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Can encoding differences explain the benefits of directed forgetting in the list method paradigm?

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Abstract

We propose that the benefits of directed forgetting are explained by the differences in recall arising from individual strategy choices used to encode List 2. In Experiment 1, inducing participants to encode both lists using the same strategy (either shallow or deep) led to significant costs of directed forgetting but abolished the benefits. In Experiment 2, inducing a shallow encoding on List 1 and a deep encoding on List 2 produced similar results, abolishing the benefits but not the costs. Reanalysis of Sahakyan and Kelley's (in press) Experiment 2 showed that the costs of directed forgetting could be detected irrespective of participants' strategy choices. However, the benefits of directed forgetting are best explained by a more frequent use of deeper encoding of the second list by the forget group participants.

In this paper, we examine the phenomenon called directed forgetting in light of the encoding strategies employed by participants while performing the task. The directed forgetting paradigm invented by Bjork, LaBerge, and LeGrand (1968) is thought to have implications for understanding the mechanisms that are typically involved in updating information in long-term memory. Others have shown that directed forgetting may have implications for understanding the ways in which people segregate information according to particular mental contexts (Sahakyan & Kelley, in press). In this paper, we will mainly focus on a particular version of the paradigm called the *list method* of directed forgetting. A typical list method directed forgetting study involves studying two lists of words followed by a recall test on both lists. The crucial manipulation involves inserting an instruction to forget the first list before the study of the second list for only one group of participants the (*forget* group), while the other group is told to continue remembering the first list of words (the *remember* group). The second list is always followed by an instruction to remember the items. The directed forgetting effect is typically reflected in (a) poorer memory for List 1 in the forget group compared to the remember group—a finding called the *costs* of directed forgetting, and (b) better memory for List 2 in the forget group compared to the remember group—called the *benefits* of directed forgetting (following Liu, Bjork, & Wickens, 1999). For a review of directed forgetting studies and indices through which it is operationalized, see MacLeod (1998).

Theoretical explanations of directed forgetting

The dominant theory of directed forgetting has been the retrieval inhibition hypothesis (Bjork, 1989). The forget instruction was said to invoke a process that at retrieval blocked or suppressed the access to the List 1 items, producing the costs. The benefits of directed forgetting have been attributed to the forget group escaping from proactive interference (PI) because inhibited List 1 items would not cause proactive interference.

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The primary evidence for this comes from studies comparing performance in the forget group with performance in a group that studies only a single list. Because the level of performance in the forget group and the no proactive interference group did not statistically differ, the forget group was said to escape from proactive interference (Bjork & Bjork, 1996; Bjork & Woodward, 1973).

Recently, Sahakyan and Kelley (in press) proposed an alternative explanation for the directed forgetting phenomenon based on contextual change. Their theory proposes that the costs and benefits of directed forgetting result from an internal context change that occurs between the presentation of the two lists in response to the forget instruction. They suggested that one way to intentionally forget a list of items would be to attempt to create a larger than normal change of context between the lists. This could happen, for example, if the forget cue led people to deliberately think of something other than the experiment. Participants in the forget group would then be more likely to treat the two lists as separate events and not maintain the context in which they initially encoded the first list when they are encoding the second list. Instead, they would generate entirely new contextual elements with which they encode the second list. The mismatch between the study context and the testing context would produce the pattern of costs and benefits typically found in the directed forgetting studies. The costs occur because the mental context at test mismatches the mental context in which List 1 was encoded. The benefits are observed because proactive interference is reduced in the forget group as a result of encoding the lists in separate contexts. Consistent with their hypothesis, experiments where a context change was deliberately induced between the study of List 1 and List 2 in the absence of an instruction to forget mimicked the pattern of List 1 and List 2 recall typical of participants in the forget group. In addition, reinstating the List 1 learning context at the time of the test reduced the costs and benefits associated with the instruction to forget, suggesting further that context change provides a viable explanation for the effects of the forget instruction.

Encoding strategies in directed forgetting

The role of encoding strategies has been largely overlooked in directed forgetting studies. Both existing theories predict a homogeneous effect of the forget instruction regardless of encoding strategy. Thus, our interest in encoding strategies was motivated by two theoretical concerns. First, we wondered if the directed forgetting effects would turn out to be contingent on the particular encoding strategy employed by a participant. For example, shallow encoding strategies like rote rehearsal might lead to larger directed forgetting effects than deeper encoding strategies like making up a story. This could happen because elaborative encoding provides a greater number of retrieval routes or easily generated retrieval cues that are useful for free recall (Einstein & Hunt, 1980; Masson & McDaniel, 1981) than maintenance rehearsal does. A recently conducted meta-analysis of context-dependent memory studies revealed that the type of encoding task at input is a significant modulator of the magnitude of the context effects for direct tests of memory such as recall (Smith & Vela, 2001). In particular, they found that non-associative processing led to larger context-dependent memory effects than did the associative inter-item processing of information. The authors speculated that forming inter-item associations at learning could decrease the encoding of contextual information, because encouraging people to concentrate more on the study items could lead to the exclusion of attention to the environment, and consequently the changes in context will have smaller or no effects on memory. Smith and Vela refer to this as an *overshadowing* hypothesis. Similarly they argued that using associative retrieval cues during retrieval could outshine or overpower weaker contextual cues leading again to smaller context-dependent memory effects. This is known as the *outshining* hypothesis. Overall, the context-dependent memory effects seem to be smaller when the use of non-contextual cues either at learning or at test increases. Therefore, it is important to explore if the directed forgetting effects, which Sahakyan and Kelley (in press) argued were similar to context-dependent memory effects, turn out to be contingent on the particular encoding strategy employed by a participant.

