

The Role of Retrieval Practice in Directed Forgetting

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Three experiments tested the possibility that retrieval-induced forgetting is responsible for directed forgetting with the list method. In Experiments 1 and 2, additional List 2 retrieval practice was given to determine whether this would increase directed forgetting. In Experiment 1 all items came from a single category, and in Experiment 2 unrelated words were used. In Experiment 3 additional List 2 study accompanied List 2 retrieval practice. There was no evidence that List 2 retrieval practice, with or without additional List 2 study, affected the magnitude of directed forgetting. It was argued that retrieval-induced forgetting could not account for these results. Accounts with greater viability include retrieval strategy disruption and a modified version of the dissociation hypothesis.

As human beings, we each daily face the task of inhibiting some thoughts in order to more effectively process others. If we do experience difficulty in dealing with undesired information, we find ourselves at a disadvantage. There is considerable evidence that inhibitory processes decrease with age and contribute to the poorer memory performance seen in older adults (e.g., Lustig, Hasher, & Tonev, 2001; Lustig, May, & Hasher, 2001). This attests to the key role inhibition is often given in theories dealing with regulation of memory. In this report we focus on the role of inhibitory processes in producing the *list-method* directed forgetting effect.¹

When the list method is used, directed forgetting participants are asked to learn one list of items, are then told to forget it (“It was just for practice”), are asked to learn a second list of items (“the real list”), and finally are asked to recall both lists of items. Recall by these directed forgetting participants is contrasted with that of control participants who also learn two lists but are not instructed to forget the first list before learning the second list. Typically, control participants recall List 1 at least as well as they recall List 2. The forget cue has the dual effect of decreasing the recall of List 1 and increasing the recall of List 2 (MacLeod, 1998).

Because the first list has already been studied before the forget cue is given, it seems reasonable to assume that it was stored and that the directed forgetting effect results from some form of interference to List 1 retrieval combined with some facilitation to List 2 storage or retrieval. Although some have recently argued for a differential rehearsal interpretation of the directed forgetting effect (e.g., MacLeod, Dodd, Sheard, Wilson, & Bibi, in press;

Sahakyan & Delaney, 2003), the longer standing position emphasizes retrieval inhibition (e.g., B. H. Basden, Basden, & Gargano, 1993; R. A. Bjork, 1989; MacLeod, 1998; Zacks, Radvansky, & Hasher, 1996). Evidence in support of retrieval inhibition includes the finding that the directed forgetting effect does not occur on recognition tests (e.g., B. H. Basden et al., 1993; E. L. Bjork & Bjork, 1996). If the forget cue affected either List 1 or List 2 storage, it should be apparent on recognition tests as well as on recall tests.

Given the assumption that retrieval inhibition underlies the directed forgetting effect, little is known about the exact mechanism that produces it. One possible mechanism was described by Robert and Elizabeth Bjork and their associates (see R. A. Bjork, 1989). They suggested that the directed forgetting cue initiates a dissociative process that limits the participant’s access to the entire first-list episode. Support for this view comes from research by Geiselman, Bjork, and Fishman (1983), who showed that the forget cue impedes access not only to intentionally learned items but also to interspersed incidentally learned items. Because access to both is impeded, the entire first-list episode appears to be dissociated from other memories. Evidence from other experiments also supports this dissociation hypothesis. E. L. Bjork and Bjork (1996) found that reexposing some of the List 1 items eliminates the directed forgetting effect. Thus, global loss and reinstatement of List 1 is consistent with the dissociation interpretation.

The dissociation view of directed forgetting has recently faced some serious challenges. One has occurred in the context of an extension of the research reported by Geiselman et al. (1983). Kimball and Metcalfe (2001) tested directed forgetting using the Geiselman et al. procedure of interspersing intentionally and incidentally learned items. However, items were presented in five-item blocks, thus restricting opportunities for integration of incidentally

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¹ Two methods of studying directed forgetting are in common use. In the *item method* each word individually is followed by a forget or remember cue. To-be-remembered and to-be-forgotten items are randomly intermingled during list presentation. The directed forgetting effect obtained with the item method is commonly attributed to differential rehearsal rather than retrieval inhibition (e.g., B. H. Basden et al., 1993).

learned items with intentionally learned items. Furthermore, incidentally learned items were imaged individually and size judgments rendered for each. Although the forget cue impaired recall of intentionally learned items, recall of incidentally learned items was not significantly impaired. Kimball and Metcalfe's results do not support the dissociation hypothesis because participants did not lose access to the list as a whole.

Another challenge to the dissociation hypothesis has come from tests of the finding (E. L. Bjork & Bjork, 1996) that reexperiencing only some of the items from List 1 reinstates the entire list as a unit. B. H. Basden, Basden, and Wright (in press) tested for release of retrieval inhibition by re-presenting 0%, 25%, 50%, 75%, or 100% of the items from List 1. They found that List 1 items were indeed recovered on a subsequent recall test, but recovery occurred only for those items that were reexposed rather than for the entire list. The effect of this partial recovery of List 1 items was a general decrease in List 2 recall, resulting in concomitant loss of the directed forgetting effect. It appears, then, that inhibition can influence individual items rather than the list as a whole. Viewed in this way, there is little to distinguish dissociation from other concepts of retrieval inhibition that apply to retrieval of individual target items.

