People Sometimes Remember to Forget: Strategic Retrieval from the List Before Last Enables Directed Forgetting of the Most Recent Information

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Abstract

List-method directed forgetting usually involves asking people to study a list, followed by a cue to forget it, and then studying a second list. Prior work suggests that List 2 encoding is necessary for directed forgetting to occur, but recent studies found that moving the forget cue from List 1 to List 2 allows people to selectively forget List 2. These results were attributed to an inhibitory mechanism. In four experiments, we aimed to replicate these findings and provide an alternative explanation based on the list-before-the-last paradigm. We propose that in the forget condition, participants may strategically retrieve List 1 in response to the forget cue, contributing to selective forgetting. Previous research suggests that explicit retrieval of earlier-leaned information causes a contextual shift, resulting in forgetting of target information. Verbal reports from Experiments 1 and 2 indicated that participants often covertly select a retrieval strategy to forget the most recent list. In Experiment 3, explicit instructions to retrieve resulted in significant forgetting. Directly manipulating forgetting strategy between participants in Experiment 4 suggested that retrieval may be one of several effective mechanisms to forget recently-encountered information. In the retrieval conditions, the data support our claim that in the absence of explicit post-cue encoding, people can strategically retrieve earlier-learned information to forget. This novel forgetting mechanism is probably also used outside of the laboratory to “roll back” memory for incorrect information.

Keywords: directed forgetting, intentional forgetting, context change, list before last, inhibition

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If you were asked to, do you think you could forget recently-learned information while it is still fresh in your mind? If you have just learned something, it may be difficult to intentionally forget it because it is recent. The current temporal context is a good cue for recent information, and so context alone may provide sufficiently good retrieval cues to enable us to retrieve it (e.g., Jang & Huber, 2008). Although we generally agree with this logic, the present paper proposes that intentional forgetting of recent information is sometimes possible, and that one way to accomplish it is via strategic retrieval of earlier-learned information in order to forget.

Intentional forgetting -- first introduced by Muther (1965) and Bjork et al. (1968) -- involves responding to an instruction to forget some previously-learned information. One variety of directed forgetting is list-method directed forgetting, which will be the focus of this paper. In list-method directed forgetting, people learn two successive lists for a final recall task. Following presentation of the first list, they receive either a remember or forget cue just before seeing the second list. After both lists are presented, participants are asked to recall all words from List 1 and then List 2, regardless of whether they were told to forget the first list. 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).

It has been known for a long time that presenting only one list and following it with a forget cue does not result in significant forgetting (Bjork, 1970, 1989, 1998; Conway et al., 2000; Gelfand & Bjork, 1985; Pastötter & Bäuml, 2007, 2010; Sahakyan et al., 2013). Thus, it was surprising that a recent paper obtained forgetting of recently learned information without subsequent encoding, by using a modified two-list directed forgetting procedure (Racsmány et al., 2018). Instead of inserting a forget cue after List 1, they inserted an instruction to forget only List 2 after studying List 2. This produced significant directed forgetting of the most recent information. Racsmány et al. proposed that the selectivity of the forget cue along with proactive interference from earlier-learned List 1 items allowed participants to forget the most recent List 2 items, perhaps via inhibition. We will see that these findings pose significant challenges for the existing theories, at least as they are currently interpreted.

Theories of Directed Forgetting

The first theory of directed forgetting was the selective rehearsal account (Bjork, 1970; Bjork et al., 1968). In selective rehearsal, the costs of directed forgetting emerge because participants who receive the forget cue 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 for List 2 recall. However, directed forgetting was successfully obtained in procedures involving incidental learning, which the selective rehearsal account could not explain (Geiselman et al., 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 directed forgetting were still obtained despite the lack of intentional encoding. Similarly, Pastötter and Bäuml (2010, Exp. 3) examined the role of selective rehearsal with respect to post-cue encoding to determine whether rehearsal borrowing during List 2 encoding could explain forgetting effects. A selective rehearsal mechanism postulates that participants in the Remember condition rehearse both List 1 and List 2 items, whereas those in the Forget condition selectively rehearse items from List 2 resulting in List 1 costs and List 2 benefits. Accordingly, List 1 recall should increase in the Remember condition with additional post-cue items due to more opportunity for List 1 rehearsal. Pastötter and Bäuml tested this by giving participants a stop-rehearsal instruction in addition to a remember cue and indicated that if forgetting were due to selective rehearsal, there should be equivalent recall in the Forget and stop-rehearsal conditions. Contrary to this, their findings revealed no forgetting or enhancement in the stop-rehearsal condition, and similar recall between stop-rehearsal and remember conditions, providing additional evidence against the selective rehearsal account.

Selective rehearsal was therefore 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 during List 2 encoding. The inhibition of List 1 items diminishes retrieval of those items and subsequently improves the learning of List 2 items by reducing proactive interference from List 1 on List 2. Several behavioral studies have asserted an inhibitory view of directed forgetting (e.g. Conway et al., 2000; Pastötter & Bäuml, 2007, 2010) as well as studies suggesting neural evidence for inhibition (Bäuml et al., 2008; Hanslmayr et al., 2012).

Another current theory is the context change theory, which explains the underlying mechanism of directed forgetting in terms of a contextual shift occurring between lists (Delaney et al., 2010; Delaney & Sahakyan, 2007; Hanczakowski et al., 2012; Lehman & Malmberg, 2009, 2011; Mulji & Bodner, 2010; Sahakyan & Delaney, 2003, 2005; Sahakyan & Kelley, 2002; Sahakyan et al., 2013). The 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. Context change is accomplished by thinking of something else besides the experiment, such as a childhood home or a recent vacation, between the lists (e.g. Delaney et al., 2010; Pastötter & Bäuml, 2007; Sahakyan & Kelley, 2002), and instructions to think of something else may cause context change even in the absence of an instruction to forget (e.g., Abel & Bäuml, 2017; Bäuml & Kliegl, 2013; Pastötter & Bäuml, 2007; Sahakyan et al., 2013; Sahakyan & Kelley, 2002). 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 better match the current context. In contrast, participants in the remember group can rely on the current context to a greater extent to recall items from both lists because they did not change internal context to the same degree between List 1 and List 2 encoding. In the earliest version of the context-change theory (Sahakyan & Kelley, 2002), contextual disparity in the forget group between list encoding and test explains both the costs and the benefits of directed forgetting (see also Lehman & Malmberg, 2009). Recall of List 2 items can be impaired by the earlier learning of List 1 items due to a buildup of proactive interference (e.g., Underwood, 1957). These conclusions 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 and more effectively monitor the source of retrieved items when recalling List 2 (see Baddeley, 1990).

Later findings dissociated the costs and benefits of directed forgetting by suggesting that the costs and benefits may be obtained independently of one another (e.g. Pastötter & Bäuml, 2010; Pastötter et al., 2012; Pastötter et al., 2017; Sahakyan & Delaney, 2003, 2005; Sahakyan et al., 2008; Sahakyan et al., 2013). The two-factor account of directed forgetting implies that a change in encoding strategy between lists is responsible for the benefits, as List 2 is more effectively encoded following a forget instruction (Sahakyan & Delaney, 2003, 2005; Sahakyan et al., 2008; Sahakyan et al., 2013). Similarly, the reset of encoding hypothesis suggests that the forget cue following List 1 resets the encoding process for early List 2 items and reduces the memory load from List 1 items, thus contributing to the benefits (Pastötter & Bäuml, 2010; Pastötter et al., 2012; Pastötter et al., 2017).

Theories of List-Method Directed Forgetting Assume Post-Cue Encoding Is Necessary

Although the theories do not necessarily require that post-cue encoding occur to obtain the costs of directed forgetting, empirical evidence aligned with these theories has led all of them to add additional assumptions to explain the absence of costs when only a single list is used. Thus, the finding by Racsmány et al. (2018) that applying the forget cue to List 2 instead of List 1 can still produce the costs provided an earlier List 1 had been studied is important because it suggests problems with these auxiliary assumptions of the theories. For example, 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 increased mismatch between context during encoding and test (Sahakyan & Kelley, 2002). A contextual shift alone (e.g., from an instruction to forget) is insufficient to cause forgetting because without subsequent learning, the original learning context can be easily reinstated (Pastötter & Bäuml, 2007). Consequently, neither mechanism should function in the absence of post-cue learning.

Numerous experiments support the claim that directed forgetting without post-cue encoding fails. For instance, 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 claimed that a new list of to-be-remembered items is necessary to cause forgetting of the previous items.

Later findings by Pastötter and Bäuml (2007) suggested 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 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, 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 recall of List 1 may be further impaired as a function of increased List 2 length, indicating that the amount of post-cue encoding further separates the contexts of List 1 and test, impairing recall of List 1 items.

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).

Racsmány et al. (2018) observed directed forgetting in the absence of this essential post-cue learning by introducing pre-cue learning instead. In Experiment 1, 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 Experiments 2 and 3, two lists of items were presented, but unlike in traditional directed forgetting procedures, the forget group participants 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 in Experiment 2 were asked to first recall items from List 2 followed by items from List 1, with recall of the most recent list occurring first. 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. These findings suggest 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. In this case, the proactive interference of List 1 items on List 2 along with the selectivity of the forget cue may have contributed to forgetting without post-cue encoding of new information.

These findings pose a challenge to the explanations provided by existing theories of directed forgetting for the need for post-cue encoding, because successful forgetting occurred despite the lack of post-cue encoding. The original findings were described as supporting an "episodic inhibition" mechanism. The article was perhaps unclear as to whether episodic inhibition was intended to refer to a suppressive mechanism, or merely a mechanism-agnostic process that causes forgetting (cf. Racsmány & Conway, 2006); according to the third author, it meant only the latter. However, a suppressive inhibitory mechanism could explain the results provided that there was sufficient competition by jettisoning the assumption that the inhibition required new learning to occur and replacing it with an assumption that competition of any sort was sufficient to produce the forgetting. Taking into account the inhibitory explanation for directed forgetting (see Sahakyan et al., 2013) it makes sense to take this seriously as a possibility for the recent findings. However, the context change theory seemingly fared less well at explaining these findings because it should still be possible to quickly reinstate the List 2 learning context when asked to do so in the absence of post-cue learning.

Proposing a Context-Based Account Grounded in the List-Before-the-Last Paradigm

The goal of the present study is to test an alternative explanation for why participants may successfully forget List 2 items that is not directly predicted by earlier theories of directed forgetting. Although the account is new, it is consistent with prior claims of the context change account. We hypothesize that participants strategically initiate retrieval of earlier learned information to forget the most recent items.

Our hypothesis is that retrieval of earlier-learned items causes a contextual shift, which results in reduced recall of the most recent list. This notion was first suggested by Jang and Huber (2008) to explain a related phenomenon, the list-before-last paradigm (discovered by Shiffrin [1970]). In list before the last procedures, participants encode multiple lists, and after each list they are instructed to either wait for the next list or to retrieve not the most recent but the previous list, also known as the list before the last (see also Sahakyan & Hendricks, 2012; Sahakyan & Smith, 2014; Ward & Tan, 2004; Unsworth et al., 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. Theoretically, context drifts gradually from one list to the next such that when asked to recall the previous list, participants can rely on the current context (of the intervening list) to retrieve items from the target list. However, interim retrieval of the list before the last disrupts the contextual similarity of the neighboring lists and subsequently when participants try to recall the target list, the contextual mismatch leads to forgetting (see Figure 1). Retrieval of the earlier learned list is assumed to change internal context, which has also been theorized to explain the costs in directed forgetting (e.g. Sahakyan & Kelley, 2002). In directed forgetting, when context is sufficiently shifted between the List 1 to-be-forgotten items and List 2 to-be remembered-items, participants show reduced recall for List 1 items compared to a control group who do not initiate a contextual change. Similarly, in list-before-last, the no-retrieval trials mimic the remember group in directed forgetting because a lack of context change leads to increased recall of the target list compared to retrieval trials and the forget group respectively. Thus, retrieval from the list-before-last may lead to significant forgetting of the target list at subsequent recall attempts due to internal context change initiated by said retrieval. Furthermore, previous research has suggested that attempted reinstatement of the previous context during retrieval trials (as opposed to successful retrieval of individual items) is sufficient to cause an internal context change, which leads to forgetting (Sahakyan & Hendricks, 2012). It is the effort to retrieve that changes context and does not depend on the difficulty of retrieval or the number of items successfully retrieved.

We propose that a similar mechanism to that in the list-before-last procedure is being covertly deployed 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). Specifically, we think participants are strategically retrieving the list context as opposed to individual items from List 1, which initiates a contextual shift following List 2, thus isolating the List 1 and List 2 contexts. Consequently, when participants are later asked to recall from List 2, it has become the new list-before-last, and List 1 is now (covertly) 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, we propose that in order to forget the most recent list (List 2), some participants will strategically and covertly engage in a retrieval trial of the previous list (List 1). Retrieval of List 1 in turn initiates a contextual shift, causing forgetting of List 2 because the retrieved List 1 context is reinstated following the List 2 context. Thus, the retrieval of List 1 reinstates the List 1 learning context, which is now operative at test. The mechanism is similar to the effects of reinstatement that have been previously observed in directed forgetting and the context-change task when deliberate instructions to reinstate the original learning context were used (Sahakyan & Kelley, 2002). Moreover, the possibility that some people may strategically attempt to retrieve other items as a way to help promote directed forgetting of unretrieved items is intuitively plausible, given the results from the list-before-last paradigm. In addition, forgetting should occur whether participants retrieve List 1 items, or the context associated with List 1. Sahakyan and Hendricks (2012) determined that the number of retrieved items does not change the magnitude of forgetting, and that merely thinking back to the previous context is enough to disrupt the current context. This differentiation is explored further in the discussion.

