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A Contextual Change Account of the Directed Forgetting Effect

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The authors propose that the costs and benefits of directed forgetting in the list method result from an internal context change that occurs between the presentations of 2 lists in response to a "forget" instruction. In Experiment 1 of this study, costs and benefits akin to those found in directed forgetting were obtained in the absence of a forget instruction by a direct manipulation of cognitive context change. Experiment 2 of this study replicated those findings using a different cognitive context manipulation and investigated the effects of context reinstatement at the time of recall. Context reinstatement reduced the memorial costs and benefits of context change in the condition where context had been manipulated and in the standard forget condition. The results are consistent with a context change account of directed forgetting.

Directed forgetting is a phenomenon first studied by R. A. Bjork, LaBerge, and LeGrand (1968) whereby people appear to be able to intentionally forget information, making it less accessible to later attempts at recall and reducing interference from that information. The paradigm involves two variations: the item method, which seems to reflect differential encoding of items, and the list method, which does not depend on differential encoding of items (Basden, Basden, & Gargano, 1993). The present work concerns the mechanism of directed forgetting with the list method. Participants are presented two lists of items to study but, immediately after List 1, half of the participants are instructed to forget List 1 (the "forget" group), whereas the remaining half are told to continue remembering List 1 (the "remember" group). The final test requires recall of both lists. Typically, the forget group recalls fewer items from the first list than does the remember group—a finding referred to as the *costs* of directed forgetting (Liu, Bjork, & Wickens, 1999; Reitman, Malin, Bjork, & Higman, 1973). Also, the forget group recalls more items from the second list than does the remember group—a finding referred to as the *benefits* of directed forgetting (R. A. Bjork, 1970; Liu et al., 1999; Reitman et al., 1973). Bjork has interpreted the benefits as an escape from proactive interference due to first list items in the forget group (E. L. Bjork & Bjork, 1996; R. A. Bjork & Woodward, 1973). For a detailed review of directed forgetting studies and indices used to measure the effects, see MacLeod (1998).

The directed forgetting costs do not appear to result from the intentional withholding of to-be-forgotten items (MacLeod, 1999). Providing a monetary incentive for additional to-be-forgotten items to be recalled does not increase performance on these items.

R. A. Bjork (1989) proposed that retrieval inhibition is the mechanism of directed forgetting, in response to a study by Geiselman, Bjork, and Fishman (1983) that ruled out differential rehearsal of to-be-forgotten and to-be-remembered lists. Geiselman et al. interleaved intentional study items with incidentally encoded items and found that the incidental study items exhibited the same pattern of directed forgetting costs as did the intentional study items. Because participants were not instructed to learn incidentally encoded items, the effects of the forget instruction on those items were unlikely to be the result of selective rehearsal. Instead, R. A. Bjork (1989) proposed that the incidental items were inhibited along with the intentional items by virtue of being "in the wrong place at the wrong time" (p. 316).

New Framework for Directed Forgetting: The Context Change Hypothesis

Changes in context produce forgetting. Findings from the context-dependent memory literature show that recall is enhanced when there is a high correspondence between the incidental or background stimuli present during the study and test conditions. Contextual effects based on internal conditions are seen in state-dependent retention studies (Eich, 1980; Goodwin, Powell, Bremer, Hoine, & Stern, 1969), and in mood state-dependent studies (Macht, Spear, & Levis, 1977; Teasdale & Fogarty, 1979). Context-dependent memory effects also occur when the physical environment is changed between study and test (Godden & Baddeley, 1975; Smith, 1979, 1984; Smith, Glenberg, & Bjork, 1978).

Mensink and Raaijmakers's (1988) mathematical model of contextual fluctuation based on search of associative memory (SAM) predicts a large number of classic interference and forgetting phenomena, including proactive interference and retroactive inhibition. In the model, contextual cues are one basis for the search process in cued recall, yet they fluctuate over time, leading to a mismatch between current context and the learning context and, consequently, leading to forgetting. Extrapolating from this model, we propose that one strategy that would allow participants to intentionally forget a list they had just encoded would be to deliberately attempt to alter their internal contextual cues, creating a larger than normal change of context between List 1 and List 2. After hearing "Forget that list; it was only for practice," participants using such a strategy would have a lower probability of maintaining the activation of contextual elements that were prev-

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alent during the encoding of List 1 while they encode List 2. If participants anticipate a test on List 1 (the remember group) they will be likely to treat List 1 and List 2 as part of the same event, and so maintain the activation of some contextual elements prevalent during List 1. However, if participants in the forget group think “that was practice” after encoding List 1, they will be more likely to treat List 1 and List 2 as two separate events and not maintain the activation of as many List 1 contextual elements. Instead, participants in the forget condition may be more likely to sample new contextual elements. In addition, the forget instruction may induce people to deliberately think about something other than the experiment, and that, too, would change context.

