episodic theory. Such a theory would assume that episodic and semantic information were independently accessible and so would expect no priming in a lexical decision task from newly learned associates. This is because logically only preexperimentally learned semantic information need be used in making a word–nonword decision. The same expectation would arise from Fischler's (1977) arguments that semantic relatedness, rather than semantic association (or association per se), is the main determinant of facilitation in lexical decision. Contrary to these expectations, Experiments 1, 2, and 3 showed that facilitation can be obtained from newly learned associates.

The question then arises as to whether models that assume a distinction between episodic and semantic memory systems can be made consistent with the results of the experiments presented here. One argument from which consistency would follow would be that the priming obtained between newly learned associates is a strategic, as compared to an automatic, process (cf. Posner & Snyder, 1975a, 1975b). In other words, given the primer word, the subject anticipates the primed word. This argument is contradicted by Neely's (1977) finding that strategic priming requires at least 500 msec; this is much longer than the 150, 250, or 300 msec available in the experiments presented here. Another way to account for priming between newly learned associates in terms of a semantic–episodic distinction would be to allow lexical decisions to be made on the basis of infor-

mation in episodic memory. That is, the episodic representation of a letter string would indicate whether or not it was a word. However, allowing semantic information into episodic memory in this way directly contradicts the assumptions of episodic–semantic theories (cf. Lockhart et al., 1976; Tulving, 1976). The third way to explain the results of the present experiments, the way that would seem most compatible with the episodic–semantic distinction, would be to allow an interaction in decision processes between semantic and episodic information. If the pair "city grass" were learned in a study list, then a simplified model of processing in the test list might go as follows. First, "city" is presented; it then makes contact with its representation in semantic memory (which allows a "yes" response) and also automatically makes contact with its episodic representation which activates the episodic representation of the associated "grass," which in turn activates the semantic representation of "grass." This activation leads to a speeded response time when "grass" is presented as the next test item. Essentially, this is the same explanation that a single-store model would give, except that the paired associate "city grass" is in a separate, episodic, memory system. This separation of memory systems makes episodic–semantic models less parsimonious than single-store models, and so one is led to ask what episodic–semantic models can offer that single-store models cannot.

The episodic–semantic distinction has been used as a way of dividing memory into two categories. Episodic memory has been characterized as being concerned with information that has personal reference and that exhibits strong context effects (Tulving, 1972; Tulving & Thompson, 1973). Semantic memory has been characterized as being concerned with relatively permanent information that is not temporally or spatially organized by personal reference and does not exhibit strong context effects. This categorization makes the point that certain properties, such as context effects, forgetting, and personal reference, are all associated in episodic memory; where one of these properties occurs, they all occur. However, this categorization can in no way be considered an explanation of why these properties are associated. Furthermore, the categorization is not clear-cut. Context effects (recognition failure of recallable words), for example, can be found with well-known semantic information (Muter, 1978) as well as with newly learned episodic information. With respect to personal reference, Wickelgren (1977, p. 233) argues that the associations between facts and personal context can be explained without recourse to a split between episodic and semantic memories; if a semantic fact A has been associated with many different contexts, B, C, D,..., then the associations between the fact and the different contexts will interfere with each other. It is also difficult to categorize episodic memory versus semantic memory in terms of forgetting characteristics. Facts that must have been in semantic memory can be forgotten and episodic facts can be remembered many years after the event. To argue that the so-called semantic facts were really episodic, and vice versa, is to submit to tautology. In terms of the kinds of relations in the two memory systems, strict categorization is not possible because the spatial–temporal relations of episodic memory are also found in semantic memory. In summary, these arguments show that the episodic–semantic distinction, as it has been formulated theoretically, is not clear-cut.

One way to proceed in an effort to support the semantic–episodic distinction is to find direct empirical results that cannot be reasonably and parsimoniously interpreted without the distinction. Shoben, Wescourt, & Smith (1978) claim to have such results from experiments that use two tasks, verification and recognition of sentences expressing well-known facts. They find that semantic relatedness affects response times in verification, a task requiring semantic information, but does not affect response times in recognition, a task requiring episodic information. There are two problems with this result. One is that it is contradicted by previous findings that semantic variables do affect responses in tasks requiring episodic information (Gossman & Meyer, Note 1; Herrmann & McLaughlin, 1973; Lewis & Anderson, 1976; Perlmutter et al., 1976). In the experiment most analogous to that of Shoben et al. (1978), Herrman and McLaughlin (1973) found that semantic relatedness affected response times in recognition of word pairs. The second problem with the result is that it does not support episodic–semantic theories over single-store theories; the explanation by Shoben et al. of why semantic relatedness affects verification but not recognition is equally consistent with both kinds of theories. In a further result, Shoben et al. (1978) find that fanning, the number of facts studied about a concept, affects recognition but not verification. This result can be countered by findings that fanning does not always affect recognition (Hayes-Roth, 1977; Smith, Adams, & Schorr, 1978).

In the light of this discussion, we see that there is little evidence for the functional separation of the semantic and episodic memory systems. Furthermore, the results of the experiments presented in this paper support a model that assumes no functional distinction between semantic and episodic memories.