In the current study, we therefore sought to replicate the results of Racsmány et al. (2018). Further, we predict that some 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 here we propose that a form of later learning is indeed occurring as covert retrieval of List 1.

Experiment 1

Data and materials for all experiments will be made available on the laboratory's webpage. The first aim of the current experiment was to conceptually replicate the main results of Racsmány et al. (2018). Specifically, we 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. Some types of retrospective verbal reports have been asserted to be a reliable source of information consistent with participant behavior and cognitive processes (for a review, see Ericsson & Simon, 1993), and are beneficial to identify various covert strategies used by participants when completing tasks (for a recent review, see Delaney et al., 2018).

The current experiment consisted of four lists of ten English words (Appendix A) selected from the Toronto Noun Pool (Friendly et al., 1982). The Racsmány et al. (2018) experiments 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. The four lists were split into two sets of two lists each and participants were instructed to forget only either List 2 or List 4 (see Figure 2 for a design schematic). Forgetting was measured as the difference in recall between List 2 and List 4; the most recent forget and most recent remember list. The original between-subjects experimental design was nested within the current design to allow for a direct replication comparison, if necessary.

Furthermore, the original experiments 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 repeating a string of numbers out loud for 30 s because experience within the current population has shown that tasks involving math problems are potentially stressful for participants and may negatively impact recall performance.

We conducted an initial experiment that resulted in no significant forgetting of the most recent list; therefore, the reviewers requested we move this first experiment to an Appendix that is accessible through an online supplement. The results of the first experiment suggested that the original distracter task, which involved reading out loud from a novel for 5 min, may have been too distracting for participants and reduced recall to near floor, thus preventing significant differences from being detected. Self-reported strategies from the initial experiment suggested that almost one in five participants focused on the contents of the reading material rather than the list items and expected a test on the distractor task rather than the word lists. For the current experiment, we replaced the novel with a string of five numbers repeated out loud for 30 s in an attempt to rectify the issue of low recall. We expected that participants would be able to forget the most recent list, in line with Racsmány et al.'s (2018) findings. We also expected that some participants would report retrieving the first list as a strategy to forget the most recent list.

For all experiments, we report sample size and exclusion criteria, all manipulations, and measures of the current study (Simmons et al., 2012). All experiments were approved by the University of North Carolina at Greensboro IRB committee and followed IRB guidelines. All analyses were planned in advance unless we explicitly marked them as post-hoc analyses.

Method

Participants. A total of 72 undergraduates in psychology courses at the University of North Carolina at Greensboro recruited through the psychology research pool participated in the experiment. 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 conditions had an equal number of participants, including replacements. We also powered to detect a within-subjects effect size of $d = 0.30$ with 80% power to be maximally conservative even though the original between-subjects effect was $d = 0.60$ (Faul et al., 2009). Experience with the current population suggests that many effects are smaller at UNCG, so we overpowered to ensure we would observe the effect, if it existed. Data from eight 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 64 participants.

Materials and Design. The experimental design and list condition labels is presented in Figure 2. Each participant saw two pairs of lists followed by the cue and final test on that pair, with the second list of each set being the critical remember or forget list. We refer to the lists in two ways: (1) the position of the list within the entire experiment, which is List 1, List 2, List 3, or List 4, and (2) the list's position within a pair of lists and its cue. The set with the remember list is referred to as the *remember set* and its lists are designated as R1 (first list in the remember set) and R2 (second list in the remember set, receiving the critical remember instruction). The set with one remember and one forget list was designated the *forget set*, and similarly the first list is F1 and the second list is referred to as F2, which is the list participants were instructed to forget. These two indexing methods are useful in different places, so we retained both of them.

The design was a 2 Lists (List 1 and List 2 vs. List 3 and List 4) x 2 Cue (Remember Set vs. Forget Set) within-subjects design with cue and list order counterbalanced across participants. 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 experiment therefore consisted of eight conditions, including counterbalancing of cue and list order 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 B for list counterbalancing). Words were presented in Microsoft PowerPoint, and recall was typed by the participant in Microsoft Word.

Procedure. An experimenter was present for all phases of the experiment to ensure participant compliance with instructions. 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, half of the participants were told to try to forget the List 2 words while the remaining half were told to keep remembering List 2. Both groups were instructed to continue remembering List 1. After a 30 s time out, during which participants were not engaged in any task and sat in silence, participants were asked to repeat a string of numbers out loud for 30 s. Following the distractor task, 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 C for experimenter instructions). Once participants completed the recall task, the experiment continued with List 3 and List 4 presentation except that participants who were given a remember instruction after List 2 were subsequently told to forget List 4 and vice versa. Participants were told that they were moving on to the next part of the experiment where they would see a new list of words appear one at a time, and to try to remember these new words for a later memory test. Therefore, participants were only instructed to forget either List 2 or List 4, while remembering all other lists. Participants then repeated a separate string of numbers out loud for 30 s followed by a second recall test where they were asked to recall from List 4 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 (retrieval), (2) pushed the words out of mind by force of will (suppression), (3) tried to distract from the experiment by thinking of something else (distraction), or (4) other. Each of the possible strategy responses correspond with a different theoretical explanation for directed forgetting. The retrieval strategy is consistent with the hypothesized list-before-last mechanism. The suppression strategy refers to the retrieval inhibition theory, and the distraction strategy 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 memory for the second list in a pair when it was followed by the forget cue (F2) and when it was followed by a remember cue (R2) to analyze forgetting within-participants (see Figure 2 and the design section for an explanation of the condition labels and design). 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 cross-list intrusions or 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 in Experiment 1 (Allen et al., 2019). A paired samples *t*-test revealed a significant difference between R2 proportion of words recalled and F2 proportion of words recalled; $t(63) = 2.90$, $p = .005$, $d = 0.36$. Participants showed significantly reduced recall of the most recent forget list (F2) compared to the most recent remember list (R2). Neither list order nor an interaction with cue were significant (both $F < 1$), so we collapsed over this factor. An additional *t*-test revealed only a marginal difference between the first list of the remember set (R1) and that of the forget set (F1); $t(63) = 1.89$, $p = .063$, $d = 0.24$. Thus, the analysis provided little evidence for benefits of the forget cue on the first study list, consistent with the findings in Racsmány et al. (2018).

Strategy Reports. Following the final recall test after List 4, participants were asked if they had tried to forget the list they were instructed to. The strategy reports for Experiment 1 indicated that 61% of participants reported thinking of the first list to help forget the second (retrieval), 11% pushed the words out of mind by force of will (suppression), 23% distracted themselves by thinking of something other than the experiment (distraction), and only 5% reported other (see Table 2). “Other” responses from participants included imagining the words leaving their head or focusing on the participant’s self-perceived “poor memory” to forget. Fewer participants reported “other” as their strategy choice in the current experiment compared to our previous failure to replicate, 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.

Post-Hoc Analysis of Strategy Effectiveness. We did not power the experiment to conduct a strategy analysis. However, a post-hoc between-subjects *t*-test was used to compare recall of the most recent forget list for participants using the retrieval strategy versus all other strategies. This analysis revealed that participants who retrieved F1 showed reduced recall of F2 ($M = .20$, $SD = .17$) compared to participants who used any of the other strategies ($M = .32$, $SD = .21$), $t(62) = 2.35$, $p = .022$, $d = 0.63$. These findings suggest that retrieving the first list to forget the most recent list was an effective forgetting strategy. The results also provided support for the list-before-last mechanism and suggest that some participants covertly use the retrieval strategy to forget.

Post-Hoc Probability of First Recall. To provide further evidence for context change, we assessed probability of first recall for Experiment 1 (Figure 4). Lehman and Malmberg (2009) examined probability of first recall in a traditional directed forgetting paradigm and showed that participants were more likely to output the first item from List 1 in the remember condition, whereas in the forget condition this likelihood was greatly diminished. They suggest that reduced access to early List 1 items in the forget condition is due to contextual differentiation. Accordingly, context cues to early List 1 items are more readily available in the remember condition. Similarly, Sahakyan and Hendricks (2012) examined probability of first recall in their list-before-last experiment where participants learned three lists of words, and between the second and third list, they were instructed either to retrieve List 1 or to solve math problems. Following List 3, participants were tested on List 2 recall in both conditions. Probability of first recall results indicated that participants who had retrieved List 1 between Lists 2 and 3 had reduced access to early List 2 items, whereas those who had solved math problems were more likely to initiate recall with early List 2 items. They discuss this in terms of the contextual change that results from interim List 1 retrieval and explain that this contextual disparity impairs access to early List 2 items (see also, Spillers & Unsworth, 2011).

Therefore, the impaired probability of first recall on early List 2 items is diagnostic of context change, and we showed similar findings in the current study. Here, the probability that participants recalled the first item from List 2 in the remember condition was $p(\text{recall}) = .36$ whereas this probability was diminished to $p(\text{recall}) = .13$ following the change in context as a result of covert List 1 retrieval. Furthermore, the probability that participants initiated recall of List 2 with a cross-list intrusion following the forget cue was p(intrusion) = .26, compared to p(intrusion) = .10 following the remember cue. This provides support for reduced access to List 2 items, as participants were more likely to initiate recall with an intrusion from another list following instructions to forget.

Conclusion

The results from Experiment 1 indicated 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, we suggest that the post-cue encoding seemingly necessary to facilitate forgetting occurs covertly as strategic retrieval of List 1 context or associated items. However, it is possible that providing participants with extended unfilled time after receiving the forget cue (30 s) inadvertently led them to retrieve the prior list. Particularly, within the 30 seconds, participants may have been inclined to retrieve items from List 1, with enough time to do so, which could account for the marginal increase in List 1 recall in the forget set vs. the remember set.

Furthermore, as previously noted, providing participants with fixed order forced response strategy options may have unintentionally led them to report a particular strategy. Therefore, in Experiment 2, we 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 to forget to avoid demand characteristics.

Experiment 2

A limitation in Experiment 1 was the fixed order response format for strategy selection. Since the order of the response options was the same for all participants, this may have led them to report a particular strategy (Delaney et al., 2018). Moreover, retrospective verbal reports can be reactive if participants are asked to reflect on their decisions (as in a button press) instead of just reporting everything they thought (cf. Ericsson & Simon, 1993). Furthermore, this raises the possibility that inhibitory processes may not be conscious, and participants may not be able to make explicit judgments of inhibition in the self-reports. For these reasons, the strategy assessment was changed to an open-ended retrospective verbal report in Experiment 2 to account for these possibilities and allow participants to elaborate in their own words how they tried to forget.

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

The primary purpose for Experiment 2 was to replicate the findings of Experiment 1, predicting that participants would successfully forget the most recent list. We also predicted, consistent with Experiment 1, 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. This is because in order to forget, some participants may try to think about other things particularly by referring to what is salient in their environment, such as the first list (e.g. Sahakyan & Kelley, 2002; Pastötter & Bäuml, 2007). A secondary purpose of Experiment 2 was to compare forgetting of the most recent list for participants using the retrieval of List 1 strategy against those using all other strategies. We expected that participants who reported 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 1.

Method

Participants. A power analysis conducted in G*Power version 3.1.9.4 (Faul et al., 2009), to detect the between-subject forgetting by strategy interaction based on the estimated effect size of d = .60 from the post-hoc analyses in Experiment 2 at 80% power and alpha set at .05 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 2 were identical to those used in Experiment 1.

Procedure. The procedure was the same as Experiment 1 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, reporting on their thoughts during the study period.

Results and Discussion

Figure 5 shows raincloud plots representing data distribution of proportion recalled and central tendencies for each list in Experiment 2 (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 again resulted in a significant difference between the most recent Forget and Remember lists; $t(98) = 3.76$, $p < .001$, $d = 0.38$, suggesting that participants again forgot the most recent information, consistent with Experiment 1. An additional *t*-test revealed no significant F1 benefits over R1, $t(98) = 1.08$, $p = .283$, $d = 0.11$. As in Experiment 1, cross-list intrusions were rare (see Table 1) and no list order effect or an interaction with cue were found (both $F < 1$).

Strategy Reports. Open-ended strategy reports were coded by the first author and a research assistant, A. Hester, (see Appendix D for coding instructions) using the strategies in Experiment 1 while blind to the recall results. The research assistant was trained on a practice set of responses and the final set consisted of 40 randomly selected responses from the results. An inter-rater reliability of 97.5% was obtained, with only one discrepancy over whether a response should be coded as “thinking of something else” or “other.” This discrepancy was settled through discussion after consulting with the second author. These reports revealed that 68% of participants self-reported thinking of the first list to forget the second (retrieval), 14% pushed words out of mind by force of will (suppression), 10% thought of something else (distraction), and 8% reported something other than those responses. “Other” responses included focusing completely on the string of numbers from the distractor task 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). The open-ended strategy reports also provide a piece of evidence contrary to concerns from Experiment 1 that inhibition is not a conscious process and may not be available for participants to make explicit judgments on. Here, many inhibit-coded responses included descriptions of forgetting such as pushing the words out of mind, preventing the words from appearing in their mind, trying not to think about the words, or allowing their minds to go blank. This suggests that at least some participants can describe an inhibitory-like forgetting mechanism.

