GILBERT, ELIZABETH T., M.A. Remember to Forget: Does Strategic Retrieval from the List before the Last Enable Forgetting of the Most Recent Information. (2020) Directed by Dr. Peter F. Delaney. 46 pp.

Successful forgetting in list-method directed forgetting procedures has only been observed when new information is encoded following the forget cue. A recent study, however, observed forgetting of the most recent information without post-cue encoding (Racsmány et al., 2018), putatively because proactive interference from previously learned to-be-remembered information is sufficient to cause forgetting. In three Experiments, I aimed to replicate the recent findings and provide an alternative explanation that post-cue encoding occurs covertly. In the forget condition, participants studied two lists of words with a forget cue after the second list, while in the remember condition both lists were cued to-be-remembered. Free recall tests followed each pair of lists. Experiment 1 resulted in no significant directed forgetting effects and thus failed to replicate Racsmány et al.'s results. However, minor changes to the procedure in Experiments 2 and 3 resulted in significant forgetting of the most recent list. The findings indicate that directed forgetting of the most recent information is possible, and that participants may do so by strategically retrieving earlier learned to-be-remembered information. Previous research indicates that explicit retrieval of earlier-leaned information causes a contextual shift, resulting in forgetting of target information.

REMEMBER TO FORGET: DOES STRATEGIC RETRIEVAL FROM THE LIST BEFORE THE LAST ENABLE FORGETTING OF THE MOST RECENT INFORMATION

by

Elizabeth T. Gilbert

A Thesis Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Greensboro
2020

Approved by

____
Committee Chair

APPROVAL PAGE

This thesis written by ELIZABETH T. GILBERT has been approved by the following committee of the Faculty of The Graduate School at the University of North Carolina at Greensboro.

Committee Chair ______________________________

Committee Members ______________________________

____

____
Date of Acceptance by Committee

____
Date of Final Oral Examination

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Suppose a professor is lecturing and suddenly announces a pop quiz. While handing out the quiz, they tell students that the information they have learned during today's class will not be on the quiz and should be forgotten so it does not influence their answers. Is it possible to forget the most recently learned information if it is fresh in your mind? Unless the professor presents additional information to the class before giving the quiz, the most recent information may be difficult to forget due to the temporal recency and associated context of those items (Sederberg, Howard, & Kahana, 2008). Students may simply rely on the current context, within which the information was learned, to retrieve the most recent items with relative ease (Jang & Huber, 2008). The present paper suggests that forgetting of recent information is sometimes possible, and it occurs in part because retrieval of earlier learned information may change the current context and enable forgetting of those items.

Intentional forgetting, first introduced by Bjork, LaBerge, and LeGrand (1968), describes a person's ability to control their memory by choosing what information to forget in favor of information they wish to remember. In list-method directed forgetting, which will be the focus of this paper, participants learn two successive lists for a final recall task. Following presentation of the first list, participants are either provided a remember or forget cue before seeing the second list.

After both lists are presented, participants are asked to recall all words, regardless of whether they were told to forget the first list or not. Typically, participants receiving the forget cue between lists show diminished recall for List 1 to-be-forgotten items (the "costs" of directed forgetting) and enhanced recall for List 2 to-be-remembered items (the "benefits" of directed forgetting) compared to the remember group (Bjork, 1989).

All currently dominant theories of directed forgetting, including the retrieval inhibition and context change theories, assume that subsequent encoding of new information after the presentation of a forget cue is crucial to forget the most recent items (Bjork, 1970, 1989, 1998; Conway, Harries, Noyes, Racsmány, & Frankish, 2000; Gelfand & Bjork, 1985; Pastötter & Bäuml, 2007, 2010; Sahakyan, Delaney, Foster, & Abushanab, 2013). Though not directly predicted by these theories, empirical evidence aligned with these theories suggests that without post-cue encoding, no forgetting occurs. The retrieval inhibition theory suggests that post-cue encoding of competing information is necessary to activate the inhibitory process of to-be-forgotten items during encoding of new information and the subsequent retrieval of to-be-forgotten items is impaired as a result of new learning (Gelfand & Bjork, 1985; Bjork, 1989).

The context change theory states that the forget cue initiates a change in the mental context between List 1 and List 2, which impairs List 1 recall at retrieval, due to the mismatch between context during encoding and test (Sahakyan & Kelley, 2002). A contextual shift alone is insufficient to cause forgetting and must be accompanied by subsequent learning (Pastötter & Bäuml, 2007). However, a recent study found successful forgetting of recently learned information without subsequent encoding (Racsmány, Demeter, & Szöllösi, 2018). Using a modified two-list procedure in Experiments 2 and 3, Racsmány et al. (2018) proposed that the selectivity of the forget cue along with proactive interference from earlier-learned List 1 items allowed participants to inhibit the most recent List 2 items. These new findings pose a challenge to the established theories of directed forgetting. Here, I explain this recent discovery and provide an alternative account for how it may be possible.

Theories of Directed Forgetting

The original theory explaining the directed forgetting phenomenon is the selective rehearsal account (Bjork, 1970; Bjork et al., 1968). In selective rehearsal, the costs of directed forgetting emerge because participants who receive the cue to forget between lists stop rehearsing the to-be-forgotten items from List 1 and focus their rehearsal time on List 2, thus simultaneously resulting in the benefits. However, directed forgetting was successfully obtained in procedures involving incidental learning, which the selective rehearsal account could not explain (Geiselman, Bjork, & Fishman, 1983; Sahakyan & Delaney, 2005). In these incidental learning procedures, participants were not instructed to memorize a set of words but rather to rate the words for pleasantness. Since the rated items were not intended to be memorized, participants had no reason to rehearse them. However, the costs and benefits of DF were still obtained despite the lack of intentional encoding.

As a consequence, selective rehearsal was replaced by the retrieval inhibition theory (e.g. Bjork, 1989). According to the retrieval inhibition theory, the forget cue initiates an inhibitory process that blocks or inhibits access to List 1 items. The inhibition of List 1 items diminishes retrieval of those items and subsequently facilitates the learning of List 2 items by reducing proactive interference from List 1 on List 2.

Subsequently, Sahakyan and Kelley (2002) explained the mechanism of directed forgetting in terms of a contextual shift occurring between lists. The context change theory states that in response to the forget cue, participants initiate an internal context change between List 1 and List 2 encoding, resulting in more forgetting of List 1 items. Since, memory retrieval is context dependent (e.g. Smith & Vela, 2001), when there is a mismatch in context between to-be-forgotten items and test, participants are less able to retrieve those items compared to List 2 items, which match the current context. In contrast, participants in the remember group can rely on the current context to recall items from both lists because they did not alter their internal context between List 1 and List 2 encoding. This contextual disparity in the forget group between list encoding and test explains both the costs and the benefits of directed forgetting. Total recall of target items from List 2 can be impaired by the earlier learning of List 1 nontarget items due to a buildup of proactive interference (e.g. Underwood, 1957). However, various manipulations in directed forgetting studies, such as receiving a forget instruction or inducing a mental context change through imagination tasks, may reduce proactive interference and subsequently increase List 2 recall (Bäuml & Kliegl, 2013). In three experiments, Bäuml and Kliegl showed that both participants who are instructed to forget earlier-learned information and participants who receive an internal context-change manipulation before learning a target list showed increased recall of the target list compared to participants in the remember or no context change groups due to a release from proactive interference. These findings are supported by the fact that minimal intrusions are typically observed by participants in the forget group; that is, participants are more able to restrict their memory search to the target list rather than searching the entire set of items when recalling List 2 (see Baddeley, 1990).

To provide a more comprehensive explanation of the directed forgetting phenomenon, the two-factor account of forgetting was proposed (Sahakyan & Delaney, 2003, 2005). Both the retrieval inhibition and context change theories state that the costs and benefits of directed forgetting arise from a single mechanism. Sahakyan and Delaney (2003) proposed that the costs are indeed a result of a change in mental contexts between List 1 and List 2, but that the benefits are instead due to a change in encoding strategy between lists. Through the use of verbal reports, Sahakyan and Delaney (2003) showed that most participants in both the remember and forget groups typically encode List 1 using shallow encoding techniques, such as adding each new word to the rehearsal set or rehearsing only the first letter of each word. However, upon receiving the forget cue, they observed some participants employing strategies to more deeply encode List 2, such as creating stories out of the words. This significantly increased recall rates of List 2 in the forget group compared to the continued shallow encoding of the remember group. The forget instruction causes some participants to evaluate their current encoding strategy and switch to a more efficient strategy for List 2 whereas the remember instruction is less likely to induce a change in strategy (see also Sahakyan et al., 2013; Sahakyan, Delaney, & Goodmon, 2008).

