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Testing the context-change account of list-method directed forgetting: The role of retention interval

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ABSTRACT

People can voluntarily forget previously studied material when cued to do so. Such directed forgetting may arise because the forget cue induces a change in mental context, thus causing context-dependent forgetting. This context-change account predicts that both context-dependent forgetting and directed forgetting should be relatively transient and be reduced, if not eliminated, after prolonged retention interval. In each of two experiments, participants studied two lists of items and between study of the lists were asked to remember or forget the first list, or engage in an imagination task. After a short or a prolonged retention interval recall of the first list items was tested. Whereas imagination induced forgetting that was restricted to short retention intervals, the forget cue induced forgetting that was present regardless of retention interval. The finding challenges the context-change account and indicates that the effects of a forget cue and induced mental context change can be nonequivalent.

Introduction

At least to some degree, humans can control the contents of their minds and, for instance, voluntarily forget stored memory contents (for a review, see Anderson & Hanslmayr, 2014). One of the tasks developed to investigate voluntary forgetting experimentally is list-method directed forgetting (LMDF; Bjork, 1970). In this task, subjects study two lists of items and, between study of the two lists, are asked to remember or to forget the first list. At test, participants' memory for list-1 items is tested irrespective of original cuing. The typical result in this task is that forget-cued participants recall fewer first list items than remember-cued participants, which is referred to as list-1 forgetting. The finding is not a mere effect of demand characteristics, because the forgetting occurs even when participants are offered money for each single recalled item (MacLeod, 1999). It arises over a wide range of study materials, including verbal material (Geiselman, Bjork, & Fishman, 1983), pictures (Basden & Basden, 1996), autobiographical memories (Barnier et al., 2007), and even habits (Dreisbach & Bäuml, 2014), and a wide range of experimental settings (for reviews, see Bäuml, Pastötter, & Hanslmayr, 2010; MacLeod, 1998; Sahakyan, Delaney, Foster, & Abushanab, 2013).

Since the finding was first reported, several accounts have been suggested to explain the forgetting arising in LMDF. Currently, primarily two accounts are discussed in the literature, the one being the inhibition account and the other the (non-inhibitory) context-change account. The inhibition account assumes that forget-cued participants engage in inhibitory control processes on the list-1 items, which, at test, impair access to list 1 and thereby reduce recall of the first list items (Geiselman et al., 1983). In contrast, the context-change account assumes that, in response to the forget cue, participants deliberately change mental context, so that the context at test no longer

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matches the context during list-1 study and recall of the first list items is impaired (Sahakyan & Kelley, 2002; for further accounts of LMDF, see MacLeod, 1998, and General Discussion below).

Distinguishing between the context-change and the inhibition account of LMDF

Over the years, a number of findings have been interpreted as specific support for each of the single accounts. For instance, the finding that divided attention during list-2 encoding can reduce or even eliminate list-1 forgetting has been regarded as evidence for an inhibitory control process that is active during list-2 encoding and requires cognitive resources to reduce interference from list-1 items (Conway, Harries, Noyes, Racsmany, & Frankish, 2000; Macrae, Bodenhausen, Milne, & Ford, 1997). Similarly, the report of a causal relationship between neural activity in the dorsolateral prefrontal cortex during list-2 encoding and the forgetting of list-1 items has been interpreted as being indicative for inhibitory action (Hanslmayr et al., 2012). In contrast, the finding that list-1 forgetting is typically absent in item recognition (e.g., Geiselman et al., 1983) but can be present on recognition tests that require greater reliance on contextual information (Sahakyan, Waldum, Benjamin, & Bickett, 2009) has been regarded as evidence for the context-change account, just like the finding of the elimination of the forgetting when categorized lists are studied and the category names of the studied items are presented as retrieval cues at test (Lehman & Malmberg, 2011). Although all of these findings may be interpreted in favor of the one account over the other, it is not always clear whether they can really provide such specific support (see also Sahakyan et al., 2013).