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 F2 words ($M = .22$, $SD = .14$) than those using all other strategies ($M = .33$, $SD = .23$); $t(97) = 2.62$, $p = .010$, $d = 0.65$ (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 post-hoc findings of Experiment 1. At the very least, it suggests that people who were the best at forgetting also reported retrieval as their main method for forgetting.

Post-Hoc Probability of First Recall. We examined the probability of first recall following F2 and R2 (Figure 7) to see if participants had reduced access to early List 2 items following the forget cue and associated context change. Here, the probability that participants initiated recall with the first item on List 2 was $p(\text{recall}) = .22$ following the remember cue and $p(\text{recall}) = .18$ following the forget cue. Though this difference is numerically smaller than what we found in Experiment 1, it is still in the anticipated direction. Furthermore, the probability that participants initiated recall with a cross-list intrusion following the forget cue was $p(\text{intrusion}) = .22$ and following the remember cue $p(\text{intrusion}) = .07$. This further suggests that the forget cue limits the ability to successfully target early items from the most recent list when they begin recall.

Conclusion

The findings from Experiment 2 replicated those of Experiment 1: many participants successfully forgot more of the most recent information when instructed to do so. Most participants reported that 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 of the most recent list than those who used all other strategies; providing support for our prediction that forgetting occurs by retrieving List 1 despite less time to do so. Compared with Experiment 1 where participants had 30 s to deploy a forgetting strategy, in Experiment 2 that time was reduced to 5 s. Therefore, we are inclined to suggest that rather than retrieving List 1 items, this time participants were probably retrieving aspects of the List 1 context in order to forget. In line with Sahakyan and Hendricks (2012), thinking back to the first list is sufficient to change internal context, and cause forgetting, and that is likely what participants who reported the retrieval strategy in the current experiment did within the 5 s.

Experiment 3

Experiments 1 and 2 allowed participants to choose any strategy they wanted. In Experiment 3, we explicitly told participants to use the retrieval strategy in order to forget. By providing the participants with the retrieval strategy, we could directly test whether the strategy is effective in producing directed forgetting, consistent with the proposed retrieval strategy mechanism. Moreover, Experiment 3 used a between-subjects design to ensure that the forgetting strategy could not involve borrowing time from the F2 lists to the R1/R2 lists, and to ensure that the strategy is not only effective with four list designs. Finally, due to difficulties recruiting UNCG students during the pandemic, we also switched the population to Prolific users.

Method

Participants. A total of 151 participants from the Prolific service completed Experiment 3 in exchange for $1.75 as compensation. A power analysis conducted in G*Power version 3.1.9.4 (Faul et al., 2009) to detect the between-subject forgetting effect based on the estimated effect size of *d* = .50 with 80% power and α = .05 resulted in an estimated sample size of 128. The effect size of *d* = .50 was based on the original Racsmány et al. (2018) reported effect size of *d* = .60 for the between-subjects forgetting effect, but to be conservative and to account for replacements we set an anticipated sample size of *n* = 150. One additional participant completed the study before it was closed resulting in the total sample size of 151. Data were excluded from 21 participants who either failed the attention check, did not comply with the forget instruction, or reported using a strategy different from the one they were instructed to use, resulting in a final sample size of *n* = 130 (59 in the Forget condition and 71 in the Remember condition). The results did not change when no participants were excluded.

Design and Materials. The experiment was a between-subjects design with two conditions where cue (either remember or forget) was manipulated between participants. The experiment was conducted on Qualtrics via the Prolific service and consisted of the first two lists of 10 nouns from the prior studies (see Appendix A). Participants who received the forget instruction were specifically told that they should try to forget the list by retrieving the earlier learned list. List order was counterbalanced across conditions.

Procedure. Participants were told that the study was meant to determine whether some strategies to forget are more effective than others. The instructions indicated that participants would learn lists of words for a memory test and for some lists they would be given an instruction to forget, but they would not know which list to forget until after the list was presented, so they should try to remember the list until they saw the forget instruction. Participants in the forget condition engaged in a practice period where they learned two short lists of three words each and were then given specific instructions on how to use the assigned strategy. The practice period instructions indicated that participants should try to forget the most recent words by thinking about the first few words they saw, including what the words were and how each word appeared. Then all participants saw the first list of 10 words followed by an instruction to keep remembering those words. They then saw the second list of 10 words followed by either an instruction to keep remembering the list or to try to forget the list using the retrieval strategy they practiced earlier. More specifically, participants in the forget condition were told that they should try to forget List 2 and they should do so by thinking back to List 1 and retrieve any items they could. After 10 s to remember or forget List 2, participants completed two-digit addition for 30 s followed by 60 s to recall any words from List 2 and then an additional 60 s to recall any words from List 1. After the experiment was over, we then asked a number of exploratory questions about their experience in the experiment for our own curiosity. Given these questions were not germane to the hypotheses, we omit discussion of them to save space.

Results and Discussion

There was a significant directed forgetting effect such that participants who received the forget instruction recalled significantly fewer words from List 2 (M = .19, SD = .14) than those who were told to remember List 2 (M = .39, SD = .25); $t(128) = 5.58$, $p < .001$, $d = 0.98$ (see Figure 8). For the List 1 benefits, participants who received the forget instruction (M = .34, SD = .22) did not outperform participants who received the remember instruction (M = .33, SD = .24),

$t < 1$, consistent with the prior experiments and the original Racsmány et al. (2018) findings (Figure 9).

The findings from the current experiment suggest that when participants are instructed to use a retrieval strategy to forget the most recent list by retrieving the previously learned list, they can successfully forget the most recent list. The prior studies did not directly manipulate strategy, so the current experiment provides direct evidence that a retrieval strategy is effective to forget the most recent list, consistent with the proposed strategic retrieval mechanism. Moreover, the effect size was the largest we have observed in any of our studies, although it is difficult to be sure whether that was due to the strategy instructions or to the change of participant populations.

At this point, we have shown that a retrieval mechanism is effective for forgetting some information, and we must consider how this may work in other areas. Similar findings in studies examining retrieval-induced forgetting show that repeated retrieval of a subset of information causes forgetting of related unretrieved information (for a review, see Anderson et al., 1994; Storm et al., 2015). Though the current study is not equivalent to traditional retrieval-induced forgetting, where the items are typically related word-pairs, the shared mechanism whereby retrieval of some information leads to forgetting of other information indicates that this may be a type of retrieval-induced forgetting. This will be addressed further in the general discussion.

Post-Hoc Probability of First Recall. We examined probability of first recall between participants in Experiment 3 (Figure 10). For participants in the forget condition, the probability that they initiated List 2 recall with the first item was $p(\text{recall}) = .19$ and for those in the remember condition this probability was $p(\text{recall}) = .30$. The reduced probability of forget-cued participants to start recall with early List 2 items compared to remember-cued participants is indicative of context change, following the findings from the previous Experiments. As for the probability of initiating List 2 recall with an intrusion from another list, this was p(intrusion) = .19 for the forget group and p(intrusion) = .08 for the remember group.

Experiment 4

Our Experiments 1 and 2 allowed participants to freely choose a forgetting strategy in response to the forget cue. Thus, they reflect what participants *chose* to do. Moreover, Experiment 3 showed that instructions to use the retrieve strategy produced a large forgetting effect. However, one possibility is that other strategies are *also* effective in causing forgetting, but that better forgetters tend to choose the retrieval strategy as the best explanation for what they are doing. If strategy choice were confounded with forgetting ability, then it would appear that only retrieval produced significant forgetting, when in fact people who were more effective forgetters tended to select that strategy. This pattern would have been masked in Experiment 3 as well, because we instructed all participants to use the retrieval strategy.

We therefore attempted to rule out this possibility by directly manipulating the forgetting strategy we instructed participants to use in Experiment 4. We told participants we were interested in exploring methods of how to forget in everyday life and explained that we would give them different instructions on how to forget a list of words and then ask them about their experience at the end, including whether they thought the assigned strategy was easy or hard, effective or not, and whether they thought they could use the strategy in their daily lives. This manipulation allowed us to examine each of the strategies (retrieval, inhibition, and context change) more closely to determine whether one of the retrieval strategies was more effective for forgetting the most recent list than the other strategies.

Method

Participants. A total of 262 participants, including both UNCG undergraduates (*n* = 117) and Prolific users (*n* = 145) participated in exchange for either partial course credit or compensation of $4.00 respectively. We mixed sources of participants because the COVID-19 pandemic significantly slowed our data collection as it shuttered our laboratory space. A power analysis conducted in G*Power version 3.1.9.4 (Faul et al., 2009) to detect a cue by strategy interaction, based on the estimated effect size of $\eta_p^2 = .02$ with 80% power and alpha set at .05, indicated an estimated required sample size of 171. We powered the experiment expecting this interaction to be a small to medium effect based on experience with the UNCG population, to ensure equivalent conditions, and to be maximally conservative. Data exclusions consisted of 24 participants who failed the attention checks, and an additional 51 participants who did not comply with either the instruction to forget or the specific strategy instructions resulting in a final sample size of 187 participants including replacements.

Design and Materials. The experimental design was a 2 Cue (forget vs. remember) x 3 Strategy (retrieve, inhibit, think of else) mixed design with cue as a within-subject manipulation and strategy a between-subject manipulation. The experiment was conducted on Qualtrics and consisted of the same four lists of ten English nouns from the previous experiments, separated into two sets of two lists each. List order was counterbalanced across conditions. Participants were instructed to forget the second list of one set using a specific forgetting strategy.

Procedure. Participants signed up for the study via either the UNCG participant pool or the Prolific online participation platform and received a link to the Qualtrics study directly. The instructions indicated that the study was designed to examine ways to intentionally forget things that are no longer relevant and that we were interested in determining whether certain strategies to forget are more effective than others. Participants were told they would learn lists of words and sometimes we would ask them to forget a list by giving them specific instructions on how to do so.

Participants then engaged in a practice period identical to that used in Experiment 3, with two additional strategies. Participants in the *retrieval condition* were told they should try to forget the most recent words by thinking about the first few words they saw, including how each word appeared. Participants in the *inhibit condition* were told to forget the most recent words by pushing the words out of mind and allowing their mind to go blank by preventing the words from coming to mind. Participants in the *think of something else condition* were instructed to forget by thinking of anything unrelated to the experiment.

After the practice period, participants began the main experiment which was identical to the procedure for Experiment 2 except they were instructed to implement the practiced strategy upon receiving the cue to forget. They had 10 s to read and implement their forgetting strategy before engaging in 30 s of two-digit addition followed by the same recall procedure as the previous experiments. Following presentation of all list sets and strategy instructions, participants completed a questionnaire where they reported what they did in response to the strategy instructions, whether they believed the strategy was effective, easy to use, and something they might try to use in their everyday life.

Results and Discussion

The final between-subjects comparison, after exclusions, included 60 participants in the *inhibit* condition, 64 participants in the *retrieve* condition, and 63 participants in the *think of something else* condition.

Directed Forgetting. For the first analysis, we sought to determine whether an overall forgetting effect emerged by collapsing across all strategies. Analyzing recall data from a total of *n* = 187 participants, an overall forgetting effect was obtained with participants recalling fewer words following the forget cue (*M* = .26, *SD* = .22) than the remember cue (*M* = .34, *SD* = .23); $t(186) = 3.88$, $p < .001$, $d = 0.28$. Consistent with the prior experiments, no benefits emerged as participants did not recall significantly more words from F1 (*M* = .34, *SD* = .23) than from R1 (*M* = .33, *SD* = .24), $t < 1$.

Forgetting by Strategy. When examining the effectiveness of each strategy individually, a mixed effect ANOVA revealed a main effect of cue $F(1,184) = 14.85$, $p < .001$, $\eta_p^2 = .075$, however, no main effect of strategy emerged nor our predicted cue by strategy interaction, both $F < 1$. Although the interaction did not approach significance, the largest forgetting effect was in the *retrieve* condition; $d = 0.34$ (Figure 11), followed by the *inhibit* condition, $d = 0.26$ (Figure 12), and the *think of something else* condition, $d = 0.24$ (Figure 13).

These findings indicate similar forgetting across the strategies, suggesting that a retrieval strategy may not be the only effective strategy to forget the most recent list and we therefore must consider that alternative strategies are possible. The findings nonetheless provide support that a retrieval mechanism may partially explain forgetting using this new method of directed forgetting. On the one hand, results from the earlier experiments suggest that when participants are free to choose a forgetting strategy, they oftentimes choose to retrieve the earlier list. On the other hand, when they are given explicit instructions on which strategy to use, the other strategies are similarly effective for forgetting. Self-reports from the current experiment suggest that when participants are instructed to inhibit the most recent list, they sometimes attempt to think of the earlier list (*n* = 5) or think of other things (*n* = 16). Therefore, when participants appropriately implement an inhibitory strategy, they can forget recently learned information, however it may be challenging to deploy spontaneously. It may be easier for participants to use a retrieval or diversion strategy, given the salience of the instructions.

