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Intentional forgetting of actions: Comparison of list-method and item-method directed forgetting

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ABSTRACT

Performing action phrases (subject-performed tasks, SPTs) leads to better memory than verbal learning instructions (verbal tasks, VTs). In Experiments 1–3, the list-method directed forgetting design produced equivalent directed forgetting impairment for VTs and SPTs; however, directed forgetting enhancement emerged only for VTs, but not SPTs. Serial position analyses revealed that both item types suffered equivalent forgetting across serial positions, but enhancement was evident mostly in the first half of List 2. Experiment 4 used the item-method of directed forgetting and obtained greater directed forgetting for VTs than SPTs. A *remember-all* baseline group allowed estimating the impairment for to-be-forgotten (TBF) items and enhancement for to-be-remembered (TBR) items. Serial position analyses showed greater impairment for TBF items from the beginning of the list than elsewhere in the list. Directed forgetting enhancement for TBR items occurred throughout the list for VTs, but only in the primacy region for SPTs.

Overall, dissociations across the list-method and item-method studies with SPTs suggest that the two methods have different underlying mechanisms. Furthermore, dissociations obtained with SPTs *within* list-method studies provide support for the dual-factor directed forgetting account and challenge the single-factor accounts.

Daily activities often involve trying not to think of certain events because they are wrong, irrelevant, embarrassing, or unpleasant. Imagine a friend who in the middle of giving you driving directions suddenly said, "Forget what I just told you – it's not the best way to go because the road is under construction. Let me give you an alternative route instead" (Golding & Keenan, 1985). To comply with your friend's request, you must segregate the relevant and irrelevant information in order to selectively retrieve appropriate memories while excluding inappropriate ones.

One oft-used technique for capturing these mechanisms in the laboratory is to instruct participants to forget a certain portion from the studied material – known as the *directed forgetting* paradigm (e.g., Bjork, LaBerge, & LeGrand, 1968). Two variations of the paradigm exist, which differ in whether the "forget" instruction is delivered on an item-by-item basis or after a block of items. In an *item-method* paradigm, participants study a list of items, some of which are cued to-be-remembered for a later test (TBR items), whereas others are cued to-be-forgotten (TBF items). Memory is unexpectedly tested for all items, and TBF items show impaired recall compared to TBR items. In the *list-method* directed forgetting paradigm, the study items are split into two blocks. Following the first block, participants are told either to forget that list ("because it was only for practice") or to keep remembering it ("that was only the first half of the items"). Then both groups study the second block and afterwards receive a memory test for all items. In the list-method paradigm, the forget instruction typically has a dual effect on memory – it impairs memory for the pre-cue items (known as the *costs* of directed forgetting), and it also enhances memory for the post-cue items (known as the *benefits* of directed forgetting) compared to the remember instruction. Taken together, these two outcomes constitute the list-method

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directed forgetting effect. For reviews of directed forgetting methodologies and their findings, see Bjork, Bjork, and Anderson (1998), MacLeod (1998), and Johnson (1994).

With some exceptions (e.g., Barnier et al., 2007; Burwitz, 1974; Golding & Keenan, 1985; Gottlob, Golding, & Hauselt, 2006; Joslyn & Oakes, 2005), the majority of directed forgetting research has been dominated by the memorization of word lists. However, many everyday memories are about actions that were performed or about activities that we participated in. What would you tell your spouse who wanted to know about your day? Your recollections would probably include actions that you had performed, saw, or heard about, but not studied words. Likewise, the most widely used example of memory updating describes the need to selectively retrieve a performed action, such as remembering where you parked your car today as opposed to yesterday (e.g., Bjork, 1989).

In this paper, we report four experiments investigating whether performed actions are susceptible to directed forgetting. Prior research found that actions suffer less from item-method directed forgetting than verbally encoded action phrases (Earles & Kersten, 2002). We predicted that different results would be obtained in the list-method directed forgetting study. To better explain these predictions, we briefly review the theoretical mechanisms involved in the two directed forgetting methodologies, and then discuss action memory findings and their implications for different directed forgetting paradigms. Our first three studies employed the list-method paradigm, and the fourth study utilized the item-method paradigm. Performed actions are appealing as study stimuli, because they (a) expand the investigation of directed forgetting beyond verbal material, (b) have certain properties that allow contrasting the predictions of various theoretical mechanisms of list-method directed forgetting, and (c) provide a novel venue for comparing the list-method and the item-method paradigms. The two methods of directed forgetting are not often compared (but see, Basden, Basden, & Gargano, 1993; Macleod, 1999; Zacks, Radvansky, & Hasher, 1996).

Theoretical accounts of directed forgetting

Impaired recall of TBF items in the item-method has been explained through differential encoding mechanism: participants stop committing the TBF items to memory once they get the forget cue, and use that time to encode the TBR items (Bjork & Geiselman, 1978; Davis & Okada, 1971; Golding, Long, & MacLeod, 1994; Basden & Basden, 1998; Basden et al.,1993; Hourihan & Taylor, 2006; MacLeod, 1975; Paller, 1990; Taylor, 2005; Woodward, Bjork, & Jongeward, 1973). In contrast, the list-method effect is likely driven by processes operating at retrieval, because the forget cue is given unexpectedly after an entire list has been encoded, and therefore the pre-cue items must be encoded equally well up to the mid-list forget or remember instruction (e.g., Bjork, 1989; Geiselman, Bjork, & Fishman, 1983). Impaired recall of TBF items in the list-method has been explained via retrieval-based mechanisms emphasizing lower *accessibility* in memory rather than *availability* in memory. Better memory for the post-cue TBR items in the list-method is sometimes explained by the same mechanism that produces impaired access to the pre-cue TBF items (single-process accounts) and sometimes by a different mechanism (a dual-process account).

According to the *selective rehearsal* hypothesis (Bjork, 1970, 1972), upon hearing the forget instruction, participants stop rehearsing the first list and devote their rehearsal to the second list, whereas participants in the remember group keep rehearsing the first list along with the second list. The costs of directed forgetting arise because of the lack of rehearsal of List 1 items in the forget group. The benefits of directed forgetting arise because the forget group rehearses only a single (second) list, whereas the remember group rehearses both lists, which reduces the success of encoding the second list. Some researchers favor selective rehearsal explanation (e.g., Benjamin, 2006; MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003; Sheard & MacLeod, 2005). Selective rehearsal is a single-process account because it invokes the same underlying process to explain the costs and the benefits of directed forgetting.

According to the *retrieval inhibition* hypothesis, directed forgetting reflects a temporary state of inhibition of List 1 items. The forget cue invokes an inhibitory process, which at the time of retrieval renders inappropriate memories inaccessible (e.g., Bjork, 1989; Bjork & Bjork, 1996, 2003; Conway, Harries, Noyes, Racsmany, & Frankish, 2000; Geiselman et al., 1983). This mechanism was advanced in response to findings that were hard to reconcile with a pure encoding-based explanation. For example, significant directed forgetting impairment is found in incidental learning (e.g., Geiselman et al., 1983; Sahakyan & Delaney, 2005). Because participants did not have to memorize incidental items, there should be no rehearsal to disrupt by a forget instruction, and consequently no decrement should be observed. Retrieval inhibition is also a single-process account, because it explains the directed forgetting costs by inhibition of List 1 items, and it attributes the benefits to the reduced proactive interference from inhibited List 1 items. If a single-list condition is included in the design (e.g., the *No-Proactive-Interference* group), then its recall is often comparable to List 2 recall in the forget group, suggesting that there is reduced proactive interference from List 1 items in the forget group (e.g., Bjork & Bjork, 1996; Bjork & Woodward, 1973).

The dual-process account attributes the costs and the benefits of directed forgetting to different mechanisms (Sahakyan & Delaney, 2005). The first component of the dual-factor account uses the *mental context change* mechanism proposed by Sahakyan and Kelley (2002) to explain the costs. This hypothesis presupposes that when committing items to memory, people encode not only the meaning of the item and the inter-item relationships, but they additionally encode the context in which the item occurred – an assumption made by many memory models (e.g., Gillund & Shiffrin, 1984; Mensink & Raaijmakers, 1988; Shiffrin & Steyvers, 1997). Contextual information refers to the incidental background cues present at the time the item was experienced, such as the temporal-spatial environment as well as the internal psychological environment (e.g., how people think about the experimental episode, and the thoughts they experience during encoding). According to the contextual hypothesis, participants in the forget group establish a new mental context in order to comply with the forget instruction. One way to accomplish this would be by changing the thoughts they experienced during List 1 learning by thinking of things unrelated to the experiment. Then the second list is encoded in the presence of those new contextual cues. During the final test, the retrieval context matches List 2 context better than List 1 context, producing forgetting. Thus, the directed forgetting costs emerge because of a mismatch between the study context and the testing context.

The second component of the dual-factor account relies on the *strategy change* hypothesis of Sahakyan and Delaney (2003) to explain the directed forgetting benefits. This viewpoint was motivated by analyses of self-reported study strategy choices, which revealed that the forget group employed a more efficient study strategy on List 2 compared to the remember group. Better encoding of List 2 in the forget group produced a memory advantage, leading to the benefits of directed forgetting. When participants studied the items using the same study strategy on both lists, the benefits of directed forgetting were eliminated, but the costs remained intact (Sahakyan & Delaney, 2003). Additional dissociations between the directed forgetting costs and the benefits which provide support for the dual-factor account can be found in Sahakyan, Delaney, and Kelley (2004) as well as in Sahakyan and Goodmon (2007). Also, recent studies provide electrophysiological evidence supporting the dual-factor account (Bäuml, Hanslmayr, Pastötter, & Klimesch, 2008; Pastötter, Bäuml, & Hanslmayr, 2008). To summarize, the dual-process account relies on a retrieval-based mechanism to handle the costs, and an encoding-based mechanism to explain the benefits.

Action memory and implications for directed forgetting

Performing simple actions during encoding (e.g., break a toothpick; known as subject-performed tasks [SPTs]) improves memory compared to encoding the same phrases verbally (known as verbal tasks [VTs]; for reviews, see Engelkamp, 1998; Nilsson, 2000; Zimmer, 2001). While rehearsal and organizational strategies usually benefit VTs, they have less impact on SPTs (for reviews, see Cohen, 1985, 1989; Engelkamp, 1997; Nilsson, 2000; Zimmer et al., 2001). For example, the well-established primacy effect, which signifies better processing of items at the beginning of the list (presumably due to rehearsal), is detected with VTs, but is consistently absent in free recall of SPTs (Bäckman & Nilsson, 1984; Cohen, 1981; Seiler & Engelkamp, 2003; Zimmer, Helstrup, & Engelkamp, 2000). Furthermore, levels-of-processing effects are either completely absent with SPTs (Cohen, 1981; Cohen & Bryant, 1991; Nilsson & Cohen, 1988; Nilsson & Craik, 1990) or substantially reduced compared to VTs (Zimmer & Engelkamp, 1999). Also, the amount of elaboration an action receives during encoding significantly improves memory for VTs but not for SPTs (Cohen, 1983; Cohen & Bryant, 1991; Helstrup, 1987; Nilsson & Cohen, 1988; Zimmer, 1986). Likewise, extra study time (up to 10 s per item) improves memory for VTs but not for SPTs (Cohen, 1985). Kausler, Lichty, Hakami, and Freund (1986) had participants perform actions continuously for between 4 and 180 s, and obtained negligible effects of duration on subsequent recall. Also, performing the same discrete action twice in a row was no better than performing it once – although spaced repetitions produced recall advantage compared to massed repetitions (e.g., Cohen, Sandler, & Schroeder, 1987; Kausler, Wiley, & Philliips, 1990).