An inhibitory mechanism that would apply to individual items can be inferred from theoretical ideas developed by Michael Anderson in conjunction with the Bjorks (Anderson, Bjork, & Bjork, 1994). In their retrieval practice procedure (Anderson et al., 1994), participants studied items from several taxonomic categories and were then given three retrieval practice tests. Retrieval practice was given on half of the items from half of those categories—for example, participants were asked to recall *orange* when cued by *Fruit—Or*. They did not engage in retrieval practice with *Fruit—Ba*, where *banana* was also a studied exemplar. On a subsequent test, recall of unpracticed members of practiced categories—for example, *banana*—was less than recall of unpracticed members of unpracticed categories. Anderson et al. argued that competitors to practiced items occurred implicitly during retrieval practice and were inhibited. Inhibition resulting from retrieval practice lasts 20 min and probably longer (Anderson et al., 1994).

It seemed to us that inhibition of unpracticed items might occur in list-method directed forgetting. When the forget cue is given, the to-be-forgotten items from List 1 may well come to mind during List 2 study and be inhibited. This idea is supported by the finding that directed forgetting fails if the forget cue for List 1 is not followed by List 2 learning (Gelfand & Bjork, 1985; see R. A. Bjork, 1989, for a complete description). In the absence of second-list learning, there would be no opportunity for retrieval-induced forgetting. Furthermore, Conway, Harries, Noyes, Racsma'ny, and Frankish (2000) and Macrae, Bodenhausen, Milne, and Ford (1997) have reported directed forgetting research that can be interpreted as consistent with the retrieval-induced forgetting interpretation. They found that when participants perform a secondary task during List 2 study, List 1 recall is sharply improved. Conway et al. argued that the attentional demands of performing the secondary task prevent participants from inhibiting the competing items from List 1.

Retrieval-induced forgetting provides such a clean, straightforward explanation of retrieval inhibition in directed forgetting that we decided to put it to the test. In our procedure, participants were given additional retrieval practice on List 2 after they had initially

studied that list but before they were given the final recall test on both lists. If additional retrieval practice on List 2 does reduce List 1 recall, then it is reasonable to assume that retrieval-induced forgetting underlies retrieval inhibition of List 1 during initial study of List 2. Note that, like Conway et al. (2000), we assume that directed forgetting groups are more likely than control groups to inhibit List 1 items that come to mind during List 2 study.

Experiment 1

To test the retrieval-induced forgetting view of directed forgetting, we interpolated 0, 1, or 3 retrieval practice tests on List 2 between initial study of the two lists and their final recall. Retrieval practice tests required participants to recall as many List 2 items as they could. Both lists contained items drawn from the taxonomic category of four-footed animals. Lists drawn from a single category were used because testing conditions would better simulate those that have been used to study retrieval-induced forgetting—that is, exemplars from List 1 were expected to compete for recall with exemplars from List 2 during List 2 study. The process is a direct analogue of the competition of unpracticed with practiced exemplars in the Anderson et al. (1994) retrieval practice paradigm. The hypotheses were that (a) the directed forgetting effect would be greater with retrieval practice tests than without and (b) the directed forgetting effect would increase with increasing amounts of interpolated retrieval practice.

Method

Design. We used a mixed three-factor design with group (directed forgetting and control) and number of retrieval practice tests on List 2 (0, 1, and 3) as between-subjects factors and list (List 1 and 2) as a within-subjects factor.

Participants. We tested 109 introductory psychology students at California State University, Fresno. They served in partial fulfillment of course requirements. Although a block-randomization assignment procedure was in use, the six groups varied in size from 17 to 20.

Materials and apparatus. The study materials comprised 24 instances drawn from the four-footed animal category (Battig & Montague, 1969). The median rank in taxonomic frequency was 37, with items ranging from high (e.g., *horse*) to low (e.g., *badger*). All selected items were judged to be orthographically dissimilar yet familiar exemplars of the category. The 24 items were randomly divided into two lists of 12 items each, and the instances were randomly ordered within each list. The random selection and ordering processes were carried out independently for each individual participant tested; that is, each participant studied a unique composition of List 1 and List 2 items.

A filler task was used for those participants given fewer than three retrieval practice tests. The name of a randomly selected state capital was displayed, and the participant's task was to type the two-letter postal code for its state. The 50 postal codes were listed to help the participant with this task. When the participant made an error, he or she was required to keep trying until the correct code was entered.

All instructions, lists, and other materials were displayed on a computer monitor. The participants typed all responses at the computer keyboard.

Procedure. Each participant was tested alone in a small cubicle. The experimenter entered the condition code into the computer, told the participant to read the monitor screen and follow the instructions, and then left the room. The instructions informed the participant that he or she would see a list of four-footed animals to study and would be tested later. The words were presented at a 4-s rate. After the first list of 12 words was presented, additional instructions were displayed. These informed directed forgetting

groups that the initial list was just for practice and should be forgotten. The upcoming list was the one to be remembered. The instructions informed control groups that they had seen one list and that a second list of items must also be learned. The second list of 12 words was then displayed at the same rate as the first. At the conclusion of list presentation, each participant engaged in 30 s of addition practice as a recency control. Two randomly selected nonzero digits were displayed, and the participant typed the sum for each set of numbers in turn.