We therefore must consider that other forgetting strategies, besides retrieval, can be effective. However, a retrieval strategy may still account for some of the forgetting that occurs here, and participants are more likely to choose a retrieval strategy to forget when they are given the autonomy to initiate a strategy on their own.

Post-Hoc Probability of First Recall. We examined the probability of first recall for the most recent list following the remember cue and following each forgetting strategy (Figure 14). After receiving the remember cue, the probability that participants initiated List 2 recall with the first item was $p(\text{recall}) = .26$. After receiving the forget cue with each forgetting strategy, including *retrieval*, *inhibition*, and *thinking of something else* the probability of initiating recall with the first item from List 2 was $p(\text{recall}) = .22$, $p(\text{recall}) = .19$, and $p(\text{recall}) = .21$ respectively. For those initiating recall with a cross-list intrusion, this probability following the remember cue was $p(\text{int}) = .04$, for *retrieval*; $p(\text{int}) = .06$, for *think of something else*; $p(\text{int}) = .08$, and for *inhibit*; $p(\text{int}) = .02$.

General Discussion

The findings from the current study identified a new mechanism that can account for some the costs associated with directed forgetting, and we view the proposed mechanism as broadly consistent with the context change theory. Four experiments reported here using both within and between-subjects designs successfully replicated earlier findings by Racsmány et al. (2018) and indicated that participants were able to forget the most recent information they learned in the absence of post-cue encoding. Verbal reports in the first two experiments indicated that participants may often choose a retrieval strategy when instructed to forget, and this covert and strategic retrieval of earlier-learned items may explain some of the forgetting, as shown by the strategy analyses in Experiments 1 and 2. Direct between-subjects manipulation of strategy in Experiment 3 showed that the retrieval strategy is effective when participants are explicitly told how to use it. Experiment 4 included all strategies and showed an overall forgetting effect, although we did not detect significant differences in forgetting between strategies. It is possible that we failed to fully control strategy, as some participants reported using strategies other than the one they were instructed to use. However, it is also possible that controlling which strategies participants use leads to equivalent forgetting, whereas when participants are free to choose a strategy, they are more likely to spontaneously implement a retrieval strategy.

Demonstrating retrieval as a forgetting mechanism is a valuable contribution. We think that the act of retrieval caused mental context to change (cf. Sahakyan & Kelley, 2002), as has been proposed as an explanation for the forgetting that occurs in the list-before-last paradigm when people are explicitly instructed to retrieve an earlier list (Jang & Huber, 2008). The finding that retrieval affected probability of first recall compared to the remember cue is a common outcome of context changes (cf. Sahakyan & Hendricks, 2012). Ours is the first study to demonstrate that a retrieval mechanism can be deployed strategically in response to directed forgetting instructions (rather than an explicit instruction to retrieve), resulting in the costs in the absence of explicit post-cue encoding.

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 disrupts the gradual contextual shift from one list to the next, thus driving an internal context 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, retrieval functions in the same way; participants retrieve the previously learned items, with or 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 Experiments 1 and 2, it is 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.

The current study joins many other studies suggesting that attempts to forget on purpose often involve thinking of something else, and that people may cast about for something salient in the environment or their current concerns as a method to forget. Verbal reports in ordinary list-method directed forgetting are consistent with the use of thinking of something else to forget (Foster & Sahakyan, 2011; Sahakyan & Kelley, 2002; Sahakyan et al., 2013). Similarly, 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 2010). In Experiment 0 (the initial failure to replicate reported in the online supplement), participants reported thinking the experiment was about remembering the reading material, and so selected thinking of the novel as a way to forget the word lists. The procedural change in Experiments 1 and 2 where the reading was replaced with a string of numbers likely accounted for the nominal differences between those who reported a retrieval strategy in Experiment 0 (where only 41% reporting retrieval) compared to Experiment 1 (61%) or Experiment 2 (68%). Since the possibility of the reading was no longer a salient distraction in Experiments 1 and 2, participants had to search for something else, which was more often the previous list.

Similarly, in the current experiments, while thinking of something else and retrieving earlier items in order to forget operate in similar ways, they diverge with respect to the content that is thought about or retrieved in order to forget. In the current study, the magnitude of forgetting via thinking of something else vs. retrieving earlier items differs when participants are free to choose a forgetting strategy (Exp 1 & 2) but is equivalent when they are instructed to use a specific strategy (Exp. 4). While we do not have strong evidence to suggest that strategy specifically determines the directed forgetting magnitude, there are several possibilities that may account for these differences. One possibility is that when participants are left to their own devices, they may interpret a retrieval strategy as the most obvious and effective forgetting strategy. The items from the previous list are salient and still need to be retained, so participants may interpret retrieval as an effective and straightforward strategy. Another possibility is that when participants are instructed to use a specific strategy, like thinking of something unrelated to the experiment, they still covertly retrieve List 1 in addition to the specific strategy. In this way, it could be that forgetting still requires some retrieval of earlier to-be-remembered items, otherwise all information (including List 1 items) would be forgotten (see Sahakyan, 2004). It may be that all strategies are effective, but participants are more likely to select a retrieval strategy because it is an obvious choice. Then, when participants are assigned to different strategy conditions, those who would usually retrieve are now spread across strategies which then equates the forgetting magnitudes. These possibilities may promote the differential directed forgetting magnitudes when participants are given the choice on which strategy to use vs. when they are told which strategy to use.

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 et al., 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 self-reported retrieving earlier learned information as a strategy to forget when given no specific strategy instructions showed reduced recall compared to remember and to all other strategies (Experiments 1 and 2). Here, it is suggested that a retrieval strategy may be effective to forget the words and certainly more effective than no strategy, as in Foster and Sahakyan's work.

Alternative Accounts of the Present Data

Our predictions were motivated by the context-change theory (Sahakyan et al., 2013; Sahakyan & Kelley, 2002), and we propose that a mechanism that partially explains forgetting of the most recent information involves a context-change based strategy. However, particularly with respect to the Experiment 4 findings, we are open to evidence that it could be partially explained by other mechanisms. A contextual account suggests forgetting only occurs when additional information is encoded post-cue, while Racsmány et al. (2018) proposed that episodic inhibition 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 with a flexible application of inhibition 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 we suggest 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. The list-before-last study by Sahakyan and Hendricks (2012) provides additional evidence conflicting with inhibitory accounts by manipulating the degree of difficulty on retrieval trials, from cueing participants with the first two letters of the List 1 words (easy retrieval condition) to providing only the second letter of List 1 words as a cue (very hard retrieval condition). An inhibitory account would suggest that the easy retrieval condition should require less inhibition of List 2 to retrieve List 1, and therefore less forgetting of List 2 items at the later test. An interference-based account of inhibition would indicate that easy retrieval of List 1 items would cause these items to be strengthened, thus interfering with List 2 items at test, resulting in more forgetting of List 2 in the easy retrieval condition. Contrary to both of these accounts, they found equivalent List 2 recall across all levels of difficulty. Instead, the findings were more compatible with a context-based account of earlier list retrieval (e.g. Jang & Huber, 2008).

Another possibility is that the forgetting was caused by a form of retrieval-induced forgetting (e.g., Anderson et al., 1994; Storm & Levy, 2012). In retrieval-induced forgetting, people study a list of cues that are each associated with multiple targets (e.g., dog-mastiff, dog-poodle, etc.). Repeated retrieval of some of the targets using the cue leads to forgetting of their competitors, and hence retrieval-induced forgetting. One could make a case that the present data represent an example of retrieval-induced forgetting. While inhibition is often proposed to explain retrieval-induced forgetting, the term more so describes how retrieval of the non-retrieved targets becomes less and less reliable (Storm & Levy, 2012). It does not necessarily require inhibition; it could involve blocking or other similar mechanisms whereby strong items reduce access to weaker items. Furthermore, it does not require actual retrieval of the items, but just the attempt to do so (see Storm et al., 2006; Storm & Nestojko, 2010). When associates are weakly associated with the cue, retrieval-induced forgetting effects are usually quite small (Murayama et al., 2014), and with our completely unrelated items, it seems unlikely that the usual retrieval-induced forgetting effect is the source of the forgetting observed here. However, these results provide a list-wise retrieval-induced forgetting effect that may be interesting to pursue further. It would be interesting to know whether this type of directed forgetting emerges in recognition testing, for example, which is true of retrieval-induced forgetting, but not ordinary list-method directed forgetting. It would also be interesting to learn whether restudying List 1 is sufficient to cause the same level of forgetting, as retrieval-induced forgetting generally requires retrieval and not just restudy (for a review, see Verde, 2012).

Here, strategy reports suggest that many participants independently selected a retrieval strategy to forget the most recent list. The strategy was consistently successful in causing forgetting when spontaneously chosen (Experiments 1 and 2) and when participants were instructed to use it (Experiments 3 and 4). We acknowledge that an inhibitory mechanism may still occur concurrently with the retrieval mechanism. One way that could occur is if the inhibition is difficult for participants to report, unconscious, or viewed as secondary to the retrieval attempt. Since the majority of participants in the first two experiments reported a retrieval strategy, it would be most plausible if any concurrent inhibition occurred through retrieval-induced forgetting. That said, in Experiment 4, explicit instructions to inhibit also appeared to produce forgetting (though we cannot be certain participants fully complied with those instructions; some reported also engaging in retrieval). Even with an unconscious concurrent form of inhibition, it is probable that the inhibition in the current study occurs primarily when people attempt to retrieve from List 1. Sahakyan and Hendricks (2012) argued that retrieval-induced forgetting is insufficient to explain the forgetting that results in list-before-last studies, and similar arguments may apply here as well. The effects of using the retrieve strategy seem most directly predicted by the context change theory, but it is difficult to explain why inhibition was also successful in producing forgetting in Experiment 4 if it is not covertly engaged by the retrieval process. It is not as important to us whether the mechanism is a context-based mechanism or a kind of retrieval-induced forgetting; what is important is that the mechanism is what people report doing, and appears to be effective. Future theoretical work can disentangle the niceties of context versus inhibition.

The present results should not be misinterpreted as suggesting that standard list-method directed forgetting effects are caused by retrieval. Findings by Basden et al. (2003) using the typical list-method directed forgetting procedure (i.e., the forget cue appears after List 1) indicated that neither strengthening of List 2 through retrieval nor restudy of List 2 items before the final test increased the directed forgetting effect. Therefore, a retrieval-induced forgetting mechanism may not underlie the costs of directed forgetting in the usual design where people are told to forget List 1. Both Basden et al.'s (2003) results and the absence of any change in the effectiveness of retrieval when only 5 s is allowed to retrieve (cf. our Experiment 2) suggests it is not the number of items retrieved that leads to the forgetting. It is unlikely to be a blocking mechanism caused by strengthening List 1 for the same reason – one would expect more retrieval time should strengthen more items, leading to greater blocking. Instead, the results are most consistent with either an inhibitory effect or a context change effect secondary to retrieval.

The current design also structurally resembles research examining dual-list free recall (e.g. Unsworth et al. 2013; Wahlheim & Huff, 2015; Wahlheim et al., 2017). In these studies, participants learn two lists of words and are instructed to recall items from List 1, List 2, or both which is compared to conditions where participants receive only a single list to recall. Therefore, one could reasonably draw a connection between the current study design and a dual-list study condition in which participants are instructed to retrieve from List 1. However, in the dual-list studies, participants are not subsequently tested on List 2, after being told to only recall from List 1. The exception to this is the "both" condition, but there, participants can recall from either list in any order they choose (see Wahlheim & Huff, 2015). In the current study, participants are similarly learning two lists, but our procedure is more closely related to the list-before-last in that reinstating prior contexts results in forgetting. All existing list-before-last studies involve subsequent learning of a third list prior to List 2 recall, enabling examination of List 3 intrusions (see Sahakyan and Hendricks, 2012). Though our procedure does not include this third list, there is no reason this would not work in principle as a two-list, list-before-last design. Therefore, the inclusion of a third list should not matter if the forgetting is caused by List 1 retrieval as opposed to List 3 intrusions. Theoretically, list-before-last effects should occur in a two-list design, as in the present experiments, which would be interesting to pursue further.

The current findings are also concordant with Karpicke, Lehman, and Aue's (2014) episodic context model of the testing effect. This theory proposed that whenever studying and retrieval take place in different temporal contexts, retrieval will reinstate and update the study context by encoding a composite of the study and retrieval contexts. During a later test, this compound context is used as a cue to restrict the search set increasing the likelihood of successful retrieval of target items at the exclusion of unwanted items (see also Lehman et al., 2014). In other words, during test the target items are associated with multiple contexts (the study and retrieval contexts) forming a composite context and thus reinstatement of either context is an effective cue for those items. In the current findings, it is conceivable that the participants recall List 1 elements following the forget cue and create a compound context of List 1 study and retrieval contexts. Later during the test, the participants may use this compound context for retrieval, but it will primarily be used to access List 1 items, thus producing the forgetting effect on List 2 items.

