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You Can't Always Forget What You Want: Directed Forgetting of Related Words

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Two experiments investigated the influence of directed forgetting on semantically related words versus semantically unrelated words. Subjects first studied a list in which a REMEMBER or FORGET instruction followed each word (e.g., *crab* . . . REMEMBER . . . *leg* . . . FORGET); they were tested on all of the words, regardless of study instruction. Recall and recognition—scored both for individual words and for word pairs—revealed a consistent pattern: Retention of FORGET words was markedly better when they followed related REMEMBER words, as opposed to when they followed related FORGET words or unrelated words. Thus, a pre-existing semantic relation was able to override an instruction to forget. This helps to explain why studies using unrelated word lists generally show substantial cued forgetting, whereas those using related material do not. The findings also place a clear constraint on the domain and explanation of directed forgetting.

The efficient use of memory often depends on the ability to segregate relevant from irrelevant information. For example, an aside about a rock song title during a serious discussion of research design would usually be considered irrelevant and would receive little further thought. How does one accomplish the segregation of information? In everyday situations, we generally use implicit cues inherent in the situation. However, in many instances we use explicit cues to designate information as irrelevant, such as telling someone that some information is not important, or even suggesting that they "forget it."

Investigations of the effect of explicit cues to forget on memory have been ongoing for over 25 years (e.g., Bjork, LaBerge, & Legrand, 1968; Muther, 1965). Primarily, this research has been guided by the directed forgetting paradigm (see Bjork, 1972, and Epstein, 1972, for early reviews). Here, explicit cues (e.g., a green background for remember versus a red one for forget, or the letters "RRRR" for remember versus "FFFF" for forget) typically are used during study to designate items as either "to be forgotten" (FORGET) or "to be remembered" (REMEMBER). Afterward, the experimenter's promise notwithstanding, both types of information are usually tested. Whether with "item-by-item"

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or "blocked" cues, the results indicate a decrease in recall of the FORGET information coupled with an increase in recall of the REMEMBER information. Jointly, these differences are known as the "directed forgetting effect."

Early on, Bjork (1972) proposed two related encoding processes to account for the effect: Set differentiation and selective rehearsal. Set differentiation refers to the functional separation of the FORGET and REMEMBER items as a result of the explicit cues. Given this segregation, selective rehearsal occurs only for REMEMBER information, or at least strongly favors the REMEMBER information. Selectivity in rehearsal results in an increase in performance for the REMEMBER information because fewer items need to be rehearsed and retrieved. Because the FORGET items are separated off and not processed as extensively as the REMEMBER items, they are relatively inaccessible and hence poorly remembered.

More recently, an alternative explanation has emerged. Geiselman and his colleagues (Geiselman & Bagheri, 1985; Geiselman, Bjork, & Fishman, 1983a; Geiselman, MacKinnon, Fishman, Jaenicke, Larner, Schoenberg, & Swartz, 1983b) have argued that a forget cue may also initiate a process during encoding that inhibits access to the forget information at the time of retrieval (see also Bjork, 1989). According to this view, the REMEMBER and FORGET items need not be differentially well learned for the directed forgetting effect to be evident. Instead, the FORGET items are suppressed during retrieval, unlike the REMEMBER items. Thus, the major difference in the two views is whether they attribute directed forgetting to differential encoding or to differential retrieval. Although we will not be directly testing these two views, we will consider our results in light of each of them.

The extensive documentation of the directed forgetting effect has generally been established using lists of unrelated words (e.g., Bjork, 1970; Bjork et al., 1968; Epstein & Wilder, 1972; MacLeod, 1989; Wetzel, 1975; Woodward & Bjork, 1971). Interestingly, there has been little prior research on the effect of relatedness between the REMEMBER and FORGET information in directed forgetting. This might seem surprising, given that semantic relatedness could interact with the explicit FORGET and REMEMBER cues. Semantically related words might not produce the directed forgetting effect, due to these words either (a) affecting differential encoding of the FORGET and REMEMBER items or (b) interfering with inhibition of the FORGET items.

Our review of the quarter century of research on directed forgetting revealed only two studies in which different instructions were applied to semantically related words. In both studies, subjects were instructed to forget some or all of one taxonomic category and to remember some or all of another. Woodward and Bjork (1971, Experiment 2) showed that the use of categorized lists led to subjects being considerably better at identifying the original instruction applied to a word; Horton and Petruk (1980) showed this to be especially true if the words in a category were all FORGET or all REMEMBER. Yet, an examination of the final free-recall results from both studies indicates that the category manipulation had relatively little impact on the magnitude of the directed forgetting effect.

Of course, category membership is only one type of semantic association, perhaps not the strongest one. The two studies just described do not address the question of whether unique individual pre-existing semantic relations would affect the potency of explicit cues. Could an individual semantic relation alter the pattern of greater free recall of REMEMBER words compared to FORGET words? The primary purpose of the present study was to investigate directly the interaction between pre-existing semantic relations and the effectiveness of directed forgetting. In our study, each word in a pair was explicitly cued after its presentation as either FORGET or REMEMBER using all four possible combinations of cuing (i.e., REMEMBER-REMEMBER, REMEMBER-FORGET, FORGET-REMEMBER, and FORGET-FORGET) over the two members of the pair. To test the importance of semantic relatedness, we chose to use associatively related versus unrelated word pairs such as *crab-leg*. Unrelated pairs simply recombined two related pairs, such that *crab-leg* and *seat-belt* yielded the unrelated *crab-belt*.

It is conceivable, of course, that the manipulation of prior semantic association would not affect the use of the explicit FORGET and REMEMBER cues. If so, then each word in a pair, whether meaningfully related or not, would be treated as an independent event in the face of the instructions. Essentially, the meaningful relation between words in a pair would be ignored. In this event, we would expect to obtain only a main effect of item instruction, such that the free recall would be better for individual REMEMBER words than for individual FORGET words regardless of whether the REMEMBER words: (a) were from related or unrelated pairs, or (b) occurred in the first or second position of a pair.