Second, we were aware that by considering only aggregate group-level data, one might postulate a mechanism based on group data when in fact no individual displays that pattern of performance (e.g., Delaney, Reder, Staszewski, & Ritter, 1998). For example, directed forgetting benefits are said to be due to the reduction or escape from proactive interference in the forget group (Bjork & Bjork, 1996; Bjork & Woodward, 1973; Sahakyan & Kelley, in press). However, benefits might actually be due to a combination of shallow and deep encoding strategies that produce a recall level that is comparable to the recall of a no-proactive interference group—even though each individual member of the forget group suffers from proactive interference.

We first sought to explore the natural distribution of strategies in the directed forgetting task. We examined a subset of the data collected by Sahakyan and Kelley (in press, Experiment 2) in which retrospective verbal reports were collected immediately following recall. The subset includes 96 participants from the control condition of the context not-reinstated group from their experiment who were equally divided into the three conditions with 32 participants in each group. We omit the details of the study that do not bear directly on our current purposes; however, we briefly report the methods of the experiment. Participants studied two lists of 15 words at a rate of 5 s per word. Then, one-third of the participants received an instruction to forget the first list (the standard forget group), the remaining participants received an instruction to keep remembering the first list of items (the remember group). However, half of the remember group participants upon the completion of study of List 1 were given 40 s to imagine their childhood home, mentally walk through it, and describe it to the experimenter—a task designed to create a context change. After the study of List 2, all groups were tested on memory for both lists following a 90 s filler task. Recall was carried out on separate sheets of paper and List 1 was always tested before List 2.

The retrospective reports were elicited using the standard instructions from Ericsson and Simon (1993), and involved asking participants to remember as much as they could about what they were thinking from the time they saw the first word on the first list. This technique has been shown to provide reliable information about processes that are too fast to report concurrently but that are potentially reportable (see Ericsson & Simon, 1993, for a review). Participants reported using a variety of strategies while memorizing the words. Because of variability in individual strategy choices and the uneven distribution of observations per cell, verbal reports were coded into three main categories (a similar approach to classifying verbal reports was taken by Perfect & Dasgupta, 1997). Maintenance rehearsal of each individual item (usually accompanied by increasing the number of items rehearsed together each time a new word was encountered), rhyming, and rehearsing only the first letter of each word comprised the *shallow* encoding strategies. Creating individual sentences with the words, using self-referencing, creating a story using all the items on the list, and picturing a scene that contained all the items as interactive images were considered to be *deep* encoding strategies. Finally, visualizing individual items or using a mixture of shallow and deep strategies on the same list were considered *intermediate* encoding strategies.

When the verbal reports were coded into categories, it became apparent that the majority of participants (79%) started out with one of the shallow encoding strategies. More interesting was the finding that participants occasionally changed their encoding strategies between lists. In most cases, the strategy change involved using a deeper, more elaborate way of encoding the List 2 items than the List 1 items. Despite the rather similar distribution of encoding strategies on List 1 in all three conditions, the participants in the forget and remember plus context change groups tended to switch to a deeper encoding strategy on List 2 more often than the participants in the remember group did (38% of participants changed to a deeper encoding in the forget group, 44% in the remember plus context change group, and 22% in the remember group). Given the variability in encoding strategies and the asymmetric rates of deep strategy use in different groups, we wondered whether a particular combination of shallow and deep strategies could be responsible for the directed forgetting benefits.

In this paper, we report two experiments that address the role of encoding strategies in directed forgetting. Our experiments directly controlled encoding strategy to assess the possibility of different directed forgetting effect sizes connected with different strategies (Experiment 1), and the possibility that the observed differences in the rate of strategy usage across conditions are responsible for the directed forgetting benefits (Experiment 2). We will suggest that while contextual change provides the best explanation for the costs of directed forgetting, the benefits appear to be due to some participants changing from a shallow to a deep encoding strategy. The change appears to be initiated in response to a change in mental context.

Experiment 1

To determine the relationship between the encoding processes and the directed forgetting effect, the encoding strategy on both lists was controlled in Experiment I. In particular, participants were told to use shallow and deep encoding strategies most commonly reported in verbal reports, namely rehearsing the words and creating a story with all the items. In retrospective verbal reports, most participants indicated that they engaged in maintenance rehearsal and added each new word into the rehearsal cycle—so this was the instruction for the shallow condition of the experiment. Other participants reported using more elaborate strategies like making up a story using all of the items on the list—so this was the instruction for the deep condition of this study. There were three types of instructions used in this study: the standard *forget* and *remember* conditions, and the *remember plus context change* condition. The latter group was included to provide a further test of the context change hypothesis. In addition, *no-proactive interference* conditions were also included in the design as reference groups. The latter groups received only the second list to study and were engaged in irrelevant activity while the other groups studied the first list. In previous studies, the performance on List 2 in the forget group matched that of the no-proactive interference group, which suggested that the benefits of directed forgetting could be attributed to the escape from proactive interference in the former group.

Method

Participants

The participants were 192 Florida State University undergraduates who participated to fulfill a course requirement. There were 24 participants in each of the six experimental conditions. In addition, 48 participants were added after the completion of the design. Half of them were tested in the shallow and half in the deep no-proactive interference conditions.

Materials

Thirty unrelated English nouns of medium frequency were drawn from the Kucera and Francis (1967) norms. Two lists of 15 words each were prepared that were followed either by the forget or remember cue resulting in four possible combinations for counterbalancing.

Design

The design of the study was an encoding strategy (shallow vs. deep) by instruction type (forget, remember, and remember plus context change) between-subjects design.