These findings join a broader literature on whether people can selectively forget some but not all previously-learned information (e.g. Aguirre et al., 2017; Akan & Sahakyan, 2018; Delaney et al., 2009; Kliegl et al., 2013; Sahakyan, 2004; Storm et al., 2013). There are several variations of selective directed forgetting, including three-list designs (e.g. Sahakyan, 2004; see also Kliegl et al., 2013) where participants are presented with three lists, with a forget cue following List 2, and they are told to forget List 2 while remembering all other lists. An alternative two-list method typically involves participants learning sentences about two characters in alternating order, with instructions to forget sentences about only one of the characters (e.g. Aguirre et al., 2014; Delaney et al., 2009; Storm et al., 2013). Findings in the selective directed forgetting literature are conflicting and suggest that participants may or may not be able to forget only some of the pre-cue information. Several studies have obtained selective directed forgetting using both word lists and sentences (Aguirre et al., 2014; Aguirre et al., 2017; Delaney et al., 2009; Kliegl et al., 2013) but several high-powered failures to replicate have suggested there is no such selective effect (Sahakyan, 2004; Sahakyan & Akan, 2018; Storm et al., 2013). Those who have argued against selective directed forgetting have suggested that the effect is nonexistent due to a lack of contextual change between the to-be-remembered and to-be-forgotten items, which according to the context change theory is necessary for forgetting. Given the selection difficulty involved in selective directed forgetting, it may be that relatively few people are able to differentiate the forget items from the remember items sufficiently to produce the effect. For example, perhaps it is the highest working memory span participants who can manage the retrieval demands, and most participants cannot.

The current study provides support that selective effects in directed forgetting are sometimes 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. Interestingly, prior research has suggested this type of directed forgetting is not possible due to the lack of context change between the to-be-remembered and to-be-forgotten pre-cue information (Sahakyan, 2004). However, the current study suggests perhaps a retrieval mechanism consistent with context change accounts may also partially explain selective directed forgetting effects.

The Benefits of Directed Forgetting (or Lack Thereof)

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 1 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 2 when given only 5 s to forget. However, in the present study, both the 5 s and 30 s delays were sufficient to cause contextual change. Similarly, Experiment 3 showed no significant benefits for List 1 in the Forget vs. Remember condition, consistent with the original Racsmány et al. (2018) findings. This is also 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 an internal context change and that successful retrieval of List 1 items may not be necessary to observe List 2 forgetting.

The lack of observed benefits make a selective rehearsal explanation of the current findings less plausible. According to a selective rehearsal explanation, in response to the forget cue following List 2, participants may begin rehearsing the List 1 items. This rehearsal theoretically strengthens the List 1 items and should subsequently increase recall proportion of these items for the Forget vs. Remember list sets. However, as noted previously, no increase in recall was observed for the first list in the forget set compared to the first list in the remember set, or for List 1 over List 2 in Experiment 3, which should emerge if those items were afforded additional processing time. Furthermore, given the current data, if selective rehearsal of List 1 items were contributing to the effect, we would expect the effect to be reduced when the proposed rehearsal time was limited from 30 s to 5 s in Experiment 2 which was not the case. Though selective rehearsal and the current context change mechanism do not make very different predictions, the lack of benefits observed in the current study suggest a context-based account is more likely.

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 (e.g., Aslan & Bäuml, 2013; Pastötter & Bäuml, 2010; Sahakyan & Delaney, 2003, 2005). Contemporary two-factor theories of directed forgetting propose that the benefits are either largely the result of a change in encoding strategy (e.g. Sahakyan & Delaney, 2003, 2005; Sahakyan et al., 2013) or to a reset of encoding mechanism (e.g., Pastötter & Bäuml, 2010; Pastötter et al., 2016), and in the current study since all information is encoded prior to the cue, there is no opportunity to switch encoding strategy or “reset encoding,” and therefore we would not expect to obtain the benefits.

Conclusions

In sum, we found that participants change their mental context by retrieving earlier-learned information, which leads to forgetting. This retrieval mechanism may partially explain how participants can forget the most recently learned information. The current findings suggest that the original Racsmány et al. (2018) results are usually driven by retrieval of the list before the last, and the forgetting effects that result are broadly consistent with both inhibitory and context-change theories of directed forgetting. Thus, people can strategically deploy retrieval as a means of forgetting, at least when they know another set of information needs to be retained.

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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*(1), 5-13. doi:10.1037/0022-3514.53.1.5

Table 1

Intrusion Rates

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

Note. Values represent proportion of cross-list intrusion errors for each list in each experiment. Values in parentheses represent ±*SD*. Lists are presented in sets (Lists 1 and 2; Lists 3 and 4), and 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

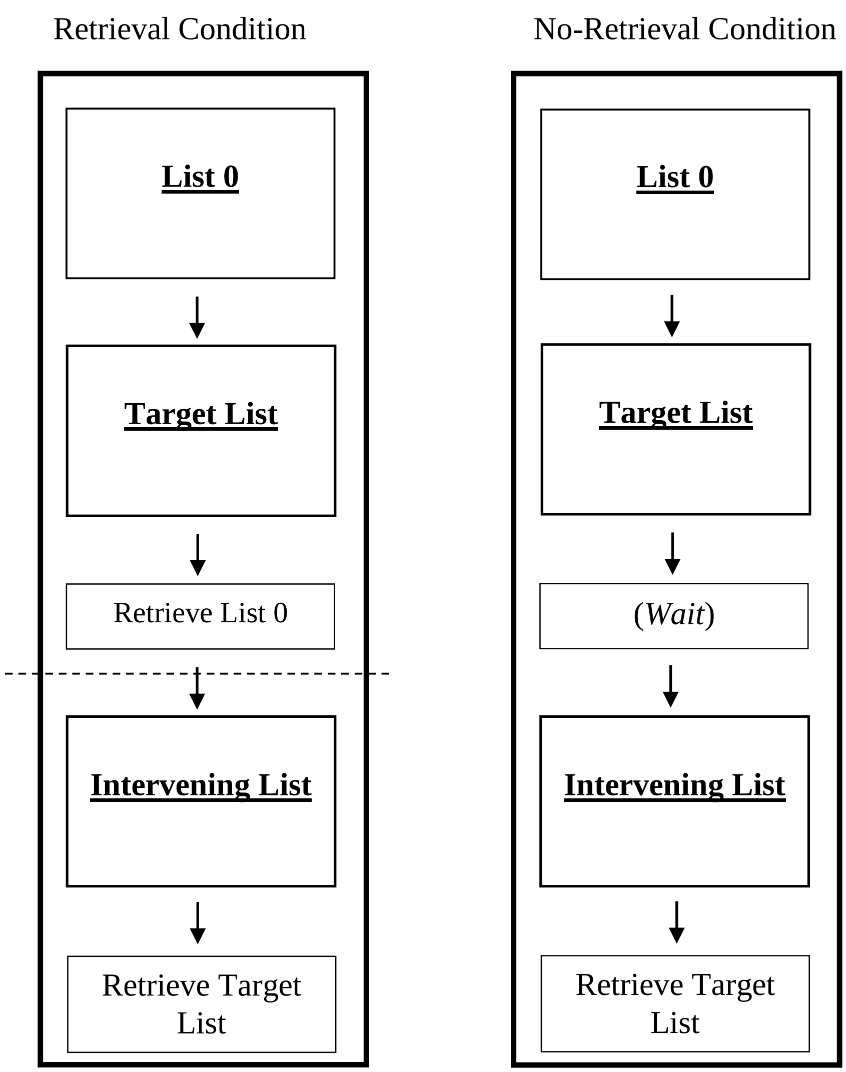
Percentage of Participants Reporting Each Strategy and Mean F2 Recall Rates by Strategy

	Retrieval		*Suppression*		*Distraction*		*Other*	
	%	*Recall*	*%*	*Recall*	*%*	*Recall*	*%*	*Recall*
Exp 1	*61*	*.20 (.17)*	*11*	*.30 (.17)*	*23*	*.29 (.19)*	*5*	*.50 (.35)*
Exp 2	*68*	*.22 (.16)*	*14*	*.26 (.22)*	*10*	*.45 (.20)*	*8*	*.30 (.24)*

Note. Percentages represent the percentage of total participants reporting each strategy by experiment. Values in parentheses represent ±*SD*. Strategies were as follows: Retrieval: try to think of the first list to help forget the second; Suppression: push the words out of mind by force of will; Distraction: distract from the experiment by thinking of something else; and Other: any other strategy.

Figure 1

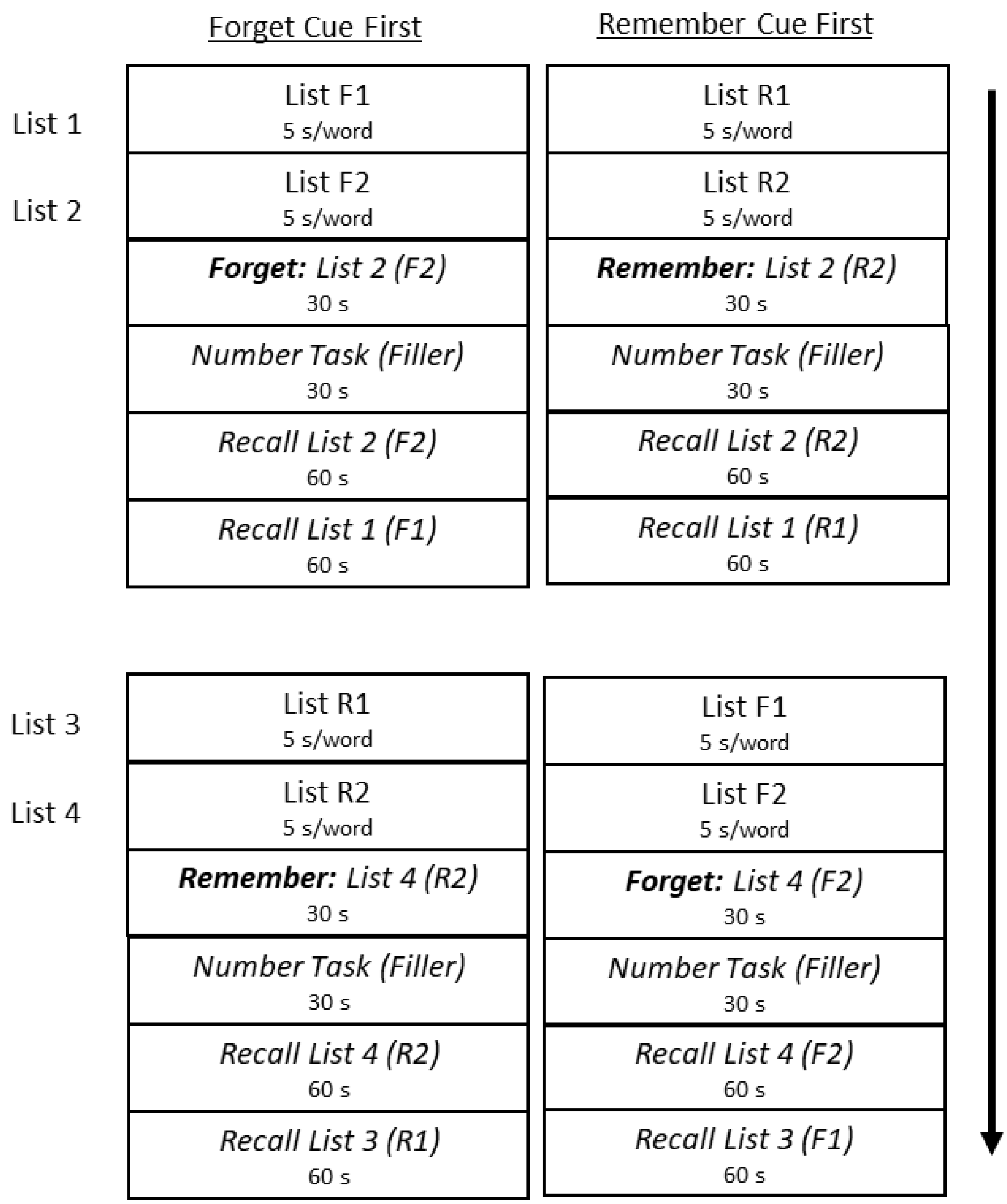
Design Figure for the retrieval and no-retrieval conditions in Jang & Huber's (2008) List before the Last Procedure



Participants studied three lists, with a "shifting window" procedure. Left panel: The retrieval trial on List 0 between the target and intervening lists disrupts the current 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 drifts gradually, and the target list is comparably better recalled than if there had been retrieval (as on the left).