After the recency control task, participants were given either 0, 1, or 3 retrieval practice tests. Before each retrieval practice test, they were instructed to recall as many words as they could from the second list they had studied. No feedback was given as to the list membership of the items that were actually recalled. Participants given fewer than three retrieval practice tests were kept busy for an equivalent time with the interpolated state-naming task. For participants given only one retrieval practice test, the state-naming task preceded that test. The duration of each retrieval practice test was 60 s, so the participants given 0 or 1 retrieval practice tests were engaged in the interpolated state-naming task for 3 min or 2 min, respectively.

The final task was a recall test for both lists. The instructions made it abundantly clear to both control and directed forgetting participants that they were to recall as many words from both of the studied lists as they could. This final test continued for 2 min.

Results

An alpha level of .05 was adopted for all statistical tests in this report. Table 1 contains the mean proportions of List 1 and List 2 items recalled on the final test by the directed forgetting and control groups as a function of the number of retrieval practice tests.

We performed a three-factor mixed analysis of variance (ANOVA) with group (directed forgetting and control) and prior retrieval practice tests (0, 1, and 3) as between-subjects factors and list (List 1 and 2) as a within-subjects factor. As indicated earlier, control participants typically recall List 1 at least as well as List 2, but directed forgetting participants recall List 2 better than List 1. Therefore, with our analysis, a directed forgetting effect would be indicated by an interaction between group and list. This interaction was significant, $F(1, 103) = 9.38, MSE = .02$. List 2 recall was significantly better than List 1 recall for directed forgetting participants, $F(1, 50) = 20.02, MSE = .02$, but not for control participants ($F < 1$). Although the overall main effect of list was significant, $F(1, 109) = 12.17$, no other effects approached significance in the overall analysis. In other words, retrieval practice

failed to influence recall overall and the magnitude of the directed forgetting effect in particular.

It is conceivable that participants mistakenly practiced and strengthened as many List 1 items as List 2 items during retrieval practice. If so, retrieval practice could hardly be expected to increase the directed forgetting effect. To determine whether that was the case, we performed statistical analyses on items recalled during the retrieval practice tests. Table 2 contains the mean proportions of List 1 and List 2 items recalled on each retrieval practice test. The means for Test 1 are based on data from participants given both one and three retrieval practice tests. Of course, the means for Tests 2 and 3 could be based only on the data from participants given three retrieval practice tests. As can be seen in the table, far more List 2 than List 1 items were recalled by each group on each test. We performed a mixed three-factor ANOVA on these data with groups as a between-subjects factor and both list and retrieval practice test as within-subjects factors. Only the data from participants given three retrieval practice tests were used in this analysis. Overall recall was greater for the directed forgetting participants ($M = .29$) than for the control participants ($M = .25$), $F(1, 35) = 6.09, MSE = .02$. Recall was greater for List 2 ($M = .42$) than for List 1 ($M = .12$), $F(1, 35) = 167.13, MSE = .03$. The interaction between list and group was also significant, $F(1, 35) = 5.03$, reflecting a larger difference between List 2 and List 1 recall for the directed forgetting groups than for the control groups. The interaction between test and list was also significant, $F(2, 35) = 3.64, MSE = .03$, reflecting a slight decrease in the difference between List 1 and List 2 recall as the number of retrieval practice tests increased. No other effects approached significance ($F_s < 1$). Clearly, participants practiced retrieving more List 2 than List 1 items.

Discussion

As expected, we observed directed forgetting. List 2 was recalled better than List 1 with the forget instruction but not with the remember instruction. Contrary to our hypothesis, the magnitude of the directed forgetting effect was not increased by additional List 2 retrieval practice but instead appeared to be slightly reduced by it. Participants recalled a moderate number of List 2 items during retrieval practice tests. In particular, the directed forgetting groups recalled considerably more List 2 than List 1 items. Thus, there was more opportunity for additional retrieval-induced forgetting for directed forgetting groups than for control groups. Despite this, directed forgetting did not increase as a function of increased retrieval practice.

More than 10% of List 1 items were recalled during retrieval practice tests on List 2. It is reasonable to assume that List 1 items occurred as intrusions because participants failed to accurately identify the source of those items. Geiselman et al. (1983) reported evidence of poor source memory in directed forgetting. List 1 items misidentified as List 2 items might be rehearsed, with the resultant strengthening of List 1 items being more likely for control participants than for directed forgetting participants. Of course, inadvertent rehearsal may also be present in standard directed forgetting procedures. The possibility of continued rehearsal of List 1 during List 2 learning is discussed in more detail below in conjunction with Experiment 3.