Procedure

Participants were tested individually. The procedure followed the list method of directed forgetting. The first list of 15 words was presented at a rate of 5 s per word on computer screens. Half of the participants in each experimental condition were instructed to learn the items using a shallow encoding strategy. Specifically, they were instructed to repeat the words aloud several times, as they appeared, and increase the number of words they repeated aloud each time by incorporating every new word that appeared on the screen into the rehearsal cycle. They were told that if they forgot some words, then they should continue repeating the words that they remembered without regard for order. The remaining half of the participants learned the items using a deeper encoding strategy. Specifically, they were instructed to make up a story using all the items on the list starting with the first word that appeared on the screen. They were told to tell the story aloud to ensure compliance with the instructions. The participants were warned that their stories could be bizarre and incoherent, but that they should nevertheless attempt to integrate each new word into the story.

Immediately after studying the first list, some participants were told to forget the items as they were only for practice and to familiarize them with the task. The other participants were told to keep remembering the items, as they were only the first half of the study list. The participants in the remember plus context change group after receiving the remember instruction were given 45 s to imagine their childhood home and describe it aloud to the experimenter by mentally walking through it. The participants in the forget and remember groups waited for an equivalent time period before beginning the study of the second list. The second list was then presented with the same encoding instruction that accompanied the first list encoding (either shallow or deep). The no-proactive interference groups solved arithmetic problems throughout the time that the other groups studied the first list. They only studied the second list with either shallow or deep instructions. The study was followed by 90 s of solving arithmetic problems for all groups before the free recall test. At test, participants were given two minutes and asked to recall the first list, followed by the second list. The recall was carried out on separate sheets of paper. The no-proactive interference groups were tested on recall of List 2 only.

Results and discussion

For all analyses, α was set at $\alpha = .05$.

As in previous studies, the costs and benefits of directed forgetting were analyzed separately. For the analyses of costs, we performed an ANOVA on proportion of correct List 1 recall by condition (forget, remember, and remember plus context change) and strategy (shallow, deep). We found a significant main effect of condition, $F(2, 138) = 9.26$, $MSE = .023$, and a significant main effect of strategy $F(1, 138) = 145.99$, $MSE = .023$. The interaction of condition and strategy was not significant, $F < 1$ (see Fig. 1). Post hoc tests confirmed by Tukey's HSD showed that the remember group recalled significantly more items than did the forget and remember plus context change groups, which did not differ from each other. This was true in both strategy groups although the deep encoding resulted in higher levels of recall overall. Thus, the costs of directed forgetting were obtained regardless of the quality of encoding.

For the analysis of benefits, we first performed an ANOVA on proportion List 2 recall by condition and strategy, excluding the no-proactive interference groups. There was only a significant main effect of strategy, $F(1, 138) = 178.10$, $MSE = .018$, confirming again that the deep encoding resulted in higher levels of recall. The

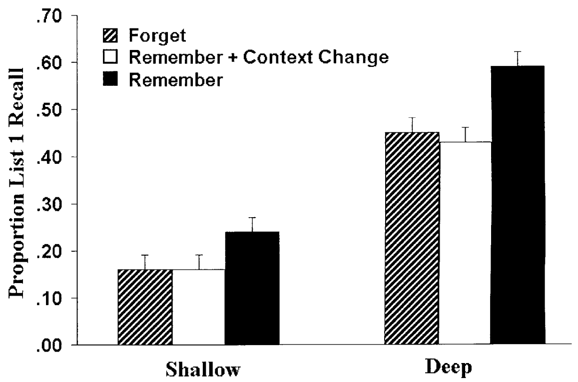

Fig. 1. Mean proportion List 1 recall (+*SE*) by condition and encoding strategy in Experiment 1, $n = 24$ per condition. For the forget group this represents the costs of directed forgetting.

main effect of condition and the interaction of strategy and condition were not significant, F's < 1. To sum up, the analyses showed that the benefits were eliminated in both strategy groups.

The absence of benefits can mean two things: either the remember group escaped proactive interference and therefore performed as well as the no-proactive interference groups, and the remember plus context change and forget groups, or the remember, forget, and remember plus context change groups all suffered proactive interference and could not escape it. To determine which was the case, we included both shallow and deep no-proactive interference groups in the analyses of benefits. The ANOVA on proportion List 2 recall by strategy and condition including the no-proactive interference groups revealed a significant main effect of encoding strategy, $F(1, 184) = 230.82$, $MSE = .330$, and a significant main effect of condition, $F(3, 184) = 19.86$, $MSE = .330$. The interaction was not significant, $F < 1$ (see Fig. 2). Post hoc tests using Tukey's HSD showed that the no-proactive interference groups recalled significantly more items than did the forget, remember, and remember plus context change groups. The latter three groups did not differ from one another.

Overall, the results showed that the benefits were abolished when the encoding strategy was controlled. The absence of the benefits in this study was due to all conditions suffering from proactive interference regardless of the encoding quality. However, the costs were present regardless of the particular encoding strategy participants were instructed to use. Thus, it appears that the type of encoding did not modulate the size of the directed forgetting costs, because they were detected in both types of learning strategies. Smith and Vela's (2001) meta-analysis revealed several important factors that contribute to the context-dependent memory effects apart from the effects of the quality of encoding. Some of these variables include the study-test interval, the type of paradigm used in a study, as well as experimenter-related factors. However, in this meta-analysis, the authors identified only significant main effects, which gives no information about possible interactions. Perhaps some combinations of these factors would decrease the differences in context-dependent memory effects between the associative and the non-associative types of encoding.