Taken together, these findings suggest that SPTs are relatively insensitive to encoding factors. Since the item-method of directed forgetting is supposed to rely on encoding differences, smaller directed forgetting would be predicted for SPTs than VTs in the item-method. Indeed, Earles and Kersten (2002) reported such results. Because SPTs rely less on rehearsal than VTs, terminating rehearsal to comply with the forget instruction should have a larger negative impact on VTs than SPTs.

However, the predicted results in the list-method paradigm depend on what theory one subscribes to. The selective rehearsal account predicts a replication of the item-method findings – there should be larger directed forgetting effects (both the costs and the benefits) for VTs than for SPTs. The inhibitory account makes fewer specific predictions because the precise nature of the inhibitory process assumed to underlie directed forgetting is not fully specified. According to this view, access to the entire list is inhibited at retrieval, and therefore all VTs and SPTs encoded as part of that list should show directed forgetting costs and benefits. However, additional assumptions are required to know whether SPTs or VTs will show varying degree of directed forgetting costs and benefits.

Finally, we consider the predictions of the dual-factor account because the latter relies on two separate mechanisms to explain the costs and the benefits of directed forgetting. Our recent research shows that the degree of forgetting of items depends on the strength of their associations with the list context, with items more strongly linked with List 1 context showing greater directed forgetting impairment than items that are more weakly associated with List 1 context (Sahakyan, Delaney, & Waldum, 2008). Therefore, predictions about forgetting of SPTs or VTs depend on assumptions about how integrated these items are with their contexts. Some researchers suggested that SPTs are poorly integrated with their contexts (Cornoldi, Corti, & Helstrup, 1994; Helstrup, 1989; Koriat, Ben-Zur, & Druch, 1991; Zimmer, 1994, 1996), and hence one might predict that they may not suffer when context changes between the study and test. The conclusions regarding poor integration of SPTs with their context were made in part from poor source monitoring of SPTs – namely, remembering the environment in which SPTs took place (e.g., Koriat et al., 1991). Identifying the origin/source of events requires retrieving the context in which the events took place. However, the context-change hypothesis is more concerned with the *cuing property of the context* rather than source monitoring. Although these two issues are quite related, they represent the opposite problems – recalling the context of a given event (i.e., source monitoring) vs. recalling the event in the presence of context cues (i.e., cuing property of context). It remains to be established whether the item-to-context associations established during encoding are bidirectional and symmetrical, and whether the evidence from the source monitoring methodology can be diagnostic of the extent to which items are integrated with their context and can benefit from the cuing property of context. If we accept that SPTs are poorly integrated with their context based on the source monitoring findings, then we would predict to obtain greater directed forgetting costs for VTs than SPTs. However, we may also observe equivalent costs for VTs and SPTs (or perhaps even a larger effect with SPTs) for two reasons. First, poor source monitoring of SPTs may not be diagnostic of whether they will suffer when there is a mismatch between the study and the retrieval context. Second, context-dependent forgetting is typically more robust with item-specific processing than with associative, inter-item processing (Smith & Vela, 2001). Because the SPT advantage is in part attributed to the enhanced item-specific processing (Kormi-Nouri, 1995; Mohr, Engelkamp, & Zimmer, 1989; Zimmer & Engelkamp, 1985), and because SPTs are typically poorly integrated with each other (Engelkamp, 1986; Zimmer & Engelkamp, 1989; but see Backman, Nilsson, & Chalom, 1986; Kormi-Nouri & Nilsson, 1999), they might actually rely more on contextual cues during recall than VTs, because recalling one action may not necessarily prompt the retrieval of the next action (e.g., Engelkamp, 1986). In other words, the enhanced item-specific processing of SPTs suggests that the costs for SPTs can be the same magnitude (or even larger) than for VTs.

Finally, according to the strategy change component of the dual-factor account, the *benefits* of directed forgetting reflect an encoding advantage in the forget group due deploying better study strategies. Participants in the forget group often report using more elaborate study strategies on List 2 items than List 1 items, such as forming connections between the items on the list, or using a story mnemonic. Thus, the strategy change account would predict larger benefits of directed forgetting in the VT condition, than in SPT condition, where the benefits should be minimal. This is because SPTs are harder to integrate with each other than VTs.

Experiment 1

The aim of this study was to evaluate directed forgetting of performed actions using the list-method paradigm. Each study list contained a mixture of SPTs and VTs to allow comparing the magnitude of forgetting across verbally encoded and enacted actions. In addition to the standard forget and remember groups, a context-change group was also included in the design. Participants in the latter condition received the mid-list remember instruction, but in addition they engaged in a diversionary thought prespecified by the experimenter. Prior research with this manipulation showed that the context-change group performed like the forget group across a range of circumstances, including mental reinstatement of context at the time of test (Sahakyan & Kelley, 2002), under different encoding strategies (Sahakyan & Delaney, 2003), across individual differences in working memory capacity (Delaney & Sahakyan, 2007), and boundary conditions for directed forgetting (Pastötter & Bäuml, 2007). The inclusion of the context-change group would allow testing the context-change account of directed forgetting costs, which would predict parallel effects for directed forgetting instruction and the context-change instruction regardless of the direction of those effects.

Methods

Participants

There were 128 undergraduate psychology students who participated in exchange for course credit. They were tested individually.

Materials

The stimuli included 32 action phrases involving an external object, which was not present in the experimental cubicle and was not a natural part of the experimental laboratory (e.g., *inflate a balloon*, *make a snowball*). The list of action phrases are shown in "Appendix" (Table A1). The phrases were split into two lists of 16 action phrases each (List A and List B) and were followed either by the forget, the remember, or the context-change instructions. Half of the action phrases on each list were assigned to the verbal encoding condition (VTs), and the remaining half were assigned to the perform condition (SPTs). Each action phrase was assigned to the SPT or VT instruction equally often. Presentation order of the lists was counterbalanced during encoding.

Design

The design was an Item Type (VT vs. SPT) $\times$ Group (Forget vs. Remember vs. Context-Change vs. No-PI) $\times$ Lists (List 1 vs. List 2) mixed factorial, with Group as the only between-subjects factor.

Procedure

At the time of encoding, each action phrase appeared on the computer screen and was accompanied either by a "PERFORM" or a "STUDY" prompt, which remained on the screen for 6 s. Participants were told to study the phrases for an unspecified memory test. They were instructed to perform the action symbolically (pretending they had the objects they needed) if the phrase was accompanied by a PERFORM prompt, and to learn the phrase if it was accompanied by a STUDY prompt. No specific mention was made on how many times to perform the action. All participants followed the instructions. We did not record how many times participants performed a given action because prior research suggests that repeatedly performing the same action does not improve memory compared to performing it once, unless repetitions are spaced apart by other actions (e.g., Cohen et al., 1987; Kausler et al., 1990). Although participants occasionally performed some actions more than once during the time allotted for performance, no one engaged in spaced repetition throughout the experiment. Presentation order of PERFORM and STUDY prompts was randomized with the constraint that no more than two prompts of the same type appeared in succession. After encoding List 1, one-third of the participants were told that the list they had studied was only for practice, to familiarize them with the task, that there was no need to remember it, and try to forget it (the *forget* group). One-third of the participants were told that the list they had studied included only the first half of the items, and that they should remember it for a later memory test (the *remember* group). The remaining participants also received the remember instruction, but in addition engaged in one of Sahakyan and Kelley's (2002) mental context-change tasks (the *context-change* group). The context-change task lasted 60 s and involved imagining walking through their parents' house, describing it out loud to the experimenter, including details regarding the furniture and its location. To equate the amount of time between the two study lists and to prevent rehearsal in the remember group without dramatically changing mental context, participants in the remember and the forget groups were asked to count out loud by two's from a pre-specified number for 60 s. Prior work in our lab shows that counting task does not disrupt memory nearly as much as the "think about your parents' house" instruction, which involves a heavier imagination component. All participants then studied List 2 phrases using PERFORM or STUDY instructions. The final recall test was administered after a short filler task, which involved solving math problems for 60 s. During recall, participants were instructed to recall List 1 first, followed by List 2. This order of recall was chosen following Sahakyan and Kelley (2002) to avoid confounding directed forgetting with output interference. Recall was carried out on separate sheets of paper, with 90 s allotted for recall of each list.

A single-list reference group was also included in the study. This group studied only List A (or List B, for counterbalancing) with PERFORM and STUDY instructions on half of the items and received a memory test after the filler task. The rationale for including this condition (further termed the *No-PI* group) was to allow estimating recall in the absence of proactive interference from List 1 items.

Results and discussion

The main predictions concerned the effects of the forget cue across VTs and SPTs on each list, and therefore the costs and the benefits of directed forgetting were evaluated separately. The dual-factor account proposes different underlying mechanisms for the effects of the forget cue on List 1 and List 2, which further justifies list-specific analyses on the theoretical grounds. Recent investigations of directed forgetting have also taken this approach (e.g., Bäuml et al., 2008; Pastötter & Bäuml, 2007; Sahakyan & Delaney, 2005; Sahakyan & Goodmon, 2007; Sahakyan et al., 2008; Zellner & Bäuml, 2006).[1] Unless otherwise specified, the results were significant at $\alpha = .05$ level.

List 1 costs

An *Item Type* (VT vs. SPT) by *Group* (forget, remember, context-change) mixed factorial ANOVA on proportion of List 1 recalled revealed a significant main effect of item type, $F(1,93) = 11.56$, $MSe = .021$, $\eta^2 = .11$ (for SPT, $M = .31$, $SD = .17$; for VT, $M = .23$, $SD = .14$). There was also a significant main effect of group, $F(1,93) = 6.94$, $MSe = .026$, $\eta^2 = .13$ (for Remember, $M = .33$, $SD = .11$; for Forget, $M = .23$, $SD = .12$; for Context-Change, $M = .24$, $SD = .11$). Specifically, the remember group recalled significantly more List 1 items than the forget group, $t(62) = 3.32$, and the context-change group, $t(62) = 3.18$. The forget and the context-change groups did not significantly differ from each other, $t < 1$. There was no significant interaction, $F < 1$, suggesting that there was equivalent magnitude of forgetting for both item types in the forget and context-change groups (see Fig. 1, top panel).