Given that the influence of relatedness should be found across the two words of a pair, the possibility that each word would be treated as an independent event also has implications for whether both words of a particular pair would be free recalled (i.e., free recall of both *crab* and *leg*). Basically, the probability of free recalling both words of a particular pair would always be highest for the REMEMBER-REMEMBER cuing condition, lower for the FORGET-REMEMBER and REMEMBER-FORGET conditions, and lowest for the FORGET-FORGET condition, regardless of the semantic relation between the words.

A different pattern of results would be expected if pre-existing semantic associations do affect the processing of the word pairs. In such a situation, both directed forgetting instructions and relatedness ought to exert an influence. However, because of the semantic relation, the effect of these two variables should vary across the relatedness conditions. At the simplest level of analysis, REMEMBER words should always be free recalled better than FORGET words. As well, related words—whether both REMEMBER, both FORGET, or one of each—should always be free recalled better than unrelated words. But a finer grained analysis ought to reveal a more informative pattern.

Specifically, we expected that FORGET words in the second position of a related REMEMBER-FORGET pair (e.g., crab . . . RRRR . . . leg . . . FFFF) should be difficult to forget because of the excellent bridge provided by the to-be-remembered first word of the pair. Therefore, for related pairs, there should be a performance gradient with REMEMBER-REMEMBER best, REMEMBER-FORGET second best, and the remaining two instruction combinations, FORGET-REMEMBER and FORGET-FORGET showing considerably inferior retention. For unrelated pairs, in contrast, only the REMEMBER-REMEMBER condition should stand above the others; there would be no bridging relation to help the FORGET item in the REMEMBER-FORGET condition.

A secondary purpose of our study was to compare free recall and recognition of the word pairs to assist in determining the relation between these tests in directed forgetting research. In the past, this relation has been equivocal (see Bjork, 1972), so it is important to include both measures when possible. Moreover, the differential encoding and differential retrieval accounts of directed forgetting discussed earlier make different predictions with regard to the effect of an instruction to forget on these measures. Previous studies have implicated differential encoding as a mechanism leading to the directed forgetting effect when recall *and* recognition are lower for FORGET information than REMEMBER information (e.g., Basden, Basden, & Gargano, 1993; MacLeod, 1975). Retrieval inhibition, on the other hand, has been implicated as a mechanism leading to the directed forgetting effect when (a) recall of FORGET information is less than that of REMEMBER information, but (b) recognition of the FORGET and REMEMBER information is equal (e.g., Geiselman et al., 1983a).

Experiment 1

The goal of this experiment was to manipulate inter-word relatedness in directed forgetting by using lists of word pairs. For one group, the two words in an experimental pair were always unrelated; for the other group of subjects, the words in each experimental pair were always related. This manipulation was performed between subjects to avoid any possible contamination across conditions. For example, if we manipulated relatedness within subjects, the danger existed that subjects might develop a strategy of trying to link the words in the unrelated experimental pairs following the model of the related experimental pairs. Most critically, subjects might notice that the unrelated experimental pairs could be recombined to form related pairs.

In both groups, the pair members were always presented successively with either the same instruction (i.e., FORGET or REMEMBER) or a different instruction applied to each word in the pair. This resulted in four possible instruction combinations. From our perspective, the critical combination was the REMEMBER-FORGET instruction sequence. Relatedness should exert its greatest differential effect here. Free recall and recognition of the FORGET word of this pair—and indeed of the entire pair—should be better for related pairs than unrelated pairs. We predicted that relatedness would encourage the initial REMEMBER word to assist retrieval of the subsequent FORGET word, something that cannot occur for unrelated pairs.

Method

Subjects. Forty-eight introductory psychology students at the University of Kentucky participated in partial fulfillment of a course requirement.

Materials. The experiment used the 40 critical words—12 experimental pairs and 8 control pairs—shown in the Appendix. For each subject, the 12 experimental pairs were either (a) related (e.g., *crab-leg, seat-belt*), or (b) unrelated (e.g., *crab-belt*). Unrelated pairs were formed by coupling the first word from one related pair with the second word from another related pair. The related pairs were selected from the set used by Peterson and Simpson (1989). The forward and backward association strengths for these pairs (Nelson, personal communication, August 27, 1993; see Nelson & McEvoy, 1979, for specific norming procedures) are presented in Table 1. The reassigned pairs were rated as unrelated in meaning by three independent judges.

The eight control pairs (e.g., *towel-stage*) comprised words different from those in the experimental pairs and were also rated as unrelated in meaning by three independent judges. These control pairs were included partly as fillers but also to assist in determining whether subjects processed the instructional cues appropriately. Assume that we obtained our predicted result, such that subjects remembered the FORGET word better from a related REMEMBER-FORGET pair (and both words from this pair) than from a related FORGET-FORGET pair, but that there was little difference for the corresponding unrelated pairs. Did relatedness overcome the forget cue in the REMEMBER-FORGET pair, as we hypothesized, or did subjects simply ignore the forget cue here? If subjects generally ignore a forget cue in a REMEMBER-FORGET pair, then the pattern should be evident in both related and control pairs. If, on the other hand, relatedness specifically prevents implementing a forget cue following a remember cue, then the pattern

TABLE 1
WORD-PAIR ASSOCIATION STRENGTHS

1	2	Forward strength	Backward strength	Number of *S*s rating forward	Number of *S*s rating backward
seat	belt	.01	.00	140	127
first	aid	.04	.29	184	148
swim	suit	.00	.03	178	148
jump	rope	.23	.06	180	178
crab	leg	.06	.00	148	165
ice	bucket	.01	.11	184	150
cheese	cake	.06	.00	164	184
roof	top	.20	.00	127	148
spray	paint	.03	.01	132	165
camp	fire	.14	.00	151	165
catcher	mask	—	.00	—	165
belly	button	.20	.01	144	146
check	book	.02	.00	150	127
table	cloth	.03	.01	156	165
barn	yard	.06	.00	127	127
dump	truck	.07	.02	147	148
	Mean	.08	.03	146	154
	SD	.08	.07	37	20

Note. 1 and 2 stand for first position and second position of a word in a pair. Dashes indicate a pair was not rated (Nelson, personal communication, August 27, 1993).

should only be evident in related pairs, consistent with our hypothesis.