The question of whether the prior work demonstrated specific evidence for one of the two accounts of LMDF directly relates to the more basic question of whether the forgetting that arises in response to a forget cue in LMDF differs from the forgetting that, in a context-change paradigm, may arise when between study of two lists a change in participants' mental context is induced, for instance, by asking the participants to mentally walk through the house of their parents or describe what they would like to do if they were invisible (e.g., Jonker, Seli, & MacLeod, 2013; Pastötter & Bäuml, 2007; Sahakyan & Kelley, 2002). On the basis of the context-change account, which assumes that both forms of forgetting are mediated by mental context change, the two forms of recall impairment should not be different and no factors should exist that influence the one form of forgetting (e.g., directed forgetting) but not the other (e.g., context-dependent forgetting).

In recent years, several studies directly compared the effects of a forget cue and induced mental context change, reporting largely parallel effects. For instance, Sahakyan and Kelley (2002) reported that context reinstatement procedures at test can reduce the forgetting induced by a forget cue as well as the forgetting induced by mental context change. Bäuml and Samenieh (2012b) found preceding selective retrieval of some first-list items to reduce the forgetting of the remaining list items, both after a forget cue and induced context change. Furthermore, the two forms of forgetting have been found to be accompanied by similar serial-position curves for list-1 items (Sahakyan & Foster, 2009), depend both on working memory capacity (Delaney & Sahakyan, 2007), and emerge in the presence, but not the absence of list-2 encoding (Pastötter & Bäuml, 2007).

Indeed, to date only few studies point to possible experimental dissociations between the two forms of forgetting. One such dissociation may be a difference in neural activity arising in the two experimental situations. Employing the standard two-list task, Bäuml, Hanslmayr, Pastötter, and Klimesch (2008) and Pastötter, Bäuml, and Hanslmayr (2008) examined physiological activities after a forget cue versus induced mental context change by measuring electroencephalograms during list-2 encoding and analyzing subjects' oscillatory brain activity. They found the forgetting of list-1 items in LMDF to be reflected by a sustained decrease in phase synchronization in a certain frequency band (11–13 Hz), but found no evidence for such a decrease when the forgetting was induced by mental context change. Because phase synchronization between electrode sites is regarded a measure of the synchrony between distant neural assemblies (e.g., Lachaux, Rodriguez, Martinerie, & Varela, 1999) and coherent firing between distant neuronal populations has been regarded a mechanism subserving binding processes (e.g., Miltner, Braun, Arnold, Witte, & Taub, 1999), the decrease in phase synchronization could reflect the unbinding of list-1 items and the inhibitory deactivation of the retrieval routes to list-1 items (see also Hanslmayr et al., 2012). The reported difference in neural activity in the two situations thus may indicate that the effects of a forget cue and induced mental context change are indeed dissociable, at least neurally. Behaviorally, no clearcut evidence for a dissociation has arisen to date.

The possible role of retention interval to distinguish between context-dependent forgetting and directed forgetting

A particularly interesting factor to examine whether the effects of a forget cue and induced mental context change are behaviorally dissociable may be the retention interval between study and test. According to the context-change account of LMDF, which assumes that the forget cue creates mental context change, both context-dependent forgetting and directed forgetting should be reduced, if not eliminated, after prolonged retention interval (e.g., Sahakyan & Kelley, 2002). Mental context is known to fluctuate over time (e.g., Estes, 1955; McGeoch, 1932) and induction of a change in mental context between study of two lists will enhance such contextual fluctuation, causing the two lists to have a greater contextual disparity than in the absence of such change and impairing recall of the first list items, at least when testing occurs shortly after study. Importantly, however, because a prolonged retention interval between study and test will change the context sufficiently far away from the list contexts, the difference between the two list contexts may become relatively small with increasing retention interval and recall of the first list items will no longer depend much on the originally induced mental context change, i.e., the forgetting of the first list items will disappear (Divis & Benjamin, 2014; Mensink & Raaijmakers, 1988; Sahakyan et al., 2013; Sahakyan & Kelley, 2002).