List 2 benefits

The same analyses were performed on List 2 recall, and the No-PI group was included in the Group variable. There was a significant main effect of item type, $F(1,124) = 52.98$, $MSe = .024$, $\eta^2 = .30$ (for SPT, $M = .43$, $SD = .20$; for VT, $M = .28$, $SD = .14$), and a significant main effect of group, $F(3,124) = 45.44$, $MSe = .014$, $\eta^2 = .52$ (for Forget, $M = .32$, $SD = .09$; for Context-Change, $M = .32$, $SD = .09$;

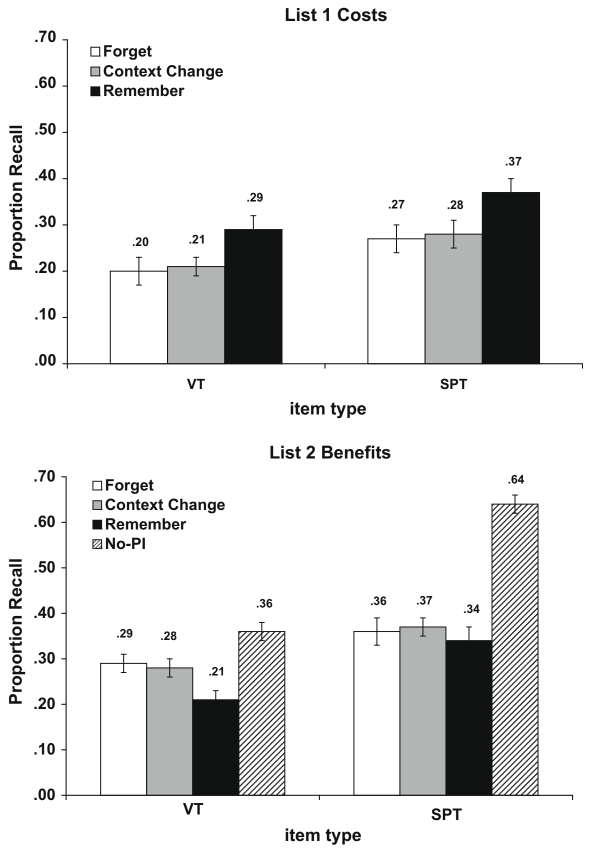

Fig. 1. Mean proportion List 1 recall (top panel) and List 2 recall (bottom panel) by group and item type in Experiment 1. Error bars represent *SE* of the means.

[1] If list is included in the analyses as a repeated factor, then there is a significant interaction of List (List 1 vs. List 2) × Group (forget, remember, context change), $F(2,93) = 9.50$, $MSe = .022$, $\eta^2 = .17$, suggesting that the mid-list instruction had a different impact on List 1 and List 2.

for Remember, $M = .27$, $SD = .09$; and for No-PI, $M = .50$, $SD = .07$). These effects were moderated by a significant item type by group interaction, $F(3,124) = 6.41$, $MSe = .024$, $\eta^2 = .13$. To follow-up the interaction, we examined recall of each item type separately as a function of group (see Fig. 1, bottom panel).

There were significant differences in List 2 VT recall between the groups, $F(3,124) = 7.60$, $MSe = .015$, $\eta^2 = .16$. Compared to the remember group, List 2 VT recall significantly improved in the forget group, $t(62) = 2.39$, in the context-change group, $t(62) = 2.35$, and in the No-PI group, $t(62) = 4.46$. However, the forget and the context-change groups had worse recall than the No-PI group (in the forget group, $t(62) = 2.30$; in the context-change group, $t(62) = 2.51$), implying that they did not completely escape from proactive interference.

There were also significant differences in List 2 SPT recall between the groups, $F(3,124) = 29.81$, $MSe = .023$, $\eta^2 = .42$. Specifically, List 2 SPT recall was not significantly different between the remember group, the forget group, and the context-change groups (all $ts < 1$), suggesting that there were no benefits from the forget or the context-change instruction. Also, all three groups had worse recall than the No-PI group (in the forget group, $t(62) = 8.58$; in the context-change group, $t(62) = 9.04$; in the remember group, $t(62) = 7.83$).

Summary and discussion

VTs showed both the costs and the benefits of directed forgetting. In contrast, SPTs revealed only partial directed forgetting – the costs were significant, but the benefits were not. Despite significant List 1 forgetting, there was no corresponding List 2 enhancement in the forget group compared to the remember group in the SPT condition. The results in the context-change group resembled the forget group findings both in terms of the costs and in terms of the benefits (or lack thereof) for VTs and SPTs. Finally, the magnitude of List 1 costs in the forget group and the context-change group was comparable across VTs and SPTs. The lack of benefits for SPTs is particularly interesting given that SPTs were on the same list as VTs, suggesting that if List 2 escaped from proactive interference as a result of forgetting List 1 items (a view that is advanced by the retrieval inhibition account), then both types of items should have benefited from it because they were on the same list. However, SPTs failed to benefit on List 2, suggesting that forgetting of List 1 items does not automatically improve recall of List 2 items.

Experiment 2

In Experiment 1, the magnitude of directed forgetting costs did not vary across the SPT and VT conditions. However, there might be true differences in the size of the memory impairment across the two item types, but the within-subjects manipulation of the item type might have suppressed these differences. For example, the presence of PERFORM condition on the same study list might predispose some participants to visualize performing the actions even when given the standard LEARN instruction. This can make the SPT and VT conditions more similar to each other than they would be if the imagery component was reduced. Therefore, in the next experiment we used pure lists of SPTs and VTs.

Our second aim was to compare the forget and the context-change conditions under more detailed level of analyses. Prior research documented that the recall rates in the context-change group resembled those in the forget group (Delaney & Sahakyan, 2007; Pastötter & Bäuml, 2007; Sahakyan & Delaney, 2003; Sahakyan, Delaney, & Goodmon, 2008; Sahakyan & Kelley, 2002), and Experiment 1 results confirmed prior reports. However, we have never compared the serial position functions across these conditions. If context-change underlies directed forgetting, then we would expect the serial position curves across the forget and the context-change groups to be similar to each other. If, however, the forget and the context-change instructions affect different portions of the curve (despite producing equivalent recall rates across these groups), then such findings would be problematic for the contextual account of directed forgetting and would imply that different processes contribute to forgetting in the forget and the context-change groups.

Serial position analyses could also be important for comparing the No-PI group and the forget group, because List 2 recall in the forget group has often been demonstrated to resemble recall in the No-PI group (e.g., Bjork & Bjork, 1996). However, these two groups have never been compared across serial positions, and it remains to be examined whether they have similar serial position functions. Differences in the shapes of their functions would be informative and would require fine-tuning of the theoretical mechanisms proposed for explaining List 2 enhancement in the forget group.

Finally, serial position analyses could be informative in light of the qualitative differences in the shapes of the functions across SPTs and VTs, with SPTs showing no primacy, but having extended recency compared to VTs (e.g., Seiler & Engelkamp, 2003; Zimmer et al., 2000). In Experiment 1, we found equivalent forgetting across VTs and SPTs. Given that both types of items were on the same list, it would be parsimonious to assume that the same mechanism was responsible for their forgetting. Thus, we would expect that despite the differences in the shapes of VT and SPT curves, the serial position functions in the forget and the remember groups should share the same relationship with each other regardless of the item type. However, a skeptic might argue that SPTs involve a heavy motor component compared to VTs, which are encoded verbally, and perhaps different mechanisms were responsible for their forgetting. If that is the case, then we would expect larger forgetting effects in the primacy region of VT curves, and larger forgetting effects in the recency region of SPT curves; otherwise, the degree of impairment cannot be equivalent across these item types. Overall, serial position analyses can provide a tool for disambiguating the mechanisms behind directed forgetting of VTs and SPTs and for testing the theories of directed forgetting.

Methods

Participants

There were 160 undergraduate psychology students who participated in exchange for course credit. None of them had participated in Experiment 1. They were tested individually.

Design

The design was an Item Type (VT vs. SPT) × Group (Forget vs. Remember vs. Context-Change vs. No-PI) × Lists (List 1 vs. List 2) mixed factorial, with Lists as the only within-subjects factor.

Materials and procedure

The materials were the same as in Experiment 1. With an exception of minor changes, the procedures were the same as in Experiment 1. During learning, participants encoded all action phrases using either the PERFORM or the STUDY instruction on both lists. The presentation order of the two lists was counterbalanced. Because PERFORM and STUDY instructions applied to all items rather than a subset of items, these prompts were not displayed along with the action phrases. Instead, the experimenter specified in advance whether the actions had to be performed during learning or simply encoded verbally. As in Experiment 1, we included also the No-PI conditions that studied List 2 using either the PERFORM or the STUDY instruction. In all other respects, the procedures were similar to Experiment 1.

Results and discussion

Unless otherwise reported, the results were significant at $\alpha = .05$ level. We report the analyses of List 1 recall first, followed by the analyses of List 2.[2] Recall of each list was evaluated by breaking the list into four quadrants (containing four items per quadrant) and conducting mixed factorial ANOVA using *Quadrant* (1st, 2nd, 3rd, 4th) as the within-subjects factor, and *Item Type* (VT vs. SPT) and *Group* (forget, remember, context-change, and No-PI) as the between-subjects factors. The No-PI group was included only in List 2 analyses.

List 1 costs

There was a significant main effect of item type, $F(1,114) = 7.79$, $MSe = .047$, $\eta^2 = .06$, revealing better memory for SPTs ($M = .29$, $SD = .12$) than VTs ($M = .24$, $SD = .11$). There was also a significant main effect of group, $F(2,114) = 14.58$, $MSe = .047$, $\eta^2 = .20$. The remember group recalled significantly more items ($M = .34$, $SD = .10$) than the forget group ($M = .23$, $SD = .11$), $t(78) = 4.44$, or the context-change group ($M = .24$, $SD = .10$), $t(78) = 4.33$. The forget and the context-change groups did not differ from each other, $t < 1$. There was neither a 2-way, nor a 3-way interaction with the group variable (both $Fs < 1$), suggesting that there was equivalent degree of forgetting of VTs and SPTs in the forget and the context-change groups compared to the remember group (see Fig. 2, top panel). Furthermore, there was no interaction with the quadrant variable suggesting that group differences were detected throughout the entire serial position curve, and were approximately of the same magnitude for both SPTs and VTs (see Fig. 3).

[2] If list is included in the analyses as a repeated factor, then the List × Group interaction is significant, $F(2,114) = 14.88$, $MSe = .012$, $\eta^2 = .21$.

In addition to the main effects of group and item type, there was also a significant main effect of quadrant ($F(3,342) = 20.40$, $MSe = .051$, $\eta^2 = .15$), which interacted with item type, $F(3,342) = 13.17$, $MSe = .055$, $\eta^2 = .10$. Namely, in the 1st quadrant, recall was higher in the VT condition than the SPT condition $t(118) = 2.78$), whereas the opposite was true in the 4th quadrant, with recall advantage for SPTs over VTs, $t(118) = 6.36$. These results replicate earlier research demonstrating that VTs have a primacy advantage, whereas SPTs have a recency advantage (e.g., Seiler & Engelkamp, 2003; Zimmer et al., 2000). However, despite the differences in the shapes of these functions, significant costs were detected throughout the entire list both in SPTs and VTs, and were approximately of the same magnitude. In addition, the serial position function of the context-change group was similar to the function in the forget group across SPT and VT recall, providing yet another parallel between these conditions under more detailed level of analyses.

List 2 benefits

List 2 recall was analyzed with mixed factorial ANOVA using Quadrant (1st, 2nd, 3rd, 4th), Group (forget, remember, context-change, No-PI), and Item Type (SPT vs. VT).