Figure 2

Design Schematic for Experiment 1

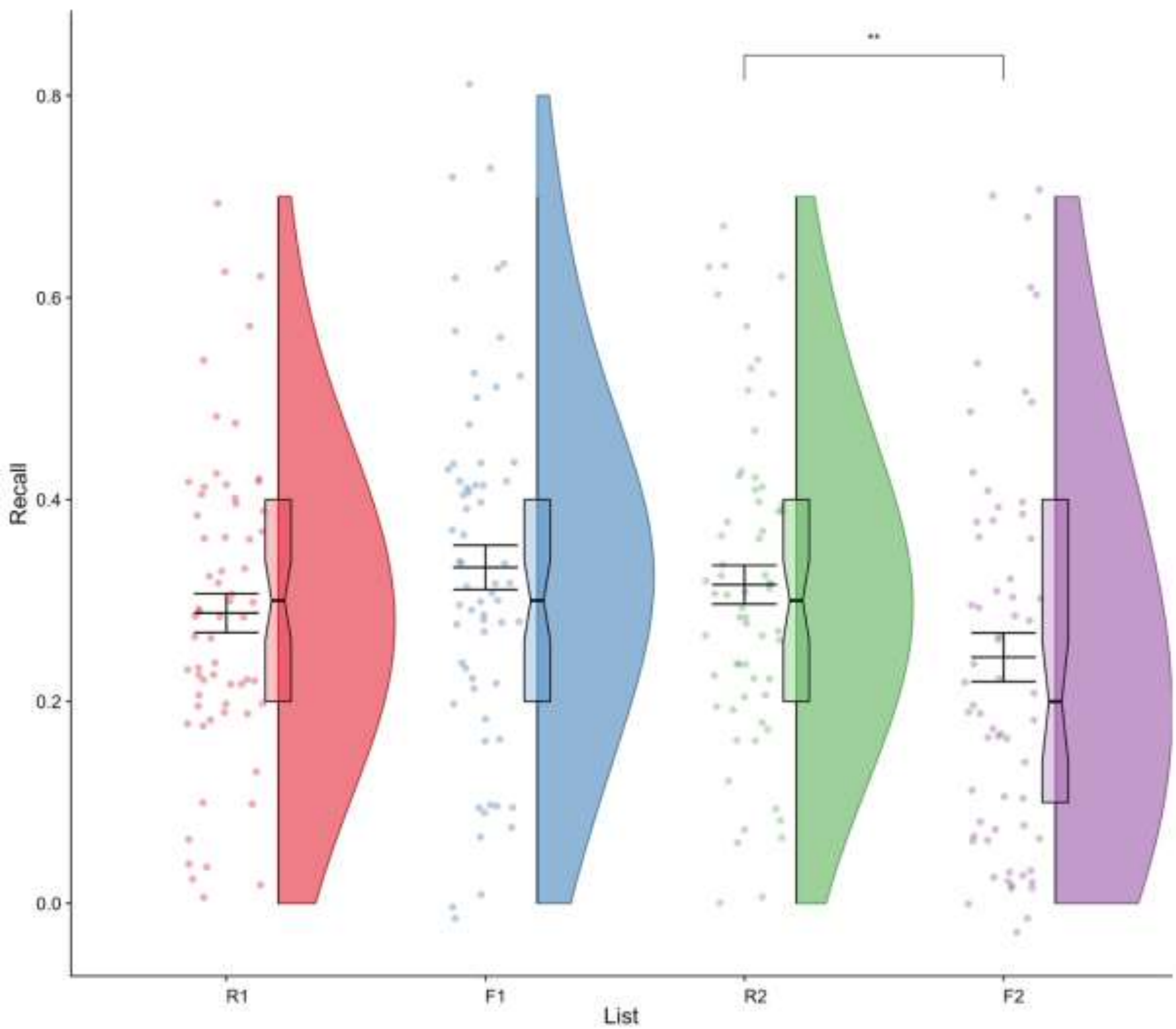


Everyone studies four lists in two pairs. Cue order was counterbalanced between participants.

Participants were always tested on the most recent list first.

Figure 3

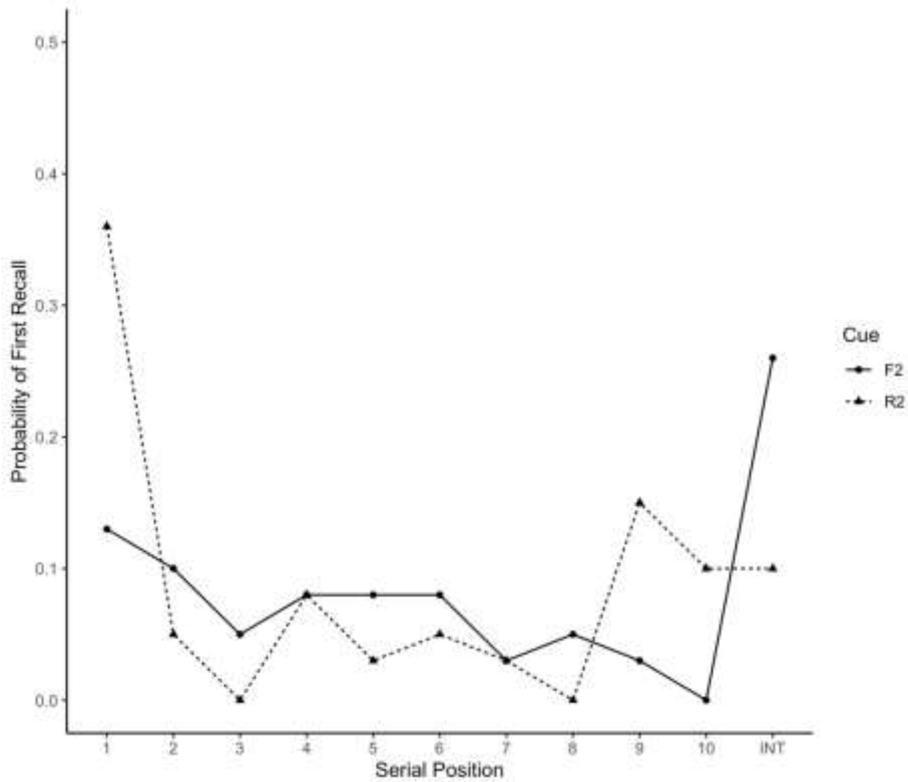
Raincloud Plots for Proportion Recall, Experiment 1



Note. 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. **: $p < .01$

Figure 4

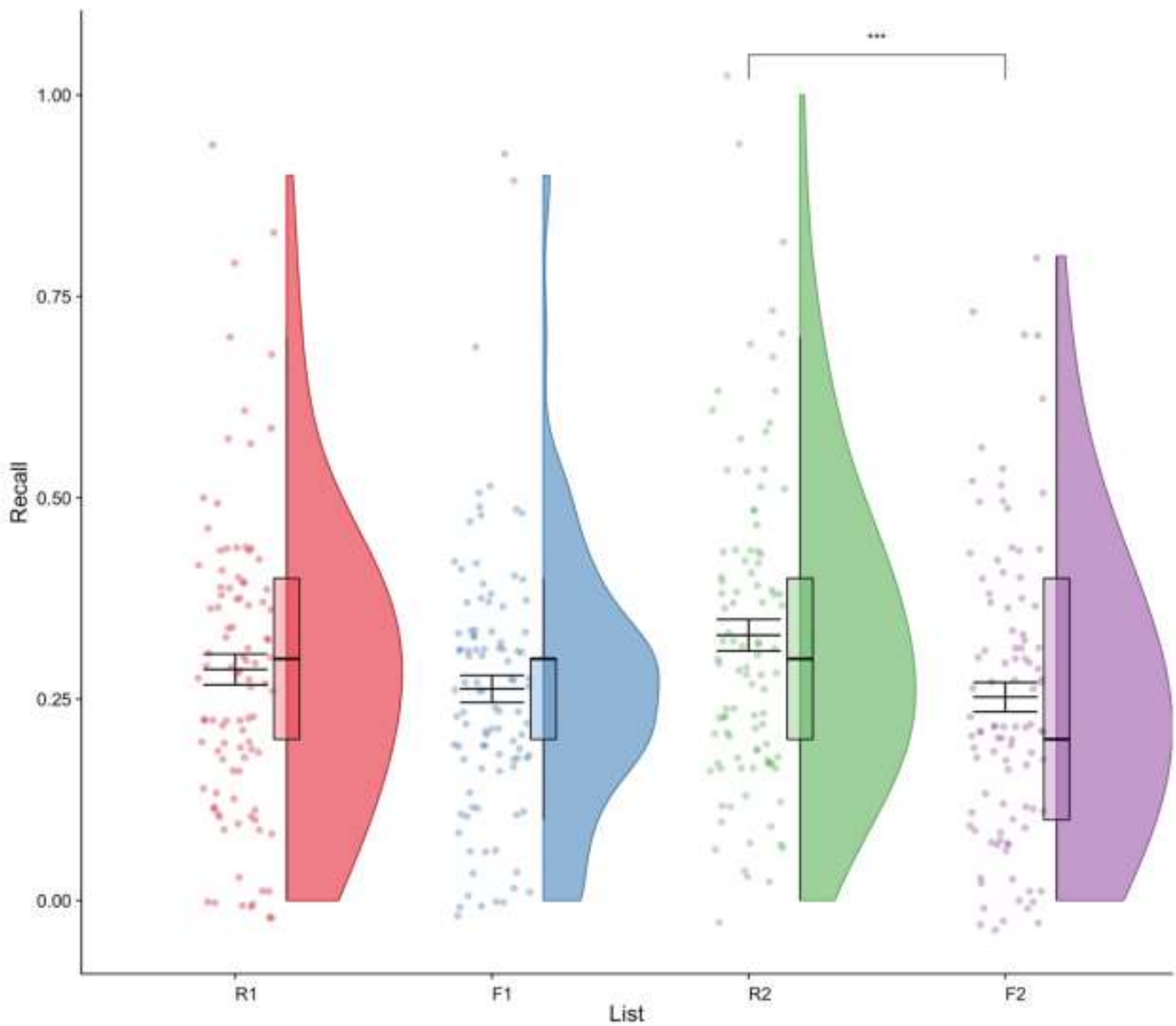
Probability of First Recall following Retrieval for Experiment 1



Note. Post-hoc probability of first recall suggests that participants were less likely to initiate recall with early List 2 items following a change in mental context due to the forget cue, *p*(recall) = .13, compared to no context change in the remember condition; *p*(recall) = .36. The last position, labeled INT, refers to the probability that participants initiated their recall with a cross-list intrusion; *p*(int) = .26 following the forget cue and *p*(int) = .10 following the remember cue.

Figure 5

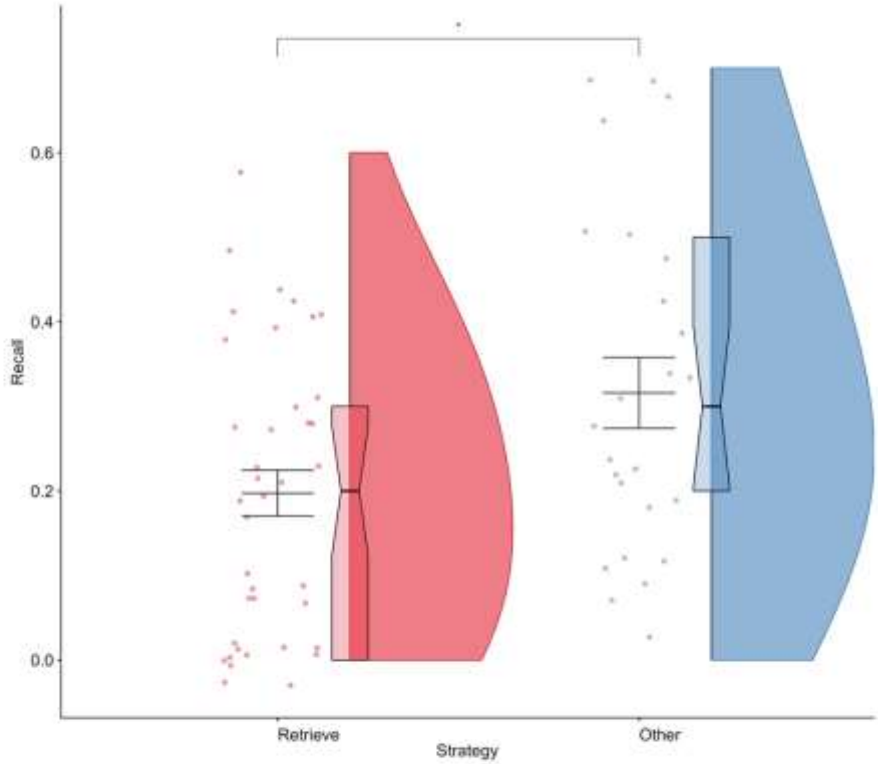
Raincloud Plots for Proportion Recall, Experiment 2