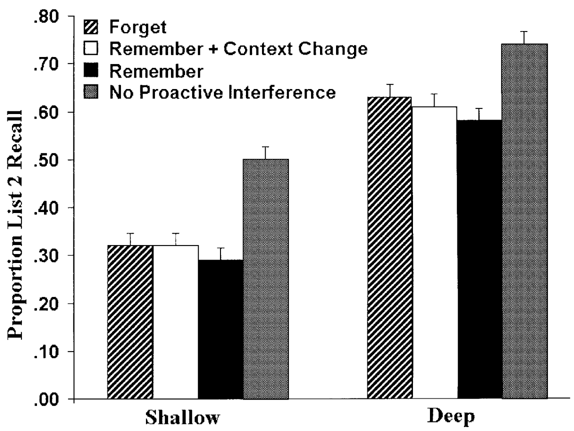

Fig. 2. Mean proportion List 2 recall (+SE) by condition and encoding strategy in Experiment 1, $n = 24$ per condition. For the forget group this represents the benefits of directed forgetting.

Experiment 2

The findings of Experiment 1 revealed a rather surprising outcome regarding the benefits of directed forgetting. The benefits were eliminated and there was significant proactive interference that was built up, even in the forget and remember plus context change groups when encoding was controlled. Previous mechanisms suggesting that the forget cue led to an overall escape from PI either via context change or alternatively via retrieval inhibition must be insufficient to explain the directed forgetting benefits.

As indicated earlier, our preliminary analysis of verbal reports showed that participants occasionally switched to a deeper encoding strategy on List 2. If one were to assume that there were differential gains associated with switching to a deeper encoding strategy across the conditions, such that the forget and remember plus context change group participants gained more on List 2 from such a strategy change than the remember group participants, then experimentally controlling the strategy change by inducing the participants to use a shallow strategy on List 1 and a deeper strategy on List 2 should nonetheless produce the benefits normally seen in directed forgetting. On the other hand, preliminary analyses of verbal reports data also indicated that the rates of strategy change across the conditions were *asymmetric* such that more participants in the forget and remember plus context change groups tended to change to a deeper encoding on List 2 than participants in the remember group did. If the source of benefits is simply the more frequent use of deep encoding strategies in the forget and in the remember plus context change groups on List 2, then experimentally inducing the strategy change in all conditions should eliminate the relative benefits for those two groups because all the groups including the remember group should benefit from such a change.

In this experiment, participants were instructed to use a shallow encoding on the first list of items and a deep encoding on the second list of items. The opposite change of strategy (deep on List 1 and shallow on List 2) was not included in the design of this experiment for several reasons. Having encoded List 1 with an elaborate strategy may preclude the use of pure shallow encoding on List 2. In addition, preliminary analyses of verbal reports indicated that such a direction of strategy change was extremely rare (less than 1%).

Method

Participants

There were 120 Florida State University undergraduates in this experiment who participated in partial fulfillment of course requirements. There were 30 participants in each of the three type of instruction conditions and 30 participants in the no-proactive interference reference group.

Materials

The materials were identical to the previous experiment.

Procedure

The procedure for this experiment was similar to Experiment 1, except for the following changes. List 1 was encoded using the shallow instructions while the second list was encoded using the deep instructions specified earlier in Experiment 1. There were four conditions in the experiment: the regular directed forgetting *forget* and *remember* groups, remember plus context change group, and no-proactive interference group which studied only List 2 using the deep encoding instructions.

Results and discussion

For the analyses of costs, a one-way ANOVA on proportion List 1 recall by condition showed a significant effect of condition, $F(2, 87) = 6.69$, $MSE = .013$ (see Fig. 3). Post hoc tests using Tukey's HSD confirmed that the remember group recalled significantly more items from the first list than did the forget and remember plus context change groups, which did not differ from each other. Thus, inducing a change of strategy from shallow to deep between the two lists still yielded significant costs.

For the benefits analyses, a one-way ANOVA on proportion List 2 recall by condition including the no-proactive interference group showed no effect of condition, $F < 1$ (Fig. 4). Thus, inducing the change from shallow to deep encoding strategy eliminated the benefits. However, the absence of benefits in this experiment, as indicated by the analyses, means that all three types of instruction conditions, including the remember condition, escaped proactive interference and hence performed at the level comparable to the no-proactive interference group.

To summarize, the results of this experiment revealed that the costs were significant regardless of strategy change between List 1 and List 2. There were also no differential gains on List 2 recall for the forget or remember plus context change groups associated with switching to a deeper encoding strategy. In fact, all three groups escaped proactive interference when asked to encode the second list using a deeper strategy. This led to the conclusion that the benefits in directed forgetting experiments may result from a more frequent use of a deep encoding strategy for the second list by participants in the forget and remember plus context change groups compared to the participants in the remember group.

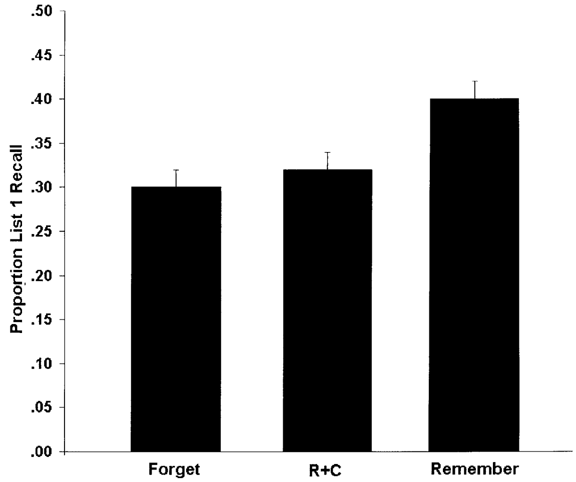

Fig. 3. Mean proportion List 1 recall (+*SE*) in forget, remember plus context change, and remember groups in Experiment 2, $n = 30$ per cell. For the forget group this represents the costs of directed forgetting.