To support the two-factor account of directed forgetting, Sahakyan and Delaney (2005) were able to obtain the costs of directed forgetting without simultaneously observing the benefits by manipulating whether participants learned word lists intentionally or incidentally. If the benefits of directed forgetting are observed as a result of better encoding of List 2 items, then participants who merely rate items for pleasantness and are not encoding these items in preparation for an upcoming test are unlikely to evaluate their performance between List 1 and List 2 and switch encoding strategies. Sahakyan et al. (2005) found significant costs in both intentional and incidental conditions, but the benefits did not arise in the incidental learning condition, a possibility that had not been predicted by either the retrieval inhibition or context change theories. Similarly, inhibitory accounts of directed forgetting proposed a reset of encoding hypothesis whereby as more items are learned, encoding efficacy decreases as memory load increases (Pastötter & Bäuml, 2010). However, providing participants with a forget cue between lists resets the encoding process for early List 2 items thus contributing to the benefits. Retrieval inhibition is therefore responsible for the costs and the reset of encoding contributes specifically to the benefits (see also Pastötter, Kliegl, & Bäuml, 2012; Pastötter, Tempel, & Bäuml, 2017). According to the earlier theories, the costs and benefits always occurred simultaneously.

Post-Cue Encoding: Controversy

Despite the different explanations of the retrieval inhibition and two-factor accounts of forgetting, empirically, it seems that post-cue encoding of new information is required to observe forgetting. In list-method directed forgetting experiments, the forget cue is always presented prior to List 2. Numerous experiments have been conducted to examine the possibility of directed forgetting without post-cue encoding and failed. Bjork et al. (1968), in an attempt to assess the role of proactive interference, showed participants blocks of consonants (CCCC) inserted into a series of digits. Some participants learned two blocks and just before presentation of the second block, they were either instructed to "drop" the first block from memory (forget condition) or keep remembering it along with the second block (remember condition). Other participants learned only a single block of consonants and all participants were subsequently tested on recall of the most recent block. Proportion recalled was superior for participants in the single block condition, followed by the "drop" condition and then the remember condition. These results indicate that recall was impaired relative to the proactive interference from the prior items. When participants only learned one block, and therefore did not experience any proactive interference nor post-cue encoding, no forgetting occurred, suggesting that successful forgetting requires interference.

In another study, Gelfand and Bjork (1985) showed participants a list of ten nouns followed by a forget or remember cue. Then, participants were split into three groups, with one group receiving a second list of nouns to learn, another group receiving a list of adjectives to rate, and the last group doing nothing while the experimenter "fumbled around" to waste time. During a final recall test, participants who did not engage in later learning after receiving a cue to forget recalled significantly more List 1 items than participants who received a subsequent list to study. Gelfand and Bjork made the claim that a new list of to-be-remembered items is necessary to cause forgetting of the previous items, in concordance with the findings of Bjork et al. (1968).

Later findings by Pastötter and Bäuml (2007) suggest that context change is only enough to cause forgetting when there is additional information encoded in the new context. In their study, subjects were presented with a list of items and then either given a cue to remember or forget the list, or a mental context change was induced by having participants imagine walking through their parent's house. Following the cue, participants either learned a second list of words or participated in an unrelated distractor task of counting backwards from a three-digit number. The results were consistent with those found by Bjork et al. (1968) and Gelfand and Bjork (1985); forgetting was only observed in the conditions where participants had to learn a second list of words. In the single list condition, participants showed similar recall regardless of whether they were given the instruction to remember or forget. Their reasoning for not observing forgetting in the single list condition was that encoding List 2 strengthens the new context, making the reinstatement of the previous List 1 context more challenging. Additionally, the presence of List 2 requires retrieval cues to differentiate between pre- and post-cue information. When one cue is sufficient for the entire set of information, and List 1 context can be easily reinstated at test, and as such directed forgetting and context dependent forgetting are impaired. Further work by Pastötter and Bäuml (2010) showed that forgetting may also be reduced as a result of increased List 2 length, indicating that the amount of post-cue encoding further separates the contexts of List 1 and test, impairing recall.

In another study, Conway et al. (2000) had participants learn a list of words followed by a remember or forget cue. Then, while learning a second list, participants in the forget group were instructed to count the total number of vowels in the List 2 words. The results indicated that participants in the forget group showed higher List 1 than List 2 recall despite the instruction to forget List 1. This suggests that performing a secondary task during List 2 encoding is enough to eliminate the costs of directed forgetting and further supporting the claim that it is not just the presence of a second list that is necessary to cause forgetting, but the act of effectively encoding post-cue items (for a review of the importance of post-cue encoding, see Sahakyan et al., 2013).

Recently, however, a study by Racsmány and colleagues (2018) observed directed forgetting in the absence of this essential post-cue learning, which is not directly predicted by either the retrieval inhibition or context change theories. However, earlier theories accommodated these findings as the problem; since no forgetting occurred without post-cue encoding, therefore post-cue encoding must be necessary. In Racsmany et al.'s first experiment, participants were shown a single list to either remember or forget. Consistent with previous findings, recall was comparable between the two groups and no forgetting was observed. In their second and third experiments, participants were presented with two lists of items, but unlike traditional directed forgetting procedures, those in the forget group were cued to forget List 2 (the most recent list) after presentation of both lists. Following a cue to either remember or forget List 2, participants completed an 8 min task during which they solved arithmetic problems. Following the arithmetic task, participants in both conditions were asked to first recall items from List 2 followed by items from List 1, with recall of the most recent list occurring first in Experiment 1. The results indicated that participants in the forget group showed diminished recall for the most recent List 2 items compared to the remember group, even without subsequent learning. The authors suggested that the presence of any to-be-remembered information in the learning episode, regardless of whether it occurs before or after the forget cue, is sufficient to cause forgetting. The proactive interference of List 1 items on List 2 contribute to forgetting without post-cue encoding of new information. These findings pose a challenge to earlier evidence and current theories of directed forgetting, because successful forgetting occurred despite the lack of post-cue encoding.

The List-Before-Last Task

The goal of the present study is to propose an alternative explanation for why participants may successfully forget List 2 items that is not directly predicted by earlier theories. Although the account is new, it is consistent with the claims of these theories. I hypothesize that participants strategically initiate retrieval of earlier learned information to forget the most recent items. This retrieval of earlier-learned items causes a contextual shift, which results in reduced recall of the target list.

This notion was suggested by Jang and Huber (2008) to explain a related phenomenon called the list before the last effect (discovered by Shiffrin, 1970). In list before the last procedures, participants encode multiple lists, and between each list they are instructed to either wait for the next list or to retrieve not the current but the previous list, also known as the list before the last (see also Sahakyan & Smith, 2014; Ward &

Tan, 2004; Unsworth, Spillers, & Brewer, 2012). Jang and Huber randomized whether a given list was tested or not (so that participants could not guess what the upcoming trial would be). Figure 1 shows a schematic of two list-before-the-last retrievals, one with an intervening retrieval trial and one with an intervening no-retrieval trial. When the list before the last was tested after another retrieval trial, forgetting was observed relative to the condition where a no-retrieval trial intervened. They explained this result using a mechanism similar to the context-change theory in directed forgetting: when context is sufficiently shifted between List 1 to-be-forgotten items and List 2 to-be-remembered items, participants show reduced recall for List 1 items compared to those in a control group who do not initiate a contextual shift. In list before the last, on no-retrieval trials, the two lists are encoded in the same context, making it difficult for participants to isolate each list and thus intervening list items intrude during recall for target list items. When participants attempt to retrieve the target list, they can rely on the most recent context of the intervening list as it most closely matches the target list, similar to the remember condition in directed forgetting procedures. Thus, they concluded that retrieval of the list-before-last led to significant forgetting of the target list on the subsequent retrieval trial.

In the current study, it is possible that the same mechanism present in the list-before-last procedure is being covertly used by participants as they try to forget the most recent list. Upon receiving the cue to forget the most recent list (List 2), participants might strategically retrieve from the prior list (List 1). This item retrieval simultaneously retrieves the previous context and therefore initiates a contextual shift between List 2 and List 1, thus isolating the lists. Consequently, when they are later asked to recall from List

2, it has become the new list before the last, and List 1 is now the most recent list. As a result of the covert contextual shift, List 2 recall is impaired (see Figure 1).

The Present Study

To explain Racsmány et al.'s (2018) results, I propose that in order to forget the most recent list (List 2), participants will strategically and covertly engage in a retrieval trial of the previous list items (List 1). Retrieval of List 1 in turn initiates a contextual shift causing forgetting of List 2. The possibility that people may strategically attempt to retrieve other items to forget is intuitively plausible, given the results of the list-before-last paradigm.