In pilot work, we asked for retrospective verbal reports from participants tested in the directed forgetting paradigm. After hearing the forget instruction, some participants reported that they attempted to “think of something else,” such as the upcoming wedding of a sister. Informal analyses of verbal reports showed that participants who reported such a strategy were more likely to show costs of directed forgetting than were participants who did not report such a strategy.

How well does the context change hypothesis account for the reported findings in directed forgetting? One way to evaluate this hypothesis is to look for parallels in the literature on global or list-wide environmental context. Global environmental context is most closely related to our conception of the type of internal context manipulation in which directed forgetting participants might engage, compared with item-specific verbal context or fast-changing pictorial context (e.g., Murnane, Phelps, & Malmberg, 1999; Tulving & Thompson, 1973). First, results from directed forgetting studies show that there is no directed forgetting effect on recognition tests (Basden et al., 1993; E. L. Bjork & Bjork, 1996; Block, 1971; Geiselman et al., 1983). Similar to directed forgetting, global environmental context-dependent memory is generally found with recall of lists of words but not with recognition testing (Eich, 1985; Godden & Baddeley, 1980; Smith, Glenberg, & Bjork, 1978; but see Smith & Vela, 2001, for a review and conditions where global context does affect recognition). Second, in directed forgetting studies there are no effects of the forget cue on priming in implicit tasks (Basden et al., 1993; E. L. Bjork & Bjork, 1996). Similarly, there are generally no context-dependent memory effects on priming in implicit tasks, such as word-fragment completion or solving anagrams (Parker, Gellatly, & Waterman, 1999; Parker, Waterman, & Gellatly, 2000). Third, the benefits of directed forgetting are attributed to a reduction of proactive interference that occurs as a result of the forget cue (E. L. Bjork & Bjork, 1996; R. A. Bjork & Woodward, 1973). A similar reduction of proactive interference occurs with changes in context such that studying multiple lists in different rooms improves recall compared with studying the lists in the same room (Coggins & Kanak as cited in Smith, 1988; Dallett & Wilcox, 1968; Eckert, Kanak, & Stevens, 1984; Greenspoon & Ranyard, 1957).

Because of these parallels between the directed forgetting results and environmental context-dependent memory results, we propose that the context change hypothesis could be one way to conceptualize the mechanism of directed forgetting. Both costs and benefits could be accounted for by this hypothesis. The costs would occur because the context at recall matches the context for List 2 encoding more than the context for List 1 encoding. If the forget cue leads people to establish a new context after encoding List 1, then List 1 recall would be lower because of the mismatch between encoding and retrieval context. The benefits of directed forgetting would be due to reduced proactive interference, again because of the mismatch between List 1 encoding context and retrieval context. The context change hypothesis would account for the Geiselman et al. (1983) results that directed forgetting occurred even for incidentally encoded words that were interleaved with intentionally encoded words because both were encoded with the same contextual cues. Thus incidentally encoded words really were in the “wrong place at the wrong time,” where “place” refers to the particular set of contextual cues active during List 1 encoding.

The contextual change account has its origins in Bjork’s original theory of directed forgetting (R. A. Bjork, 1970), which invoked set differentiation and selective rehearsal as mechanisms. Bjork initially proposed that people use the forget cue in two ways: They functionally segregate List 1 from List 2 (the set differentiation component) and further devote all mnemonic and rehearsal abilities to List 2 (the selective rehearsal component). This explanation emphasizes the necessity of both components in explaining the directed forgetting findings. That is, for selective rehearsal to take place, the lists need to be successfully differentiated; for list differentiation to occur, the items within each list need to be rehearsed together as a set. The contextual change account is different from the earlier set differentiation and selective rehearsal explanation in that it proposes a different process of set differentiation. The context interpretation of list differentiation hinges on the idea of sampling new contextual cues in response to the forget instruction. In addition, according to the context change hypothesis, segregation of the lists is necessary but not sufficient to produce the costs and benefits of directed forgetting. A key element in addition to segregating or differentiating the lists is that the context at retrieval mismatches List 1 encoding context and more closely matches List 2 encoding context.

To test the context change hypothesis of directed forgetting we induced participants to directly alter their context after List 1 was studied, independent of whether a forget cue was presented. If the directed forgetting costs and benefits result from the changes in contextual cues, then it should be possible to obtain such effects in the absence of forget instructions by merely manipulating participants’ internal context after the presentation of List 1. Experiment 1 was designed to test these hypotheses.

Experiment 1

Experiment 1 tested people in the directed forgetting paradigm with the forget and remember conditions. After studying List 1, we induced a change of internal context by requiring half of the participants to imagine being invisible and to report in writing what they would like to do knowing that they would not have to take responsibility for their actions. This manipulation was intended to induce a large alteration in internal context. There were four conditions in this study: the standard directed forgetting forget condition and the remember condition, the forget-plus-context-change condition, and the remember-plus-context-change condition. We predicted that performance in the remember-plus-context-change condition would reveal costs and benefits akin to those found in the forget condition.