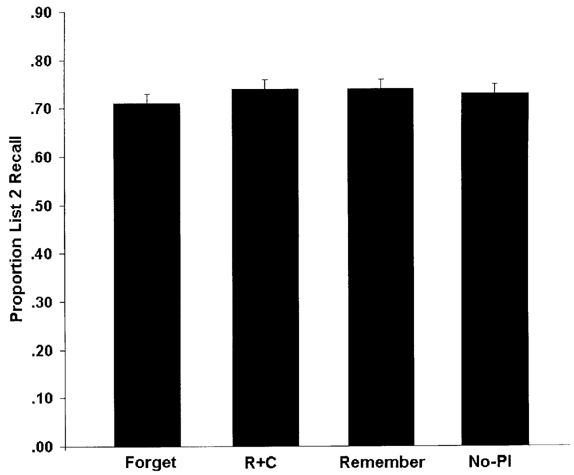

Fig. 4. Mean proportion List 2 recall (+*SE*) in forget, remember plus context change, and remember groups in Experiment 2, $n = 30$ per cell. For the forget group this represents the benefits of directed forgetting.

A strategy-based account of directed forgetting benefits

As stated in the introduction, the benefits of directed forgetting have been attributed to the escape from proactive interference in the forget group (Bjork & Bjork, 1996; Bjork & Woodward, 1973; Sahakyan & Kelley, in press). However, the results of our experiments showed that only those participants that switched from a shallow to a deep encoding strategy actually escaped from proactive interference (Experiment 2). Furthermore, there was no difference in List 2 recall among the conditions whenever we controlled the strategy (Experiment 1). Therefore, we conclude that a global mechanism, such as inhibition of List 1 items or context change that allows participants to escape from proactive interference, is insufficient to explain the benefits.

Our two experiments showed that using a deep encoding strategy on List 2 doubled recall rates compared to using shallow encoding strategy, as one would expect from a standard depth of processing effect. The fact that the forget group participants tended to switch to a deeper encoding on List 2 more often than the remember group participants could make the average group performance on List 2 comparable to the no proactive interference group, when in fact it really represents a mixture of some people using deep and shallow encoding. Therefore, we propose a *strategy-based hypothesis* to explain the benefits of directed forgetting, which attributes benefits to the difference in the frequency with which the participants use deep encoding across the conditions.

To test our strategy-based hypothesis, we conducted several analyses. In all subsequent analyses, we excluded the participants employing intermediate strategies from Sahakyan and Kelley's subset of verbal reports data. The analyses contrast the classical forget and remember groups of directed forgetting studies to better generalize to previous studies reported in the literature. However, the identical set of analyses including the remember plus context change group did not substantially alter the pattern or interpretation of the results on both costs and benefits in all subsequent analyses reported below.

Statistically controlling for strategy effects

The first analysis was aimed at determining whether strategies alone could explain the directed forgetting costs and benefits. A stepwise regression was used to reanalyze a subset of verbal reports data from Sahakyan and Kelley (in press). After excluding the intermediate strategy, the final sample submitted for the analyses included 27 participants in the forget group and 25 participants in the remember group. Without considering strategy, this subset of the data showed the usual pattern of costs and benefits. On List 1, the remember group recalled a larger proportion of items than the forget group (.39 vs. .19), $F(1,50) = 21.72$, $p < .001$. On List 2, the remember group recalled a smaller proportion of items than the forget group (.29 vs. .44), $F(1,50) = 12.03$, $p < .001$.

For the costs, the effects of strategy on List 1 were regressed out first, then strategy on List 2, their interaction, and finally instruction type (forget vs. remember). We chose this order because we wanted to eliminate all of the variance due to strategy first and then test whether cue would still capture additional variance. Psychologically, the interaction between the strategy choices captures whether participants changed strategies between the lists. The results indicated that strategy on List 1 was significant, $F(1,50) = 25.80$, $MSE = .022$, $p < .001$, explaining 34% of the variance in List 1 recall. The strategy on List 2 accounted for an additional 7% variance and was significant, $F(1,49) = 5.78$, $MSE = .020$, $p < .05$.[1] The effect was in the direction of a deeper encoding on List 2 producing poorer recall of List 1. The interaction was not significant, $F < 1$. However, even after all of the variance due to strategy on each of the lists was extracted, the effect of instruction type was still significant, $F(1,47) = 18.12$, $MSE = .015$, $p < .001$, explaining an additional 16% of the variance in List 1 recall. The difference in proportion recalled while holding strategy constant was .17, with the remember group recalling more items than the forget group. These results indicate that for the costs, despite the significant differences in recall performance arising from an individual's choice of strategy on List 1 and List 2, the instruction type still made an independent contribution.

For the benefits, the effects of strategy on List 2 were regressed out first, then strategy on List 1, their interaction, and finally instruction type. As before, we wanted to regress out all of the effects of strategy and then test whether the cue would still capture additional variance. We entered strategy on List 2 first because we expected that it would provide the bulk of the variation in performance on List 2. However, even when the strategy on List 1 is entered as the first predictor instead of strategy on List 2, it does not alter the pattern or interpretation of the results reported below. Only the strategy on List 2 was significant, $F(1,50) = 49.97$, $MSE = .014$, $p < .001$, explaining 50% of the variance in List 2 recall. The effect of strategy on List 1 did not account for any additional variance, $\Delta R^2 = .02$, $F(1,49) = 1.81$, $MSE = .014$, $p = .18$, and neither did their interaction, $F < 1$. The effect of instruction type did not reach significance either, $\Delta R^2 = .02$, $F(1,47) = 2.11$, $MSE = .13$, $p = .12$. These results suggest that the benefits arise from individual's choice of strategy on List 2, consistent with the strategy-based hypothesis.