***: $p < .001$

Figure 6

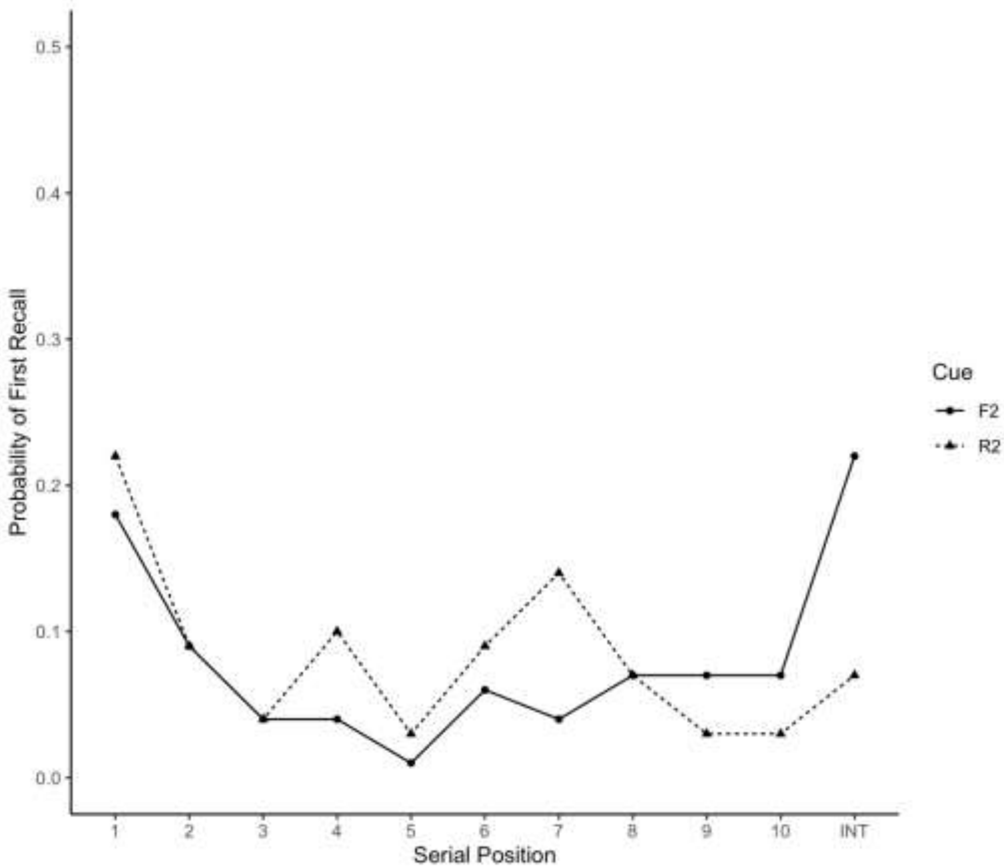
Raincloud Plots for Proportion F2 Recall by Strategy in Experiment 2



Note. Retrieve is the distribution of proportion recalled from F2 by participants reporting retrieving the first list to help forget the second (*N* = 67). Other is the proportion recalled from F2 by participants reporting all other strategies to forget (*N* = 32). *: $p = .01$

Figure 7

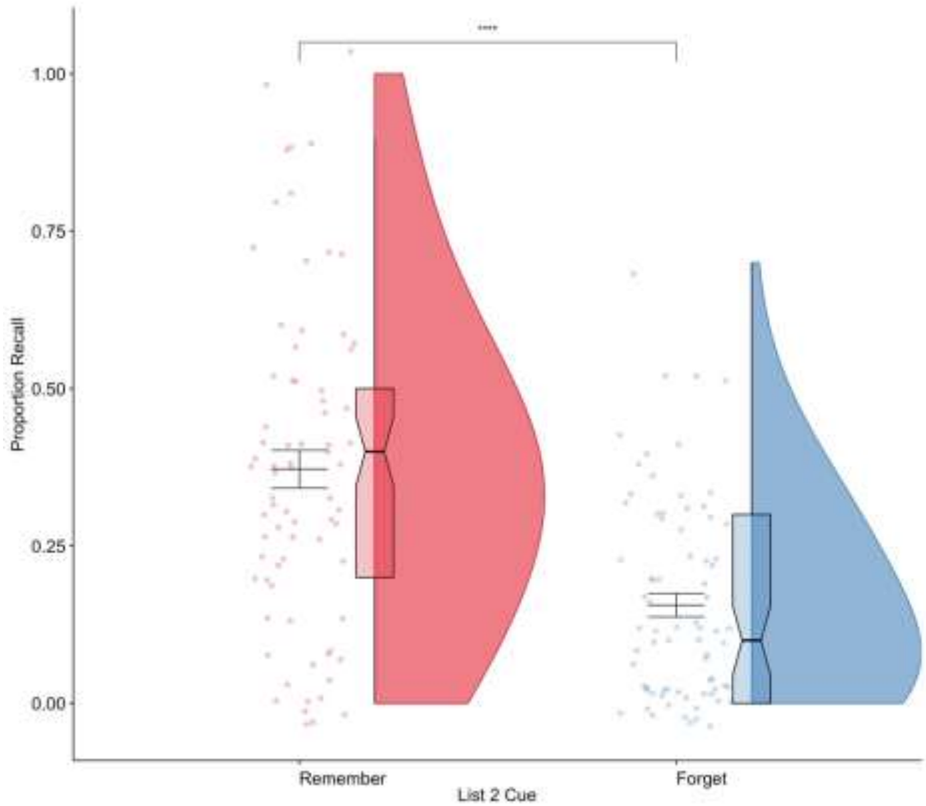
Probability of First Recall following Retrieval for Experiment 2



Note. The probability participants initiated recall with the first item following the remember cue (R2) was *p*(recall) = .22 and following the forget cue (F2) *p*(recall) = .18. The probability that participants initiated recall with a cross-list intrusion (INT) following the forget cue was *p*(int) = .22 and following the remember cue was *p*(int) = .07.

Figure 8

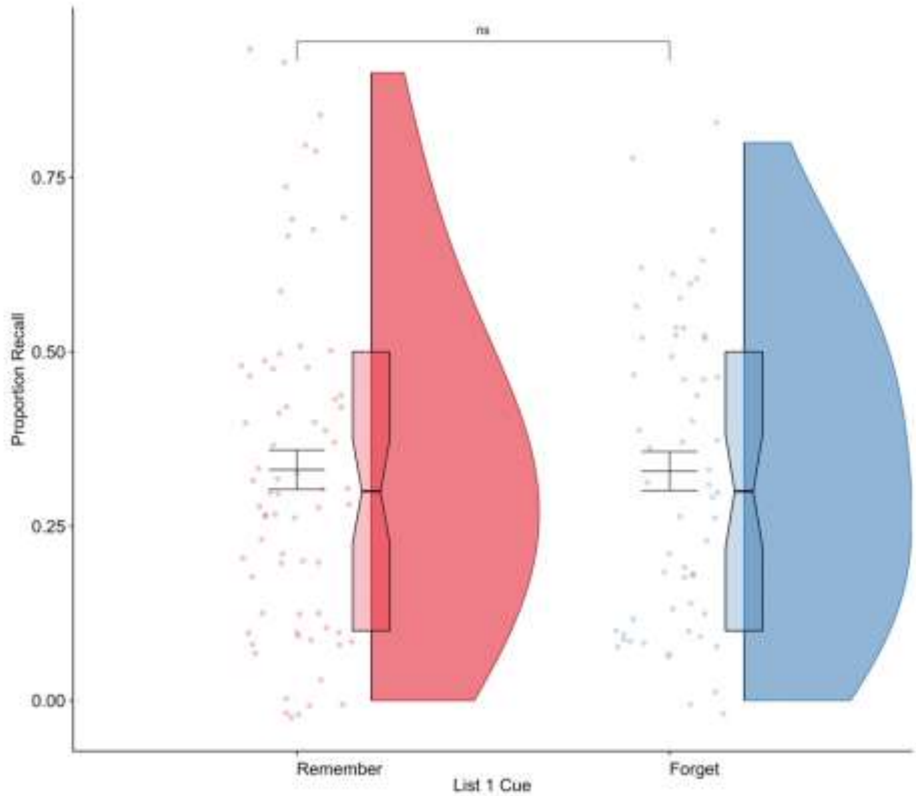
Raincloud Plots for List 2 Recall in Experiment 3



Note: ****: $p < .001$

Figure 9

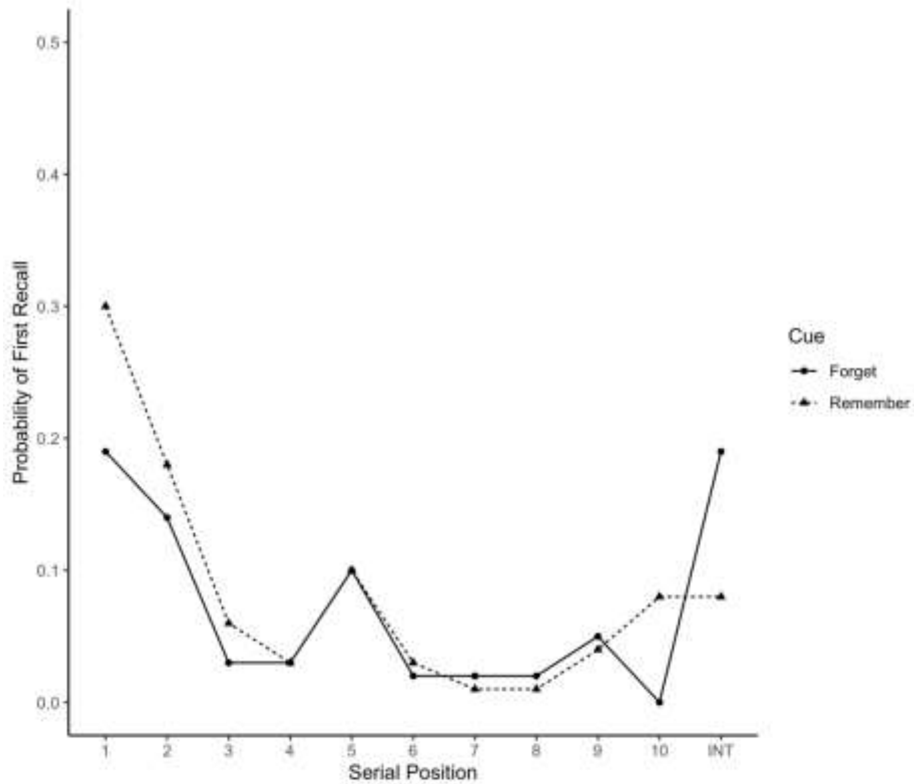
Raincloud Plots for List 1 Recall in Experiment 3



Note. No benefits observed for List 1 in the Forget vs. Remember conditions, ns: $p > .05$.

Figure 10

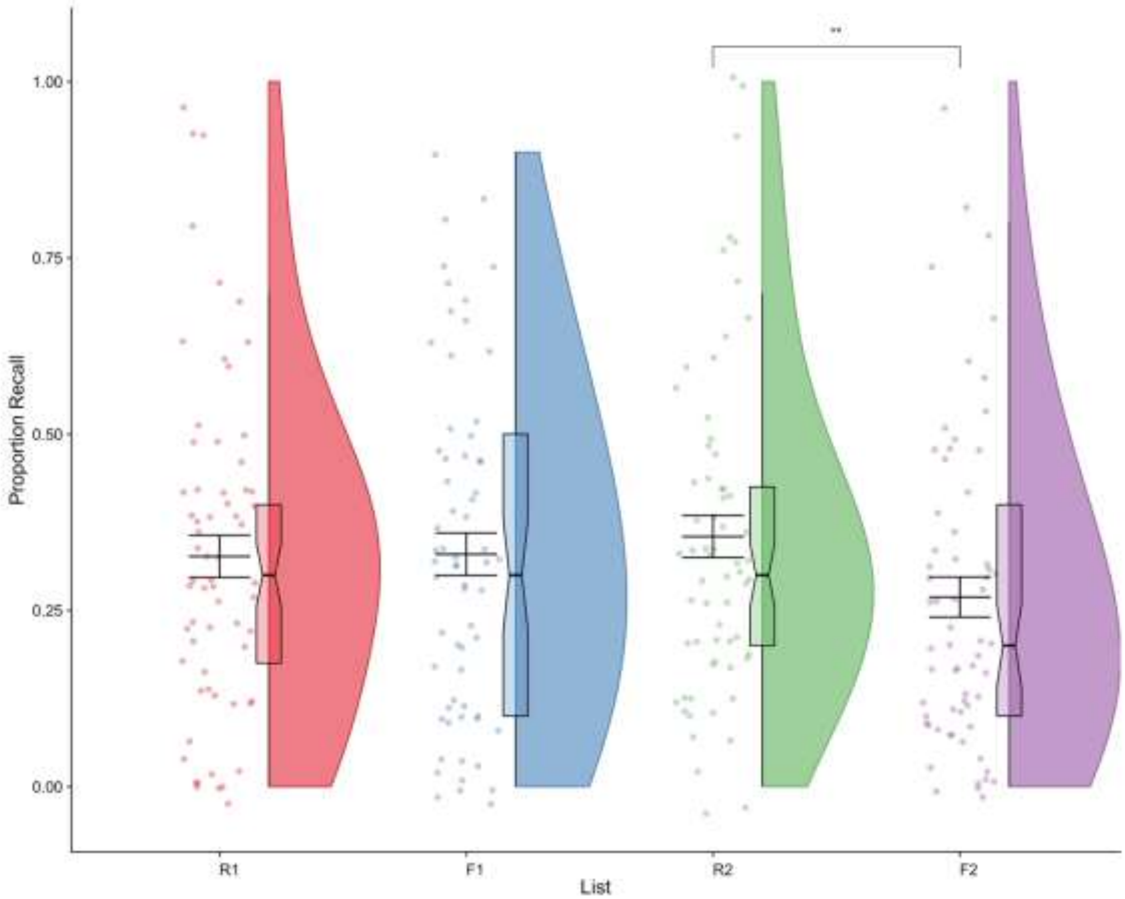
Probability of First Recall following Retrieval for Experiment 3



Note. The probability participants initiated recall with the first item following the remember cue was *p*(recall) = .30 and following the forget cue *p*(recall) = .19. The probability that participants initiated recall with a cross-list intrusion (INT) following the forget cue was *p*(int) = .19 and following the remember cue was *p*(int) = .08.