We also tested the forget-plus-context-change condition to determine whether it produced larger costs and benefits than either the forget condition or the remember-plus-context-change condition. As noted in the introduction, in the forget condition, participants are told that List 1 is only practice, whereas in the remember condition, they are told that List 1 is the first half of the items to be learned. Thus, participants in the forget condition treat the two lists as two separate events, whereas participants in the remember condition treat them as one list with a break between them. That difference alone may lead to a contextual change between List 1 and List 2 that is separate from the context change induced by thinking about being invisible. Alternatively, there could be combined effects of retrieval inhibition and the context change manipulation in the forget-plus-context-change condition, in contrast to only the context change manipulation in the remember-plus-context-change condition.

Method

Participants. The 176 undergraduate student participants, who participated in partial fulfillment of course requirements, were recruited from the general psychology course of Florida State University. They were tested in groups of four to six, with 44 participants in each of the four experimental conditions.

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

Procedure. The procedure followed the list method of directed forgetting. List 1 was presented to participants' individual computer screens in a computer lab at a rate of 5 s per word. After study of List 1, a cue (remember or forget) was verbally presented by the experimenter. The forget cue specified that List 1 was "only for practice" to familiarize participants with the task and that there was no need to remember those items. The remember cue specified that List 1 included only the first half of the items from the study list and that those items needed to be remembered for a later memory test. Following the forget or remember instructions, participants in the remember-plus-context-change condition and the forget-plus-context-change condition were given 45 s to imagine and write down the things they would like to do if they were invisible and did not have to take responsibility for their actions. The purpose of this task was to shift their internal cognitive context from studying words in an experiment to something quite different. Participants in the forget and remember conditions simply waited for an equivalent time for the experimenter to present List 2. Then all participants studied List 2, followed by 90 s during which they solved arithmetic problems before the free recall test. At test, participants in the forget condition were first told to recall the practice list (List 1) and were given 1 min to carry out the recall. They were then given a new sheet of paper and told to recall the real experimental items (List 2) during the next minute. Participants in the remember condition were told to recall List 1 and then to recall List 2. The recall was also carried out on separate sheets of paper with 1 min to recall words on each list.

Results and Discussion

The probability of a Type I error was set at .05 for all analyses. In all future analyses the dependent measure was operationalized as the proportion correct recall from the corresponding sheet of paper on which it was carried out. Intrusion errors, such as the recall of the items from the erroneous list, were minimal and were analyzed separately.

The directed forgetting costs and benefits were analyzed separately. For the cost analysis, a one-way analysis of variance (ANOVA) was calculated on the proportion of List 1 recall in the four conditions. The analysis revealed a significant difference between conditions, $F(3, 172) = 7.16$, $MSE = .003$, $p < .01$ (see Figure 1). Post hoc comparisons using Tukey's honestly significant difference (HSD) method indicated that the forget, remember-plus-context-change, and forget-plus-context-change groups did not differ from each other. However, all showed significantly worse recall than the remember group. Thus, we replicated the costs of directed forgetting in the forget condition, and mimicked the costs of directed forgetting by simply inducing in participants an imaginal change of mental context.

For the analysis of directed forgetting benefits a one-way ANOVA was performed on the proportion of List 2 recall in the four conditions. The analysis revealed significant differences between conditions, $F(3, 172) = 4.82$, $MSE = .005$, $p < .05$; see Figure 2. Post hoc Tukey's HSD analyses confirmed that the forget, remember-plus-context-change, and forget-plus-context-change groups did not differ from each other but that all three groups were significantly higher than the remember group. Thus we also replicated the benefits of directed forgetting in the forget group, and mimicked the benefits of directed forgetting with the context change manipulation.

Intrusion errors from the wrong list were also computed and subjected to further analyses. A one-way ANOVA on proportion of List 2 intrusions during List 1 recall in four groups was not significant ($F < 1$). The mean proportion of errors for the forget, remember, remember-plus-context-change, and forget-plus-context-change groups were .020, .023, .021, and .018 respectively. A one-way ANOVA on proportion of List 1 intrusions during List 2 recall in four groups was also not significant, ($F < 1$). The intrusion rates were again low (.036 for the forget, .039 for the remember, .039 for the remember-plus-context-change, and .042 for the forget-plus-context-change groups).