[1] If the remember plus context change group was included, the only change in any of our analyses was that for the costs, strategy on List 2 was not significant, $p = .11$.

Reproducing benefits through strategy mixture

To further test the strategy-based explanation of directed forgetting benefits, we used the actual means from our Experiment 1 and Experiment 2 to reproduce the benefits obtained in the verbal reports data of Sahakyan and Kelley (in press). If our experimental manipulation of shallow and deep encoding was not different from the self-reported strategies in Sahakyan and Kelley's experiment, then we expected to obtain the levels of performance on List 2 comparable to those from the verbal reports data. As before, we used the same sample of participants from verbal reports experiment, excluding those who used intermediate strategies.

We generated a strategy-based model prediction for each participant from Sahakyan and Kelley's experiment based on the mean observed proportion List 2 recall from our current experiments. That is, for example, if the participant in verbal reports indicated using a shallow or deep encoding strategy on both lists, we used the mean proportion List 2 recall for participants from our Experiment 1 (using the mean for the shallow or the mean for the deep group as appropriate). If the participant switched from using a shallow encoding strategy on List 1 to using a deep encoding strategy on List 2, we used the mean proportion recall on List 2 from our Experiment 2. In those rare instances (less than 1%) when the participants reported changing from deep to shallow encoding, no prediction was generated. Fig. 5 shows the actual mean performance of the subset of participants we analyzed from Sahakyan and Kelley's study along with the predictions of the strategy-based model. The model explained 54% of the variance in List 2 recall from the verbal reports experiment, $F(1, 49) = 56.72$, $MSE = .012$, $p < .001$.

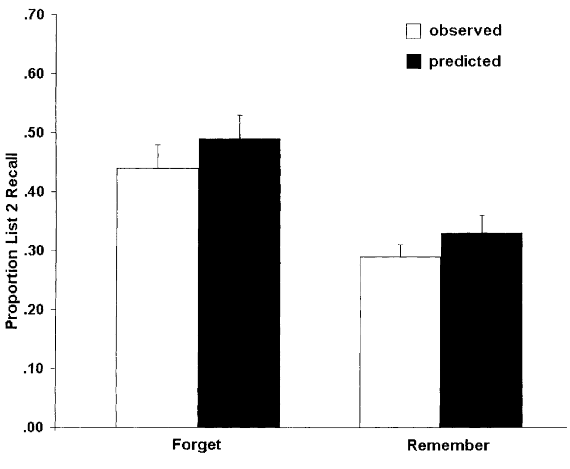

Fig. 5. Mean proportion List 2 recall (+*SE*) from subset of Sahakyan and Kelley's study (in press) and the strategy-based model prediction.

Our model demonstrated that the pattern of benefits from Sahakyan and Kelley's experiment could be accounted for by averaging the List 2 performance of participants who were instructed to use a particular strategy, verifying both our experimental results and the strategy-based model.

A single- or a two-factor model of benefits?

The context change hypothesis and the retrieval inhibition theory of directed forgetting both have attributed the benefits to theoretical mechanisms that produce an escape from PI. According to the strategy-based explanation the benefits arise from the differences in the rates with which participants use deeper encoding on List 2 across the conditions. However, in Experiment 2 participants who changed their encoding strategy from shallow to deep also showed an escape from proactive interference. The escape from proactive interference could make the recall of List 2 even higher than the level of recall that would be expected from a deep encoding alone. Therefore, it is important to explore whether the escape from proactive interference explained significant additional variance in List 2 recall above and beyond that explained by strategies alone.

Two model predictions for each participant from the verbal reports data from Sahakyan and Kelley (in press) were generated. The first model prediction was based on the assumption that List 2 *strategy alone* could explain the pattern of benefits. The performance levels from the deep condition from Experiment 1 were used (i.e., without assuming that anyone escaped PI through a mechanism such as context change or retrieval inhibition of List 1). Thus, the strategy alone model's prediction represents the assumption that the different strategy choices of individual participants are responsible for the directed forgetting benefits as there was significant proactive interference in the groups that learned both lists through the deep strategy in Experiment 1. The build up of significant PI in all conditions implies that secondary mechanisms such as a context change or retrieval inhibition were either not operating or if present, then failed to produce an escape from PI effect. The second model prediction was based on the *combined effects* of strategy and some other mechanism of escaping proactive interference. The performance levels from Experiment 2 for the participants who switched strategies were used, because in Experiment 2 they used deep encoding on List 2 and showed an escape from PI. The second model thus represents a two-factor model that is based on strategy change plus a second factor that allows escaping PI. The second factor contributing to an escape from PI can be context change, retrieval inhibition, or any mechanism such as distinctive encoding of List 1 versus List 2. Processing two lists with the same instruction, such as deep instruction, would lead to more PI than processing the lists with dissimilar instructions (e.g., shallow on List 1 and deep on List 2). Therefore, switching encoding processes from shallow to deep can itself mediate the reduction of PI due to processing dissimilarity, which has been shown to decrease interference effects (i.e., Burns & Gold, 1999).