Design. There were three independent variables, two within subjects and one between subjects. The first within-subjects variable, Instruction, was whether a given word was to-be-forgotten (FORGET) or to-be-remembered (REMEMBER). The second within-subjects variable, Pairing, was whether a given word was paired with a FORGET word or a REMEMBER word. Factorial combination of these produced four pairing-instruction combinations: REMEMBER-REMEMBER, REMEMBER-FORGET, FORGET-REMEMBER, and FORGET-FORGET. Finally, there was the between-subjects variable of Relatedness—whether the experimental word pairs were related or unrelated.

To ensure the comparability of the related and unrelated conditions, the following counterbalancing was used. For the related-pairs condition, four minilists were constructed, each containing three related pairs and two control pairs. For the unrelated-pairs condition, the same tactic was used: Four minilists were again constructed, each containing three unrelated pairs and two control pairs. Assignment of a particular minilist to one of the four pairing-instruction combinations was counterbalanced across subjects using a Latin square. Order of presentation of the 20 pairs was then randomized independently for each subject.

Procedure. Stimulus presentation was controlled by IBM-compatible PC computers. Subjects were informed that they would be participating in a memory experiment and that a list of words would be presented. Each word would appear for 1 s, followed by an instruction either to remember (RRRR) or to forget (FFFF). The instruction would remain on the screen for 3 s. Subjects were told that the list was long and they would be tested only on words they were instructed to remember, so it was a good idea to following the remember/forget instructions. They were then told that words would be presented as pairs, with a signal prior to the presentation of each new pair. Although subjects in the related pairs group were not explicitly informed of the semantic relation between the two words of some pairs, none failed to notice. A partial sequence of presentation illustrating one related pair and one control pair is shown in Table 2.

Before presentation of the critical materials, subjects received four unrelated practice pairs to familiarize them with the procedure. Then the actual experiment began. First, two unrelated REMEMBER-REMEMBER buffer pairs were presented to minimize primacy effects. Next, the 20 experimental and control pairs were presented in a random order. Finally, two more REMEMBER-REMEMBER buffer pairs were presented to minimize recency effects. Subjects then were asked to recall all the words presented to them, including the FORGET words. The free recall test was followed by a YES/NO recognition test made up of the 40 critical words and an equal number of distractors equated for word type and for word frequency using the Kucera and Francis (1967) norms.

Analyses. Two sets of analyses were conducted on both the recall and the recognition results, one on individual words and one on word pairs. The individual-word analyses allow us to compare our item-specific directed forgetting results to others in the literature; the word-pair analyses help to address the relatedness between words in a pair, treating them as a unit. For the individual-word analyses, separate 2 (Instruction) × 2 (Pairing) × 2 (Relatedness) mixed analyses of variance (ANOVA) were conducted on the free recall and recognition of words in the first and second position of a pair. (Because the words in the two positions were never the same, and because we also wanted to do item analyses, we could not treat position as a fourth independent variable.) In addition, separate 2 (Instruction) × 2 (Pairing) × 2 (Relatedness) mixed analyses of variance were conducted on the words in each position of the control pairs because these pairs contained different words than in the experimental pairs.

For the word-pair analyses, Fisher's Least Significant Difference Test (LSD) was conducted on the free recall and recognition of word pairs for each related, unrelated, and control pair. Analyses for the control pairs were conducted after collapsing across the list-wide relatedness variable because initial 4 (Instruction Combination) × 2 (Relatedness) analyses found, as expected, no effect on the control pairs of whether the experimental pairs had been related or unrelated.

TABLE 2
ILLUSTRATION OF SCREEN PRESENTATION FOR TWO-WORD PAIRS

	Time (s)
NEW PAIR	1
crab	1
RRRR	3
leg	1
FFFF	3
NEW PAIR	1
towel	1
FFFF	3
stage	1
RRRR	3

Note. RRRR and FFFF represent instructions to remember and to forget, respectively.

Results

All effects in both experiments were tested with a significance level of $p < .05$. For both experiments, all analyses were conducted twice, once using subjects as a random variable and once using items as a random variable. These analyses yielded very consistent patterns, with very few analyses significant by one type of analysis but not by the other. Any exceptions are noted in the relevant text and table. To reduce redundancy, we have chosen to present the by-subjects analyses in the text, unless otherwise noted.

Individual-word free recall. The results for individual-word free recall are presented in the top section of Table 3. We begin with words presented in the first position of a pair. The ANOVA on the experimental pairs yielded a significant main effect of Instruction, $F(1,46) = 35.86$, $MS_e = .07$. Subjects recalled considerably more REMEMBER words ($M = .34$) than FORGET words ($M = .11$). There was also a significant effect of Relatedness, $F(1,46) = 7.84$, $MS_e = .05$; first position words from related pairs ($M = .27$) were recalled better than those from unrelated pairs ($M = .18$). For words in the first position of control pairs, the only significant factor was that of Instruction, $F(1,46) = 42.23$, $MS_e = .06$. REMEMBER words ($M = .28$) were recalled better than FORGET words ($M = .05$).

These analyses for the first-position words paint a very simple picture. As expected, words in the first position showed a strong—and equivalent—directed forgetting effect whether in related, unrelated, or control pairs. For the experimental words, coming from a related pair also improved memory regardless of instruction.

We turn now to words presented in the second position of a pair. Here, the ANOVA for related and unrelated pairs once again yielded a significant main effect of Instruction, $F(1,46) = 38.42$, $MS_e = .08$. REMEMBER words ($M = .36$) were recalled considerably better than FORGET words ($M = .10$). There were also reliable main effects of Relatedness, $F(1,46) = 5.21$, $MS_e = .06$, and Pairing, $F(1,46) = 4.78$, $MS_e = .04$.