In the current study, I therefore sought to replicate the results of Racsmány et al. (2018). Further, I predict that participants who receive the forget cue may decide to strategically and covertly retrieve the previous list (List 1) as a means to forget the current list (List 2). By doing so, they are updating their current context, as evidenced by the list-before-last paradigm and integrating it with the previous list (List 1) context. When participants attempt to recall the most recent list (List 2), the current context mismatches the context during List 2 encoding, reducing recall performance of that list. Earlier directed forgetting studies have shown that post-cue encoding is crucial to observe forgetting, and I propose that later learning is indeed occurring; however, it occurs as covert retrieval of List 1.

CHAPTER II

EXPERIMENT 1

Data and materials for all experiments will be made available on the laboratory's webpage. The first aim of Experiment 1 was to conceptually replicate the main results of Racsmány et al. (2018). Specifically, I hypothesized that participants would be able to successfully forget the most recent list. The second aim was to determine, through verbal reports, whether participants were strategically retrieving earlier learned items in order to forget. Retrospective verbal reports have been asserted to be a reliable source of information consistent with participant behavior and cognitive processes (e.g. Ericsson & Simon, 1993), and are beneficial to identify various covert strategies used by participants when completing tasks (for a recent review, see Delaney, Wallander, & Preheim, 2018).

The current experiment consisted of four lists of 12 English words (Appendix B) selected from the Toronto Noun Pool (Friendly, Franklin, Hoffman, & Rubin, 1982). The original authors used a between-subjects design, thus using only two lists. The current study used four lists of words to enable a within-subjects analysis and to increase power. Racsmány et al.'s (2018) original between-subjects experimental design was nested within the current design to allow for a direct replication comparison, if necessary. The original authors used an 8 min distractor task of arithmetic problems following List 2 to reduce rehearsal of items before the final recall test. In the current experiment, the arithmetic was replaced with reading out loud for 5 min because experience within the current population has shown that tasks involving math problems are potentially stressful for participants and may negatively impact recall performance. I expected that participants would be able to forget the most recent list, in line with Racsmány et al.'s (2018) findings. I also expected that they would report retrieving the first list as a strategy to enable forgetting of the most recent list.

In the Method and Results sections, I report sample size and exclusion criteria, all manipulations, and measures of the current study (Simmons, Nelson, & Simonsohn, 2012). All experiments were approved by the University of North Carolina at Greensboro IRB committee and followed IRB guidelines.

Method

Participants. Data were collected from 75 undergraduates in psychology courses at the University of North Carolina at Greensboro recruited through the psychology research pool. The original authors collected data from 60 participants in their first two experiments, therefore the stopping rule in the current study was set at 72 participants to closely match the original, and so that each of the eight conditions had an equal number of participants, including replacements. An additional three participants had signed up to participate in the study before reaching the stopping rule, so their data were included in the analysis. Data from 10 participants who failed to comply with the directions to forget were excluded, including individuals responding "no" when asked if they tried to forget the list they were told to and those who reported intentionally remembering the to-be-forgotten items, resulting in a total analysis of 65 participants.

Materials and Design. This experiment had a 2 List Set (Lists 1 and 2 vs. Lists 3 and 4) x 2 Cue (Remember vs. Forget) x 2 cue counterbalancing within-subjects design. In all experiments, participants were instructed to forget either List 2 or List 4 and then participated in recall tests following both of these lists. The experimental design is presented in Figure 2.

The experiment consisted of eight conditions, with cue and list order counterbalanced so that for each order of the four separate word lists, half of the participants were instructed to forget List 2 and the rest to forget List 4 (see Appendix C for list counterbalancing). Words were presented in Microsoft PowerPoint, and recall was typed by the participant in Microsoft Word.

Procedure. Participants were told they would see a list of words appear one word at a time on a computer screen and that they should remember these words for a later memory test. The words were presented on the screen for 5 s each with no interstimulus interval. After presentation of the first list, participants were told they would see a second list appear one word at a time. Following presentation of the second list, 37 participants were told to try to forget the List 2 words while the remaining 38 participants were told to keep remembering List 2. Both groups were instructed to continue remembering List 1. After a 30 s time out, participants were asked to read out loud from a history of the Russian revolution — *October* by China Miéville (2017) — for 5 min. After 5 min of reading aloud, participants were given 1 min to first recall words from List 2 followed by an additional minute to recall words from List 1 without access to their previous List 2 responses (see Appendix D for experimenter instructions). Once participants completed the recall task, the experiment continued with List 3 and List 4 presentation with the same instructions as before, except that participants who were given a remember instruction after List 2 were subsequently told to forget List 4 and vice versa. Participants then read aloud from the same history for an additional 5 min starting from where they previously left off. A second recall test followed where participants were asked to recall from List 4 first for 1 min followed by an additional minute to recall List 3. Participants were not allowed to access their previous lists' responses for any reason. Since the experimental question was whether participants could forget the most recent items without post-cue encoding, they were always tested on the most recent list first.

Following the final recall task, participants were asked if they had tried to forget the list they were instructed to. Those that responded "no" were subsequently excluded from the data analysis due to noncompliance with the forget instruction. If participants responded "yes" they did try to forget, they were then asked to indicate which strategy they used out of four options: (1) tried to think of the first list to help forget the second, (2) pushed the words out of mind by force of will, (3) tried to distract from the experiment by thinking of something else, or (4) other. Each of the possible strategy responses correspond with a different theoretical explanation for directed forgetting. Strategy 1 is consistent with the hypothesized list-before-last mechanism. Strategy 2 refers to the retrieval inhibition theory, and Strategy 3 is consistent with the original context change theory. Those who responded "other" were asked to elaborate in as much detail as possible what they did specifically to forget the list, such as what thoughts they had or any decisions they made.

Results and Discussion

The primary analysis compared the most recent forget (henceforth referred to as F2) to the most recent remember (R2) lists to analyze forgetting within-participants. Here and in subsequent experiments, words were counted as correct if they were recalled for the correct list, during the designated recall period. Minor spelling errors were counted as correct, but changes to the meaning of the word were not (e.g. *paint* and *painting* were counted wrong for *painter*). Intrusions, as in words recalled from the incorrect list, are reported in Table 1 for all experiments. Figure 3 shows raincloud plots that represent the data distribution of proportion recalled for each list (Allen, Poggiali, Whitaker, Marshall, Kievit, 2019). A paired-samples *t*-test revealed no significant differences in proportion recalled between R2 (M = .18, SD = .15) and F2 (M = .15, SD = .15), $t(64) = 1.175$, p = .244. Thus, Experiment 1 failed to replicate Racsmány et al.'s (2018) critical finding of reduced recall for the most recent list when cued to forget.

An additional *t*-test revealed no significant difference between the first list of the remember set (R1) and that of the forget set (F1); $t(64) = .257$, $p = .798$, $d = .033$. These results suggest that there was no benefit for the first study list and are consistent with the findings of Racsmány et al. Intrusions were rare for all lists (e.g. recalling items from List 1 when instructed to recall List 2 items) and are reported in Table 1.

Following the final recall test after List 4, participants were asked if they had tried to forget the list they were instructed to or not. The strategy reports resulting from Experiment 1 showed that 47% of subjects tried to think of the first list to help forget the second (Strategy 1), 24% of participants pushed the words out of mind by force of will

(Strategy 2), 12% tried to distract themselves from the experiment by thinking of something else (Strategy 3), and 17% reported other (see Table 2). When those responding “other” as their strategy were probed further, they overwhelmingly responded that they tried to focus on the reading materials or assumed they would be tested on the information from the book rather than the word lists. In fact, recall for all four lists regardless of instruction was relatively low. This indicated that perhaps the reading material was too distracting and functioned as an unintended lure preventing participants from recalling items from any list.

Conclusion

The results of Experiment 1 suggested that potentially, forgetting the most recent list was not possible for participants in the current study. However, as indicated by the distribution of recall (shown in Figure 3) and responses to the strategy question, it is possible the use of the novel distractor task was too distracting for participants and reduced recall to near floor, thus preventing a significant difference from being detected. Experiment 2 included changes to the distractor task in an attempt to rectify the issue of low recall.

CHAPTER III

EXPERIMENT 2

Strategy reports from Experiment 1 revealed that almost one in five participants focused on the contents of the reading material rather than the list items, which may have impacted recall performance for all lists. Therefore, in Experiment 2, the history reading was replaced with a string of five numbers repeated out loud for 30 s. Additionally, word lists were reduced from 12 to 10 words to increase recall performance. Thus, the goal of Experiment 2 was the same as Experiment 1 but correcting for the unintentional lure that was the history reading. I expected that the number task would be less distracting than the history reading along with reducing the number of items on each list to increase recall.

Method

Participants. A total of 72 undergraduates participated in Experiment 2. Data exclusion of eight participants who failed to comply with the instruction to forget resulted in a total analysis of data from 64 participants. The data collection stopping rule was the same as in Experiment 1.