The results suggest that alteration of internal context between study lists is a possible mechanism for the costs and benefits of directed forgetting. In addition, the context change manipulation

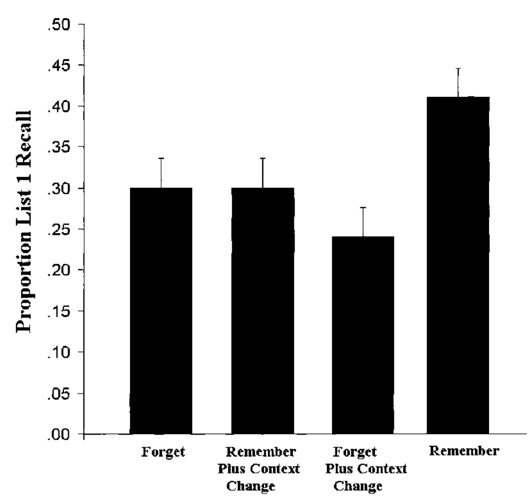

Figure 1. Mean proportion of List 1 recall (+*SE*) in forget, remember-plus-context-change, forget-plus-context-change, and remember conditions in Experiment 1 ($n = 44$ per condition). For the forget condition, this represents the costs of directed forgetting.

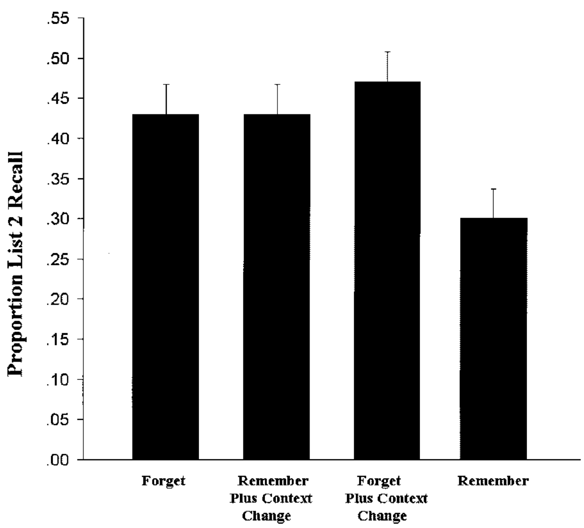

Figure 2. Mean proportion of List 2 recall (+*SE*) in forget, remember-plus-context-change, forget-plus-context-change, and remember conditions in Experiment 1 ($n = 44$ per condition). For the forget condition, this represents the benefits of directed forgetting.

did not significantly increase the effect of the standard forget instructions; that is, the forget-plus-context-change group did not produce larger costs and benefits than the standard forget group. We also ran more liberal tests to observe whether the forget-plus-context-change condition showed the largest costs and benefits using independent *t* tests. The only hints of an increase came in the costs for the forget-plus-context-change condition, which tended to be larger than in the remember-plus-context-change condition, $t(86) = 2.02$, $p = .05$. Our best guess is that there might be a small increase in context change when participants are told to forget List 1, rather than treat it as the first half of a list to be remembered. Alternatively, the instructions to forget might lead to retrieval inhibition in the forget-plus-context-change condition, but that too, seems to be a small effect relative to the effect of the context change manipulation. A posteriori power estimate of the main effect was .98.

Experiment 2

Our goals for this experiment were twofold. The first goal was to verify the generalizability of the findings from the previous experiment. To do so, we used a different interpolated task as a context change manipulation. In this task, participants were asked to imagine their parents' house, mentally walk through it, and describe it in a drawing.

Our second goal for this experiment was to further test the context change hypothesis of directed forgetting. We used a context reinstatement technique that has been shown to reduce or abolish context-dependent memory effects (Smith, 1979, 1984) to diagnose whether the forget group has undergone more context change than the remember group. The context reinstatement technique devised by Smith involves instructing participants to mentally recreate their original list learning environment and generate their own contextual cues from memory. Smith found that participants who were tested in a new context (i.e., in a different room) but were not given the context reinstatement instruction recalled less than those tested in the original environment, showing a standard context-dependent memory effect. However, participants who were instructed to imagine the original study context while being tested in a new room were not different from those who were tested in their original environment. To explain the results, Smith (1979, Experiment 2) proposed a strategy hypothesis that states that both same-context and different-context participants are equally capable of remembering the original list learning environment but that the likelihood of using the strategy of remembering initial context to facilitate recall of words is lower in the different-context participants. Thus, instructing the participants to use this strategy eliminates the differences found between these conditions.

On the basis of Smith's (1979, 1984) results, we predicted that context reinstatement instructions at test would improve memory for List 1 for the conditions in which we hypothesized that context change was responsible for lower memory of List 1, namely, the condition in which we manipulated context change after study of List 1 and in the standard forget condition. However, we predicted a negligible effect of context reinstatement at test for the remember condition because we assume that in the absence of manipulations of context change, and in the absence of forget instructions, context merely drifts slowly over time. Therefore, when we gave the instructions to recall the original context and use it as a retrieval aid, we believed that participants in the forget condition and in the remember-plus-context-change condition would show improved memory for List 1 (relative to when context is not reinstated) to the extent that they can effectively recreate or sample the contextual cues that were present during the study of List 1.