In contrast to the context account of LMDF, the inhibition account of LMDF does not allow clearcut predictions on the role of retention interval in LMDF, although some expectation on the effects of retention interval in LMDF may arise if results on retrieval-induced forgetting [RIF] - the finding that selective retrieval of some studied items can impair recall of related items (Anderson, Bjork, & Bjork, 1994) - were generalized to LMDF. Like LMDF, RIF has been attributed to inhibition (e.g., Anderson, 2003; for alternative accounts, see Jonker et al., 2013; Raaijmakers & Jakab, 2013) and in both forms of forgetting some features of the forgotten items have been proposed to be disrupted (e.g., Anderson, 2005; Bjork, Bjork, & Anderson, 1998; Conway et al., 2000). Upon this common theoretical idea and the results of a recent large-scale meta-analysis, which shows that RIF can persist across delays of several hours or even days (see Murayama, Miyatsu, Buchli, & Storm, 2014),[1] one may expect that LMDF also persists with delay. Such expectation is not obligatory, however, because inhibition as suggested in LMDF and inhibition as suggested in RIF differ in conceptual detail and reflect context-based forgetting (LMDF) versus item-based forgetting (RIF; e.g., Anderson, 2005; Bjork, 1989), and the two forms of forgetting have been experimentally dissociated in a number of studies (see Bäuml et al., 2010; Bjork et al., 1998). Therefore, even if both RIF and LMDF were mediated by inhibition, they may well differ in the persistence of the forgetting.

To date, only few studies examined the role of retention interval in LMDF and after induced mental context change. Regarding the effects of induced mental context change, Divis and Benjamin (2014) examined how semantic generation of extralist items between the study of successively presented lists affects later recall of the first list items. Recall was tested after a short retention interval of 1 min between study and test (Experiment 1) and a prolonged retention interval of 15 min (Experiment 3). On the basis of the view that semantic generation can induce a change in participants' mental context (e.g., Jang & Huber, 2008; Pastötter, Schicker, Niedernhuber, & Bäuml, 2011) and context change does not induce lasting forgetting of first-list items (e.g., Mensink & Raaijmakers, 1988; Sahakyan & Kelley, 2002), the authors expected recall impairment of list-1 items after the short but not the prolonged retention interval. The results were consistent with the predictions, supporting the view that induced mental context change creates relatively transient forgetting.

To the best of our knowledge, there are six previous studies that addressed the role of retention interval in LMDF. These studies provide fairly mixed results. Two data sets indicate that LMDF may not persist with delay. The dissertation work by Liu (2001) applied regular word lists as study material and found that LMDF was intact after a short delay of 3 min, but was decreased after a prolonged delay of 22 min. However, the critical interaction of type of cue (remember, forget) and retention interval (short, long) did not reach significance, leaving it unclear whether list-1 forgetting was really reduced by delay. In another study, Shapiro, Lindsey, and Krishnan (2006) employed a more applied setting and investigated the potential role of LMDF for advertising. Participants studied a first list of product attributes relevant to shopping for a new notebook and then were asked to imagine that radical technological change had occurred, making it necessary to forget the first list and to memorize a second list with new product attributes. The results showed list-1 forgetting after a short delay of 3 min, but no forgetting after a delay of 18 min. However, because the procedure did not only include the presentation of a forget cue, but may additionally have included induced mental context change (see General Discussion), the results may reflect the effects of induced mental context change rather than the effects of the forget cue.