Materials. The four lists of words from Experiment 1 were reduced from 12 to 10 words for Experiment 2 based on frequency of recall in Experiment 1 (see Appendix B).

Procedure. The procedure for Experiment 2 was identical to Experiment 1, except for the distractor task. Instead of reading aloud from the history book for 5 min, participants repeated a string of five numbers out loud for 30 s.

Results and Discussion

Figure 4 shows raincloud plots that represent the data distribution of proportion recalled for each list in Experiment 2 (Allen et al., 2019). As in Experiment 1, the primary analysis observed critical forgetting by comparing F2 and R2 recall.

A paired samples *t*-test revealed a significant difference between R2 proportion recalled (M = .32, SD = .15) and F2 proportion recalled (M = .24, SD = .19); $t(63) = 2.90$, $p = .005$, $d = 0.36$. Participants showed significantly reduced recall of the most recent forget list (F2) compared to the most recent remember list (R2), contrasting the findings from Experiment 1, where no forgetting was observed. Neither list order or an interaction with cue were significant (both $F < 1$), so I collapsed over this factor.

Strategy reports for Experiment 2 indicated that 61% of participants reported thinking of the first list to help forget the second (Strategy 1), 11% pushed the words out of mind by force of will (Strategy 2), 23% distracted themselves by thinking of something other than the experiment (Strategy 3), and 5% reported other (see Table 2). “Other” responses from participants included imagining the words leaving their head or focusing on participant’s perceived “poor memory” in order to forget. Fewer participants reported “other” as their strategy choice in Experiment 2 compared to Experiment 1, suggesting that changing the procedure from reading out loud from the book to repeating a series of numbers was less engaging and allowed participants to use more effective forgetting strategies. As in Experiment 1, no benefits of F1 over R1 were observed; $t(63) = 1.89$, $p = .06$, $d = 0.24$.

A post-hoc between-subjects *t*-test was used to compare recall of the most recent list for participants using Strategy 1 (retrieve earlier list) versus all other strategies. This analysis revealed that participants who retrieved List 1 showed lower recall of the most recent list (M = .20, SD = .17) compared to participants who used any of the other strategies (M = .32, SD = .21), $t(62) = 2.35$, $p = .02$, $d = .63$. These findings suggest that retrieving the first list as a way to forget the most recent list is a more effective forgetting strategy than thinking of something unrelated to the experiment or forcefully pushing the words out of mind. The results also provide support for the list before the last mechanism and suggest that participants are covertly using this mechanism in order to forget.

Conclusion

The results from Experiment 2 indicate that it is possible to forget recently learned items, as participants successfully forgot the most recent list, and a majority responded that they did so by retrieving an earlier list. Therefore, I suggest that the post-cue encoding seemingly necessary to facilitate forgetting occurs covertly as strategic retrieval of List 1 items. However, it is possible that providing participants with extended time after receiving the forget cue (30 s) inadvertently led them to retrieve the prior list. Furthermore, providing participants with forced response strategy options may have unintentionally led them to report a particular strategy. Therefore, in Experiment 3, I reduced the time after the cue to 5 s and replaced the strategy selection option with an open-ended question asking participants what they did in order to forget.

CHAPTER IV

EXPERIMENT 3

The original study by Racsmány et al. (2018) did not include a 30 s time-out in their procedure and previous research in typical list-method directed forgetting show that this length of time is not necessary to obtain forgetting. Providing participants with 30 s following the forget cue may have inadvertently suggested to them the strategy of retrieving the previous list items and given them enough time to do so. Therefore, I reduced this time from 30 s to 5 s to more closely resemble the original procedure and expecting that it would not impact the results.

Furthermore, a forced choice response format for strategy selection may have been reactive and suggested to participants which strategy to indicate in Experiments 1 and 2. Therefore, in Experiment 3 the strategy question was changed to an open ended format to allow participants to elaborate in their own words how they tried to forget.

The primary purpose for Experiment 3 was to replicate the findings of Experiment 2, predicting that participants would successfully forget the most recent list. I also predicted, consistent with Experiment 2, that participants would freely report retrieving the earlier-learned list as a strategy to forget the most recent list, without explicitly given the strategy option. A secondary purpose of Experiment 3 was to compare forgetting for participants using Strategy 1 and those using all other strategies, expecting that participants reporting retrieving the first list would show more forgetting of the most recent list compared to participants reporting alternative strategies, consistent with the post-hoc analysis in Experiment 2.

Method

Participants. A power analysis conducted in G*Power version 3.1.9.4 (Faul, Erdfelder, Buchner, & Lang, 2009), to detect the between-subject forgetting by strategy effect with 80% power at an alpha set at a = .05, based on the estimated effect size of d = .60 from post-hoc analyses in Experiment 2 resulted in an estimated sample size of 96. The data collection stopping rule was set according to the power analysis and so that each condition had an equal number of participants including replacements for data exclusions. Data were collected from 118 UNCG undergraduate students participating for course credit. Data exclusions comprised 19 participants who self-reported suspicion of experimenter instructions, or purposefully remembered words they were instructed to forget resulting in a total of 99 participants. Three additional participants had signed up to participate in the study before the stopping rule was reached, so we included their data in the analysis.

Materials. The materials for Experiment 3 were identical to those used in Experiment 2.

Procedure. The procedure was the same as Experiment 2 except the 30 s break between cue and recall was reduced to 5 s to observe whether participants could successfully forget recent items given a shorter amount of time. Additionally, participants responded to the strategy question in an open-ended rather than forced choice format.

Results and Discussion

Figure 5 shows rain cloud plots representing data distribution of proportion recalled for each list in Experiment 3 (Allen et al., 2019). The primary analysis sought to determine whether there was significant forgetting of F2. A paired samples *t*-test comparing proportion recalled for R2 and F2 resulted in a significant difference between the most recent Forget (M = .25, SD = .18) and Remember (M = .33, SD = .20) lists; $t(98)$ = 3.76, p = .0003, d = 0.38, suggesting that participants again forgot the most recent information, consistent with Experiment 2. An additional *t*-test revealed no significant F1 benefits (t = 1.08 , p = .283). As in Experiment 2, intrusions were rare (see Table 1) and no list order effect or an interaction with cue were found (both $F < 1$).

Open-ended strategy reports were coded by the experimenter using the strategies in Experiment 2 while blind to the recall results. These reports revealed that 68% of participants self-reported thinking of the first list to forget the second, 14% pushed words out of mind by force of will, 10% thought of something else, and 8% other. “Other” responses included focusing completely on the string of numbers from the distractor task as a means to block the words from the to-be-forgotten list, as well as thinking of random unrelated words, or letting the words “flow” from their mind (Table 2).

For the secondary analyses, a planned between-subjects *t*-test comparing forgetting by strategy revealed that participants who self-reported thinking of the first list to help forget the second recalled a smaller proportion of words (M = .22, SD = .14) than those using all other strategies (M = .33, SD = .23); $t(97)$ = 2.62, p = .01, d = .65 (see Figure 6). These findings provide support for the list before the last mechanism (retrieving previously learned information) as an effective strategy to forget the most recent information compared to other strategies, consistent with the findings of Experiment 2.

Conclusion

The findings from Experiment 3 replicated those of Experiment 2: participants successfully forgot the most recent information. Most of the time, they did so by strategically and covertly retrieving earlier learned, to-be-remembered, information. Additional analyses indicated that participants who reported using this retrieval strategy showed more forgetting than those who used all other strategies; providing support for my prediction that forgetting occurs by retrieving List 1.

CHAPTER V

GENERAL DISCUSSION

The findings from the current study identified a new mechanism for the costs associated with directed forgetting, consistent with the context change theory. Both Experiments 2 and 3 successfully replicated earlier findings by Racsmány et al. (2018) and indicate that participants are able to forget the most recent information they have learned, in the absence of post-cue encoding. Verbal reports indicate that forgetting occurs because participants covertly and strategically retrieve earlier-learned items as shown by strategy analyses in Experiments 2 and 3. Specifically, participants who retrieve earlier-learned items as a forgetting strategy showed reduced recall of the target list compared to participants using all other strategies. This act of retrieval causes mental context to change (e.g. Howard & Kahana, 2002), as in the list-before-last paradigm (Jang & Huber, 2008).