There were significant main effects of item type ($F(1,152) = 19.96$, $MSe = .060$, $\eta^2 = .12$), group ($F(3,152) =$

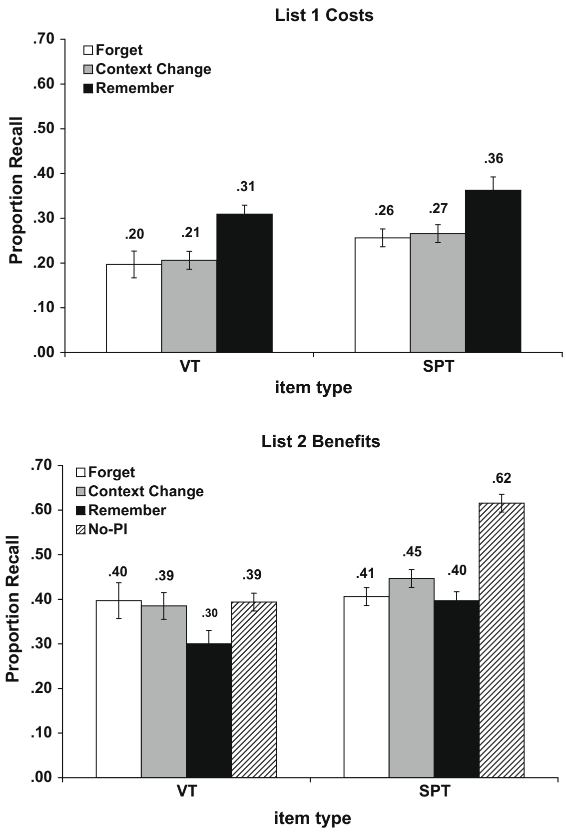

Fig. 2. Mean proportion List 1 recall (top panel) and List 2 recall (bottom panel) by group and item type in Experiment 2. Error bars represent *SE* of the means.

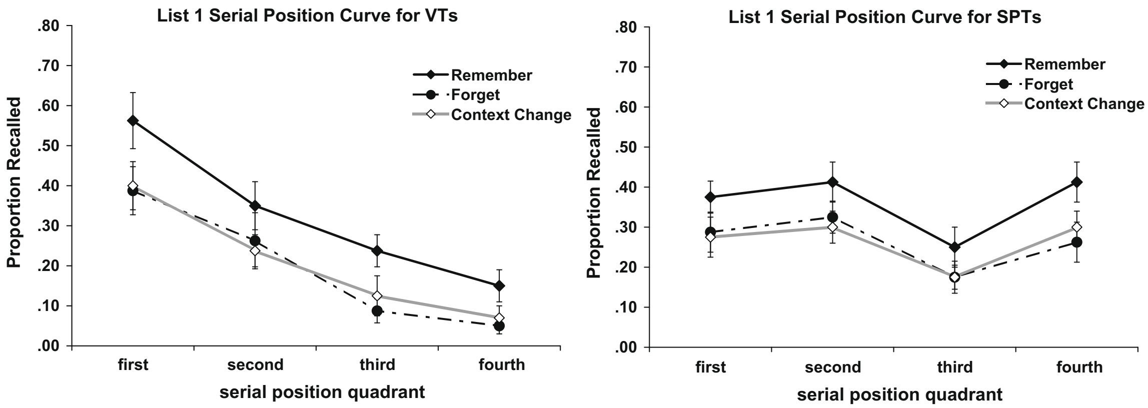

Fig. 3. Serial position curve for List 1 VT recall (left panel) and SPT recall (right panel) by serial position quadrant and group in Experiment 2. Error bars represent *SE* of the means.

11.62, *MSe* = .060, $\eta^2 = .19$), and quadrant ($F(3,456) = 5.86$, *MSe* = .069, $\eta^2 = .04$). These main effects were qualified by a significant group × item type interaction ($F(3,152) = 6.27$, *MSe* = .060, $\eta^2 = .11$), item type × quadrant interaction ($F(3,456) = 9.08$, *MSe* = .069, $\eta^2 = .06$), and a 3-way interaction ($F(9,456) = 1.89$, *MSe* = .069, $\eta^2 = .04$). First, we will examine the group × item type interaction because it allows evaluating directed forgetting benefits across VTs and SPTs, in parallel to the analyses performed in Experiment 1. Next, we will examine how these benefits depended on the quadrant of the list, as implied by the 3-way interaction.

One-way ANOVA on List 2 VT recall revealed significant differences between the groups, $F(3,76) = 3.03$, *MSe* = .013, $\eta^2 = .11$. Compared to the remember group, recall was significantly higher in the forget group, $t(38) = 2.33$, and in the context-change group, $t(38) = 2.34$. The latter two groups neither differed from each other, nor from the No-PI group (all *t*s < 1). These findings suggest that the forget and the context-change instruction benefited List 2 VT recall (see Fig. 2, bottom panel). There were also significant differences between the groups in List 2 SPT recall, $F(3,76) = 21.85$, *MSe* = .009, $\eta^2 = .46$. However, these differences were due to the No-PI group recalling more List 2 items than either the forget, the context-change, or the remember group (all *p*s < .001). There were no differences between the remember, forget, and the context-change groups (all *t*s < 1), suggesting that there were no benefits from these instructions. Together, these findings replicate Experiment 1 results, which revealed the benefits for VTs but not for SPTs.

Next, we evaluate how the benefits varied as a function of serial position as implied by the significant 3-way interaction. To follow-up this interaction, we conducted separate *Group* × *Quadrant* ANOVAs on VT and SPT recall. Fig. 4 summarizes the results. In the SPT condition, there was a significant effect of quadrant, $F(3,228) = 4.77$, *MSe* = .064, $\eta^2 = .06$, reflecting higher recall in the 4th quadrant (.53) than in the 1st quadrant (.39) or the 3rd quadrant (.42). These results confirm a strong recency effect, and the absence of primacy in the SPT condition. There was no group × quadrant interaction ($F < 1$).

In the VT condition, the *Group* × *Quadrant* ANOVA revealed a significant main effect of quadrant, $F(3,228) = 9.84$, *MSe* = .073, $\eta^2 = .12$, reflecting higher recall in the 1st quadrant (.49) than in the 2nd (.34), in the 3rd (.27), or in the 4th (.37) quadrants (all *p*s < .01). In addition, the 2nd quadrant was better recalled than the 3rd quadrant ($p < .01$), confirming a strong primacy effect in the VT condition. Importantly, there was a significant group × quadrant interaction, $F(9,228) = 2.66$, *MSe* = .073, $\eta^2 = .10$. Follow-ups to the interaction showed that there were no group differences in the 3rd or in the 4th quadrant of the list (both *F*s < 1), reflecting the lack of benefits in the second half of List 2. However, significant group differences were found both in the 1st quadrant ($F(3,76) = 5.22$, *MSe* = .090, $\eta^2 = .17$) and in the 2nd quadrant, $F(3,76) = 4.50$, *MSe* = .062, $\eta^2 = .15$.

Namely, in the 1st quadrant, there were benefits in the context-change group ($t(38) = 2.18$), in the No-PI group ($t(38) = 4.16$), and in the forget group ($t(38) = 1.91$, $p = .06$) compared to the remember group. The forget and the context-change groups did not differ from each other ($t < 1$), although recall in each of these conditions was worse than in the No-PI group. In contrast, in the 2nd quadrant, there were significant benefits in the forget group ($t(38) = 3.07$), and in the context-change group, ($t(38) = 3.04$), but not in the No-PI group ($t(38) = 1.21$, $p = .23$) compared to the remember group. The forget and the context-change groups did not differ from each other, $t < 1$. Interestingly, the forget and the context-change groups had *better* recall in the 2nd quadrant compared to the No-PI group in contrast to what was found in the 1st quadrant. When the 1st and the 2nd quadrants were analyzed as a function of group, there was a significant interaction, $F(3,76) = 3.23$, *MSe* = .077, $\eta^2 = .11$.

To summarize, we found significant benefits for VTs but not SPTs, consistent with Experiment 1 results. Furthermore, the benefits in VT recall varied as a function of serial position, with significant benefits observed only in the first half of the list, but not in the second half of List 2. Compared to the remember group, the benefits in the forget and the context-change groups were found both in the 1st quadrant and in the 2nd quadrant; however, in the

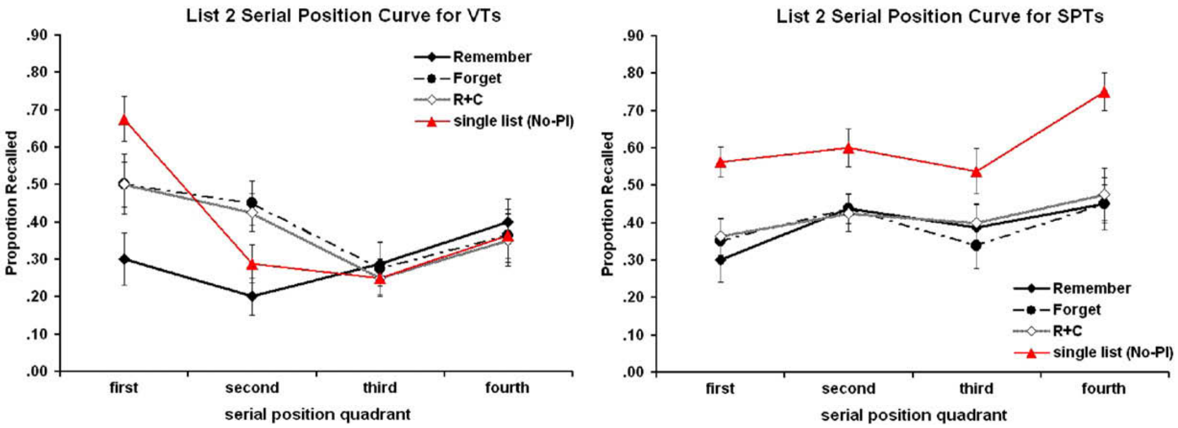

Fig. 4. Serial position curve for List 2 VT recall (left panel) and SPT recall (right panel) by serial position quadrant and group in Experiment 2. Error bars represent *SE* of the means.

No-PI group the benefits emerged only in the 1st quadrant of the list. We defer further discussion of these findings to the "General discussion" section.

Experiment 3

The results of Experiments 1 and 2 demonstrated that SPTs showed the same magnitude of directed forgetting costs as VTs. In both studies, actions were performed symbolically, without the use of real objects. In contrast, prior research reporting smaller item-method directed forgetting with SPTs than VTs involved the use of real objects for half of the actions (Earles & Kersten, 2002). Thus, a possibility still exists that performing the actions with real objects reduces the magnitude of directed forgetting. This could happen, for example, because during the test it may be easier to mentally reinstate a real object than an imaginary object presumably because the former is perceptually more distinctive. It is known that mental reinstatement of the study context during the test reduces directed forgetting (Sahakyan & Kelley, 2002). Therefore, even if participants attempted to forget the performed actions in response to directed forgetting, they may overcome it at the time of test if they can easily reinstate the object, which in turn could cue the action associated with that object. The aim of Experiment 3 was to have participants perform the actions using the real objects and to compare the magnitude of list-method directed forgetting across SPTs and VT.

Methods

Participants

There were 80 undergraduate psychology students who participated in exchange for course credit. None of them had participated in the previous experiments. They were tested individually.

Materials

Two new lists of 16 phrases per list were created. Although many action phrases were similar to those used in Experiments 1 and 2, we changed some of the phrases to ensure that an action could be performed in the laboratory with the use of an external object (e.g., *make a snowball* would be impossible to perform in the laboratory setting, and hence some phrases were replaced). The list of action phrases are shown in "Appendix" (Table A2). As in the previous experiments, we ensured that none of the objects were visible in the lab environment. They were provided only during the enactment. The order of the two lists was counterbalanced during encoding.