Figure 11

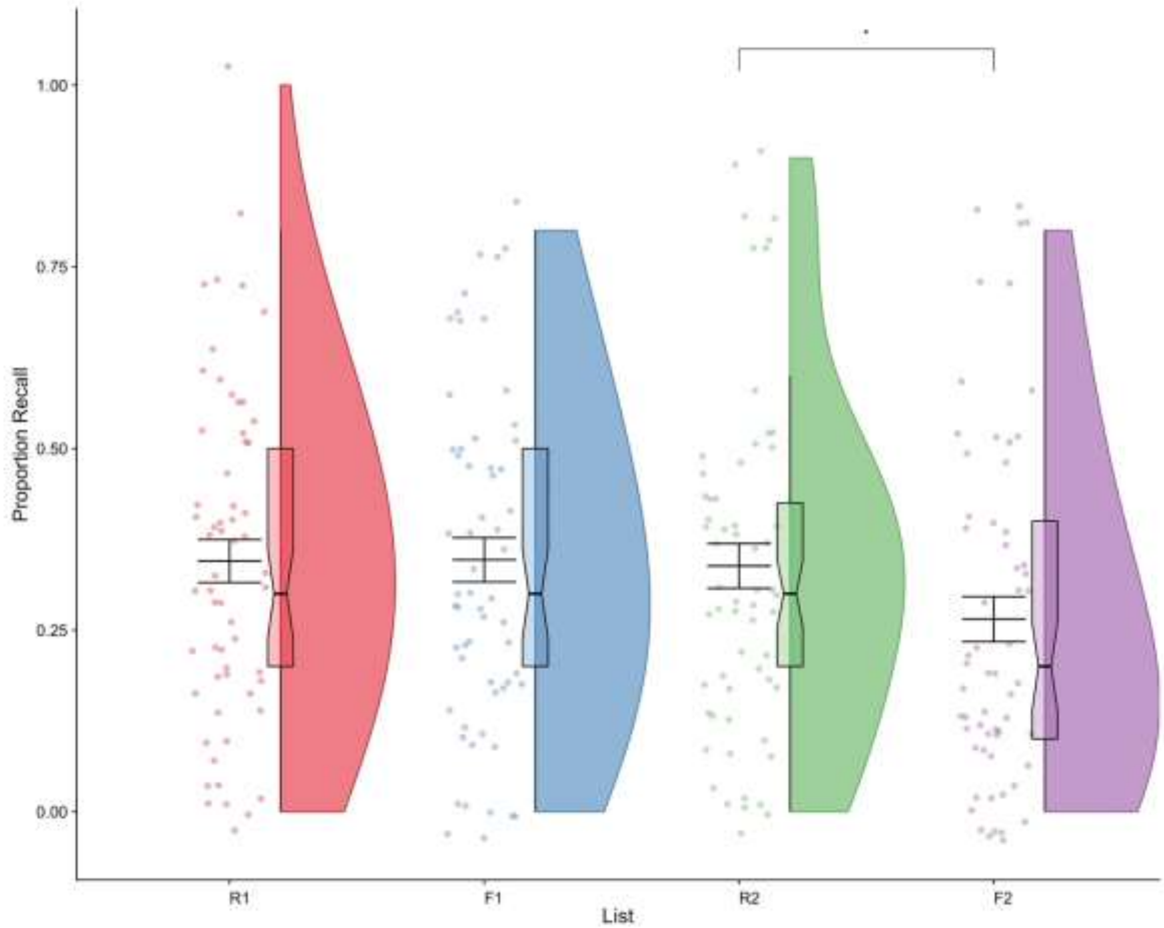
Raincloud Plots for Retrieve Condition Recall in Experiment 4



Note: **: $p < .01$

Figure 12

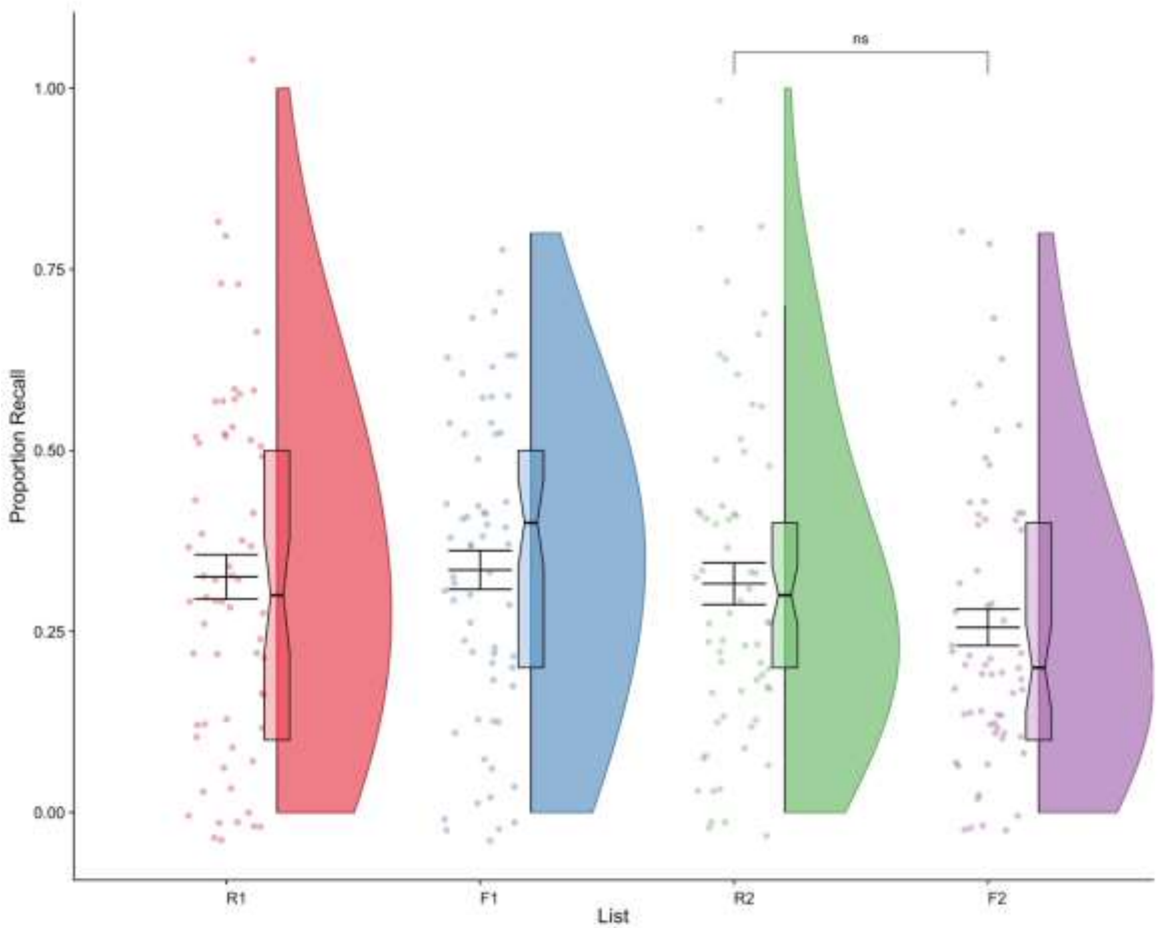
Raincloud Plots for Inhibit Condition List Recall in Experiment 4



Note: *: $p < .05$

Figure 13

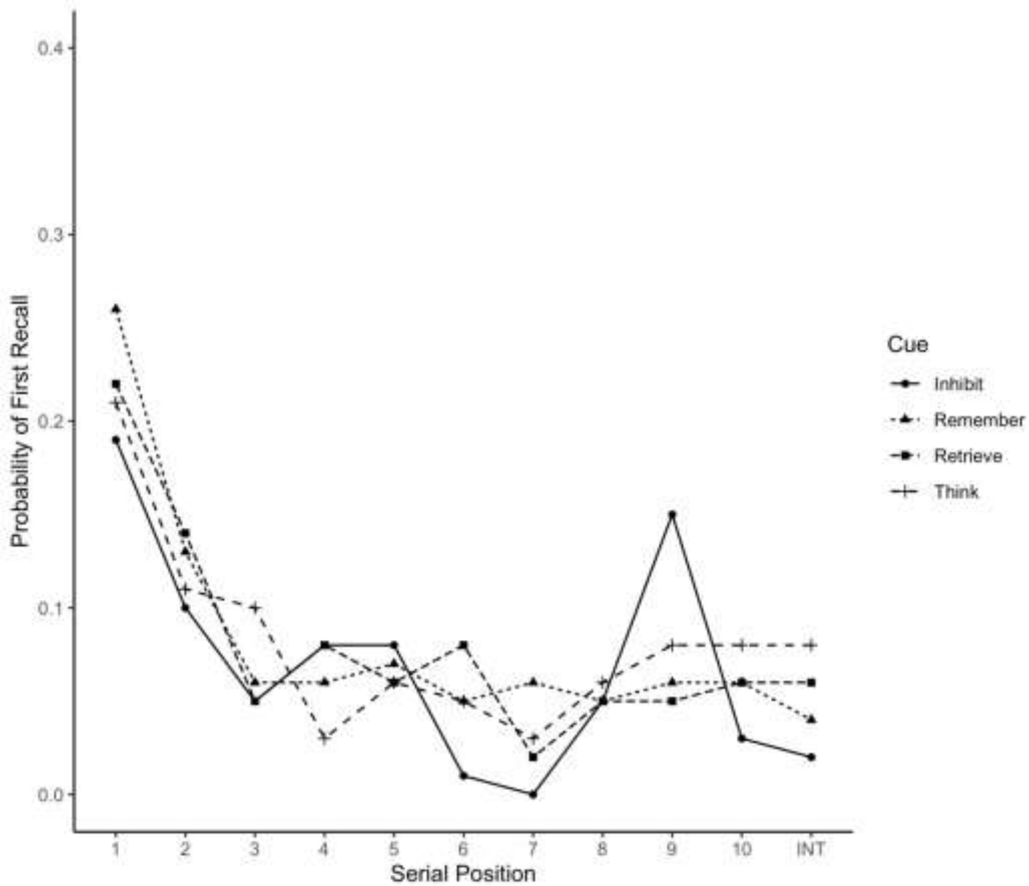
Raincloud Plots for Think of Else Condition List Recall in Experiment 4



Note. ns: $p > .05$

Figure 14

Probability of First Recall following all Strategies for Experiment 4



Note. The probability participants initiated recall with the first item following the remember cue was *p*(recall) = .26. For each strategy, the probability of initiating recall with the first item in the retrieve condition; *p*(recall) = .26, in the think of something else condition; *p*(recall) = .26, and in the inhibit condition; *p*(recall) = .19. The probability that participants initiated recall with a cross-list intrusion (INT) following the remember cue was *p*(int) = .04 and following each strategy was retrieve; *p*(int) = .06, think of something else; *p*(int) = .08., and inhibit, , *p*(int) = .02.

Appendix A

Word Lists

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
Pistol	Blessing	Hammer	Carriage
Painter	Pony	Perfume	Cattle
Cherry	Olive	Sheriff	Carpet

Note: Words were always presented in the same order in each list, but order of list presentation was counterbalanced across conditions.

Appendix B

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 A.

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 C

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:

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."

Remember Condition: "That was List 2, please keep remembering these words as well as the words from List 1 for a memory test"

Between First Set and Second Set:

"You will now see a new list of words appear on at a time on the screen. Please try to remember these words for a later memory test. This is List 3."

Note: Script repeats for List 3 and List 4

After List 4:

Forget Condition: Same instructions as above List 2 forget condition.

Remember Condition: Same instructions as above for List 2 remember condition.

Appendix D

Coding Instructions for Experiment 2

The following instructions were presented before a practice set of responses was administered to a research assistant. After discussion of the practice responses, the first author and a research assistant coded 40 randomly selected strategy responses from participants in Experiment 2.

"Code the following responses as either Yes or No depending on whether the participant complied with the instructions to forget.

A. "No"
    a. If the participant responded "no" when asked if they tried to forget the list they were instructed to forget, either because they were suspicious of the instructions or because they did not use any active strategies to attempt to forget. This data will be excluded from further analysis.

B. "Yes"
    a. If the participant responded "yes" when asked if they tried to forget the list they were instructed to forget, code their responses into the following categories based on the criteria below:
        i. Tried to think of the first list to help forget the second
            1. Any mention of thinking back to the previous list, whether they tried to remember it, focus on it, think about it, or bring the earlier words back into mind
            2. Any mention of attention to the prior list or thoughts about how they would do on a test of the prior list

ii. Tried to push the words out of mind by force of will

1. Any mention of allowing their mind to go blank, trying to block the forget words from entering their mind or stopping themselves from thinking of the words

iii. Tried to distract myself and think of something other than the experiment

1. Any mention of non-experimental influences such as thinking of past/future events or plans, current state, personal concerns, focusing on the contents of the environment (such as the testing room or the building)

iv. Other

1. Anything that does not explicitly fall into the above categories should be coded as "other" including thinking about the distractor task

Code strategies using the best fit and only the best fit strategy, do not select more than one strategy per participant. If participants report using more than one strategy, code according to the first strategy they report."