Though the account proposed here is new (i.e., that participants covertly retrieve other information as a means to forget), the mechanism itself is not. In list-before-last procedures, participants are instructed to explicitly retrieve earlier-learned items between encoding of each list. This retrieval updates the current context with aspects of the previous list (the list before the last's) context, driving a contextual change. It is evident from the list-before-last studies that explicit retrieval between lists causes forgetting (or reduced recall) of the target list on the next retrieval trial, again consistent with context change theories of forgetting. In the current study, covert retrieval functions in the same way; participants retrieve the previously-learned items without explicit instruction from the experimenter resulting in reduced recall of the most recent list. These results are interpreted as indicating that the empirically critical post-cue encoding in directed forgetting studies is indeed occurring, but in these studies, it was covert and self-initiated by participants. When participants receive the cue to forget List 2, they strategically retrieve List 1, making List 1 and the context associated with that list the most recent list, and moving List 2 into the list before last position. This is consistent with traditional list-method directed forgetting in which the first list is the forget list, and the most recent list is the remember list.

As demonstrated in the current study, and as previous literature suggests, when people have to forget some information they have learned, they sometimes try to think about other things, particularly by referring to what is salient in their environment (e.g. Sahakyan & Kelley, 2002; Pastötter & Bäuml, 2007). For instance, in the classic white bear study by Wegner et al. (1987), they explained that when participants were instructed specifically to avoid thinking about a white bear, they often verbalized strategies including intent to think of something else. As long as participants were able to continue verbalizing their thoughts of something else, they were able to prevent themselves from either thinking about or reporting that they had thought about the white bear. Similarly, when current concerns are particularly salient, attention can shift away from the primary task (such as the word lists) and subsequent task performance may be impaired, for instance by reduced recall (e.g. Klinger, 2009; McVay & Kane 2010a).

Though forgetting is often framed as a byproduct of time, it is important to note that directed forgetting is an effortful process (e.g. Foster & Sahakyan, 2011; Sahakyan, Delaney, & Goodmon, 2008). Foster and Sahakyan (2011) manipulated forget-cue salience, either by explicitly telling participants to forget List 1 or by telling participants they would only be tested on List 2, to examine the magnitude of the directed forgetting effect. The authors also asked participants what strategies they used, if any, to forget List 1 (which inspired the procedure in the current study.) Upon separating the participants into "do-something" and "do-nothing" groups, Foster and Sahakyan's results indicated that those who reported actively doing something to forget showed significantly reduced recall compared to the remember control group, whereas the group who reported doing nothing had comparable recall to the remember group. Thus, engaging in an active forgetting strategy is critical for obtaining directed forgetting effects. In the current study, participants who reported retrieving earlier learned information as a strategy to forget showed reduced recall compared to remember and to all other strategies. Here, it is suggested that certain forgetting strategies may be more effective than others, and certainly more effective than no strategy, as in Foster and Sahakyan's work.

While I have suggested a context-based mechanism, the results are not in principle inconsistent with an inhibitory account. Racsmány et al. (2018) initially suggested that inhibition caused forgetting of the most recent list. A contextual account suggests forgetting only occurs when additional information is encoded post-cue, while inhibition in principle could occur with any interference (from items presented either pre- or post-cue). Inhibition requires competing information during retrieval in order to inhibit access to the unwanted items, which may occur in the current study as recalling List 1 items. However, the context change account directly predicts the list before last findings and therefore the current findings without a new mechanism. According to context change theories, later learning is necessary to set the new context, and here I argue that later learning is happening in the form of List 1 retrieval. This also provides important evidence that later learning does not need to be completely new material, but any form of new learning (or relearning of old material) is sufficient to change context and lead to forgetting.

If later learning occurs as List 1 retrieval, one might be inclined to expect List 1 benefits during recall, which were not significant in the present findings. An examination of the data in Experiment 2 indicates that List 1 benefits were not significant, but in the right direction, which may be a direct result of the 30 s time-out participants received following the forget cue. When given enough time, participants may be retrieving items from List 1, as opposed to retrieving only the context of List 1 such as in Experiment 3 when given only 5 s to forget. However, in the present study, both the 5s and 30 s delays were sufficient to cause contextual change. This is consistent with previous research by Sahakyan and Hendricks (2012) which suggests that the process of merely thinking back to List 1 is sufficient to cause internal context change and that successful retrieval of List 1 items may not be necessary to observe List 2 forgetting. In a modified list-before-last procedure, they manipulated the difficulty of List 1 retrieval on retrieval trials by providing participants with cues for List 1 recall with either the first two letters (easy), just the first letter (hard), or just the second letter (very hard) of List 1 items. The temporal context model (Howard & Kahana, 2002) suggests that as more List 1 items are retrieved (such as in the easy retrieval condition) more forgetting of List 2 should occur due to a greater change in context. However, Sahakyan and Hendricks observed similar forgetting for List 2 across all difficulty levels, suggesting that simply thinking back to List 1 was enough to change context and impair recall for the recent items. Additionally, these results provide support for the two-factor accounts of directed forgetting that suggest the costs and benefits may be obtained independently of one another. The benefits in list-method directed forgetting are proposed to be a result of a change in encoding strategy (e.g. Sahakyan & Delaney, 2003) and in the current study since all information is encoded prior to the cue, there is no opportunity to effectively switch encoding strategy and therefore I would not expect to obtain the benefits.

Previous research by Pastötter & Bäuml (2010) suggest that as the amount of post-cue encoding increases, recall of pre-cue information decreases. Longer lists following the forget cue further separate the contexts of List 1 and test in traditional list-method designs thus impairing recall, however the current findings suggest that the amount post-cue encoding using the current design may not impair recall. Retrieval of earlier-learned information is the catalyst for forgetting in the present study, as opposed to post-cue encoding, therefore the addition of a List 3 with increasing length should have no effect on participant's ability to selectively forget List 2.

These findings join a broader literature on whether or not there are selective effects in directed forgetting (e.g. Aguirre, Gómez-Ariza, Andrés, Mazzoni, & Bajo, 2017; Delaney, Ngheim, & Waldum, 2009; Kliegl, Pastötter, & Bäuml, 2013; Sahakyan, 2004; Storm, Koppel, & Wilson, 2013). Findings in the selective directed forgetting literature are controversial and suggest that participants may or may not be able to forget only some of the pre-cue information. In three experiments, Sahakyan (2004) showed that participants were unable to forget only some of the information they had learned and that all information preceding a forget cue suffered from forgetting due to a contextual shift. Later findings by Delaney, Ngheim, and Waldum (2009) showed the opposite effect and found that participants were able to successfully forget a portion of the pre-cue information, without impairments in recall for other information, though these findings replicate sporadically. Consistent across the selective directed forgetting literature, all cues are followed by additional learning. The current study provides some support that selective effects in directed forgetting are possible even without post-cue learning. Participants in the current study encoded all information (List 1 and List 2) prior to receiving the cue to forget only some of that information (List 2). Here, participants were able to successfully forget some pre-cue information, in the absence of post-cue encoding, and without comparable detriments to the pre-cue to-be-remembered items.

Overall, the findings of the present study are directly predicted by the context change theory of directed forgetting. Here, I show that participants change their mental context by retrieving earlier-learned information, which leads to forgetting. The current findings bring the original Racsmány et al. (2018) results in line with predictions of the context change theory through strategic retrieval of the list before the last. Thus, people strategically deploy retrieval as a means of forgetting, at least when they know another list needs to be retained.

REFERENCES

Aguirre, C., Gómez-Ariza, C. J., Andrés, P., Mazzoni, G., & Bajo, M. T. (2017). Exploring mechanisms of selective directed forgetting. *Frontiers in Psychology, 8.*

Allen, M., Poggiali, D., Whitaker, K., Marshall, T. R., & Kievit, R. A. (2019). Raincloud plots: A multi-platform tool for robust data visualization [version 1; peer review: 2 approved]. *Wellcome Open Res* 2019, 4:63.

Baddeley, A. (1990). *Human memory: Theory and practice*. Needham Heights, MA: Allyn &Bacon.

Bäuml, K.-H. T., & Kliegl, O. (2013). The critical role of retrieval processes in release from proactive interference. *Journal of Memory and Language, 68,* 39-53.

Bjork, R.A. (1970). Positive forgetting: The noninterference of items intentionally forgotten. *Journal of Verbal Learning and Verbal Behavior, 9,* 255-268.

Bjork, R. A. (1989). Retrieval inhibition as an adaptive mechanism in human memory. In H. L. Roediger & F. I. M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honor of Endel Tulving* (pp. 309-330). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bjork, R. A. (1998). Intentional forgetting in perspective: Comments, conjectures, and some directed remembering. In *Intentional forgetting: Interdisciplinary approaches* (pp. 453-481). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bjork, R. A., LaBerge, D., & LeGrand, R. (1968). The modification of short-term memory through instructions to forget. *Psychonomic Science, 10,* 55–56.

Conway, M.A., Harries, K., Noyes, J., Racsmány M., Frankish, C.R. (2000). The disruption and dissolution of directed forgetting: Inhibitory control of memory. *Journal of Memory and Language*, *43*, 409-430.