Design

The design was an Item Type (VT vs. SPT) × Group (Forget vs. Remember) × Lists (List 1 vs. List 2) mixed factorial, with Lists as the only within-subjects factor.

Procedure

With a few minor changes the procedures were similar to Experiment 2. Throughout the experiment the objects were hidden from the participants' view, except during the time allotted for performance. They were stored in a large container that was placed behind the participant's seat. During encoding, the experimenter handed the objects to the participants and instructed them to perform the action described on the computer screen. No specific mention was made on how to perform the action or how many times to perform the action. After performance, the experimenter took the object away and put it out of sight. Actions were presented at a rate of 6 s per phrase, and were separated by a 2 s inter-stimulus interval. This was done to ensure the experimenter had adequate time to hide and locate the next object. We eliminated the counting task between the two study lists because there was no context-change condition in the experiment, and there was no need to equate the time between the lists. Because there was no filler task after List 1, we also eliminated the filler task at the end of List 2 in order not to penalize List 2 items more than List 1 items (Malmberg, Lehman, & Sahakyan, 2006). In all other respects, the procedures were identical to the SPT condition of Experiment 2. In the VT condition, participants never saw the objects, and they were told to learn the action phrases for a later memory test.

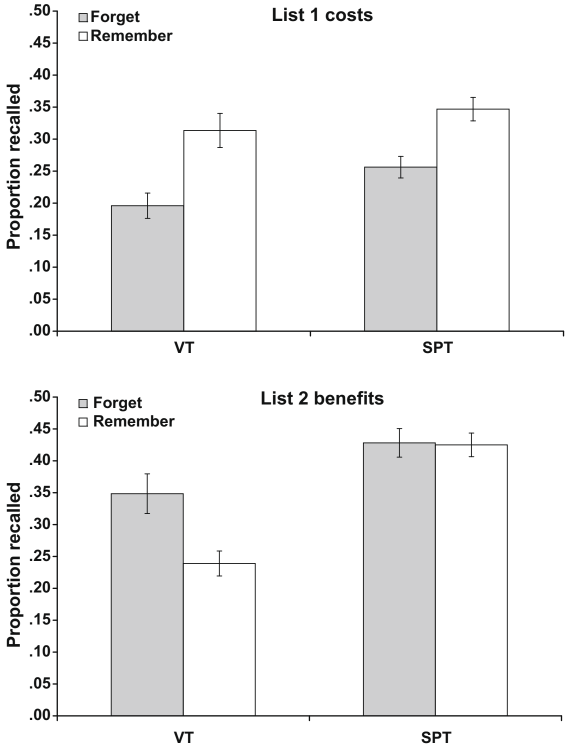

Fig. 5. Mean proportion List 1 recall (top panel) and List 2 recall (bottom panel) by group and item type in Experiment 3. Error bars represent *SE* of the means.

Results and discussion

Unless otherwise reported, the results were significant at $\alpha = .05$ level. We report the analyses of List 1 recall, followed by the analyses of List 2 recall.[3] Recall of each list was evaluated by mixed factorial ANOVA using *Quadrant* (1st, 2nd, 3rd, 4th) as the within-subjects factor, and *Item Type* (VT vs. SPT) and *Group* (forget vs. remember) as the between-subjects factors.

List 1 costs

There was a significant main effect of item type, $F(1,76) = 5.42$, $MSe = .035$, $\eta^2 = .07$, showing better recall of SPTs ($M = .30$, $SD = .09$) than VTs ($M = .25$, $SD = .12$). There was also a main effect of cue, $F(1,76) = 30.05$, $MSe = .035$, $\eta^2 = .28$, with better recall in the remember ($M = .33$, $SD = .10$) than the forget group ($M = .22$, $SD = .09$). There was neither a 2-way, nor a 3-way interaction with the group variable (both $Fs < 1$), suggesting that the magnitude of directed forgetting costs was identical across VTs and SPTs (see Fig. 5, top panel).

In addition to the main effects of item type and group, there was also a significant main effect of quadrant ($F(3,228) = 15.68$, $MSe = .057$, $\eta^2 = .17$), which interacted with item type, $F(3,228) = 6.86$, $MSe = .057$, $\eta^2 = .08$. Namely, in the 1st quadrant, recall was higher in the VT condition than the SPT condition $t(78) = 1.96$, $p = .05$), whereas the opposite was true in the 4th quadrant, with recall advantage for SPTs over VTs, $t(78) = 4.47$. These results replicate prior published findings as well as the results from Experiment 2. Despite the differences in the shapes of serial position functions across VTs and SPTs, an equivalent magnitude of directed forgetting costs were detected throughout the entire list for both item types as evidenced by the lack of 2-way and 3-way interactions with group variable (see Fig. 6).

List 2 benefits

For the analyses of directed forgetting benefits, a similar ANOVA was performed on the proportion of List 2 recall. Again, we obtained a significant main effect of item type, $F(1,76) = 27.60$, $MSe = .045$, $\eta^2 = .27$, showing better recall of SPTs ($M = .41$, $SD = .09$) than VTs ($M = .29$, $SD = .13$). There was also a significant main effect of cue, $F(1,76) = 6.90$, $MSe = .045$, $\eta^2 = .08$, with better recall in the forget ($M = .38$, $SD = .13$) than the remember group ($M = .32$, $SD = .13$). However, these effects were modified by a significant interaction between the item type and cue, $F(1,76) = 4.99$, $MSe = .045$, $\eta^2 = .06$. Follow-up comparisons showed that the benefits were significant in the VT group ($t(38) = 3.54$), but not in the SPT group, $t < 1$ (see Fig. 5, bottom panel).

In addition to these effects, there was also a significant main effect of quadrant ($F(3,228) = 5.51$, $MSe = .068$, $\eta^2 = .06$), which interacted significantly with the item type, $F(3,228) = 3.84$, $MSe = .068$, $\eta^2 = .05$. There was a significant advantage in the SPT compared to the VT condition in the 3rd quadrant ($t(78) = 3.31$) and the 4th quadrant ($t(78) = 4.43$). There was no 3-way interaction with the group variable, $F < 1$.

Because directed forgetting benefits were significant only in the VT condition, we examined them as a function of serial position quadrant to evaluate whether they were found throughout the entire list or whether they were confined to specific portions of the curve as found in Experiment 2. There was a significant recall advantage in the forget group compared to the remember group in the 1st quadrant ($t(38) = 2.07$), and in the 2nd quadrant ($t(38) = 2.80$); however, there were no group differences in the 3rd or in the 4th quadrants of the list (both $ts < 1$). The same analyses in the SPT condition revealed no differences in any portion of the curve (all $ts < 1$). Fig. 7 summarizes the results.

To summarize, when actions were performed with real objects there were reliable directed forgetting costs of equal magnitude both for VTs and for SPTs. The impairment was found throughout the entire serial position curve despite qualitative differences in the shapes of the functions across VTs and SPTs. However, despite the impaired recall of List 1 items, there were no List 2 benefits for SPTs, whereas the benefits were found for VTs – a pattern that replicates the results of previous two experiments. Also, consistent with the findings of Experiment 2, the benefits in the VT condition were found only in the first half of the serial position curve, but they were not detected in the second half of the list.

[3] If list is included in the analyses as a repeated factor, then there is a significant List × Group interaction, $F(1,76) = 34.82$, $MSe = .007$, $\eta^2 = .31$.

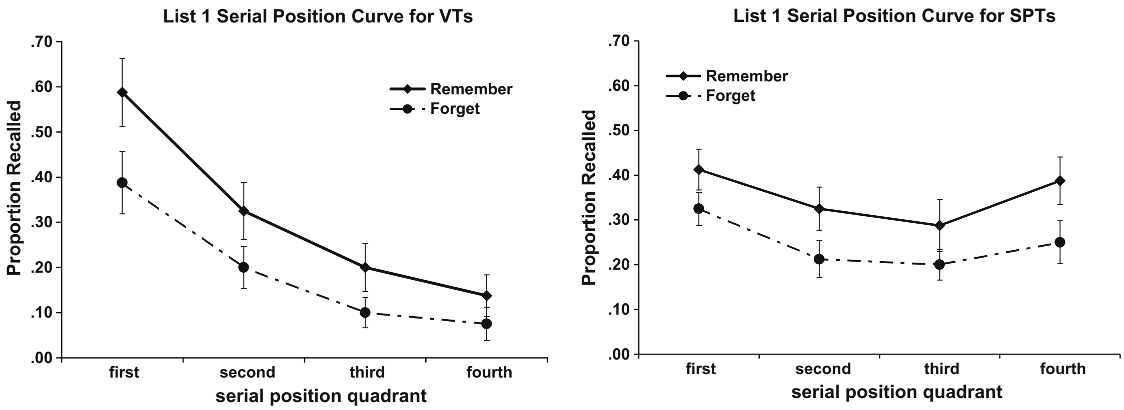

Fig. 6. Serial position curve for List 1 VT recall (left panel) and SPT recall (right panel) by serial position quadrant and group in Experiment 3. Error bars represent *SE* of the means.

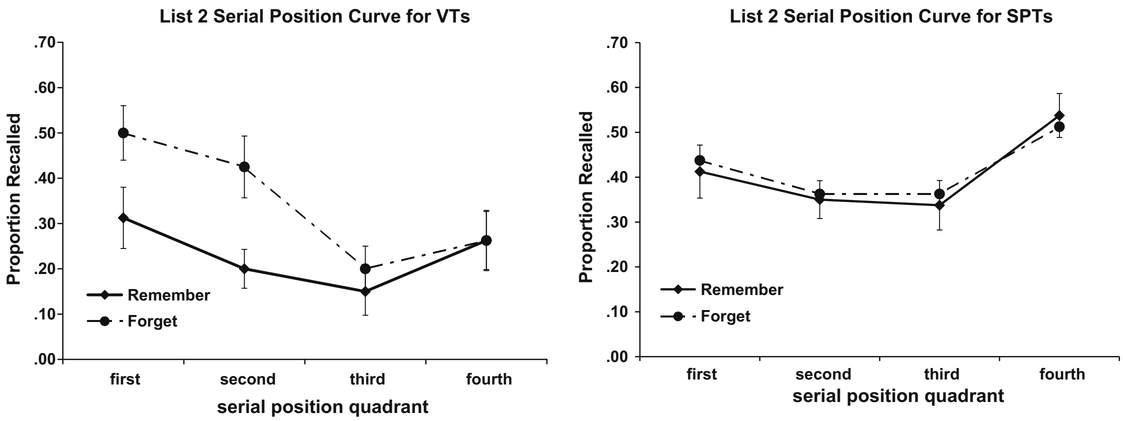

Fig. 7. Serial position curve for List 2 VT recall (left panel) and SPT recall (right panel) by serial position quadrant and group in Experiment 3. Error bars represent *SE* of the means.

Experiment 4

In Experiments 1–3, the list-method directed forgetting procedure led to equivalent degree of forgetting across VTs and SPTs. In this experiment, we wanted to verify that we would obtain larger directed forgetting for VTs than SPTs if we used the item-method procedure. In addition to the VT condition, we included two SPT conditions, with one SPT group performing the actions with real objects, and the second SPT group engaging in symbolic enactment. In a similar item-method directed forgetting study, Earles and Kersten (2002) had manipulated the presence or absence of objects within-subjects, but they only reported the combined directed forgetting effect regardless of the object status. They found a numerical directed forgetting effect in the SPT condition, but it did not reach significance in their study. It could be that the presence or absence of objects during enactment affected the size of the item-method forgetting effect in the SPT condition, and we aimed to evaluate this in the current experiment.