These two model predictions were identical for those participants who used a shallow strategy on both lists. They were also identical for those who used a deep strategy on both lists. However, they differed for those who switched strategies. If a participant indicated using shallow encoding on List 1 and deep encoding on List 2 in their verbal reports, then the strategy alone prediction for this participant used the mean proportion recall for List 2 from Experiment 1 from the group of participants using deep strategy on both lists—thus representing the assumption that superior encoding on List 2 alone could primarily account for the benefits. The second model prediction for the same participant was instead based on the mean proportion recall for List 2 from Experiment 2—thus representing the assumption that an additional mechanism that produced escape from PI contributed to the benefits above and beyond strategy alone, because all participants in that experiment escaped proactive interference.

The strategy alone model estimate and the strategy plus secondary factor model estimate, along with the instruction type (forget vs. remember), were then entered as predictors of the actual observed proportion List 2 recall from Sahakyan and Kelley's (in press) verbal reports data using stepwise regression to determine which provided a better account of benefits. The whole model captured 54.9% of the variance in proportion List 2 recall and was significant. $F(3,47) = 19.08$, $MSE = .013$, $p < .001$. The strategy alone model when entered first accounted for significant variance, $R^2 = .53$, $F(1,49) = 54.99$, $MSE = .013$, $p < .001$, while the combination model estimate did not account for additional significant variance, $\Delta R^2 = .01$, $F < 1$. The instruction type was not significant either, $F(1,47) = 1.31$, $MSE = .013$, $p = .28$, $\Delta R^2 = .01$, indicating that there were no further benefits to be explained.

It appears that a mixture of encoding strategies on List 2 can explain the benefits in Sahakyan and Kelley (in press) verbal reports data without having to consider a second mechanism that produces a small escape from PI effect that occurred when participants switch from shallow to deep encoding strategies. Although the escape from PI effect is real, as shown by Experiment 2, it is a very small effect and did not greatly contribute to the benefits observed here. Instead, the bulk of the variance was explained by the differences in frequency of deep strategy use across the conditions consequently leading to superior performance on List 2. It is possible, however, that the gains due to the escape from PI can be large enough and prove an important result in their own right, but in this experiment they were of little practical importance. For example, if in the forget condition switching encoding strategy between the lists would involve changing from one type of deep processing to another form of deep processing, such as forming sentences on the first list and creating a story on the second list, then the dissimilar processing would lead to the reduction or escape of PI which in turn may significantly contribute to the benefits and prove an important result in its own right.

General discussion

In this paper, we presented evidence highlighting the role of encoding processes in the directed forgetting effect—mainly in its benefits.The costs of directed forgetting were detected, even when experimentally or statistically controlling for the quality of encoding. However, the benefits were abolished when encoding strategy was induced to be the same on both lists. The loss of benefits was due to significant build up of PI in all experimental conditions. The benefits were also abolished when participants were forced to switch to better encoding on List 2 that resulted in an escape from PI in all experimental conditions. Given all these findings, what is the status of Sahakyan and Kelley's (in press) proposed context change hypothesis of directed forgetting?

It appears that the context change theory still provides the best explanation of the costs of directed forgetting because the control of encoding strategy either experimentally or statistically did not alter the costs; they were still detected. In addition, mentally reinstating the original List 1 learning context during the test was shown to reduce the costs (Sahakyan & Kelley, in press). The implications of the context change in the explanation of the benefits of directed forgetting are indirect, however. Although the particular mechanism that was tentatively advanced for explaining the benefits in the context change theory (i.e., that context change aided escape from PI) was not validated in this paper, the findings from verbal reports showed that the remember plus context change group had rates of strategy change similar to those induced by the forget instruction. In addition, in current experiments the remember plus context change group again behaved in all respects like the forget group as shown earlier by Sahakyan and Kelley (in press). This suggest that the context change manipulation simulated the benefits of directed forgetting through a mechanism similar to the one induced by the forget instruction. Therefore, the contextual change theory must be modified to assume that contextual shifts somehow result in more efficient List 2 encoding for some participants in order to fully explain the benefits of directed forgetting.

In this paper, we have demonstrated that the strategy-based explanation provided a better account of directed forgetting benefits than did the previous mechanisms of retrieval inhibition or context change. Even though both the retrieval inhibition theory and the contextual change theory of directed forgetting attributed the benefits to the overall reduction or escape from proactive interference by the forget group, our Experiment 1 demonstrated a significant build-up of proactive interference in all groups when the encoding strategy was induced to be the same on both lists. Furthermore, we have shown that although the escape from PI effect did occur in participants who switched from shallow to deep encoding between lists, the effects were extremely small and did not contribute to significant additional variance beyond the strategy-based account of the benefits. Finally, even if someone were to find a larger effect of escape from PI due to switching strategies, we found an escape from PI even for participants in the *remember* group who switched—implying that the observed escape from PI arose not from the cue but rather from strategy changes.

Although the costs of directed forgetting are consistently found in directed forgetting studies irrespective of sample size, the benefits have not always achieved significance, even though the means were in the predicted direction (e.g., Conway, Harries, Noyes, Racsma'ny, & Frankish, 2000, Exp 1; Whetstone, Cross, & Whetstone, 1996). Both studies cited here that did not find significant benefits had smaller sample sizes than were used in similar studies successfully detecting the directed forgetting benefits. Overall, the effect size of benefits varies considerably from study to study, with the effect of benefits sometimes approximating that of the costs (Geiselman, Bjork, & Fishman, 1983, Exp. 1; Liu et al., 1999; Sahakyan & Kelley, in press, Exp. 2), sometimes being smaller than the costs (Conway et al., 2000, Exp. 1; Geiselman et al., 1983, Exp. 3; Whetstone et al., 1996), and even sometimes being larger than the costs (Geiselman et al., 1983, Exp. 2, Exp. 4). This kind of variability in outcomes is what one might expect if directed forgetting benefits were largely a result of a small proportion of participants who switch strategies between lists. As shown in the verbal reports, some proportion of participants in the remember group also change to a deeper encoding strategy, making it more difficult to detect the benefits of directed forgetting. Even if the base rates of strategy switches were invariant across studies (which is not necessarily true), one would expect more highly variable benefits with smaller samples.