Table 1
Mean Proportions of List 1 and 2 Items Recalled on the Final Recall Test in Experiment 1 as a Function of Prior Retrieval Practice

Group	Prior retrieval practice		
	0	1	3
Directed forgetting			
List 1	.35	.42	.43
List 2	.50	.54	.52
Control			
List 1	.48	.41	.41
List 2	.42	.45	.45

Table 2
Mean Proportions of List 1 and 2 Items Recalled During Retrieval Practice Tests in Experiment 1

Group	Retrieval practice test		
	1	2	3
Directed forgetting			
List 1	.10	.11	.14
List 2	.48	.47	.46
Control			
List 1	.11	.14	.13
List 2	.39	.38	.37

Note. Results for groups given one and three retrieval practice tests are combined for the first retrieval practice test; results for groups given three retrieval practice tests are shown for the second and third retrieval practice tests.

List 2 retrieval practice did not significantly affect List 2 recall on the final test. If nothing else, overt rehearsal during retrieval practice tests should have increased retention of List 2 items over the 3-min interval between List 2 study and the final test.

There are a number of explanations for the absence of retrieval-induced forgetting with our procedures. In the standard retrieval-induced forgetting procedure, retrieval cues are provided to control which items are practiced. We could similarly have guided retrieval to specific List 2 items—for example, by providing a cue such as *Animal—Sk* to cue the recall of *skunk*—but our intention was to determine whether retrieval-induced forgetting influences directed forgetting under conditions that prevail under standard directed forgetting procedures. We see no evidence from the results of Experiment 1 that it does.

Another possibility is that participants practiced only easily retrieved List 2 items, thus preventing competition from List 1 items. However, retrieval practice tests on List 2 apparently brought a number of List 1 competitors to mind as indicated by the relatively high percentage of overt intrusions from List 1. In any case, guided retrieval practice as used in retrieval-induced forgetting procedures (Anderson et al., 1994) seems even less likely than ours to encourage retrieval of competing uncued items from the same category. For example, why would a participant, when cued with *Fruit—Or*, retrieve *banana*?

A third possibility is that List 1 recall was not decreased by additional retrieval practice on List 2 because retrieval-induced forgetting was already asymptotic after a single study trial.² This interpretation seems strained in that the retrieval-induced forgetting procedure (e.g., Anderson et al., 1994) typically involves presentation of three successive retrieval practice tests, just as ours does. In addition, the initial strength of the cue to target association (e.g., *Fruit—Apple*) is stronger than with our materials (e.g., *Animal—Skunk*).

As mentioned previously, we chose to use the same category of items in both lists to favor the occurrence of retrieval-induced forgetting. However, because of our use of the same category, retrieval practice on List 2 may have ensured the continued implicit activation of List 1. Anderson and McCullough (1999) suggested that when practiced and unpracticed items are strongly related, participants may form integrated units that negate the inhibitory effects of retrieval practice. If this were the case with the

single-category lists we used, interlist item integration might account for our failure to observe an increase in directed forgetting with additional retrieval practice. Use of the same category in the two lists might also have increased the occurrence of List 1 intrusions not discriminated from List 2 items during retrieval practice. Participants might be better able to discriminate between List 1 and List 2 items during retrieval practice tests if the two lists are not drawn from the same category. These considerations led us to replicate Experiment 1 with lists composed of unrelated words. Of course, should we find that additional retrieval practice increases the directed forgetting effect when unrelated words are used, we would face the problem of explaining why the directed forgetting effect occurs at all when related words are used.

Experiment 2

Once again, our hypothesis was that additional retrieval practice on List 2 would increase the directed forgetting effect. Lists of unrelated words were used (a) to prevent interlist item integration during retrieval practice and (b) to reduce List 1 intrusions during retrieval practice tests on List 2.

Method

Participants. We tested 146 participants of the same description as in Experiment 1. Although a block-randomized assignment procedure was in use, actual group sizes varied from 21 to 26.

Materials and apparatus. The materials and apparatus were the same as those used in Experiment 1 with the exception of the list items. In this experiment the list comprised 24 unrelated words in place of the 24 category exemplars used in Experiment 1. Two-syllable five- to seven-letter words were selected from the Paivio, Yuille, and Madigan (1968) norms so that all were medium to high (A) in frequency and moderately high in imagery ($M = 5.83$).

Design and procedure. All aspects of the design and procedure in this experiment were identical with those used in Experiment 1.

Results

Table 3 contains the mean proportions of List 1 and List 2 items recalled on the final test by the directed forgetting and control groups as a function of the number of retrieval practice tests on List 2.

A mixed three-factor ANOVA was performed with group (directed forgetting and control) and number of prior retrieval practice tests (0, 1, and 3) as between-subjects factors and list (List 1 and 2) as a within-subjects factor. Prior retrieval practice increased final recall, $F(2, 140) = 10.10$, $MSE = .05$. List 2 ($M = .39$) was recalled better than List 1 ($M = .30$), $F(1, 140) = 23.25$, $MSE = .02$. As in Experiment 1, group interacted with list, $F(1, 140) = 7.95$. The difference between List 2 and List 1 recall was significant with the forget cue, $F(1, 71) = 27.69$, $MSE = .02$, but not with the remember cue, $F(1, 69) = 2.13$, $MSE = .02$. No other effects were significant in the main analysis.