We predicted that context reinstatement at test would have a complementary effect on recall of List 2. That is, reinstating List 1 context at the time of test should reduce List 2 recall by creating a greater mismatch between the context of List 2 at study and the context of List 2 at test. This should be particularly true for the cases in which List 2 was studied in a different context than List 1, namely, in the remember-plus-context-change condition and in the forget condition (if people indeed do respond to the forget cue by attempting to change their internal context). However, because participants in the remember condition studied List 1 and List 2 with largely overlapping contexts, reinstatement of List 1 context at test should have a smaller detrimental effect on the recall of List 2 in the remember condition. The net result is that context reinstatement should reduce the benefits and the costs of directed forgetting.

Method

Participants. The 192 undergraduate student participants, who participated in partial fulfillment of course requirements, were recruited from the general psychology course of Florida State University. They were tested in groups of four to six, with 32 participants in each of the six experimental conditions.

Materials and design. The materials and paradigm were similar to that used in Experiment 1, but we manipulated internal context in a different way. We again tested participants in the remember, forget, and remember-plus-context-changed condition. However, half of the participants in each condition were guided through the imaginal reinstatement of the initial experimental context prior to their attempt to recall the two lists. For the remaining participants, context was not reinstated. Thus the design of the experiment was a 3 (cue) × 2 (context) between-subjects design.

Procedure. To provide a distinctive initial experimental context, we played the main theme from the soundtrack of *Star Wars* at the beginning of the experiment while the participants read and signed their consent forms. After the presentation of List 1 and the instruction that followed it (either to remember or to forget), the participants in the forget condition and in the remember condition waited 45 s until the next list was presented. Participants in the remember-plus-context-change condition were asked to imagine their parents' house and to mentally walk through it.

> Please close your eyes for a second and try to picture your parents' house. If you see it clearly, you may open your eyes. Now please describe your parents' house from the moment you enter through the front door. Describe what you would see if you walked through every room including the details about the furniture and their location. Mentally walk through the house and draw a layout of all the rooms including the furniture. To save time, do not draw the pictures of furniture items, but instead use rectangles, squares, or circles to indicate a furniture item. Make sure you label them and explain the appropriate labels somewhere on your drawing. Please use the next 45 s to draw as much as possible.

Next, all three groups studied List 2 and then solved arithmetic problems for 90 s before the free recall test. At test, List 1 recall always preceded List 2 recall.

The procedure for the context reinstated groups in the three cue conditions was similar in all respects to the context not-reinstated groups except for the context recall instruction that was given immediately prior to final recall. Participants in the forget, remember, and remember-plus-context-change conditions were told the following:

> Please take a minute to recall and write down in brief phrases or words what you were doing immediately prior to experiment and where you came from. [Pause.] Now please try to recall and write down what were some thoughts, feelings, or emotions that you had when you entered this room. Perhaps there was something about the room that caught your attention. If you remember having specific thoughts, please write them down, otherwise do not make up any at this point. [Pause.] Now try to recall the minute when I assigned you your seat. Recall what the screen of the computer said, what color it was, and write this down. [Pause.] Now try to recall any specific thoughts, feelings, or emotions that you had while you studied the first list of items. [Pause.] Finally, try to recall what you were thinking of while studying the items, recall how you studied the items, and what kinds of things you did in order to memorize them. What you have done so far might help you remember the items better during the memory test. Use this information to help you recall as many items as you can remember from the first list that you studied.

To equate the time during which the context-reinstated groups followed the context reinstatement instructions, the participants in the context not-reinstated groups continued solving arithmetic problems for the same duration of time (45 s). After the recall of List 1, the participants were tested on their memory for List 2 and were given 2 min for recall. The recall was carried out on separate sheets of paper.

Results and Discussion

We first tested whether the new context manipulation produced the costs for List 1 recall and the benefits for List 2 recall, as we had found with the invisibility context manipulation in Experiment 1. For the analysis of costs a one-way ANOVA was performed on proportion of List 1 recall in the condition where context was not reinstated. The results revealed a significant difference among conditions, $F(2, 93) = 19.47$, $MSE = .002$, $p < .01$. Post hoc Tukey's HSD analyses showed that the forget and remember-plus-context-change conditions did not differ from each other and that both were significantly different from the remember group. Thus, as in Experiment 1, directed forgetting costs were obtained in the forget condition, and those costs were mimicked in the remember-plus-context-change condition.

For the analysis of benefits a one-way ANOVA was calculated on proportion of List 2 recall for the three conditions in which context was not reinstated. The results showed a significant difference among the groups, $F(2, 93) = 6.74$, $MSE = .003$, $p < .05$. Post hoc Tukey's HSD tests showed that the forget and remember-plus-context-change groups were not different from each other and both were significantly different from the remember group. Again, parallel to Experiment 1, directed forgetting benefits were obtained for the forget group and those benefits were mimicked in the remember-plus-context-change condition.