Our results also clarify why the benefits of directed forgetting survive manipulations that eliminate the costs, consistent with some authors' suspicions that different proximal causes are at work for the costs and the benefits. For example, Liu et al. (1999) have shown that the benefits hold up despite the delay or the relearning of List 1 after the study of List 2. Such manipulations would be expected to have little detrimental effect on List 2 performance if it were studied using a deep encoding strategy.

In some ways, our account of list-method directed forgetting benefits is reminiscent of the account originally proposed by Bjork (1970), which was a two-process theory of directed forgetting. Bjork proposed that participants respond to a forget instruction by separating the two lists in a way that makes them highly discriminable (*set differentiation*) and by devoting all mnemonic and rehearsal activities to the second list (*selective rehearsal*). The theory assumed that both processes co-implied each other and were necessary prerequisites for each other. That is, participants can selectively rehearse the second list only to the degree that they have succeeded in differentiating that list from the first list. On the other hand, to differentiate the second list as a set, the items from that list must be rehearsed together.

Our strategy-based explanation of directed forgetting benefits is similar to Bjork's (1970) selective rehearsal hypothesis in that both hypotheses explain the result through superior encoding of List 2. However, Bjork's account of benefits focused on the allocation of resources, while the present account proposed changes in encoding processes. The use of verbal reports and experimental control of strategies reveals what processes were involved in the directed forgetting benefits. Additionally, Bjork's (1970) two-process explanation requires that the lists be successfully differentiated for selective rehearsal to take place. However, in Experiment 2 the remember group escaped from PI (i.e., showed apparent benefits) while similar groups in Experiment 3 did not escape from PI. This occurred even in the absence of instructions to forget, which were normally assumed to lead to set differentiation. High levels of recall were achieved purely as a result of deeper encoding of List 2. Although one could reasonably argue that using different encoding strategies can potentially create set differentiation, such a differentiation becomes a consequence rather than an antecedent of selective rehearsal.

Bjork's (1970) hypothesis was rejected in favor of retrieval inhibition because of critical findings by Geiselman et al. (1983). In the Geiselman et al. (1983) study, two types of items were intermingled, one set of which was supposed to be studied for later recall and the other set of which was to be judged for pleasantness. They found that the to-be-judged words exhibited the same pattern of costs and benefits as the intentional study items, albeit at a lower level of recall. Bjork (1989) later argued that there would be no reason to expect this outcome based on the selective rehearsal account, because to-be-judged items should not be rehearsed anyway.

However, recent research has revived interest in the selective rehearsal account of directed forgetting by modifying several problematic aspects of the Geiselman et al. (1983) study. Kimball and Metcalfe (2001) found that it was possible to dissociate the effect of the forget cue on to-be-judged and to-be-learned items by reducing the potential for creating inter-item associations between them. Their results further suggested that in the Geiselman et al. (1983) study, the to-be-learned items functioned as retrieval cues for to-be-judged items, leading to a similar pattern of results for both types of items. Thus, there is converging evidence that alternatives to the retrieval inhibition hypothesis are viable explanations.

An important question that warrants further investigation is *why* there is a higher strategy change rate in the forget and remember plus context change groups compared to the remember group. Because the remember plus context change group again behaved in all respects like the regular forget group even under more detailed level of analyses, including the rates with which the participants in the latter group change the strategies between the lists, we speculate that it is perhaps a mental context shift with a corresponding escape from mental set that is responsible for the greater chance of switching strategies in these groups. Some authors have proposed a similar escape from mental set effect due to contextual shifts in problem solving research (e.g., Smith, 1995). Smith (1995) proposed that when people become fixated on an incorrect solution in an initial context, an incubation interval increases the likelihood that context will change, thus lowering the accessibility of the incorrect solution or set. Consequently, the probability of solving the problem later is improved. A process similar to this may be taking place in groups where the change of context was produced experimentally, as in the remember plus context change group (or as has been assumed to occur in response to the forget cue in the forget group) leading to an escape from strategy set.

Another possibility, which we are currently investigating is that a context change suggests to participants that they engage in an assessment of their own performance after the first list, leading some participants to recognize that the shallow encoding strategy is not going to lead to high recall levels. This idea is based on an intuitive assumption that event segmenting could lead to a performance evaluation. The participants in the remember group may be more likely to treat the lists as the parts of the same event, and therefore less likely to assess their List 1 performance between the lists, consequently failing to recognize an inefficient strategy. Participants in the forget group, on the other hand, may view List 1 as a complete event and evaluate their performance at the end of the event. Also, they may change their encoding strategy as a way of maximizing the distinctiveness between the lists. Participants in the remember plus context change condition may also break the experiment into two events (i.e., List 1 and List 2) due to a large change of flow of events that takes place between the study of two lists, such as interpolated task. Rosch (1978) argued that change marks the boundaries of events and proposes that the structure of the flow of occurrences dictates the boundaries of events. This change may prompt people that it can be an opportunity to change their performance strategy. If this were true, it would have interesting implications for the ways in which people segregate their experiences and under what conditions people are more likely to engage in self-monitoring to assess their own performance.

In conclusion, this research opens up many new questions about what causes participants to change strategies or to retain their current strategy. It also reinforces the conclusion that a more complete understanding of the role of mental context and the effects of mentally segregating events may be necessary to understand many real-world memory tasks.

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