² We are grateful to Patrick Dolan for pointing out this possibility. Results of Experiment 2, as contrasted with Experiment 1, bear out the possibility that initial strength of the association between the retrieval cue and the item may influence the effect of retrieval practice tests.

Table 3
Mean Proportions of List 1 and 2 Items Recalled on the Final Recall Test in Experiment 2 as a Function of Prior Retrieval Practice

Group	Prior retrieval practice		
	0	1	3
Directed forgetting			
List 1	.22	.29	.36
List 2	.33	.47	.48
Control			
List 1	.27	.36	.33
List 2	.26	.37	.45

As in Experiment 1, we performed statistical analyses on items recalled during the retrieval practice tests. The mean proportions of List 1 and List 2 items recalled during retrieval practice tests are shown in Table 4. The means for Test 1 include data for groups given both one and three retrieval practice tests. A mixed three-factor ANOVA was performed with groups (directed forgetting and control) as a between-subjects factor and retrieval practice test (1, 2, and 3) and list (1 and 2) as within-subjects factors. Only data from participants given three retrieval practice tests were included in this analysis. Recall was greater for List 2 ($M = .45$) than for List 1 ($M = .10$), $F(1, 43) = 86.45$, $MSE = .10$. No other effects approached significance ($F_s < 1$). These results verify that participants practiced more List 2 than List 1 items.

Discussion

The only methodological difference between Experiments 1 and 2 was our use of unrelated words in Experiment 2 in place of exemplars of the four-footed animal category in Experiment 1. We had speculated that the lack of an effect of List 2 retrieval practice on the directed forgetting effect in Experiment 1 resulted from our use of lists from a single category. Interlist integration might have prevented retrieval-induced forgetting from taking place. We had, therefore, expected use of unrelated words in this experiment to result in an increase in the directed forgetting effect with additional List 2 retrieval practice. Contrary to this expectation, retrieval practice tests on List 2 again failed to increase the magnitude of the directed forgetting effect.

Although the results of the two experiments were generally similar, there was one major difference between the two. Retrieval practice significantly increased final recall levels for both lists in Experiment 2 but not in Experiment 1. One explanation for the difference is that initial recall levels were lower in Experiment 2 than in Experiment 1. As a consequence, items were further from asymptote and more susceptible to the strengthening effects of retrieval practice. As can be seen in Table 3, increased recall of List 2 with additional retrieval practice produced a paradoxical directed forgetting effect in control participants. However, paradoxical directed forgetting was not the result of decreased final recall of List 1 and hence is contrary to a retrieval-induced forgetting interpretation of directed forgetting.

Although increased final recall through retrieval practice may resemble hypermnnesia, in a strict sense hypermnnesia was absent because recall during the retrieval practice tests themselves did not

increase. Perhaps because participants were told to recall only List 2 items during retrieval practice, they withheld items of uncertain list membership. Because items from both lists are acceptable on the final test, restraint is no longer exercised. The chief importance of the increase in List 2 recall on the final test is that it is inconsistent with retrieval-induced forgetting. During retrieval practice tests, items of uncertain list membership that compete with List 2 items should have been inhibited, resulting in decreased rather than increased recall.

Retrieval practice was no more effective in increasing directed forgetting with unrelated words than with categorized words. However, List 1 intrusions were less frequent in Experiment 2 than in Experiment 1, which may indicate less interlist integration in Experiment 2. Despite the decrease in intrusions, List 1 recall did not decrease more for directed forgetting groups than for control groups. Thus, the results of Experiment 2 provide no greater support for the idea that retrieval-induced forgetting underlies directed forgetting than do the results of Experiment 1. Of course, fewer List 1 intrusions in Experiment 2 than in Experiment 1 also suggest that the four-footed animal category does indeed provide a more effective cue for the retrieval of competing items during retrieval practice than do unrelated words, just as we had anticipated.

As mentioned earlier, directed forgetting does not occur in the absence of new learning. Perhaps, as suggested by Conway et al. (2000), it is retrieval-induced forgetting that occurs during List 2 study that inhibits List 1. In Experiment 3, we extended the design to include additional study trials on List 2 to determine whether these would increase the directed forgetting effect.

Experiment 3

In this experiment we varied both the number of interpolated List 2 study trials and the number of interpolated List 2 retrieval practice tests. If retrieval-induced forgetting occurs during List 2 study, then additional List 2 study should increase directed forgetting. Our results from Experiments 1 and 2 suggest that retrieval practice tests alone will have relatively little influence on the directed forgetting effect.

Table 4
Mean Proportions of List 1 and 2 Items Recalled During Retrieval Practice Tests in Experiment 2

Group	Retrieval practice test		
	1	2	3
Directed forgetting			
List 1	.13	.12	.11
List 2	.46	.45	.46
Control			
List 1	.07	.08	.08
List 2	.44	.45	.45

Note. Results for groups given one and three retrieval practice tests are combined for the first retrieval practice test; results for groups given three retrieval practice tests are shown for the second and third retrieval practice tests.