To determine the effects of context reinstatement on the forget, remember, and remember-plus-context-change conditions a two-way ANOVA with context (reinstated vs. not-reinstated) and cue (forget vs. remember vs. remember plus context change) was computed on proportion of List 1 recall. There was a significant main effect of cue, $F(2, 186) = 19.90$, $MSE = .002$, $p < .01$, and a significant effect of context, $F(1, 186) = 9.75$, $MSE = .002$, $p < .01$. However, these effects were moderated by a significant Context $\times$ Cue interaction, $F(2, 186) = 3.53$, $MSE = .002$, $p < .05$; see Figure 3. The analyses of simple effects confirmed that the forget condition recalled significantly more when context was reinstated than when it was not, $F(1, 186) = 9.95$, $MSE = .002$, $p < .01$. The remember-plus-context-change condition also recalled significantly more when context was reinstated than when it was not, $F(1, 186) = 6.74$, $MSE = .002$, $p < .01$. However, the regular remember group was not affected by the context reinstatement instructions ($F < 1$).

These results confirmed our predictions that context reinstatement would benefit recall of List 1 for those conditions in which context had changed most between study and test, for example, the remember-plus-context-change condition and the forget condition.

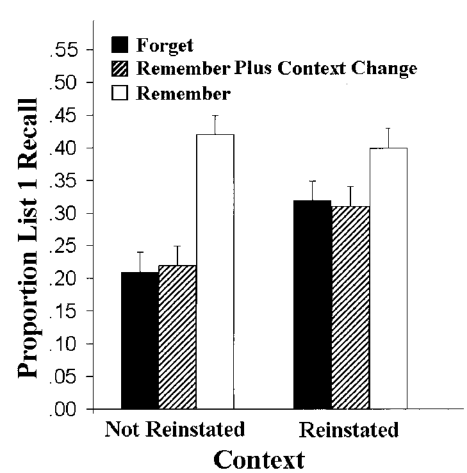

Figure 3. Mean proportion of List 1 recall (+*SE*) as a function of context and cue in Experiment 2 ($n = 32$ per cell). For the forget condition, this represents the costs of directed forgetting.

As a consequence, context reinstatement reduced the costs of directed forgetting.

Our second set of predictions focused on the measure of the benefits of directed forgetting. We predicted that memory for List 2 would decrease in the forget and the remember-plus-context-change groups as a result of context reinstatement and that the remember group would be less affected. To test these predictions, we performed a 2 (context) × 3 (cue) ANOVA on proportion of List 2 recall (see Figure 4). There was a significant main effect of cue, $F(1, 186) = 5.54$, $MSE = .004$, $p < .01$, and a significant main effect of context, $F(1, 186) = 7.71$, $MSE = .004$, $p < .01$. However, contrary to our predictions, the interaction effect was not significant ($F < 1$). Benefits appear to be smaller effects than costs in directed forgetting (Conway, Harries, Noyes, Racsma'ny, & Frankish, 2000). We carried out several planned comparisons to test the primary predictions. The first contrast, which was between the context reinstated and context not-reinstated conditions for the remember cue, revealed that recall did not change with context reinstatement ($F < 1$). The second contrast, which was between the context reinstated and context not-reinstated conditions for the forget cue, showed that the reinstatement significantly decreased List 2 recall, $F(1, 186) = 3.98$, $p < .05$. The final contrast for the similar conditions in the remember-plus-context-change group revealed a significant decrease in List 2 performance as a result of context reinstatement, $F(1, 186) = 5.23$, $p < .05$. Thus, recall of List 2 decreased after reinstatement of List 1 context for the conditions in which we predicted that context had changed between study of List 1 and study of List 2.

The results of the experiment strengthened the results from Experiment 1 by mimicking the directed forgetting costs and benefits in the remember-plus-context-change group with a different contextual change manipulation. Also, our predictions regarding the costs of directed forgetting were confirmed with the context reinstatement manipulation. Participants in the forget and in the remember-plus-context-change groups significantly improved their List 1 memory as a result of reinstatement whereas the remember group did not benefit from these instructions. Planned contrasts revealed the complementary pattern for the benefits on List 2 recall of the forget and the remember-plus-context-change condition—benefits were reduced when List 1 context was reinstated.

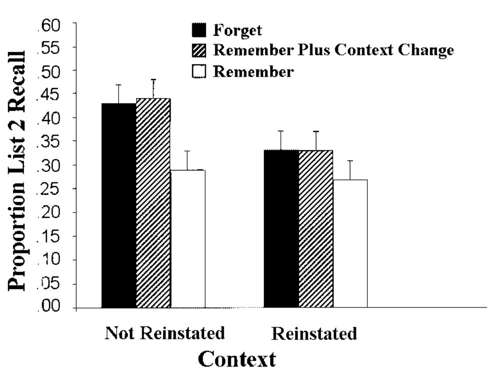

Figure 4. Mean proportion of List 2 recall (+*SE*) as a function of context and cue in Experiment 2 ($n = 32$ per cell). For the forget condition, this represents the benefits of directed forgetting.