Contrasting with these studies, four other reports indicate that LMDF may persist with delay. Two published book chapters, containing brief descriptions of relevant experiments only, reported evidence that the forgetting of list-1 items can still be present, or even be numerically enhanced, after a retention interval of 20 min compared to an immediate recall condition (Basden & Basden, 1998; MacLeod, Dodd, Sheard, Wilson, & Bibi, 2003). Unfortunately, in both studies, no remember condition was included and all participants were cued to forget list 1 and remember list 2. Directed forgetting was inferred from subtracting recall of list-1 items from recall of list-2 items, a method that includes possible effects of the forget cue on both list 1 and list 2 and thus leaves it open to what extent the cue influenced list-1 recall in the single retention interval conditions. A study by Joslyn and Oakes (2005) examined directed forgetting of autobiographical events, using a 2-week diary paradigm. After the first week, subjects were asked either to forget the diary entries recorded during the first week or to remember them for a later test. At the end of the second week, after recording more diary events, a significant directed forgetting effect was observed for events from the first week. While the authors interpreted this finding as evidence for long-lasting directed forgetting of real-life memories, caution is warranted because no short-delay baseline was included in this design and the 1-week delay was filled with the encoding of the second "list" of events. Finally, applying word lists as study material, Abel and Bäuml (2013a) investigated the forgetting of first list items by varying whether recall occurred after a 20-min or a 12-h retention interval, the latter including either wakefulness or regular nocturnal sleep. Intact forgetting was found after both the 20-min and the 12-h wake delay, whereas a 12-h delay filled with sleep eliminated the forgetting. However, no immediate-recall condition was included, leaving it unclear whether the forgetting during the first 20 min after study was reduced.

Due to the many differences in methods and results, the findings from these six studies do not allow to draw firm conclusions on whether the forgetting in LMDF dissipates

[1] In Murayama et al.'s (2014) meta-analysis, RIF was found to persist across prolonged retention interval, though only when study materials do not consist of (related) text materials. Indeed, such text materials do not induce RIF after short delay and can even cause retrieval-induced facilitation after prolonged delay (see Chan, 2009; Chan, McDermott, & Roediger, 2006).

with time and whether it is present or absent after prolonged retention interval. In particular, because, in none of the previous studies, the forgetting as induced by a forget cue was directly compared to the forgetting as induced by mental context change, the results are effectively silent on whether directed forgetting and context-dependent forgetting differ in the persistence of the recall impairment.

The present study

The results of two experiments are reported designed to examine whether directed forgetting and context-dependent forgetting differ in the persistence of the induced forgetting of first list items, and whether directed forgetting is mediated by mental context change. In each experiment, the effects of a forget cue on the forgetting of first list items were directly compared to the effects of induced mental context change, after both a short and a prolonged retention interval. In both experiments, participants studied two lists of items and between study of the lists were asked to remember the first list (*remember cue condition*), forget the first list (*forget cue condition*), or imagine walking through their childhood homes (*imagination task condition*). After study of the second list, participants were tested on the first list items, after a short retention interval or a prolonged retention interval. Following prior work on the role of retention interval in context-dependent forgetting and LMDF (Basden & Basden, 1998; Divis & Benjamin, 2014; MacLeod et al., 2003; Shapiro et al., 2006), a prolonged retention interval of 20 min was employed in Experiment 1. Following other prior work on the role of retention interval in LMDF (Abel & Bäuml, 2013a), an even longer retention interval of 24 h was used in Experiment 2. According to the context-change account of LMDF, in both experiments the forgetting of list-1 items should be present after the short retention interval but be reduced, or even be eliminated, after the prolonged intervals. This pattern should arise regardless of whether the forgetting was induced by the forget cue or the imagination task.

Experiment 1

Method

Participants

144 students at Regensburg University participated in the experiment, with 24 participants in each condition. Mean age was 22.4 years (range 18–30 years). All subjects were fluent in German.

Material

Item material comprised two lists of items; sequence of lists was counterbalanced across participants. Each list consisted of 16 German nouns that were chosen so that the items in each list were unrelated and had unique initial letters.[2] Recent research that applied LMDF and imagination tasks showed that, in both tasks, recall of list-1 items in the remember condition can decrease and recall of list-1 items in the forget and imagination task conditions can increase with increasing output position at test, indicating that, in both LMDF and context-dependent forgetting, forgetting of list-1 items can grow weaker with increasing output position (Bäuml & Samenieh, 2010, 2012b). Thus, to reduce possible effects of output position and get more pure measures of LMDF and context-dependent forgetting, we decided a priori, before data collection began, to restrict analysis of recall to the first half of items at test. For this purpose, eight items were randomly chosen from each list. For each subject, these target items were always tested first at test, and analysis was restricted to this set of items (for a similar procedure, see also Abel & Bäuml, 2013a). For the sake of completeness, we provide mean nontarget recall and additional analyses for *all* list-1 items in Appendix A.