Method

Design. A mixed four-factor design was used with groups (directed forgetting and control), number of interpolated study trials on List 2 (0 and 3), and number of retrieval practice tests on List 2 (0 and 3) as between-subjects factors. List (List 1 and 2) was manipulated within subjects.

Participants. We tested 234 participants of the same description as in our earlier experiments. Although a block-randomization assignment procedure was in use, group sizes varied from 26 to 32.

Apparatus and materials. The word pool was increased to 30 unrelated words by adding 6 more unrelated words to the pool used in Experiment 2. The apparatus and materials were in all other respects the same as in the earlier experiments.

Procedure. The procedure was the same as in Experiments 1 and 2 with the following exceptions. Participants received either 0 or 3 additional List 2 presentations and either 0 or 3 List 2 retrieval practice tests. These were interpolated between the initial study trial on List 2 and the final recall test for both lists. The single retrieval practice test condition of Experiments 1 and 2 was omitted in this experiment. When both List 2 retrieval practice tests and additional List 2 study trials were given, each study trial was followed by a retrieval test. As in previous experiments, participants receiving fewer than three interpolated study trials and three retrieval practice tests were kept busy with state-naming tasks for an equivalent period of time—that is, the final recall test was delayed so that it was separated from the presentation of Lists 1 and 2 by the same interval of time in all conditions. For participants given only interpolated study trials, the state-naming task followed each of the three trials. For participants given only retrieval practice tests, the state-naming task preceded each such test. We increased the list length to 15 unrelated words per list to avoid a ceiling effect from the additional study trials.

Results

The mean proportions of words recalled on the final test from each list in each condition are shown in Table 5. It is confusing to contrast List 1 recall with List 2 recall when study is not equivalent for the two lists. In this experiment all of the participants studied List 1 only once, but some of the participants studied List 2 once and others studied it on three additional trials. For this reason we chose to examine the effects of the between-subjects factors separately for List 1 and List 2 in this experiment. This denies us the power advantage of a repeated measures analysis but presents us with a more easily interpreted result.

Final test List 1 recall. We performed a completely randomized three-factor ANOVA on List 1 recall with group, number of study trials, and number of prior retrieval practice tests as between-subjects factors. Recall was poorer for those given the forget cue

($M = .16$) than for those given the remember cue ($M = .22$), $F(1, 226) = 6.15$, $MSE = .17$. List 1 recall was poorer with three List 2 interpolated study trials ($M = .14$) than with no additional List 2 interpolated study trials ($M = .24$), $F(1, 226) = 16.91$. However, as can be seen in Figure 1, there was no hint of an interaction between group and number of study trials ($F < 1$), so additional study of List 2 did not increase the difference between directed forgetting and control participants in List 1 recall. Number of prior retrieval practice tests did not affect the difference between directed forgetting and control groups in List 1 recall ($F < 1$), but the interaction of interpolated study trials and retrieval practice tests approached significance, $F(1, 226) = 2.78$, $p = .09$, suggesting that retrieval practice may have increased that difference somewhat more when additional study trials were given than when they were not. The absence of a significant interaction between group and prior retrieval practice ($F < 1$) indicates that additional retrieval practice, like additional study, did not increase the difference between directed forgetting and control participants in List 1 recall. In summary, neither additional study trials nor retrieval practice tests had greater influence on the List 1 recall for directed forgetting groups than for control groups.

Final test List 2 recall. We performed the same analysis for List 2 recall as we had performed for List 1 recall. As is usually the case, List 2 recall was better for participants given the forget cue ($M = .50$) than for participants given the remember cue ($M = .46$), $F(1, 226) = 5.34$, $MSE = .03$. Not surprisingly, List 2 recall was greater with three interpolated study trials on List 2 ($M = .68$) than with no additional interpolated study trials on List 2 ($M = .30$), $F(1, 226) = 260.28$. The interaction between group and number of study trials approached significance, $F(1, 226) = 3.41$, $p = .07$. The boost to List 2 recall enjoyed by the directed forgetting participants with no additional List 2 study was essentially gone after three additional trials of List 2 study. Recall was greater after three prior retrieval practice tests on List 2 ($M = .55$) than after no prior retrieval practice tests on List 2 ($M = .41$), $F(1, 226) = 39.83$. No other effects approached significance.

Recall on retrieval practice tests. The proportions of List 1 and List 2 words recalled on retrieval practice tests are shown in Table 6 for each of the four groups given such tests. As can be seen, participants clearly recalled more List 2 words than List 1 words during retrieval practice tests on List 2. This is despite the wide variation in List 2 recall across conditions and tests.

We performed a mixed three-factor ANOVA on List 1 intrusions during List 2 retrieval practice tests with group (directed forgetting and control) and number of interpolated study trials (0 and 3) as between-subjects factors and retrieval practice test (1, 2, and 3) as a within-subjects factor. As one might expect, the intrusion rate was greater when participants did not see List 2 three additional times ($M = .07$) than when they did ($M = .01$), $F(1, 117) = 26.69$, $MSE = .01$. The interaction between number of interpolated study trials and number of retrieval practice tests was also significant, $F(2, 234) = 5.23$, $MSE = .003$. List 1 intrusions declined over tests when participants were given additional study trials on List 2, but not when there were no additional study trials on List 2. No other effects approached significance.