These results also yielded the more important significant interaction of Pairing with Relatedness, $F(1,46) = 11.57$, $MS_e = .04$. For the related pairs, recall of both FORGET and REMEMBER words was enhanced by being paired with a REMEMBER word in the first position ($M = .36$) compared to being paired with a FORGET word in the first position ($M = .19$), $t(23) = 3.70$. In contrast, for the unrelated condition, there was virtually no difference for words paired with a prior REMEMBER word ($M = .18$) versus a prior FORGET word ($M = .20$), $t(23) < 1$.

For words in the second position of control pairs, only the main effect of Instruction was significant, $F(1,46) = 34.54$, $MS_e = .09$. REMEMBER words ($M = .30$) were recalled better than FORGET words ($M = .05$). The magnitude of these effects was of the same order as that for the critical related and unrelated pairs.

These data for words in the second position of pairs support and extend the free recall data for words in the first position. As before (and as anticipated) there was a strong effect of Instruction, augmented by an additional contribution of Relatedness. However, for words in the second position

TABLE 3
EXPERIMENT 1: MEAN PROPORTIONS OF INDIVIDUAL WORDS RECALLED AND RECOGNIZED FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION AND POSITION

	Instruction							
	REM-REM (1 – 2)		REM-FOR (1 – 2)		FOR-REM (1 – 2)		FOR-FOR (1 – 2)	
Recall								
Related	.43	.49	.38	.22	.14	.35	.13	.04
Unrelated	.31	.28	.25	.07	.06	.33	.10	.08
Control	.24	.26	.32	.04	.06	.33	.04	.05
Recognition								
Related	.81	.69	.72	.57	.39	.76	.38	.40
Unrelated	.74	.54	.67	.37	.42	.65	.43	.38
Control	.59	.63	.63	.34	.33	.68	.45	.36

Note. REM stands for a remember instruction; FOR stands for a forget instruction. 1 and 2 stand for first position and second position of a word in a pair.

of a pair, a new factor became influential. Now the relation between the words of a pair became crucial. If the word in the first position of a pair was a REMEMBER word, then the second word was much more likely to be recalled, but this was only true for related pairs. It is harder to forget on cue if the word you are told to forget is semantically related to the immediately preceding REMEMBER word.

Word-pair free recall. The word-pair free recall data are presented in the top section of Table 4, and unambiguously support our prediction concerning relatedness. A Fisher's LSD Test (MS_e = .04, LSD = .11) indicated that the REMEMBER-REMEMBER instruction combination led to higher recall of both words of a particular pair than any of the other three instruction combinations. In addition, the REMEMBER-FORGET instruction combination led to higher recall than both the FORGET-REMEMBER and FORGET-FORGET combinations; the latter two did not differ reliably.

A Fisher's LSD Test (MS_e = .005, LSD = .06) on the unrelated pair results found the REMEMBER-REMEMBER instruction combination led to higher recall than the three other combinations; the latter three combinations did not differ reliably. Finally, for the control pairs, a Fisher's LSD Test (MS_e = .01, LSD = .04) indicated that the REMEMBER-REMEMBER instruction combination led to higher recall than the other three combinations. These latter three instruction combinations did not differ reliably. The same pattern of results for the control pairs was obtained in both experiments for all measures; the specifics of these analyses are omitted for the sake of brevity.

These word-pair recall results tell the same straightforward story as do the individual-word data. When the two words of a pair are not related, performance is uniformly poor unless both of the words are to be remembered. Probably subjects encoded the two words of a pair together when they were told to remember both items. The REMEMBER-REMEMBER combination also leads to the best performance for related words, but that performance is considerably superior to the corresponding situation with unrelated words. What is most noteworthy is that the REMEMBER-FORGET combination also leads to increased recall, but only for related words. Remembering the first word provides a bridge to the second word of such pairs, assisting their re-

TABLE 4

EXPERIMENT 1: MEAN PROPORTIONS OF WORD PAIRS RECALLED AND RECOGNIZED FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION TYPE

	Instruction			
	REM-REM	REM-FOR	FOR-REM	FOR-FOR
Recall				
Related	.42[a]	.21[b]	.08[c]	.04[c]
Unrelated	.10[a]	.03[b]	.03[b]	.01[b]
Control	.13[a]	.01[b]	.01[b]	.00[b]
Recognition				
Related	.65[a]	.44[b]	.32[b,c]	.24[c]
Unrelated	.40[a]	.23[b]	.29[a,b]	.15[b]
Control	.45[a]	.24[b]	.21[b]	.23[b]

Note. REM stands for a remember instruction; FOR stands for a forget instruction. Means in each row with different superscripts differed significantly ($p < .05$) by both subjects and items using Fisher's Least Significant Difference Test, with two exceptions: (a) the unrelated condition in recall, which differed significantly by items only, and (b) the REM-FOR and FOR-REM related conditions in recall, which differed significantly by subjects only.

trieval and reducing the impact of the forget instruction.

Individual-word recognition. The individual-word recognition results are presented in the bottom section of Table 3. Overall false-alarm rate was 11%. As with recall, the ANOVA on the words in the first position of related and unrelated pairs showed strong evidence of directed forgetting. There was a significant main effect of Instruction, $F(1,46) = 70.72$, $MS_e = .07$. Subjects recognized considerably more REMEMBER words ($M = .74$) than FORGET words ($M = .41$). For the control pairs, Instruction was also the only significant factor, $F(1,46) = 20.64$, $MS_e = 0.11$. REMEMBER words ($M = .61$) were recognized better than FORGET words ($M = .39$).

For words presented in the second position of a pair, the ANOVA for related and unrelated pairs again yielded a significant main effect of Instruction, $F(1,46) = 30.45$, $MS_e = .09$. REMEMBER words ($M = .66$) were recognized better than FORGET words ($M = .43$). There was also a reliable main effect of Relatedness, $F(1,46) = 6.74$, $MS_e = 0.11$. Related words ($M = .61$) were recognized more often than unrelated words ($M = .48$). Unlike the individual-word recall results, the interaction of Relatedness with Pairing was not significant for recognition. For words in the second position of control pairs, only the main effect of Instruction was significant, $F(1,46) = 26.88$, $MS_e = 0.16$, with REMEMBER words ($M = .66$) being recognized better than FORGET words ($M = .35$).