The second goal of this study was to include baseline conditions, where all items are followed by the *remember* cue. The inclusion of such baseline is critical for estimating the weakening effect of TBF items (i.e., the *costs* of item-method) and the strengthening effect of TBR items (i.e., the *benefits* of item-method) compared to the baseline recall. Typically, in the prior item-method directed forgetting studies, baseline conditions were not included in the designs, and the directed forgetting effect was captured by the differences in the recall of TBF items relative to the TBR items (e.g., Basden et al., 1993; Bjork & Geiselman, 1978; Bjork & Woodward, 1973; Davis & Okada, 1971; Geiselman & Bagheri, 1985; Horton & Petruk, 1980; MacLeod, 1999; Woodward & Bjork, 1971; Woodward, Park, & Seebohm, 1974; Woodward et al., 1973). However, we argue that the recall difference between the TBR and TBF items combines the strengthening and the weakening effects into one measure, and therefore confounds the nature of the processes contributing to the item-method directed forgetting. For instance, it would be premature to interpret the deflated recall of TBF items relative to the TBR items as evidence of *forgetting*, if in fact the TBF items did not suffer from directed forgetting manipulation, but instead the TBR items were strengthened relative to the *remember-all* baseline. Therefore, it is important to include such baseline group in the design and evaluate the processes involved in the item-method directed forgetting because any experimental manipulation may have a greater impact on one or the other process.

Finally, the third goal was to conduct serial position analyses akin to those reported in Experiments 2 and 3. If the item-method and the list-method directed forgetting are mediated by different mechanisms, we would expect those differences to show up in the serial position analyses. For example, if the item-method directed forgetting effect arises from terminating rehearsal of TBF items, then we would expect much larger effect at the beginning of the serial position curve, where rehearsal has a greater impact, than in the remaining portions of the curve. Also, we expect this effect to be more evident for VTs than for SPTs, because the former rely more heavily on rehearsal than SPTs.

Methods

Participants

There were 120 UNCG psychology students who participated in exchange for course credit. None of them had participated in the previous studies. There were 20 participants per group in each of the six study conditions. They were tested individually.

Materials and procedure

The materials were the same as in Experiment 3. We created two different presentation orders, by combining together the items from Lists A and B, and reversing the order of the lists for half of the participants. Each action phrase was presented on the computer screen for 8 s, and was followed either by the *forget* or the *remember* cue, which remained on the screen for 6 s (modeled after Earles and Kersten's (2002) study). These cues were presented with the constraint that throughout the list, the same cue did not appear for more than three times in a row, and that the resulting list contained an equal number of TBF and TBR items in each of the four quadrants of the list. The latter constraint was relevant for the serial position analyses. For half of the participants, we swapped the forget and the remember cues to ensure that each action phrase was followed equally often by the forget and the remember instruction. Participants were warned that some of the action phrases will be followed by the forget cue, which meant that they would not be tested on the item, and other items will be followed by the remember cue indicating that they would have to recall the action later on.

During encoding, one-third of the participants simply read the action phrases and memorized them for a later test (*VT* group). The remaining participants were told to perform the action denoted in the action phrase. Half of these participants were given a real object for enactment (SPT^+ group), and the remaining participants had to perform the action symbolically, pretending they had the objects (SPT^- group). The experimenter monitored compliance with the instructions. None of the objects were visible in the laboratory setting. They were hidden in a large container, placed behind the participant's seat. In the SPT^+ group, the experimenter handed the object to the participant during the encoding of each phrase, and hid the object after performance. Following the last action phrase, participants were given a blank sheet of paper and given 3 min to recall the items, including those they were told to forget. The total recall time was equated to the previous experiments reported in this paper.

In addition to the three experimental conditions, we included three baseline groups (*VT* baseline, SPT^- baseline, and SPT^+ baseline). Participants in these groups followed the same procedures as those in the directed forgetting groups, except that during study, all forget cues were replaced by the remember cues, which appeared on the screen after each phrase for the same duration of time. After recall, participants in all conditions were asked to provide retrospective verbal reports regarding how they attempted to memorize the items when they received the Remember cue, and how they attempted to forget the items when they received the Forget cue. In the baseline group, participants only explained their memorization strategy because all items were TBR items.

Design

The design was Items (TBR vs. TBF) × Group (VT vs. SPT^+ vs. SPT^-) mixed factorial, with Items as the within-subjects factor. In addition to three experimental groups, there were also three corresponding baseline groups that were exposed only to the TBR items.

Results and discussion

First we evaluated the magnitude of the item-method directed forgetting effect by analyzing recall in the experimental groups. In these analyses, we relied on the recall difference between the TBR and TBF items as an index of the magnitude of the directed forgetting effect, which is the popular measure in the literature. Then we compared the recall of TBR and TBF items in the experimental groups to the recall in the baseline conditions in order to discern the nature of processes contributing to the directed forgetting effect. Finally, we conducted the serial position analyses in experimental groups, and compared those functions to the serial position curves in the baseline groups. Unless otherwise reported, the results were significant at $\alpha = .05$ level.

Overall item-method directed forgetting effect

We analyzed recall across experimental conditions with mixed factorial ANOVA, using *Items* (TBR vs. TBF) as the within-subjects factor and *Group* (VT vs. SPT^+ vs. SPT^-) as the between-subjects factor. The results are summarized in Fig. 8. There was a significant main effect of Items, $F(1,57) = 72.12$, $MSe = .014$, $\eta^2 = .56$ (for TBR, $M = .49$, $SD =$ 14; for TBF, $M = .31$, $SD = .15$). There was also a significant main effect of Group, $F(2,57) = 6.10$, $MSe = .018$, $\eta^2 = .18$ (for VT, $M = .34$, $SD = .12$; for SPT^-, $M = .40$, $SD = .08$; for SPT^+, $M = .45$, $SD = .09$). However, these were qualified by a significant interaction, $F(2,57) = 17.34$, $MSe = .014$, $\eta^2 = .38$. Follow-up comparisons showed that there was a significant directed forgetting effect in the *VT* group ($t(19) = 7.97$), in the SPT^+ group ($t(19) = 2.98$), and in the SPT^- group

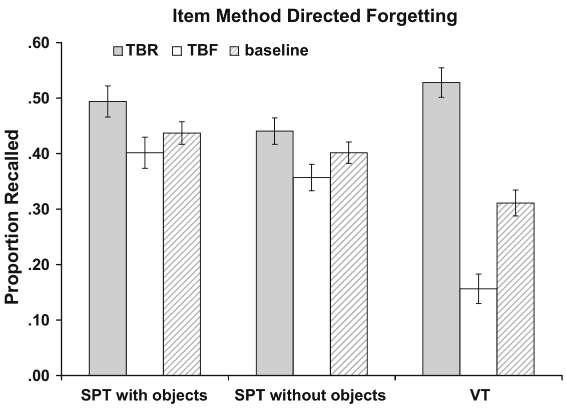

Fig. 8. Proportion of TBF and TBR items recalled as a function of experimental group in Experiment 4. The baseline groups represent recall of TBR items only. Error bars represent *SE* of the means.

($t(19) = 2.74$). However, the magnitude of the effect was much larger in the *VT* group (37%) than in the *SPT*+group (9%), or in the *SPT*− group (9%). These findings contrast the list-method results reported in the previous experiments, where the degree of directed forgetting impairment was equivalent across the VT and SPT conditions.

To evaluate the processes contributing to the item-method directed forgetting, we compared recall of TBR and TBF items in each experimental group against the recall in the corresponding baseline group. In the *VT* experimental group, there was both a significant benefit for the TBR items (15%), $t(38) = 4.41$, and a significant cost for the TBF items (22%), $t(38) = 4.36$, compared to baseline recall. In the *SPT*+ experimental group, there was a 4% numerical cost to the TBF items ($t(38) = 1.03$, $p = .30$), and a 5% numerical benefit to the TBR items compared to the baseline recall ($t(38) = 1.89$, $p = .07$); however, these effects were not significant. A similar pattern emerged also in the *SPT*− experimental group, with 5% numerical cost for the TBF items ($t(38) = 1.35$, $p = .18$), and 4% numerical benefit for the TBR items ($t(38) = 1.70$, $p = .10$) compared to the baseline group. Again, neither of these effects were significant. When we collapsed the data from the two experimental SPT groups because they were quite similar, then the benefits for TBR items became significant when compared against the combined SPT baselines, $t(78) = 2.27$; however, the costs remained non-significant, $t(78) = 1.87$, $p = .07$.

To summarize, in the VT experimental condition, both the costs and the benefits were contributing to the item-method directed forgetting effect. In contrast, in the SPT groups, the costs and the benefits were small and they were not significant when evaluated against the baseline group (although the combined analysis of both SPT groups revealed significant benefits). However, given that both the costs and the benefits were present numerically in the SPT groups, the recall difference measure between the TBR and TBF items revealed significant item-method forgetting in both SPT groups.

Serial position analyses

In the next step, we evaluated the serial position functions in the *VT*, *SPT*+, and *SPT*− experimental groups. We broke down the list into four quadrants (there were four TBR and four TBF items in each quadrant), and evaluated recall using *Items* (TBF vs. TBR) by *Quadrant* (1st, 2nd, 3rd, 4th) by *Group* (*VT*, *SPT*+, *SPT*−) mixed ANOVA. The baseline groups were not included in the 3-way analyses because they had only recall values for TBR items as all items were followed by a remember instruction. There was a significant 3-way interaction, $F(3,171) = 8.23$, $MSe = .060$, $\eta 2 = .13$. To follow-up the interaction, we evaluated directed forgetting across serial positions in experimental groups separately. Afterwards we compared the TBR and TBF recall in each serial position quadrant against the corresponding baseline recall. Fig. 9 summarizes the findings.

VT condition

There was a significant *Items* × *Quadrant* interaction in the experimental *VT* group, $F(3,57) = 4.18$, $MSe = .047$, $\eta 2 = .18$. This interaction showed that although there were recall differences between the TBR and TBF items in all quadrants of the list (all $ps < .01$), the effect was much larger in the 1st quadrant (56%) than in the remaining quadrants (29% vs. 30% vs. 23%). When the recall of TBR and TBF items was compared against the baseline recall across serial position quadrants, then in the 1st quadrant of the list, there was a significant benefit to the TBR items, accompanied by a significant cost to the TBF items (both $ps < .001$). However, in the 2nd and the 3rd quadrants, only the benefits were significant (both $ps < .01$), but the costs were not ($p = .21$ and $p = .14$, respectively). In the 4th quadrant, neither of these effects were significant (both $ps = .17$).

SPT+ *condition*

There was a significant *Items* × *Quadrant* interaction in the *SPT*+ experimental group, $F(3,57) = 3.37$, $MSe = .060$, $\eta 2 = .15$. This interaction showed that there was a significant recall difference between the TBR and TBF items in the 1st quadrant of the list ($p < .01$); however, there were no recall differences in the remaining quadrants (all $ts < 1$). When the recall of TBR and TBF items was compared against the baseline recall, there was only a significant benefit for the TBR items in the 1st quadrant ($p < .01$). However, there were neither costs, nor any benefits anywhere else in the list (all $ts < 1$).