A similar analysis was performed on List 2 recall during retrieval practice tests. The interaction of group, number of interpolated study trials, and retrieval practice test was significant, $F(2, 234) = 7.86$, $MSE = .01$. List 2 recall remained essentially

Table 5
Mean Proportions of List 1 and 2 Items Recalled on the Final Test in Experiment 3 as a Function of Prior Retrieval Practice (PRP) and/or Interpolated Study Trials (IST)

Group	PRP 0		PRP 3	
	IST 0	IST 3	IST 0	IST 3
Directed forgetting				
List 1	.21	.14	.22	.07
List 2	.31	.59	.38	.77
Control				
List 1	.23	.20	.28	.17
List 2	.16	.58	.33	.76

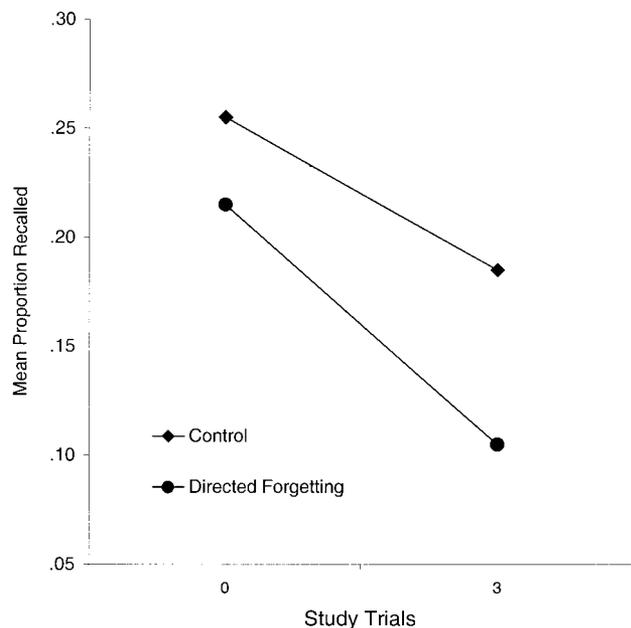


Figure 1. Mean proportional recall of List 1 as a function of number of interpolated study trials and group in Experiment 3.

unchanged across tests when there were no additional study trials but increased across tests when there were three additional study trials. That increase was more marked for participants given the remember cue than for participants given the forget cue. The initial advantage in List 2 recall for directed forgetting participants had essentially disappeared after three additional study trials on List 2.

Discussion

The purpose of this experiment was to determine whether retrieval-induced forgetting increases the directed forgetting effect when retrieval practice is combined with additional study of List 2. Giving additional List 2 study trials and retrieval practice tests should provide more opportunity for List 1 items to come to mind and be inhibited by directed forgetting participants. Although recall of List 1 was reduced by additional study of List 2, this reduction occurred to the same degree for participants given the remember cue as for participants given the forget cue. This reduction is, therefore, more likely a function of increased retroactive interference than of retrieval-induced forgetting. The advantage in List 2 recall normally enjoyed by directed forgetting participants was essentially eliminated by additional List 2 study. In other words, additional List 2 study did not alter the effect of the forget cue on List 1 recall and reduced the effect of the forget cue on List 2 recall. There appears to be no evidence from this experiment to support the idea that additional retrieval practice on List 2 increases the directed forgetting effect.

General Discussion

We began this research with the idea that retrieval-induced forgetting might be the mechanism to explain the retrieval inhibition seen in list-method directed forgetting. In Experiment 1 we

used members of a single category for both lists and found additional retrieval practice for List 2 had no effect on the magnitude of the directed forgetting effect. We entertained the possibility that using words from a single category for both lists resulted in interlist integration. Therefore, in Experiment 2 we switched to unrelated words. Once again, retrieval practice on List 2 failed to increase the magnitude of the directed forgetting effect. Because retrieval practice in the Anderson et al. (1994) paradigm involves additional study of some list items during guided retrieval practice, we considered the possibility that retrieval practice is ineffective in the absence of additional study. Therefore, we included additional List 2 study trials in Experiment 3. Although additional List 2 study boosted List 2 recall and reduced List 1 recall, it affected directed forgetting and control groups in the same way. Therefore, we have found no evidence that additional retrieval practice on List 2 increases the magnitude of the directed forgetting effect. Although we cannot rule out the possibility that retrieval-induced inhibition makes a small contribution to directed forgetting, it seems clear that some other mechanism (or mechanisms) make more important contributions to the phenomenon. Perhaps the “no-think” mechanism recently outlined by Levy and Anderson (2002) will suffice.