Appendix 1

Materials of Experiments 1, 3 and 4

Semantically unassociated	Semantically associated	Target	Semantically unassociated	Semantically associated	Target
naughty	afraid	scared	revenge	anger	madness
plainly	appear	see	stocking	arm	leg
widow	baby	child	divide	bake	cake
pasture	barn	cow	village	bath	clean
wicked	beautiful	ugly	costume	black	white
prison	blade	knife	painting	blossom	flower
shower	blue	sky	tiny	boy	girl
feeble	brain	wave	sugar	bread	butter
monster	butterfly	insect	export	cabbage	lettuce
velvet	carpet	rug	engine	cars	trucks
bedroom	ceiling	floor	liquor	cheese	cracker
canal	city	town	meadow	clear	foggy
hotel	cold	hot	enforce	command	order
passion	controversy	argument	invade	country	nation
fabric	covering	blanket	berry	crust	pie
cellar	dark	light	little	deep	shallow
angel	doctor	nurse	orange	dog	cat
wooden	door	knob	silver	eagle	bird
conquest	earth	ground	perform	expose	show
vanish	find	lose	jolly	foreigner	stranger
cunning	fraud	fake	decay	fruit	apple
tight	glue	stick	stay	go	come
pursue	grasp	hold	city	green	grass
orchard	grow	plant	traitor	guns	shoot
metal	hammer	nail	entire	hand	finger
ribbon	hard	soft	uncle	hate	love
narrow	head	foot	muscle	heal	wound
open	here	there	lying	high	low

APPENDIX 1—*Continued*

Semantically unassociated	Semantically associated	Target	Semantically unassociated	Semantically associated	Target
marble	house	home	alive	human	being
away	in	out	reflect	joy	happy
attempt	jump	leap	sunset	justice	peace
cookie	kind	nice	honest	king	queen
penny	large	small	log	leaf	tree
package	lift	carry	rubber	lining	coat
naked	lion	tiger	weary	live	die
tower	long	short	listen	loud	noise
patient	man	woman	notion	memory	think
proud	minor	major	opera	moon	stars
hunter	mountain	hill	gentle	music	song
picture	mutton	lamb	missing	needle	thread
legal	numbers	letters	gone	on	off
jungle	path	way	repair	pavement	sidewalk
twinkle	peek	look	college	people	crowd
active	play	games	island	porthole	ship
sacred	priest	church	boot	road	dirt
hollow	roll	ball	chimney	roof	top
sandwich	salt	pepper	beyond	satellite	space
condemn	scissors	cut	import	sell	buy
button	shine	shoe	native	sickness	health
mistress	sleep	bed	bullet	slow	fast
autumn	smell	odor	stubble	smooth	rough
attack	socialism	communism	voyage	soldier	army
mutter	speak	talk	crazy	spider	web
middle	square	round	crawl	stand	sit
kitten	stomach	food	highway	stove	pipe
danger	street	avenue	lovely	sweet	sour
parlor	table	chair	jewel	thief	steal
cook	thin	fat	author	think	study
garden	thirsty	water	machine	tobacco	smoke
traffic	trouble	bad	beggar	vegetable	carrot
began	walk	run	prairie	wet	dry
toy	wish	want	lemon	whiskey	drink
devil	whistle	blow	question	why	because
iron	window	door	legend	young	old

APPENDIX 2

MATERIALS OF EXPERIMENT 2

Semantically unassociated	Target	Semantically unassociated	Target
beggar	gallant	revenge	likely
canoe	shallow	goodbye	invite
perfume	excess	island	horror

APPENDIX 2—*Continued*

Semantically unassociated	Target	Semantically unassociated	Target
journal	author	widow	cunning
infant	wrinkle	quiet	pepper
province	campaign	forehead	asleep
winter	ski	empire	keeper
sparrow	helpless	acid	deadly
captain	lonely	weapon	cruel
virtue	mistress	castle	maiden
orchard	basket	awful	football
fountain	building	jewel	amethyst
dragon	lance	missing	complain
pony	equip	hotel	ancient
cabin	mountain	agent	struggle
danger	odor	butcher	gentle
lemon	costly	daylight	welcome
machine	exhaust	invent	harness
colonel	foreign	student	whisper
wagon	convey	artist	prairie
grateful	shepherd	rabbit	angry
opera	violin	oyster	diamond
candy	bitter	lightly	cotton
cottage	willow	pigeon	stable
ribbon	blanket	summer	envy
helmet	sergeant	autumn	perfect
merchant	offer	funeral	victim
river	country	dreadful	thunder
lady	striking	singer	excite
concert	supper	rapid	depart
purple	forest	planet	decay
amuse	uncle	berry	frozen
spider	candle	congress	resolve
mischief	darkness	bedroom	affair
cannon	assault	sailor	aboard
embrace	marriage	lawyer	robber
dislike	quarrel	baby	protect
blossom	yellow	husband	crazy
dinner	liquor	meadow	cattle
servant	perform	hunter	eagle
youthful	noble	monster	murder
onion	kitchen	scholar	college
ocean	resort	shower	moisture
velvet	garment	market	farmer
gallop	sheriff	wedding	passion
marble	rocky	pistol	fatal
twilight	golden	lazy	model
sandwich	salad	valley	pasture
travel	compass	pretty	feather
clothing	fabric	adopt	parent
kingdom	princess	luncheon	turkey
orange	button	cellar	below

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