SPT− *condition*

In the *SPT*− experimental group, there was a significant *Items* × *Quadrant* interaction, $F(3,57) = 5.58$, $MSe = .060$, $\eta 2 = .22$, with significant recall difference between the TBR and TBF items in the 1st quadrant ($p < .01$), but no recall differences in the remaining quadrants (all $ts < 1$). When the TBR and TBF recall was compared against the baseline group, there was only a significant benefit for the TBR items in the 1st quadrant ($p < .01$). However, there were neither costs, nor any benefits anywhere else in the list (all $ts < 1$).

Summary of the serial position findings

The results suggest that the item-method directed forgetting (as measured by the recall difference between TBR and TBF items) was greater in the 1st quadrant of the list

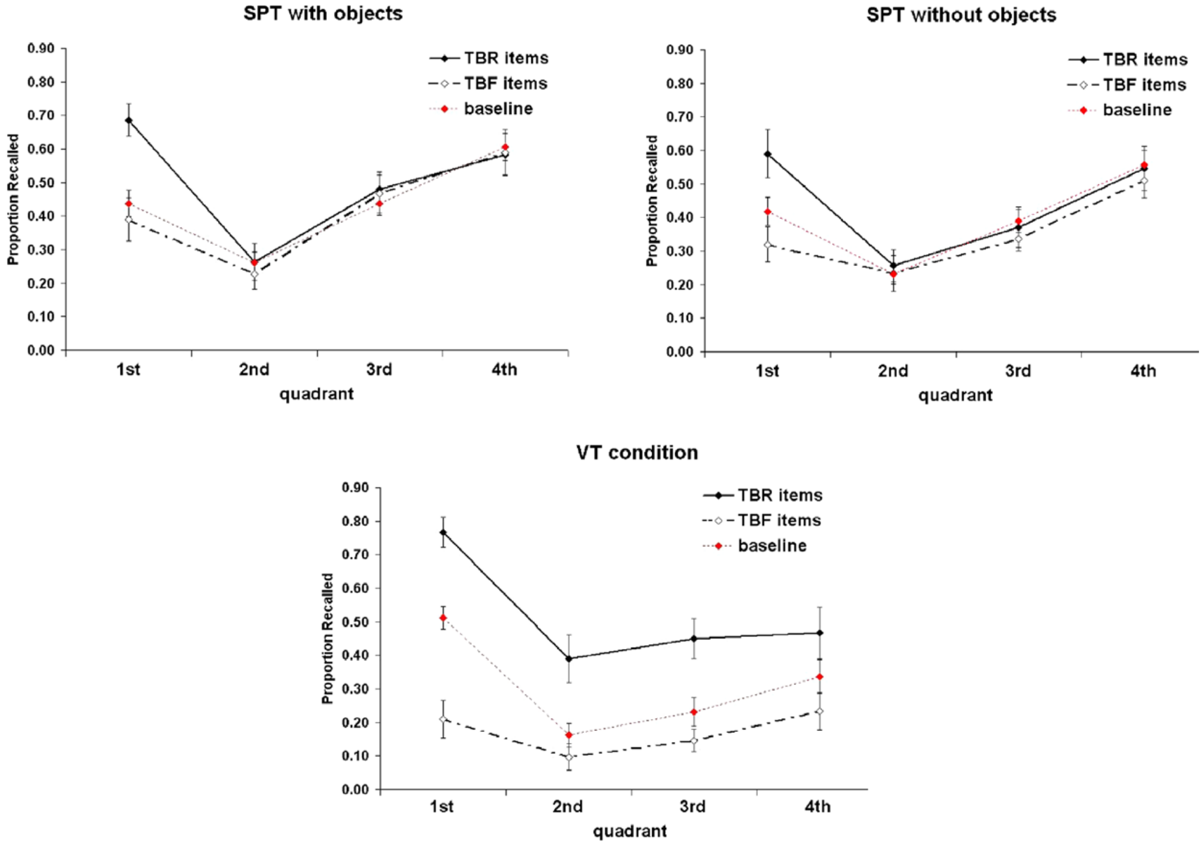

Fig. 9. Serial position curves for TBR and TBF item recall as a function of serial position quadrant in the *SPT*⁺ group (top left panel), *SPT*⁻ group (top right panel), and *VT* group (bottom panel) in Experiment 4. The baseline groups represent recall of TBR items only. Error bars represent *SE* of the means.

than in the remaining quadrants. This was observed in all experimental groups. However, in both *SPT* groups (regardless of the object status), directed forgetting emerged only in the 1st quadrant, whereas in the *VT* group, it was observed not only in the 1st quadrant, but also beyond.

When recall of TBR and TBF items for the *VT* group was compared to the baseline recall to evaluate the processes contributing to the recall difference between these items, directed forgetting reflected a combination of costs to TBF items and the benefits to the TBR items. Both of these effects were present in the 1st quadrant of the list; however, beyond the 1st quadrant, directed forgetting in the *VT* group came primarily from the benefits to TBR items, whereas the costs to TBF items became smaller and were no longer significant. In contrast, in both *SPT* groups, directed forgetting reflected primarily the benefits to TBR items, which emerged only in the 1st quadrant of the list. However, there were no costs to the TBF items throughout the entire list.

General discussion

In this paper, we evaluated the list-method and the item-method directed forgetting across VTs and SPTs. Because of the extensive nature of the results, we will first discuss the list-method findings from Experiments 1–3, and then evaluate the item-method findings from Experiment 4.

List-method directed forgetting

The first three experiments demonstrated significant List 1 costs for both SPTs and VTs, but List 2 benefits only for the VTs. This pattern of results was observed regardless of whether actions were performed symbolically (Experiments 1 and 2) or with real objects (Experiment 3). The magnitude of List 1 impairment was identical across SPTs and VTs in both mixed and pure lists (Experiments 1–3). Recall in the context-change group in Experiments 1 and 2 resembled the pattern observed in the forget group. Just like the forget cue, the context-change instruction significantly impaired recall of List 1 VTs and SPTs, but it only improved List 2 VT recall without improving List 2 SPT recall.

We propose that these findings are consistent with the dual-process account of list-method directed forgetting. We explain the costs for SPTs and VTs by the mental context-change taking place in response to the forget cue. If participants attempt to distract themselves with other thoughts in order to comply with the forget instruction, such strategy is likely to produce forgetting. Consistent with this argument, a context-change group that engaged in a diversionary thought (but was not instructed to forget anything) produced forgetting comparable to the group that received the forget cue. Therefore, the spontaneous use of such strategies in the forget group could produce impaired recall of List 1 items. The serial position curves also looked identical across the forget and context-change groups, despite qualitative differences in the shapes of VT and SPT curves. Replicating published findings, we found stronger primacy for VTs, and stronger recency for SPTs; however, there was approximately equivalent forgetting throughout the entire List 1 curve. Similar results were reported also by Geiselman et al. (1983) in directed forgetting of single words. These findings suggest that directed forgetting creates impaired access to entire List 1 context.

In prior published studies, we reported similar amounts of forgetting following the context-change and the directed forgetting instructions (Sahakyan, Delaney, & Goodmon, 2007; Sahakyan & Kelley, 2002). These findings hold up across variations in the encoding strategy (Sahakyan & Delaney, 2003), working memory capacity (Delaney & Sahakyan, 2007), and the boundary conditions for directed forgetting (Pastötter & Bäuml, 2007). In the current list-method experiments, the context-change instruction again mirrored the results in the forget condition under more detailed level of analyses, such as the serial position functions. It is increasingly clear that the context-change instructions produce results similar to the forget instruction, and some context-change tasks are more effective than others. For example, speeded reading (Delaney & Sahakyan, 2007), counting forward task (Sahakyan et al., 2007), three-digit arithmetic task (Sahakyan et al., 2004), and the counting backward task used in the current paper produce less forgetting than a task that engages a heavy imagination component, such as imagining one's childhood home, or imagining being invisible (Sahakyan & Kelley, 2002). A systematic investigation as to why certain types of context-change instructions are more effective than others is increasingly warranted.

We propose that the benefits for VTs arise from application of better encoding strategies on List 2 in the forget and the context-change groups. Prior research in our laboratory shows that when forget group participants are told that the list was "for practice", it predisposes them to reflect on the efficiency of their List 1 study strategy and adopt a better List 2 study strategy (Sahakyan et al., 2004). A mental context disruption might also lead to strategy changes because it might reinforce an escape from a prior mental set, and the study strategies associated with it. Given that SPTs are insensitive to encoding factors, the absence of benefits of SPTs is consistent with the strategy-based explanation of benefits. Participants may have attempted to employ better encoding strategies on List 2, but were unable to improve memory for these items because SPTs have been shown to be insensitive to encoding factors. Alternatively, perhaps participants did not know better ways of encoding List 2 SPTs compared to how they had encoded SPTs on List 1. Some researchers proposed that people have more knowledge about their verbal system than the action memory system. This was evidenced by poor metacognitive assessment made during encoding regarding the probability of future recall of SPTs despite more accurate predictions regarding future VT recall (e.g., Cohen, 1988; Cohen & Bryant, 1991). Overall, the absence of benefits with SPTs given significant benefits with VTs is fully consistent with encoding-based mechanism of directed forgetting benefits (Sahakyan & Delaney, 2003).

Additional support for this view comes from the serial position analyses of List 2 VTs, which revealed that the benefits from the forget instruction and the context-change instruction were evident both in the 1st and in the 2nd quadrant of the list. Similar results were reported also by Geiselman et al. (1983). In contrast to the forget and the context-change groups, the benefits in the No-PI group were found only in the 1st quadrant, whereas in the 2nd quadrant, the No-PI group was not significantly different from the remember group. If the forget and the context-change groups benefited List 2 by stopping rehearsal of List 1 items and starting a new rehearsal cycle on List 2, then we would expect to see serial position curves like those in the No-PI group, which most likely engaged in rehearsal. However, the curves were different across these conditions, and we suspect that the forget and the context-change groups likely changed their study strategy on List 2 into some sort of item-specific processing (for example, by visualizing performing the actions). As a result, the benefits of the strategy change extended beyond the 1st quadrant into the 2nd quadrant, whereas the rehearsal benefits in the No-PI group were restricted primarily to the 1st quadrant of List 2. It is interesting to note that List 2 primacy in the forget and the context-change groups was much reduced compared to the No-PI group (and compared to List 1). Research by Sharps, Price, and Bence (1996) suggests that imagery instructions reduce the primacy effect. If participants in VT condition were visualizing performing the actions on List 2 in the forget and the context-change groups, then this would explain why primacy effect was reduced in those conditions. Also, Seiler and Engelkamp (2003) showed that item-specific processing of VTs makes their serial position curves look similar to SPTs. In general, List 2 curves in the VT condition in the forget and the context-change groups were more similar to the shape of the List 1 SPT curve than to the shape of the No-PI group. Overall, these results are consistent with the strategy change explanation of benefits; however, further empirical evidence is needed to identify the strategies used across two list encoding.