The provision of additional study trials on List 2 also provides a test of differential rehearsal accounts of directed forgetting. In addition to Kimball and Metcalfe (2001), MacLeod et al. (in press) conducted research interpreted as evidence inconsistent with inhibition that could instead be best interpreted in terms of differential rehearsal. According to that interpretation, the forget cue curtails rehearsal of List 1 and enhances rehearsal of List 2. Earlier we mentioned that new learning (i.e., learning of List 2) is a prerequisite to obtaining the directed forgetting effect (Gelfand & Bjork, 1985). According to the differential rehearsal hypothesis, it would have to be the case that control participants continue to rehearse List 1 during List 2 study, but directed forgetting participants do not. However, in all three experiments reported here, increased opportunity to rehearse List 2 failed to influence the magnitude of directed forgetting. This failure occurred when rehearsal practice tests on List 2 were given alone (Experiments 1 and 2), when additional study trials on List 2 were given alone (Experiment 3), and when both additional List 2 study and List 2 retrieval practice were given (Experiment 3). If we are to accept the curtailed List 1

Table 6
Mean Proportions of List 1 and 2 Items Recalled During Retrieval Practice Tests (RPT) in Experiment 3

Group	IST 0			IST 3		
	RPT			RPT		
	1	2	3	1	2	3
Directed forgetting						
List 1	.08	.08	.09	.03	.00	.00
List 2	.35	.34	.33	.55	.70	.75
Control						
List 1	.05	.07	.06	.03	.01	.00
List 2	.33	.24	.28	.45	.69	.77

Note. Data only from groups given three retrieval practice tests are included. IST = interpolated study trial.

rehearsal hypothesis, we would have to assume that List 1 rehearsal continues during initial List 2 presentation but not during additional List 2 study or retrieval practice tests. Although certainly possible, this alternative seems unlikely.

Other evidence that speaks against a differential rehearsal interpretation are findings indicating that (a) performance on implicit tests is equivalent for Lists 1 and 2 (B. H. Basden et al., 1993), (b) recognition is equivalent for Lists 1 and 2 (B. H. Basden et al., 1993), and (c) more List 1 than List 2 items are added to recall and more List 2 than List 1 items are lost from recall with reexposure (B. H. Basden et al., in press).

According to Sahakyan and Delaney (2003), the forget cue has two effects: It results in a decrease in List 1 recall (attributed to context change) and an increase in List 2 recall (attributed to the participants' changing to a more effective encoding strategy). Sahakyan and Kelley (2003) first suggested the context-change interpretation of directed forgetting. Final recall is said to favor List 2 because the context at final recall overlaps more with that during List 2 study than during List 1 study. We see no evidence here in support of the context-change hypothesis inasmuch as additional retrieval tests on List 2 were no more advantageous to List 2 recall than was our filler task. For participants who did not complete retrieval practice tests or study-retrieval practice tests, the intervening time was spent on an interpolated task that did not resemble List 2. For those participants, the List 2 context would no longer be in place. As a result, the context-change interpretation would predict increased directed forgetting after interpolated practice on List 2 because the List 2 context would remain dominant. That interpretation also fails because it cannot account for the findings in which some but not all of List 1 is inhibited. Thus, the context-change interpretation of directed forgetting has the same weakness as the original dissociation hypothesis—that is, both predict that changes in accessibility are global rather than item specific.

As an alternative to differential rehearsal and retrieval-induced forgetting views, we have extended the strategy disruption hypothesis we originally offered to explain part-list cuing inhibition (D. R. Basden & Basden, 1995) to directed forgetting (B. H. Basden & Basden, 1998). According to this strategy disruption view, the forget cue causes the participant to abandon his or her retrieval strategy based on List 1 items and instead develop a revised retrieval strategy tailored to the List 2 items. The participant's revised retrieval strategy would, of course, be less effective in retrieving List 1 than List 2 on the final test. In addition, we have argued that retrieval strategies in directed forgetting are based on relational processing. Thus, the results reported by Kimball and Metcalfe (2001) can be explained in terms of greater relational processing of intentionally learned than of incidentally learned items. Their procedure permitted relational processing of intentionally learned items but prevented relational processing of incidentally learned items and intralist integration of the two types of items. Relational processing provides a basis for the retrieval of integrated groups of items; items not relationally processed would be less likely to be recalled. For the present findings, retrieval practice on List 2 may modify the List 2 retrieval strategy but leave the List 1 retrieval strategy unaltered. Thus, List 2 recall is influenced by retrieval practice but List 1 recall is not. The strategy disruption account does not rely on true inhibition (in the sense of negative activation) of to-be-forgotten items to account for di-

rected forgetting. Instead, to-be-forgotten items suffer simply from reduced accessibility. In this sense, the strategy disruption account is similar to the context-change account proposed by Sahakyan and Kelley (2003).

Fundamentally, the present results are not at odds with the Bjorks' (e.g., E. L. Bjork & Bjork, 1996) dissociation hypothesis. Furthermore, that hypothesis could readily be modified to encompass results indicating that accessibility is not altered on a global level. Perhaps the dissociation process targets subgroups of items within a list rather than the entire list. Items not integrated within subgroups would not be targeted for dissociation. A similar mechanism was proposed by Postman and Underwood (1973) as a variation to their concept of response-set suppression.

Although progress toward pinpointing the specific mechanisms responsible for directed forgetting is slow, science is relentless. Further research will eventually lead to a full understanding of the nature of retrieval inhibition/interference in list-method directed forgetting.

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