Delaney, P. F., Ngheim, K. N., & Waldum, E. R. (2009). The selective directed forgetting effect: Can people forget only part of a text? *The Quarterly Journal of Experimental Psychology, 62,* 1542-1550.

Delaney, P. F., Wallander, R., & Preheim, G. A. (2018). Protocol analysis. In D. S. Dunn (Ed.),*Oxford Bibliographies Online: Psychology.* New York: Oxford University Press.

Ericsson, K. A., & Simon, H. A. (1993). *Protocol analysis: Verbal reports as data.* (Rev. ed.).Cambridge, MA: MIT Press.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods*, *41*, 1149-1160.

Foster, N. L., & Sahakyan, L. (2011). The role of forget-cue salience in list-method directed forgetting. *Memory, 19*, 110-117.

Friendly, M., Franklin, P. E., Hoffman, D., & Rubin, D. C. (1982). The Toronto word pool: Norms for imagery, concreteness, orthographic variables, and grammatical usage for 1,080 words. *Behavior Research Methods and Instrumentation*, *14*, 375–399.

Geiselman, R. E., Bjork, R. A., & Fishman, D. (1983). Disrupted retrieval in directed forgetting: A link with posthypnotic amnesia. *Journal of Experimental Psychology: General, 112,* 58–72.

Gelfand, H., & Bjork, R. A. (1985, November). *On the locus of retrieval inhibition in directed forgetting.* Paper presented at the 26th annual meeting of the Psychonomic Society, Boston.

Howard, M. W., & Kahana, M. J. (2002). A distributed representation of temporal context. *Journal of Mathematical Psychology, 46,* 269-299.

Jang, Y., & Huber, D. E. (2008). Context retrieval and context change in free recall: Recalling from long-term memory drives list isolation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34,* 112–127.

Kliegl, O., Pastötter, B., & Bäuml, K.-H. T. (2013). List-method directed forgetting can be selective: Evidence from the 3-list and the 2-list tasks. *Memory & Cognition, 41*, 452-464.

Klinger, E. (2009). Daydreaming and fantasizing: Thought flow and motivation. In K. D. Markman, W. P. Klein, J. A. Suhr, K. D. Markman, W. P. Klein, & J. A. Suhr (Eds.), Handbook of imagination and mental simulation (pp. 225–239). New York, NY: Psychology Press.

McVay, J. C., & Kane, M. J. (2010a). Adrift in the stream of thought: The effects of mind wandering on executive control and working memory capacity. In A. Gruszka, G. Matthews, & B. Szymura (Eds.), Handbook of individual differences in cognition: Attention, memory, and executive control (pp. 321–334). New York, NY: Springer.

Miéville, C. (2017). *October: The story of the Russian revolution.* Brooklyn, NY: Verso.

Pastötter, B., & Bäuml, K.-H. T. (2007). The crucial role of postcue encoding in directed forgetting and context-dependent forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*, 977–982.

Pastötter, B., & Bäuml, K.-H. T. (2010). Amount of postcue encoding predicts amount of directed forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*, 54-65.

Pastötter, B., Kliegl, O., & Bäuml, K.-H. T. (2012). List-method directed forgetting: The forget cue improves both encoding and retrieval of postcue information. *Memory & Cognition, 40,* 861-873.

Pastötter, B., Tempel, T., & Bäuml, K.-H. T. (2017). Long-term memory updating: The reset-of encoding hypothesis in list-method directed forgetting. *Frontiers in Psychology,8.*

Racsmány, M., Demeter, G., & Szöllösi, A. (2018). Successful list-method directed forgetting without retroactive interference of post-instruction learning. *Memory*, *27*, 224-230.

Sahakyan, L. (2004). Destructive effects of “forget” instructions. *Psychonomic Bulletin & Review, 11*, 555-559.

Sahakyan, L., & Delaney, P. F. (2003). Can encoding differences explain the benefits of directed forgetting in the list-method paradigm? *Journal of Memory and Language, 48,* 195-201.

Sahakyan, L., & Delaney, P. F. (2005). Directed forgetting in incidental learning and recognition testing: Support for a two-factor account. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 789–801.

Sahakyan, L., Delaney, P. F., Foster, N. L., & Abushanab, B. (2013). List-method directed forgetting in cognitive and clinical research: A theoretical and methodological review. *Psychology of Learning and Motivation*, *59*, 131–189.

Sahakyan, L., Delaney, P. F., & Goodmon, L. B. (2008). Oh honey, I already forgot that: Strategic control of directed forgetting in older and younger adults. *Psychology and Aging*, *23,* 621-633.

Sahakyan, L., & Hendricks, H. E. (2012). Context change and retrieval difficulty in the list before-the-last paradigm. *Memory & Cognition, 40,* 844–860.

Sahakyan, L., & Kelley, C. M. (2002). A contextual change account of the directed forgetting effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 1064–1072.

Sahakyan, L., & Smith, J. R. (2014). "A long time ago, in a context far, far away": Retrospective estimates and internal context change. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40*, 86-93.

Sederberg, P. B., Howard, M. W., & Kahana, M. J. (2008). A context based theory of recency and contiguity in free recall. *Psychological Review, 115*, 893–912.

Shiffrin, R. M. (1970). Forgetting: Trace erosion or retrieval failure? *Science, 168*, 1601-1603.

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2012). A 21-word solution. *Dialogue: The Official Newsletter of the Society for Personality and Social Psychology*, *26*, 4–7.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review, 8*, 203-220.

Storm, B. C., Koppel, R. H., & Wilson, B. M. (2013). Selective cues to forget can fail to cause forgetting. *The Quarterly Journal of Experimental Psychology, 66*, 29-36.

Underwood, B. J. (1957). Interference and forgetting. *Psychological Review*, *64*, 49–60.

Unsworth, N., Spillers, G. J., & Brewer, G. A. (2012). Evidence of noisy contextual search: Examining the dynamics of list-before-last recall. *Memory, 20*, 1–13.

Ward, G., & Tan, L. (2004). The effect of the length of to-be-remembered lists and intervening lists on free recall: A reexamination using overt rehearsal. *Journal of Experimental Psychology*: *Learning, Memory, and Cognition*, *30*, 1196–1210.

Wegner, D. M., Schneider, D. J., Carter, S. R., & White, T. L. (1987). Paradoxical effects of thought suppression. *Journal of Personality and Social Psychology, 53*, 5-13.

APPENDIX A

TABLES AND FIGURES

Table 1

Descriptive Statistics

	List	Intrusions *M (SD)*
	R1	.02 (.06)
Experiment 1	R2	.07 (.10)
	F1	.03 (.07)
	F2	.08 (.10)
	R1	.03 (.08)
Experiment 2	R2	.06 (.08)
	F1	.03 (.06)
	F2	.07 (.10)
	R1	.02 (.06)
Experiment 3	R2	.07 (.11)
	F1	.03 (.06
	F2	.10 (.11)

Note. M = mean, *SD* = standard deviation. Values represent proportion of intrusions for each list in each experiment. Lists are presented in sets (Lists 1 and 2; Lists 3 and 4), therefore R1 and F1 represent the first list in each set, and R2 and F2 represent the second list in each set. R2 and F2 are the most recent Remember and most recent Forget list, respectively.

Table 2

Strategy Percentages and F2 Recall by Strategy

Strategy	1		2		3		4	
	%	*M(SD)*	%	*M(SD)*	%	*M(SD)*	%	*M(SD)*
Experiment 1	47	.16 (.18)	24	.16 (.15)	12	.13 (.13)	17	.14 (.11)
Experiment 2	61	.20 (.17)	11	.30 (.17)	23	.29 (.19)	5	.50 (.35)
Experiment 3	68	.22 (.16)	14	.26 (.22)	10	.45 (.20)	8	.30 (.24)

Note. M = mean, *SD* = standard deviation of the proportion of words recalled from F2 by strategy. Percentages represent the percentage of total participants reporting each strategy by experiment. Strategies are as follows: (1) try to think of the first list to help forget the second, (2) push the words out of mind by force of will, (3) distract from the experiment by thinking of something else, (4) other.