Although we interpreted the list-method directed forgetting findings from the perspective of the dual-factor account (Sahakyan & Delaney, 2005), we now consider them from the perspective of the inhibitory account (e.g., Bjork, 1989). Some researchers proposed that inhibition in the list-method directed forgetting is aimed at the representation of entire List 1 episode (e.g., Anderson, 2005; Bjork & Bjork, 1996, 2003; Bjork et al., 1998). Others have argued that inhibition in directed forgetting occurs when List 1 items come to mind during List 2 learning, and therefore they must be suppressed in the forget condition (Conway, 2001; Conway & Fthenaki, 2003; Conway et al., 2000). According to the latter view, inhibition must occur at an item-level akin to the effects observed in the think/no-think or retrieval-induced forgetting paradigms (e.g., Anderson, Bjork, & Bjork, 1994; Anderson & Green, 2001). In retrieval-induced forgetting, for example, highly interfering competing items suffered greater impairment than weakly interfering items (Anderson et al., 1994). If inhibition in directed forgetting occurs because List 1 items come to mind and should therefore be suppressed, then we should have seen more forgetting of SPTs than VTs in the list-method experiments, because SPTs are more likely to come to mind and therefore more likely to be inhibited than VTs. However, the results revealed an equivalent degree of forgetting for both VTs and SPTs, making the argument for an item-level inhibition in directed forgetting problematic.

If, on the other hand, inhibition occurs at the list-level, then inhibition of List 1 items should have led to reduction of proactive interference on List 2 (e.g., Bjork & Bjork, 1996). This is because inhibition is a single-process account that ties the costs and the benefits of directed forgetting to the same mechanism. In other words, inhibition of List 1 items should lead to the escape from proactive interference on List 2. However, the results did not support this prediction. In Experiments 1–3, VTs benefited on List 2, but SPTs did not, although both types of items suffered significant List 1 costs. Interestingly, when the two types of items were intermixed on the same list (Experiment 1), VTs showed both the costs and the benefits of directed forgetting, whereas SPTs showed only the costs. It is unclear why inhibition of entire List 1 differentially reduced proactive interference for some items on that list (e.g., VTs) but not for other items on that list (e.g., SPTs). One might attempt to explain the absence of benefits for SPTs by suggesting that VTs may be more sensitive to the release from interference than SPTs. However, prior research shows significant release from proactive interference of SPTs in Wickens, Born, and Allen's (1963) release-from-PI type of paradigm (Nilsson & Bäckman, 1991). Thus, the absence of directed forgetting benefits for SPTs is inconsistent with the inhibitory view.

An alternative inhibitory mechanism that might also produce List 2 advantage in the forget group is the *retrieval-induced forgetting hypothesis* of directed forgetting benefits. In the Remember group, List 1 items may be retrieved during List 2 learning, leading to retrieval-induced forgetting of List 2 items. Because the forget instruction discourages retrieval of List 1 items, List 2 recall will be higher in the forget group compared to remember group. If SPTs are less susceptible to retrieval-induced forgetting than VTs, this could explain the absence of directed forgetting benefits with SPTs but not VTs. List 1 SPTs might be less likely to be retrieved during List 2 learning than the corresponding VTs because SPTs are less likely to be processed in relationship to other SPT items (e.g., Engelkamp, 1986; Zimmer & Engelkamp, 1985, 1989). This could lead to less retrieval-induced forgetting in SPT than VT condition.

Whether SPTs are more immune to retrieval-induced forgetting than VTs remains an empirical question that requires future investigation. Two interesting observations from the current experiments highlight the need for such investigation. When the recall of VTs and SPTs is compared across Experiment 1 and Experiment 2 in the No-PI groups, it appears that VT recall was lower in the mixed lists (Experiment 1) than the pure lists (Experiment 2), whereas the opposite was true for SPTs. In other words, when VTs were competing with strong SPTs on the mixed lists, they suffered greater retrieval competition than SPTs, which appeared to have benefited from the presence of VTs in the same list. These results suggest that SPTs may be less susceptible to competition at retrieval than VTs. At the same time, another observation from the current experiments suggests the opposite. Namely, in Experiments 1 and 2, List 2 recall in the Remember group was much *lower* compared to the No-PI group in the SPT condition than the same comparisons in the VT condition. In the Remember group, List 2 was always retrieved after List 1, whereas in the No-PI group, it was retrieved immediately. It could be that retrieval of List 1 prior to List 2 created greater output interference in the SPT condition than in the VT condition, suggesting that SPTs are more susceptible to output interference. These hypotheses require additional research and are beyond the scope of current investigation.

We defer discussing the selective rehearsal mechanism because the role of rehearsal processes in directed forgetting becomes easier to evaluate when the list-method findings are considered in the context of the item-method findings.

Item-method directed forgetting

In Experiment 4, the item-method directed forgetting manipulation revealed greater forgetting for VTs than for SPTs, consistent with prior research (Earles & Kersten, 2002). This was observed regardless of whether actions were performed symbolically or with real objects. Comparing recall of TBF and TBR items to the baseline conditions in which the participants encoded all items using the remember cue allowed finer-grained analyses of the processes contributing to the item-method directed forgetting. Specifically, the analyses in the VT group showed that the item-method directed forgetting occurred because TBF items suffered and TBR items benefited compared to the baseline recall. Furthermore, the costs were much larger in the first quadrant, than in the remaining quadrants, where the costs became smaller, but the benefits remained throughout the list. The results in the SPT groups, on the other hand, showed no impairment for TBF items throughout the entire list, suggesting that SPTs did not suffer from the item-method directed forgetting. However, the TBR items benefited in the first quadrant of the list compared to the baseline recall, and this was found in both SPT groups, regardless of the object status. The reasons why VTs showed impairment but SPTs did not become evident when we inspect the shapes of the serial position curves in the baseline conditions for VTs and SPTs. Fig. 9 shows that the VT baseline curve has marked primacy, whereas SPT baseline curves do not. Given that rehearsal is heavily implicated in the primacy effect (e.g., Tan & Ward, 2000), terminating rehearsal of TBF items will have larger consequences for VTs than for SPTs, because the latter do not rely on rehearsal to the extent that VTs do. Indeed, retrospective verbal reports provided by the participants in Experiment 4 confirm that in the VT baseline conditions, they often processed several items together by rehearsing and inter-relating the actions to each other. In contrast, in the SPT baseline groups, the encoding strategies were predominantly item-specific, such as focusing on performing the current action. These reports are consistent with the item-specific processing account of SPTs (e.g., Kormi-Nouri, 1995; Mohr et al., 1989; Zimmer & Engelkamp, 1985). Overall, the impaired recall of TBF items in the VT group but not SPT groups underscores the role of selective rehearsal in the item-method directed forgetting, such that terminating rehearsal of TBF items hurt memory more for VTs than for SPTs.

Although there was no impairment of TBF items in the experimental SPT groups, there was a benefit for TBR items compared to the baseline recall as evidenced by the primacy effect in the TBR functions. At first, such benefits seem at odds with published literature documenting the insensitivity of SPTs to many encoding variables such as extra study time (Kausler et al., 1986), lengthening of inter-item intervals (Cohen, 1985), levels-of-processing (Zimmer & Engelkamp, 1999), intentional vs. incidental encoding (Kausler & Hakami, 1983; Kausler et al., 1986), and the lack of primacy in serial position curves (Seiler & Engelkamp, 2003; Zimmer et al., 2000). However, one variable that was shown to improve SPT recall was spacing of repetitions compared to performing the same action twice in a row (e.g., Cohen et al., 1987; Kausler et al., 1990). We explain the benefits to TBR items through a related mechanism – namely, through *study phrase retrieval* (Greene, 1989). Specifically, we argue that when participants received the forget cue, they used that time to covertly retrieve earlier actions. Indeed, retrospective verbal reports confirm that in response to the question "what did you do when the forget instruction appeared on the screen?" participants almost always reported thinking back and attempting to retrieve earlier actions.

It remains to be investigated why the benefits for SPTs were confined only to the beginning of the list, whereas the benefits for VTs were found throughout the entire list. It could be the case that during the forget cue, retrieval of some VTs triggered retrieval of other VTs because VTs had formed inter-item associations; in contrast, SPTs were encoded in more item-specific ways, and thus retrieval of SPTs during the forget cue did not cue other SPTs. This could explain why the benefits for SPTs were limited to fewer items than for VTs. Alternatively, it might take longer to retrieve SPTs than VTs, and therefore more VT items were covertly retrieved during the forget cue instruction than SPTs. Finally, SPTs are associated with poor source monitoring (Hornstein & Mulligan, 2004; Koriat et al., 1991). Therefore, if participants in the SPT groups were less effective in monitoring which actions were associated with the forget or the remember cue, they may be covertly retrieving fewer TBR actions compared to the VT group participants.

Comparing findings across directed forgetting methodologies

Across list-method and item-method directed forgetting procedures, VTs showed both the costs and the benefits. However, in the list-method, VTs showed approximately equivalent costs across serial positions, whereas in the item-method they showed greater impairment in the primacy region than in the remaining regions of the curve. Serial position analyses helped disambiguate the underlying mechanisms between these two methodologies, and they underscore that terminating rehearsal plays a larger role in the recall impairment with item-method than in the list-method designs. As for the benefits, VTs showed list-method benefits in the first two quadrants of List 2, whereas in the item-method, the benefits for TBR items were found throughout the list. These results suggest that the benefits in the list-method and the item-method come from two different sources. In the list-method, we attribute the benefits to encoding processes, such as the use of better study strategies, whereas in the item-method, the benefits arise from study phase retrieval.

The results with SPTs provide additional support for the argument that the two directed forgetting methods have different underlying mechanisms (e.g., Basden et al., 1993). In the list-method, SPTs showed the costs, but not the benefits, whereas in the item-method, SPTs showed the benefits, but not the costs. If selective rehearsal could explain the list-method directed forgetting, then we would expect to have obtained the same results for SPTs across both directed forgetting methods. However, we obtained dissociations between the costs and the benefits *across* directed forgetting methodologies with SPTs. Overall, these findings highlight the differences in the theoretical mechanisms involved in two directed forgetting methodologies. In addition, they also provide support for the two-factor rather than single-factor accounts of list-method directed forgetting because with SPTs we obtained dissociation between the costs and the benefits within list-method directed forgetting studies.

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Appendix

Stimulus Materials

See Tables A1 and A2.

Table A1
Action phrases used in Experiments 1 and 2.

Change the light bulb	Seal the envelope
Smoke a cigarette	Throw the dice
Iron the shirt	Open the umbrella
Aim the bow	Cool yourself with a fan
Pet the cat	Draw a circle
Light the candle	Close the book
Drive a car	Drink from a cup
Chop the onions	Cut the fabric
Put on the hat	Lock the safe
Inflate the balloon	Break a toothpick
Clip the nails	Smell the flower
Flip the coin	Peel the potatoes
Hammer the nail	Throw the ball
Crush the bug	Blow the whistle
Make a snowball	Remove the ring
Talk on the phone	Shake the bottle

Table A2
Action phrases used in Experiment 3 and 4.

Change the light bulb	Seal the envelope
Highlight the text	Throw the dice
Iron the napkin	Open the umbrella
Lift the weight	Cool yourself with a fan
Pet the cat	Wave the flag
Put the candle in the holder	Close the book
Staple the papers	Pour coffee into the mug
Grind some pepper	Put the key in the safe
Inflate the balloon	Break a toothpick
Look through the binoculars	Smell the flower
Sharpen the pencil	Peel the carrot
Flip the coin	Swing the racquet
Hammer the nail	Jingle the bell
Swat the fly	Measure the board
Water the plant	Try on the scarf
Talk on the phone	Shake the bottle

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