However, reinstatement did not completely eliminate the impairment that was caused by the forget instruction. Although memory for List 1 improved significantly by instructing the participants to mentally recreate their original study context, it did not reach the same levels of recall as in the remember group. Smith (1979) showed that imaginal reinstatement of context was effective to the degree that participants were able to access memory of the context. Therefore, perhaps the costs were not abolished completely by context reinstatement because participants in the forget and remember-plus-context-change groups were not totally effective at recreating the original study context.

General Discussion

The present experiments provide support for the context change hypothesis of directed forgetting which proposes that such forgetting is a result of changes in mental context in the forget condition participants between study of List 1 and study of List 2. Both experiments revealed that it is possible to obtain effects parallel to the costs and benefits of directed forgetting in the absence of a forget instruction by directing participants to mentally change contexts between study of List 1 and study of List 2. In Experiment 2, when participants were instructed to mentally reinstate the List 1 context prior to recall, those who had experienced a context change between lists (the remember-plus-context-change condition) benefited from those instructions in their List 1 recall performance more than did those in the standard remember group and, importantly, those in the forget condition also benefited from context reinstatement as one would expect if the forget instructions had led to a change of mental context. These results thus add another parallel between studies of directed forgetting and context-dependent memory.

The context change account of directed forgetting has its roots in Bjork's (R. A. Bjork, 1970) original theory of directed forgetting, which invoked set differentiation and differential rehearsal to account for the effects of directed forgetting instructions (see also Johnson, 1994; Whetstone, Cross, & Whetstone, 1996). Whetstone et al. attempted to test the contextual set differentiation hypothesis by inducing set differentiation without directed forgetting instructions. Participants in one condition were warned that they would have to remember both lists of words, but that they would also have to remember the list membership of each word. However, this did not produce the pattern of costs and benefits seen in directed forgetting. The manipulation of contextual segregation in the current experiment was perhaps more direct (e.g., "think about what you would do in the world if you were invisible," or "think about the rooms in your parents' house") to parallel the strategy reported by some participants in our pilot study. According to the context change hypothesis, segregation of the lists is necessary but not sufficient to produce the costs and benefits of directed forgetting. A key element in addition to segregating or differentiating the lists is that the context at retrieval mismatches List 1 encoding context and more closely matches List 2 encoding context.

The results of the current experiments support the viability of context change as a mechanism of directed forgetting, but they do not rule out other mechanisms of directed forgetting, such as retrieval inhibition. There may be multiple mechanisms that can produce the costs and benefits of directed forgetting. However, a key finding of Experiment 2 was that participants in the forget condition benefited from context reinstatement, which stems directly from the prediction that people do use a strategy of "thinking about something else" when told to forget List 1. It is unclear why retrieval inhibition would be lifted or lessened by efforts to reinstate context.

How well can the context-change hypothesis account for prior findings regarding directed forgetting? In the introduction we reviewed various parallels between context dependent memory research and directed forgetting research and we consider additional findings here. One strength of the context change hypothesis is that it allows one to build on prior research and theory of the effects of global context change as an aid to understanding directed forgetting. Context change has long been invoked as a basis for forgetting (e.g., Bower, 1972) and plays an important role in determining the accessibility of memories in many mathematical models of memory. Mensink and Raaijmakers's (1988) model of context fluctuation inspired the contextual change hypothesis of directed forgetting and thus serves as a basis for predictions about directed forgetting (if directed forgetting effects indeed stem from context change between lists). For example, this model predicts spontaneous recovery of List 1 with an increasing delay between study of List 2 and final recall. Mensink and Raaijmakers explain such recovery by the changing ratio of the contextual strengths prevalent during List 1 versus List 2, and that ratio is an increasing function of retention interval. Their model is a model of cued recall rather than free recall but by extrapolation one could predict that the costs of directed forgetting would diminish over time, as found by Liu et al. (1999).

Macrae, Bodenhausen, Milne, and Ford (1997) and Conway et al. (2000) found that divided attention during the encoding of List 2 abolished the costs of directed forgetting. Conway et al. interpreted these results as reflecting the attentional demands of inhibition but the results might also reflect the attentional demands of maintaining a new mental context. Conway et al. also found that the costs of directed forgetting were eliminated when half of the items on List 1 were strong associates of the items on List 2. To the extent that such a manipulation increased the likelihood that participants were reminded of a List 1 word when they encountered the associate on List 2, interlist associations would be formed between items, and context would then play less of a role in determining access to List 1 items (Smith & Vela, 2001).