Like the individual-word recall results, there was a strong directed forgetting effect on recognition of words in the first position of related, unrelated, or control pairs. In addition, there was an increase in recognition for related words compared to unrelated words. For words in the second position of pairs, there were also strong effects of Instruction and Relatedness. The absence of a Relatedness × Pairing interaction for words in the second position indicates that there was a greater likelihood for subjects to recognize the second word of a related pair without recognizing the pair's first word across all of the instruction combination conditions.

Word-pair recognition. The word-pair recognition results are presented in the bottom section of Table 4. For the related pairs, a Fisher's LSD Test ($MS_e = .08$, LSD = .16) indicated that the REMEMBER-REMEMBER combination led to higher recognition than did the other three. As in recall, the REMEMBER-FORGET instruction combination led to higher recognition than did the FORGET-FORGET combination. Although numerically lower than the REMEMBER-FORGET condition, the FORGET-REMEMBER instruction combination was not reliably different from the REMEMBER-FORGET or from the FORGET-FORGET combinations.

A Fisher's LSD Test ($MS_e = .07$, LSD = .15) on the unrelated pairs indicated that the REMEMBER-REMEMBER instruction combination led to higher recognition than the REMEMBER-FORGET and the FORGET-FORGET combinations, but not the FORGET-REMEMBER combination. The REMEMBER-FORGET combination did not differ reliably from either the FORGET-FORGET or the FORGET-REMEMBER combinations. To round out the picture, the FORGET-FORGET and FORGET-REMEMBER instruction combinations also did not differ reliably.

These results are very similar to the word-pair recall results, and thus support our predictions. Recognition of both members of a pair is increased for related, unrelated, and control pairs if both words were REMEMBER words. However, only for related pairs does the REMEMBER-FORGET combination also lead to an increase in memory performance. Remembering the first word provides a link to the second word of the pair, assisting its retrieval and reducing the impact of the forget instruction. These results also indicate that although relatedness may increase subjects' recognition of related words in the second position, only when the associated first position word is to be remembered will recognition for both words of the pair be increased.

Discussion

Overall, the data tell a straightforward story. When the two words of a pair are unrelated, recall and recognition are only a function of the instruction following each word. Thus, individual REMEMBER words are remembered better than individual FORGET words, and only the REMEMBER-REMEMBER word pairs outperform the other instructional pairings. It is probably the case that subjects encoded the two words of a pair together when they were told to remember them both. What is most noteworthy is that the REMEMBER-FORGET combination leads to different results across the related and unrelated conditions. Direct manipulation of relatedness affects the degree to which subjects can differentially encode to-be-forgotten from to-be-remembered information in a standard directed forgetting situation. Differential encoding is considerably less successful when the to-be-forgotten information relates back to earlier to-be-remembered information. As a consequence, the specific FORGET word is encoded with its associated REMEMBER word, and the forgetting of both words of a pair is sharply diminished. Notice that word-pair recall and recognition of the reversed condition—FORGET before REMEMBER—shows no corresponding advantage. The pattern, then, is very much as we predicted.

Experiment 2

The second experiment was designed to replicate and extend the results of Experiment 1 by: (a) manipulating relatedness as a within-subjects factor, and (b) including a group of subjects who were only tested on their recognition of the word pairs. The purpose of the within-subjects manipulation of relatedness was to determine the extent to which experience with related information in the same list encourages subjects to adopt different strategies for remembering unrelated information. This change was also justified by the facts that: (a) the control words in Experiment 1 were not differentially affected by the rest of the list being made up of only related or only unrelated pairs, and (b) there were no other indications that such a change would be problematic. Given that Experiment 1 was the first demonstration of how individual-item relatedness could disrupt the segregation of to-be-remembered and to-be-forgotten information in directed forgetting, it was also important to demonstrate its replicability. Finally, Experiment 2 also included a new group of subjects who received only a recognition test. This was done to ensure that the consistency in recall and recognition found in Experiment 1 was not an artifact of the recall test preceding the recognition test.

Method

Subjects. Eighty introductory psychology students at the University of Kentucky who did not participate in Experiment 1 participated in this study as partial fulfillment of a course requirement. Forty-eight subjects received both a recall and a recognition task. Thirty-two subjects, tested afterward as a separate group, received only a recognition task.

Materials. The experiment involved 48 critical words comprising 16 experimental pairs and 8 control pairs (see Appendix). For each subject, the 16 experimental pairs included 8 related pairs (e.g., *crab-leg, seat-belt*) taken from Peterson and Simpson (1989), and 8 unrelated pairs formed by recombination as in Experiment 1. Recombined pairs were judged to be unrelated in meaning by three independent judges. The same control pairs were again included as a manipulation check that subjects were processing the instructional cues appropriately.

Design. The design involved the same three independent variables as Experiment 1, but now all three were manipulated within subjects. All subjects received some experimental word pairs that were related and some that were unrelated.

Four lists of word pairs were constructed; each contain two related pairs, two unrelated pairs, and two control pairs. Assignment of a particular list to an instruction combination (e.g., REMEMBER-FORGET) was counterbalanced across subjects using a Latin square. The order of presentation of the 24 critical pairs was randomized independently for each subject. The related pairs in Lists 1–4 were used to construct unrelated pairs for Lists 5–8. The control pairs remained the same, regardless of which list was presented.

Procedure, scoring, and analyses. The procedure was the same as that used in Experiment 1, except that (a) subjects received 24 critical experimental and control pairs instead of 20 pairs, and (b) 48 subjects received both the recall and the recognition task, whereas 32 subjects received only the recognition task. The same scoring method was used as in Experiment 1, and the analyses were conducted as in Experiment 1, except that semantic relatedness was analyzed as a within-subjects factor.