Design

The experiment had a 3 × 2 between-subjects design. The first factor was INSTRUCTION (remember cue, forget cue, imagination task). After list-1 study but before list-2 study, subjects were either asked to remember the first list, to forget the first list, or to engage in an imagination task. The second factor was DELAY (30 s, 20 min). Whereas one half of the subjects in each condition were asked to take the final test on the studied material after a short delay of 30 s, the other half of the subjects were asked to take the same test after having been distracted for 20 min.

Procedure

Study phase. Subjects consecutively studied the two lists of items. For each list, items were presented one at a time, in a new random order for each subject, and for 5 s each centrally on a computer screen. There were two study cycles for each list in order to avoid floor effects after the prolonged retention intervals (see also Abel & Bäuml, 2013a). Items were presented in a new random order on the second study cycle. When list 1 study was complete, subjects received either the forget or the remember cue for the first list, or they were asked to engage in an imagination task. In the forget condition, we simulated a software crash to make the coverstory more plausible that a wrong list had been presented (e.g., Abel & Bäuml, 2013a; Barnier et al., 2007). Subjects were asked to forget the first list and to focus on the list coming up next instead. Simulating the software crash and presenting the cover story took roughly 60 s. In contrast, in the remember condition, subjects were instructed to try to remember the first list for a later memory test. Subjects then counted backwards in steps of two from a three-digit number for 60 s before being asked to additionally memorize list 2. In the mental context change condition, subjects were asked to engage in an imagination task. They should imagine walking through their childhood homes and draw a sketch of the house (e.g., Sahakyan & Kelley, 2002). After 60 s, subjects additionally memorized the second item list. Thus, duration of between-list instructions was held constant between conditions and always filled an interval of roughly 60 s. Before the final test, all participants were asked to count backwards in steps of two for 30 s. In the

[2] The stimuli used in the present experiments are available on the authors' website: http://www.uni-regensburg.de/psychologie-paedagogik-sport/psychologie-baeuml/publications.

20-min delay condition, participants additionally engaged in several distractor tasks before taking the final memory test, like the connect-the-numbers test (Oswald & Roth, 1987) and the d2 test of attention (Brickenkamp & Zillmer, 1998).

Test phase. Before testing started, subjects who had received the forget cue were debriefed about the simulated software crash and were asked to try to recall as many of the first-list items as possible, irrespective of the previous instruction to forget the list. In all conditions, the eight target items of the first list were tested first, with the items' unique initial letters being presented as retrieval cues for 10 s each and in a new random order for each subject. Subjects were asked to try to complement the cues with previously studied items from list 1 and to write their answers on separate pages of a test booklet. Subsequently, the remaining list-1 items were tested as well.

At the end of the test phase, the list-2 items were tested in the same manner as the list-1 items. Indeed, the forget cue in the LMDF task has not only been shown to impair recall of first-list items, but to also enhance recall of second-list items (Bjork, 1970, 1972). However, prior work clearly indicates that list-2 recall results are often affected by preceding list-1 recall and, in many cases, preceding list-1 recall even eliminates list-2 enhancement (see Pastötter, Kliegl, & Bäuml, 2012). Because the present study concentrates exclusively on the forgetting effect of the first-list items, the focus of the analysis was on first-list items and possible enhancement effects on the second-list items were ignored in this manuscript. For the sake of completeness, a short summary of results for list-2 items is reported in Appendix B.