Our manipulations of context change were guided by the experimenter and gave participants a substantial amount of time to think about being invisible or to think about being in their childhood homes. However, prior studies of directed forgetting do not provide as long an interval for such a process to occur. In fact, in some studies (e.g., R. A. Bjork, 1970) the cue to forget prior items was simply a change in background color of the slide during presentation of the next item. Are people capable of engaging in fast context change strategies on their own in standard directed forgetting experiments? Certainly the emotional component of context can change rapidly, as anyone who has been told an exam has been canceled or that they have won a contest knows. Future research should address the time parameters of a context change strategy.

An alternative to the context change hypothesis is that participants in the remember group engaged in rehearsal of List 1 during the unfilled 45-s interval between the lists. Our choice of an unfilled delay as opposed to a filled delay was largely motivated by limited knowledge regarding how elements of an intervening filler task might be capable of creating a larger or smaller internal context change. This is an important issue itself and requires further investigation. In other directed forgetting studies in our laboratory we have found that filling the interval with arithmetic problems produced comparable directed forgetting effects (e.g., Sahakyan & Kelley, 2000, Experiment 2), as did shortening the length of the unfilled interval to 15 s. These findings suggest that selective rehearsal of List 1 by the remember group in the interval between lists is not the key mechanism of directed forgetting costs and benefits.

A second interval where participants across groups might engage in selective rehearsal is during the delay between List 2 and recall. That interval was filled with arithmetic problems for all groups (and all groups solved comparable numbers of problems correctly [$F < 1$]). However, to the extent that participants engaged in rehearsal during that interval, the costs and benefits of directed forgetting would have increased by producing a list strength effect.[1] Participants in the two forget conditions would rehearse List 2 items, thereby making those items stronger and further reducing the accessibility of List 1 items. Participants in the two remember conditions might attempt to rehearse both lists. Because of the context change in the remember-plus-context-change condition, List 1 would be more difficult to access during rehearsal, thereby making List 2 items stronger and further reducing the accessibility of List 1 items. Only participants in the remember condition would not be creating a list strength effect by means of differential rehearsal. Interestingly, in SAM, the list-strength effect in free recall is itself a context effect in that stronger items have more context stored (Shiffrin, Ratcliff, & Clark, 1990). This list strength account leads to the prediction that an unfilled delay between List 2 and test would increase the costs and benefits of directed forgetting relative to a filled delay.

The process of directed forgetting may be similar to the processes involved in thought suppression in the "white bear" paradigm in that protocols gathered during suppression experiments reveal that many participants verbalize a strategy of "okay, I'll think of something else" (Wegner, Schneider, Carter, & White, 1987, p. 7). The problem with thought suppression seems to be that thinking of something else is difficult to sustain, and participants end up thinking about various uninvolving aspects of the testing room, such as the light switch. Those contextual cues then serve as triggers of the thought during the expression period, creating a rebound effect. Participants instructed to think of a particular distractor (a red Volkswagen) during the suppression period showed less of a rebound effect. Wegner et al. proposed that dissociating the contexts in which suppression and expression were performed was the key to reducing the rebound of the suppressed thought. Like thought suppression, directed forgetting might depend on one's ability to come up with a compelling alternative to thinking about the to-be-forgotten material.

The context change hypothesis of directed forgetting ties directed forgetting to other phenomena in which forgetting has a beneficial effect. Strategic changes of internal context might be useful during studying and learning as well as during repetitive cognitive tasks, such as grading exams. Studying different information in different rooms is more effective than studying all the

[1] We thank Kenneth Malmberg for this suggestion.

information in a single environment (Smith, 1982; Smith & Rothkopf, 1984). Because mentally changing one's cognitive context is under more strategic control than changing one's location of study, pausing to think of something dramatically different would help to overcome interference and benefit performance. Change in context has also been hypothesized as important for incubation (Smith, 1995), which refers to the alleged benefits of temporarily setting a problem aside when stuck rather than working on it continuously. Smith proposed that when people become fixated on a wrong solution in the initial context, an incubation interval increases the likelihood that context will change and thus lower the accessibility of the wrong solution or set. Consequently, the probability of solving the problem later is improved. The results of our experiments suggest that an attempt to mentally change internal context could have similar benefits. Part of the benefits of directed forgetting could result from an increased likelihood of using a new strategy of encoding on List 2 (Sahakyan & Delaney, in press). Such a change in encoding strategy would also reduce interference between the lists.

Overall, changes in mental context that can be brought under one's strategic control serve to reduce interference. Because the directed forgetting benefits appear to be more permanent than the costs (Liu et al., 1999), benefits play a more important role in the process of updating information. The main value of contextual shifts is to protect new information from overwhelming interference while it is being established in memory.

Encoding events in specific contexts provides a solution to the problem of how we can access particular memories across a lifetime that includes similar events (cf. Murnane et al., 1999). We are aided in this task when the structure of our lives creates distinctive contexts such that memories of similar events do not mutually interfere. Yet, when faced with repetitive, highly similar events that call for memory updating, people can use the strategy of creating distinctive encoding contexts by means of imagination and thus reduce accessibility of out-of-date information.

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