Results and Discussion

Individual-word free recall. The results for individual-word free recall are presented in Table 5, and offer a clear replication of the results from Experiment 1. For words presented in the first position of a pair, the ANOVA for the related and unrelated pairs yielded a significant main effect of Instruction, $F(1,47) = 68.27$, $MS_e = .14$. Subjects free recalled REMEMBER words ($M = .37$) better than FORGET words ($M = .06$). There was also a significant effect of Relatedness, $F(1,47) = 8.52$, $MS_e = .06$. Unlike Experiment 1, there was also a significant interaction between Relatedness and Pairing, $F(1,47) = 10.56$, $MS_e = .04$. For related pairs, words paired with REMEMBER words ($M = .30$) were recalled better than words paired with FORGET words ($M = .21$), $t(47) = 2.71$. In contrast, for unrelated pairs, words paired with REMEMBER words ($M = .16$) were not recalled better than words paired with FORGET words ($M = .20$), $t(47) = 1.10$, $p > .10$.

With regard to recall of words in the first position of control pairs, there was again a significant main effect of Instruction. $F(1,47) = 46.04$, $MS_e = .06$, with REMEMBER words ($M = .29$) being recalled better than FORGET words ($M = .05$). This effect was qualified by a significant Instruction by Pairing interaction, $F(1,47) = 4.56$, $MS_e = .06$. When paired with a second-position REMEMBER word, first-position words were recalled better if they were REMEMBER words than if they were FORGET words, $t(47) = 6.14$; similarly, when paired with a second-position FORGET word, first-position REMEMBER words were recalled better than first-position FORGET words, $t(47) = 4.45$. Neither of the other pairings reached significance, both $ts < 1.70$.

The ANOVA for words presented in the second position of a pair yielded the usual

TABLE 5
EXPERIMENT 2: MEAN PROPORTIONS OF INDIVIDUAL WORDS RECALLED FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION AND POSITION

	Instruction							
	REM-REM (1 – 2)		REM-FOR (1 – 2)		FOR-REM (1 – 2)		FOR-FOR (1 – 2)	
Related	.48	.44	.37	.24	.12	.35	.04	.03
Unrelated	.29	.23	.35	.04	.03	.32	.04	.08
Control	.34	.26	.24	.09	.02	.23	.07	.05

Note. REM stands for a remember instruction; FOR stands for a forget instruction. 1 and 2 stand for first position and second position of a word in a pair.

significant main effect of Instruction, $F(1,47) = 68.44$, $MS_e = .08$. REMEMBER words ($M = .34$) were recalled better than FORGET words ($M = .10$). The significant main effect of Relatedness, $F(1,47) = 17.08$, $MS_e = .05$ was qualified by the critical significant interaction of Relatedness with Pairing, $F(1,47) = 11.12$, $MS_e = .10$. For related pairs, words paired with REMEMBER words ($M = .34$) were recalled better than words paired with FORGET words ($M = .19$), $t(47) = 3.19$. In contrast, for unrelated pairs, words paired with REMEMBER words ($M = .14$) were not recalled better than words paired with FORGET words ($M = .20$), $t(47) = 1.87$, $p = .07$; indeed, the trend here was in the wrong direction.

With regard to the memory of words in the second position of control pairs, the only significant effect was that of Instruction, $F(1,47) = 16.08$, $MS_e = .09$, with REMEMBER words ($M = .25$) being recalled more than FORGET words ($M = .07$).

Word-pair free recall. The word-pair free recall results presented in Table 6 completely replicate those of Experiment 1. A Fisher's LSD Test ($MS_e = .06$, LSD = .09) on the related pairs found that the REMEMBER-REMEMBER combination led to higher recall than any of the three other combinations. In addition, REMEMBER-FORGET pairs were recalled better than either FORGET-REMEMBER pairs or FORGET-FORGET pairs, the latter two of which were not reliably different.

For the unrelated pairs, once again, a Fisher's LSD Test ($MS_e = .03$, LSD = .07) indicated the REMEMBER-REMEMBER pairs were recalled better than the three other types, and these other three instruction combinations did not differ reliably.

Individual-word recognition. The data for individual-word recognition are presented in Table 7 for (a) subjects who received a recall test prior to the recognition test (i.e., recognition last); (b) subjects who received only the recognition test; and (c) all subjects. For all subjects, there was an overall false-alarm rate of 5%. Extensive preliminary analyses of all recognition data including Test Condition (recognition last vs. recognition only) as a factor produced only a few marginal interactions either by subjects or by items, but not both. For this reason, we collapsed over Test Condition in both the individual-word and word-pair recognition analyses.

An ANOVA on the words in the first position of experimental pairs yielded results similar to those of Experiment 1. There was a significant main effect of Instruction, $F(1,79) = 121.54$, $MS_e = .19$, with REMEMBER words ($M = .75$) being recognized better than FORGET words ($M = .37$). There was also a main effect of Relatedness, $F(1,79) = 4.71$, $MS_e = .07$, with related words ($M = .58$) being recognized better than unrelated words ($M = .53$). For the control pairs, the ANOVA yielded a main effect of Instruction, $F(1,79) = 114.67$, $MS_e = .09$, with REMEMBER

TABLE 6

EXPERIMENT 2: MEAN PROPORTIONS OF WORD PAIRS RECALLED FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION TYPE

	Instruction			
	REM-REM	REM-FOR	FOR-REM	FOR-FOR
Related	.39[a]	.20[b]	.08[c]	.02[c]
Unrelated	.17[a]	.03[b]	.01[b]	.01[b]
Control	.19[a]	.03[b]	.01[b]	.00[b]

Note. REM stands for a remember instruction; FOR stands for a forget instruction. Means in each row with different superscripts differed significantly ($p < .05$) by both subjects and items using Fisher's Least Significant Difference Test.