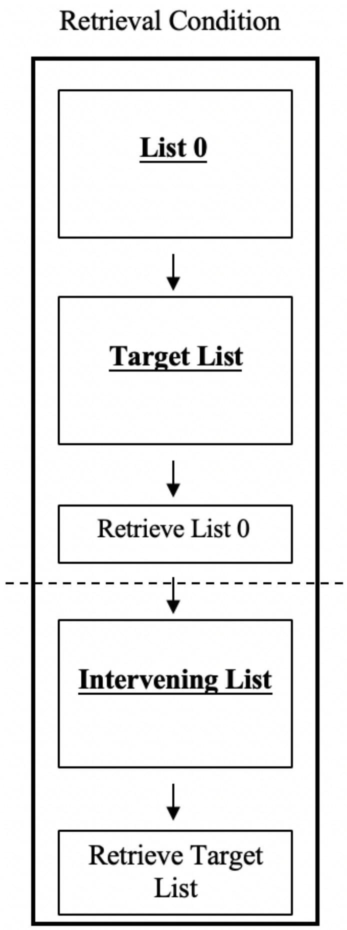

Figure 1. Design Figure for the List before Last Procedure. Includes the retrieval and no-retrieval conditions in Jang & Huber's (2008) list before the last procedure. People study three lists, with a "shifting window" procedure. Left panel: The retrieval trial on List 0 between the target and intervening lists causes the current context to integrate with the List 0 context, causing forgetting of the target list when it is tested after the intervening list. The dashed line is a visual representation of where the internal context is changed as a result of retrieving from List 0. Right panel: when there is no test on List 0 after the target list, context does not change, and the target list is comparably better recalled than if there had been retrieval (as on the left).

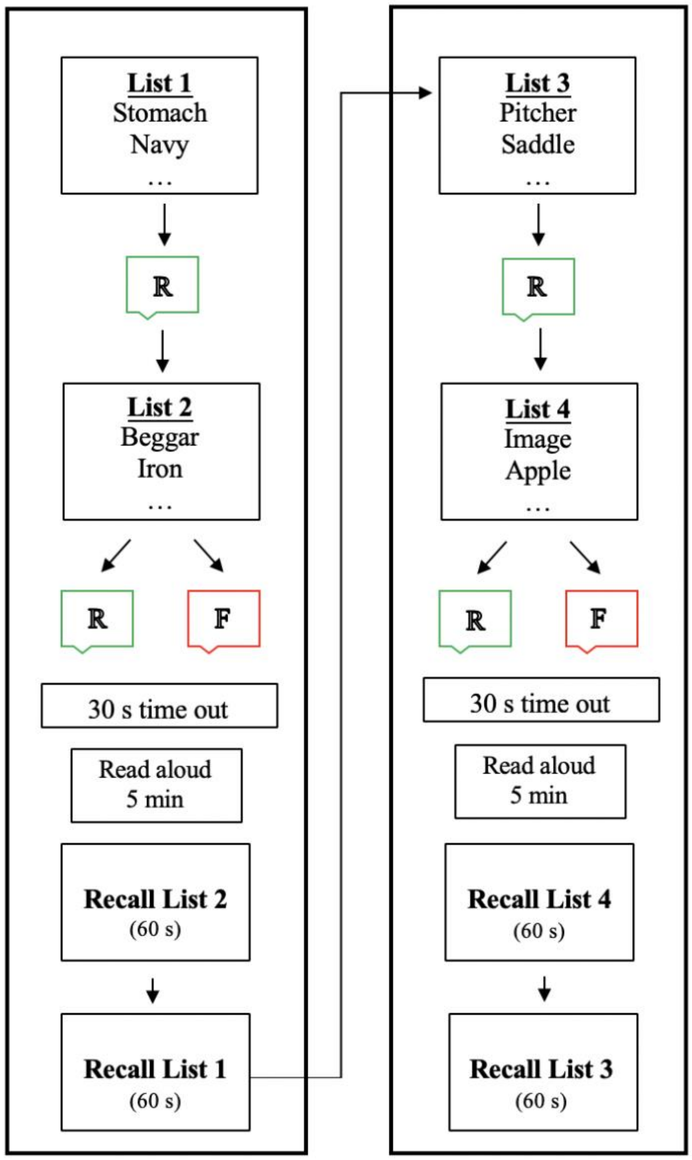

Figure 2. Design for Experiment 1. Participants who receive a Forget instruction for List 2 will receive a Remember instruction for List 4 and vice versa. Additionally, because the experimental question is whether participants are able to forget the most recent items, they will always be tested on the most recent list first.

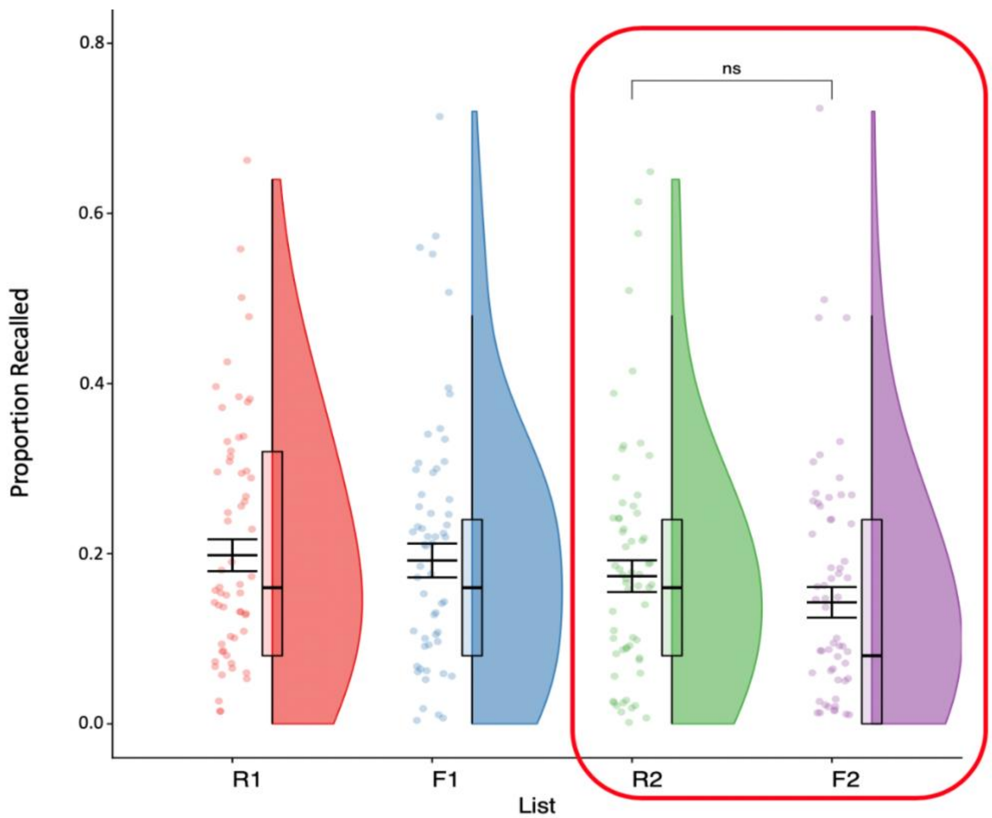

Figure 3. Raincloud Plots for Experiment 1. Raincloud plots represent distribution of proportion recalled for each list. Box plots embedded indicate median recall, whisker plots over data points indicate mean and standard error. R2 and F2 represent the most recent Remember and Forget lists, respectively, which are the lists I am interested in comparing.

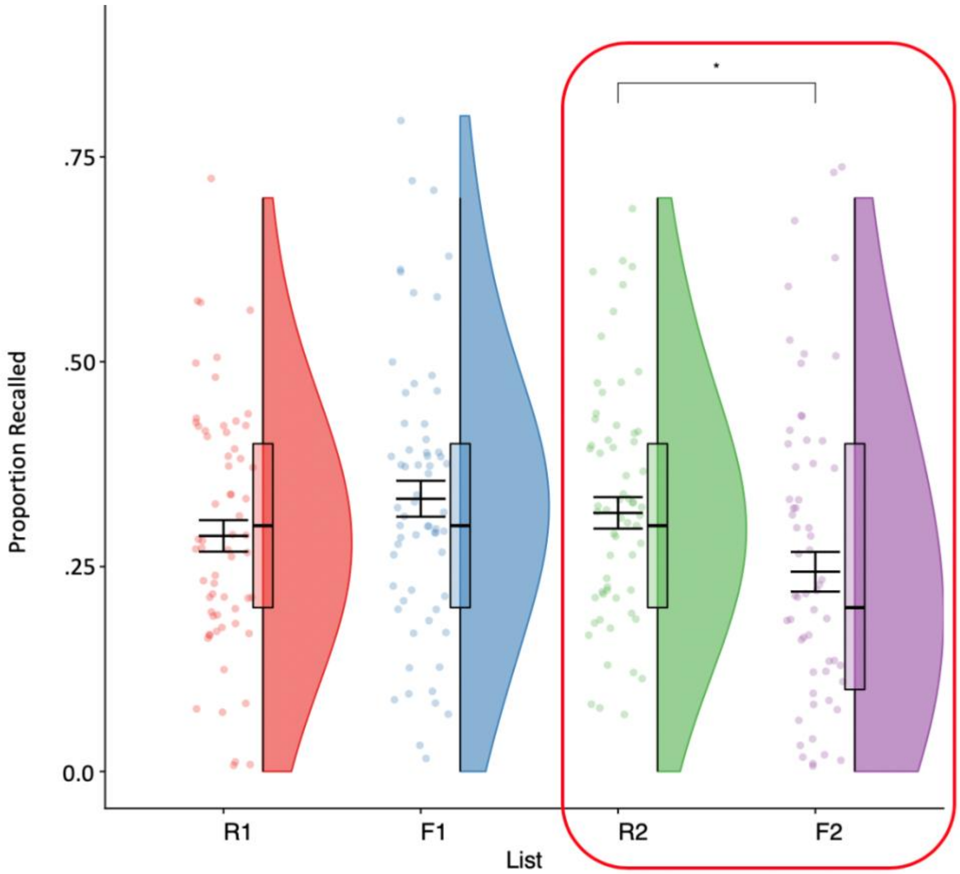

Figure 4. Raincloud Plots for Experiment 2.