Results

Fig. 1 shows mean recall of target items as a function of INSTRUCTION (remember cue, forget cue, imagination task) and DELAY (30 s, 20 min). A 3 × 2 ANOVA showed a significant main effect of INSTRUCTION, $F(2,138) = 8.98$, $MSE = .04$, $p < .001$, $\eta^2 = 0.12$, indicating that, on average, target recall differed between the remember cue ($M = 56.8\%$), the forget cue ($M = 40.6\%$), and the imagination task conditions ($M = 49.7\%$). Furthermore, a significant main effect of DELAY emerged, $F(1,138) = 14.74$, $MSE = .04$, $p < .001$, $\eta^2 = 0.10$, with better target recall after the 30-s ($M = 55.0\%$) than the 20-min interval ($M = 43.1\%$). These main effects were accompanied by a significant interaction of DELAY and INSTRUCTION, $F(2,138) = 3.41$, $MSE = .04$, $p = .036$, $\eta^2 = 0.05$, indicating that delay affected target recall in the remember cue, forget cue, and imagination task conditions differently.

Indeed, planned comparisons demonstrated that, after the short 30-s delay, target recall was reduced in both the forget cue and the imagination task conditions relative to the remember cue condition (49.0% and 50.0% vs. 66.2%), $t(46) = 3.19$, $p = .003$, $d = 0.92$, and $t(46) = 3.22$, $p = .003$, $d = 0.93$, whereas there was no difference between the forget cue and the imagination task conditions, $t(46) < 1.0$, $p = .816$. Yet, further planned comparisons showed that, after the 20-min delay, target recall was reduced in the forget cue condition relative to the remember cue condition (32.3% vs. 47.4%), $t(46) = 2.51$, $p = .016$, $d = 0.73$, whereas there was no longer a difference in target recall between the imagination task and the remember cue conditions (49.5% vs. 47.4%), $t(46) < 1.0$, $p = .734$. Consistently, target recall in the forget cue condition was also impaired relative to the imagination task condition (32.3% vs. 49.5%), $t(46) = 3.25$, $p = .002$, $d = 0.94$.

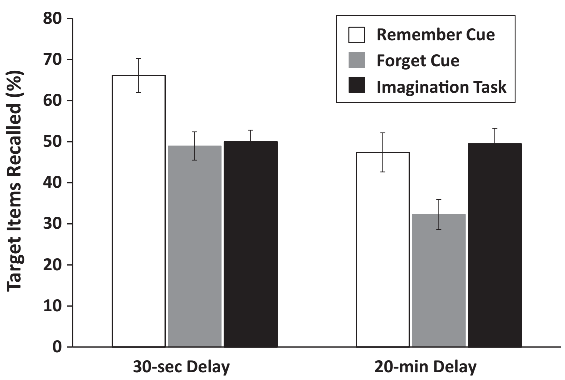

Fig. 1. Results of Experiment 1. Mean recall performance is shown as a function of between-list instruction (remember cue, forget cue, imagination task), and delay (30 s, 20 min). Error bars represent ±1 standard errors.

Discussion

The results of Experiment 1 replicate prior work by showing that, after short retention interval, both the presentation of a forget cue and an imagination task between study of two lists can impair recall of the first list items (e.g., Pastötter & Bäuml, 2007; Sahakyan & Kelley, 2002). Going beyond the prior work, the results also show that the effect of the imagination task is no longer present after a retention interval of 20 min, which is consistent with the theoretical view that mental context change creates relatively transient forgetting (e.g., Divis & Benjamin, 2014; Mensink & Raaijmakers, 1988; Sahakyan & Kelley, 2002). Most important, the results of Experiment 1 indicate that, in contrast to the effect of the imagination task, the effect of the forget cue on list-1 items can persist and be present after a retention interval of 20 min. This finding is the first demonstration of a behavioral dissociation between directed forgetting and context-dependent forgetting and suggests that the two forms of forgetting can be nonequivalent.

The goal of Experiment 2 was to replicate the observed dissociation between directed forgetting and context-dependent forgetting and extend it to a longer retention interval. Like in Experiment 1, participants studied two lists of items and between study of the two lists received either a remember cue, a forget cue, or engaged in an imagination task. Based on previous work showing that LMDF may be present for retention intervals of up to 12-h (Abel & Bäuml, 2013a), here we used an even longer retention interval of 24 h. We expected to replicate the results of

Experiment 1 and find transient forgetting with the imagination task but persistent forgetting in response to the forget cue.