TABLE 7

EXPERIMENT 2: MEAN PROPORTIONS OF INDIVIDUAL WORDS RECOGNIZED FOR EACH TEST CONDITION AND COMBINED ACROSS TEST CONDITION FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION AND POSITION

	Instruction							
	REM-REM (1 − 2)		REM-FOR (1 − 2)		FOR-REM (1 − 2)		FOR-FOR (1 − 2)	
Recognition last								
Related	.74	.71	.76	.50	.39	.71	.39	.34
Unrelated	.66	.60	.72	.31	.26	.71	.32	.30
Control	.72	.60	.68	.40	.27	.65	.34	.33
Recognition only								
Related	.78	.77	.83	.50	.41	.81	.37	.39
Unrelated	.84	.73	.67	.42	.44	.77	.44	.23
Control	.81	.69	.73	.33	.41	.75	.48	.34
Combined								
Related	.76	.73	.79	.50	.39	.75	.38	.36
Unrelated	.73	.66	.70	.36	.33	.73	.37	.27
Control	.76	.64	.70	.37	.33	.69	.40	.34

Note. REM stands for a remember instruction; FOR stands for a forget instruction. 1 and 2 stand for first position and second position of a word in a pair.

words (M = .73) recognized better than FORGET words (M = .36). The control words also yielded a marginal interaction of Instruction with Pairing. $F(1,79) = 3.77$, $p = .056$, $MS_e = .09$.

For the related and unrelated words in the second position, a 2 × 2 × 2 ANOVA yielded the usual significant main effect of Instruction, $F(1,79) = 152.70$, $MS_e = .12$, with REMEMBER words (M = .72) being recognized better than FORGET words (M = .38). There was also a marginal interaction of Instruction with Pairing, $F(1,78) = 3.81$, $p = .055$, $MS_e = .09$, by subjects and $F(1,14) = 3.69$, $p = .075$, $MS_e = .02$, by items. As in Experiment 1, the Relatedness × Pairing interaction was not significant.

With regard to words in the second position of control pairs, the only significant effect was that of Instruction, $F(1,79) = 57.44$, $MS_e = .13$. REMEMBER words (M = .66) were recognized better than FORGET words (M = .35).

Word-pair recognition. The data for word-pair recognition are presented in Table 8 separately for the same two Test Conditions and collapsing over them. For related pairs, a Fisher's LSD Test (MS_e = .10, LSD = .10) found that the REMEMBER-REMEMBER combination was recognized better than the other three combinations. The REMEMBER-FORGET pair also was reliably different from the FORGET-FORGET and the FORGET-REMEMBER pair, the latter two of which differed significantly.

For the unrelated pairs, a Fisher's LSD Test (MS_e = .09, LSD = .09) again indicated that the REMEMBER-REMEMBER pair had higher recognition than the other three types of pairs. Both the REMEMBER-FORGET combination and the FORGET-REMEMBER combination differed reliably from the FORGET-FORGET combination, but they did not differ from each other.

The extent of replication of the word-pair recognition results in Experiment 1 was striking. For clarity, we will point out here the few minor differences. In Experiment 1, the advantage of REMEMBER-FORGET over FORGET-REMEMBER in the recognition of related pairs was not reliable (although very much in the expected direc-

TABLE 8

EXPERIMENT 2: MEAN PROPORTIONS OF WORD PAIRS RECOGNIZED FOR EACH TEST CONDITION AND COMBINED ACROSS TEST CONDITION FOR THE RELATED, UNRELATED, AND CONTROL CONDITIONS AS A FUNCTION OF INSTRUCTION TYPE

	Instruction			
	REM-REM	REM-FOR	FOR-REM	FOR-FOR
Recognition last				
Related	.56	.45	.27	.18
Unrelated	.47	.24	.23	.08
Control	.51	.26	.21	.17
Recognition only				
Related	.58	.45	.37	.22
Unrelated	.62	.27	.37	.14
Control	.55	.27	.36	.23
Combined				
Related	.57[a]	.45[b]	.31[c]	.19[d]
Unrelated	.51[a]	.25[b]	.29[b]	.11[c]
Control	.52[a]	.26[b]	.27[b]	.27[b]

Note. REM stands for a remember instruction; FOR stands for a forget instruction. Means in each row with different superscripts differed significantly ($p < .05$) by both subjects and items using Fisher's Least Significant Difference Test.

tion); this effect was significant in Experiment 2. The same lack of a reliable difference existed between REMEMBER-REMEMBER and FORGET-REMEMBER unrelated pairs in Experiment 1; again, this was significant in Experiment 2. Finally, whereas there was no recognition advantage of either REMEMBER-FORGET or FORGET-REMEMBER pairs over FORGET-FORGET pairs for unrelated pairs in Experiment 1, these differences were reliable in Experiment 2. Perhaps this is the lone consequence of mixing related and unrelated pairs in the same list, although there was also a hint of this pattern in Experiment 1.

Apart from these small changes in the recognition data, none of which suggest different conclusions, the results of the two experiments were virtually identical. Thus, the switch from a between-subjects to a within-subjects design, and the use of a group which received only recognition, had essentially no effect. The findings we have already reported are both highly replicable and generalizable, and differential strategies apparently do not play much, if any, role.

GENERAL DISCUSSION

Our purpose was to investigate directly the relation between pre-existing semantic associations and the effectiveness of explicit REMEMBER versus FORGET cues. The results demonstrated that the well-established ability of people to forget specified information on cue is constrained in at least one important way. If subjects are asked to forget information having a direct semantic relation to other information that they have already been told to remember, the forget instruction is much less effective than usual. It appears that the related REMEMBER information provides too good a context for the forget cue to exert its usual effect. Put another way, relatedness probably undermines a person's ability to differentially encode the FORGET and the REMEMBER information, and this disruption is specific to the form of the relation.

With the two exceptions discussed in the introduction to this article (Horton & Petruk, 1980; Woodward & Bjork, 1971, Experiment 2), all prior studies of directed forgetting have distributed instructions over materials such that the FORGET information was unrelated to the REMEMBER information. Although a few directed forgetting studies have used semantically related materials (e.g., category exemplars in Elmes & Wilkinson, 1971, and in MacLeod, 1975; sentences in Geiselman, 1975), the semantic relation has been constrained to be within instruction rather than across instructions. Furthermore, even these studies are atypical in that the bulk of the directed forgetting literature has used unrelated materials. Our experiments are the first to manipulate semantic relatedness locally at the level of individual words. Our results suggest that such relatedness is important in directed forgetting, certainly at least for strongly related associates. When a FORGET word follows a REMEMBER word during the study episode, that word, and the REMEMBER-FORGET pair itself, is much less likely to be forgotten later if the two words are related than if they are unrelated. Although performance on the REMEMBER-FORGET pairs did not reach the level shown by the REMEMBER-REMEMBER pairs, it was clearly superior to that shown by the FORGET-REMEMBER and FORGET-FORGET pairs both for free recall and for recognition.