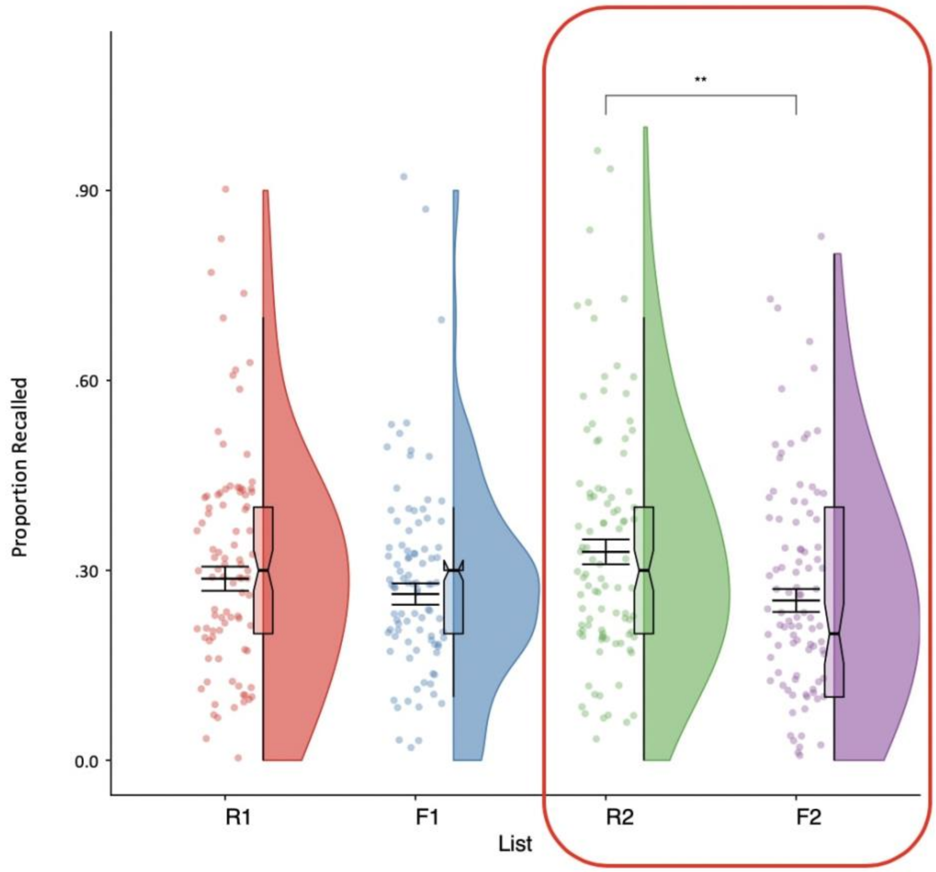

Figure 5. Raincloud Plots for Experiment 3.

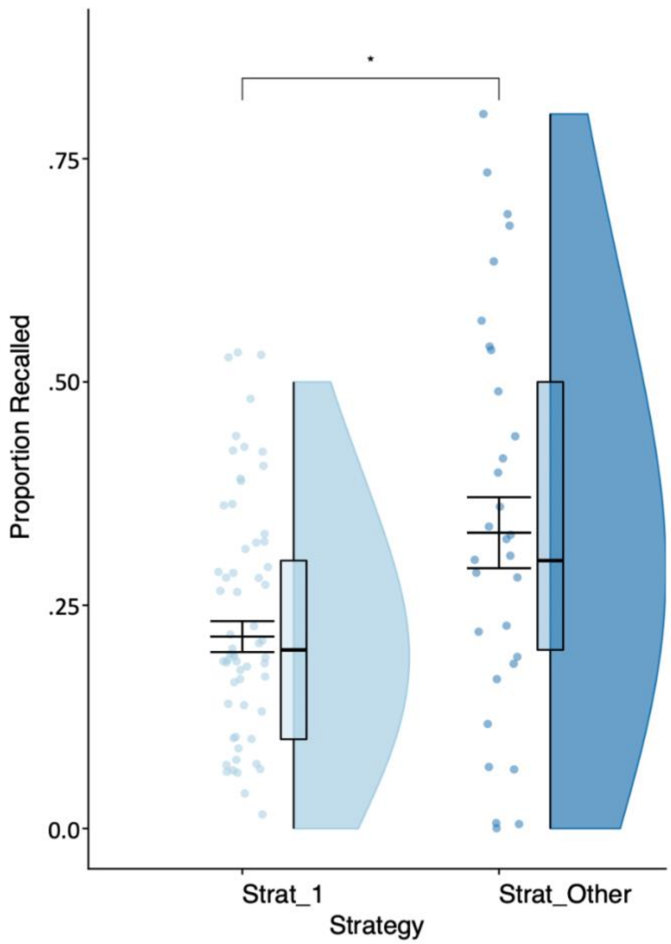

Figure 6. Raincloud Plots for Proportion F2 Recall by Strategy in Experiment 3. Strat_1 plot is the distribution of proportion recalled from F2 by participants reporting retrieving the first list to help forget the second (*N* = 67). Strat_Other is the proportion recalled from F2 by participants reporting all other strategies in order to forget (*N* = 32).

APPENDIX B

WORD LISTS

Words are always presented in the same order in a given list, but order of list presentation is counterbalanced across conditions. For Experiments 2 and 3, two words from each list were eliminated based on frequency of recall in Experiment 1. The words were List 1: Survey and Mayor, List 2: Rival and Sickness, List 3: Fabric and Project, and List 4: Rattle and Stocking creating 4 lists of 10 words each.

List 1	List 2	List 3	List 4
Stomach	Beggar	Pitcher	Image
Navy	Iron	Saddle	Apple
Oven	Error	Music	Refuge
Compass	Novel	Dragon	Devil
Madam	Captain	Merchant	Factory
Credit	Pigeon	Wisdom	Kitten
Forehead	Water	Poetry	County
Survey	Blessing	Hammer	Rattle
Mayor	Rival	Fabric	Carriage
Pistol	Pony	Perfume	Stocking
Painter	Olive	Project	Cattle
Cherry	Sickness	Sheriff	Carpet

APPENDIX C

CONDITIONS

The conditions were created by rotating the order of the word lists so that each list appeared in every position at least once. Cues are counterbalanced within each condition so that every order of lists will have one instance of "Forget List 2" and one instance of "Forget List 4" to minimize carryover effects. The design of each condition is presented here using the first word from each list in the above Appendix B.

Condition	List 1	List 2	List 3	List 4	Forget List
A	Stomach	Beggar	Pitcher	Image	List 4
B	Stomach	Beggar	Pitcher	Image	List 2
C	Image	Stomach	Beggar	Pitcher	List 4
D	Image	Stomach	Beggar	Pitcher	List 2
E	Pitcher	Image	Stomach	Beggar	List 4
F	Pitcher	Image	Stomach	Beggar	List 2
G	Beggar	Pitcher	Image	Stomach	List 4
H	Beggar	Pitcher	Image	Stomach	List 2

APPENDIX D

EXPERIMENTER SCRIPT

Before List 1: You are going to see a list of words appear on the screen one at a time. Please try to remember these words for a later memory test. This is List 1; you may hit the space bar when you are ready to begin.

Between List 1 and List 2: That was the first list, please keep remembering those words for a later memory test. You will now see List 2. You may hit the space bar when you are ready to begin.

After List 2: For those in the forget condition: That was List 2, now I want you to do whatever you can to forget those words. You will still be tested on List 1, but you should try to forget List 2. For those in the remember condition: That was List 2, please keep remembering these words as well as the words from List 1 for a memory test. (Script repeats for List 3 and 4).

After List 4: For those in the forget condition: That was List 4, now I want you to do whatever you can to forget those words. You will still be tested on List 3, but you should try to forget List 4. For those in the remember condition: That was List 4, please keep remembering these words as well as the words from List 3 for a memory test.