Although our results indicate that semantic relatedness is important in directed forgetting, it may not be the only type of relation that could affect the processing of to-be-forgotten information. Other preexisting associations between words (e.g., rhyming, shared initial sounds, spelling) could also have a similar effect. For example, it might be difficult to forget the second word of a REMEMBER-FORGET pair if the words rhymed, yet did not share a strong semantic relation (e.g., *cave-shave*). Future research should examine other types of relations with regard to directed forgetting.

These results are most consistent with the notion of differential encoding as an explanation of directed forgetting, although they do not completely rule out the possible contributions of inhibition (Geiselman et al., 1983a). Specifically, the pattern of results across recall and recognition was extremely consistent (see MacLeod, 1975): It did not appear to be the case that unrelated FORGET words were "released" from inhibition during recognition (see Geiselman et al., 1983a). Under differential encoding, the second word of a related pair is more likely to be encoded with the first member during study than would be the case for an unrelated pair. This is true, however, primarily when the first member of the pair is to be remembered. Although some early studies of directed forgetting found effects to be larger in recall or present only in recall (e.g., Block, 1971; Elmes, Adams, & Roediger, 1970), most subsequent studies have not found such a disparity, especially in item-by-item presentation studies (e.g., Basden et al., 1993; Bjork & Geiselman, 1978; David & Okada, 1971; MacLeod, 1975, 1989). Our results confirm those more recent findings, and extend them to the case of related materials. Such materials provide a reasonably strong test ground for differences between measures of retention.

A few years ago, one of us (MacLeod, 1989) argued in favor of the retrieval inhibition account and against the selective rehearsal account of directed forgetting. That argument hinged on then prevalent evidence that implicit measures of memory seemed insensitive to elaborative manipulations, in contrast to explicit measures (see Richardson-Klavehn & Bjork, 1988). If directed forgetting were seen as due to differential encoding—that is, as an elaborative manipulation—then it should have affected only explicit and not implicit tests. Because directed forgetting affected both types of memory tests, the retrieval inhibition account was favored. More recently, research has shown that MacLeod's (1989) results may not have been due to retrieval inhibition. Elaborative manipulations sometimes do affect implicit tests (e.g., Challis & Brodbeck, 1992; Masson & MacLeod, 1992), although perhaps less than they affect explicit tests. Thus, the logic MacLeod (1989) offered for preferring the inhibition explanation is no longer valid. It is quite plausible that the directed forgetting manipulation affects encoding—at least as plausible as that its effect is on retrieval. In our view, MacLeod's (1989) results can as readily be seen as another instance of an encoding/elaboration manipulation that affects implicit tests of memory, and hence his results are not diagnostic of retrieval inhibition.

A final note should be made about the similarity in recall and recognition results. It might have been anticipated that the greater retrieval demands of recall as compared to recognition would make the effect of relatedness more pronounced in recall, but such was not the case. In fact, the effect of relatedness was more pronounced in recognition than in recall. In recognition of the second word of a pair there was a main effect of relatedness, whereas in recall a relatedness effect was only found when the first word was a REMEMBER word.

Overall, this study has achieved its main intention of examining the impact of relatedness on the ability to forget cued information. Our conclusion is that it is much more difficult to forget specified information when that information is semantically related to other information that one is trying to remember. This conclusion has a key implication: It clearly limits the domain of both the successful application and the appropriate explanation of directed forgetting. Specifically, it may not be possible for an instruction to forget to override already existing associations, especially when one is already trying to retain some part of that association. Such a relation strongly undermines the well-intentioned subject's effort to forget specified information.

This conclusion may prove to be critical for other researchers investigating the use of explicit cues to segregate. Besides traditional directed forgetting research using unrelated words, an increasing number of studies have investigated the effect of explicit cues to segregate where relatedness crossed the remember/forget barrier. These studies have included research with behaviors (e.g., Golding, Fowler, Long, & Latta, 1990; Wyer & Unversagt, 1985), with verbal directions to a destination (Golding & Keenan, 1985), and with court transcripts or summaries (e.g., Sue, Smith, & Caldwell. 1973). Interestingly, these studies using related materials often do not find evidence of directed forgetting. The present results raised the possibility (mentioned in Golding et al., 1990) that the differences between these studies using related materials and more traditional directed forgetting studies using unrelated materials are due, at least in part, to the differing semantic relatedness of materials typically used in the two domains.

APPENDIX

The Word Pairs in Experiments 1 and 2

Related pairs: Experiment 1	Unrelated pairs: Experiment 1	Related pairs: Experiment 2	Unrelated pairs: Experiment 2	Control pairs: Both experiments
seat-belt	seat-fire	seat-belt	seat-rope	war-moon
first-aid	first-mask	swim-suit	swim-button	down-flea
swim-suit	swim-button	jump-rope	jump-fire	dagger-stool
jump-rope	jump-bucket	crab-leg	crab-belt	seek-paste
crab-leg	crab-belt	ice-bucket	ice-paint	towel-stage
ice-bucket	ice-paint	cheese-cake	cheese-suit	birth-puppet
cheese-cake	cheese-suit	roof-top	roof-cake	star-dry
roof-top	roof-aid	spray-paint	spray-yard	chip-washing
spray-paint	spray-cake	camp-fire	camp-leg	
camp-fire	camp-leg	catcher-mask	catcher-truck	

APPENDIX 1—*Continued*

Related pairs: Experiment 1	Unrelated pairs: Experiment 1	Related pairs: Experiment 2	Unrelated pairs: Experiment 2	Control pairs: Both experiments
catcher-mask	catcher-top	belly-button	belly-top	
belly-button	belly-rope	sling-shot	sling-cloth	
		check-book	check-bucket	
		table-cloth	table-shot	
		barn-yard	barn-mask	
		dump-truck	dump-book	

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