Experiment 2

Method

Participants

216 students took part in the experiment. Mean age was 22.0 years (range: 18–34 years) and subjects were again fluent in German. There were 36 participants in each condition. Sample size was increased relative to Experiment 1, because, due to the increase in retention interval, we expected a higher degree of variance in the data of this experiment.

Material

New item material was compiled. It again comprised two lists of items; each list contained 16 unrelated German nouns with unique initial letters. Sequence of lists was counterbalanced across participants. Like in Experiment 1, eight items were randomly chosen from each list to serve as target items. For each subject, this set of target items was always tested first at test.

Design

The experiment had the same 3 × 2 between-subjects design as Experiment 1. With regard to the first factor of INSTRUCTION, subjects after list-1 study were again asked to either remember the first list, forget the first list, or complete an imagination task, i.e., imagine to walk through their parents' home. With regard to the second factor of DELAY, one half of the participants took the final test after a delay of 3 min, whereas the other half were asked to come back to the lab after 24 h to complete the same test. It was ensured that all participants completed the learning phase before 2 p.m. (see General Discussion).

Procedure

The procedure was almost identical to Experiment 1. In contrast to Experiment 1, however, all participants after list-2 encoding were asked to engage in an unrelated cognitive task for 3 min (i.e., the connect-the-numbers test, Oswald & Roth, 1987). Subjects in the short-delay condition were then immediately tested, whereas subjects in the long-delay condition left the lab and came back to complete the same test after 24 h.

Results

Fig. 2 shows mean recall of target items as a function of INSTRUCTION (remember cue, forget cue, imagination task) and DELAY (30 s, 24 h). A 3 × 2 ANOVA showed a significant main effect of INSTRUCTION, $F(2, 210) = 10.94$, $MSE = .03$, $p < .001$, $\eta^2 = 0.09$, suggesting different target recall rates in the remember cue ($M = 51.7\%$), forget cue ($M = 37.5\%$), and imagination task conditions ($M = 43.1\%$). Furthermore, a significant main effect of DELAY was observed, $F(1,210) = 15.80$, $MSE = .03$, $p < .001$, $\eta^2 = 0.07$, indicating

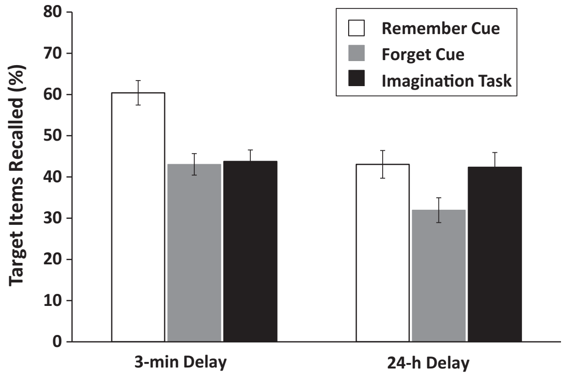

Fig. 2. Results of Experiment 2. Mean recall performance is shown as a function of between-list instruction (remember cue, forget cue, imagination task), and delay (3 min, 24 h). Error bars represent ±1 standard errors.

that target recall was higher after the short 3-min delay ($M = 49.1\%$) than after the longer 24-h delay ($M = 39.1\%$). In parallel to Experiment 1, the ANOVA again revealed a significant interaction between DELAY and INSTRUCTION, $F(2, 210) = 3.44$, $MSE = .03$, $p = .034$, $\eta^2 = 0.03$, suggesting that delay affected target recall in the remember cue, forget cue, and imagination task conditions differently.

Planned comparisons showed that, after the short 3-min delay, target recall was impaired in both the forget cue and the imagination task conditions relative to the remember cue condition (43.1% and 43.8% vs. 60.4%), $t(70) = 4.39$, $p < .001$, $d = 1.04$, and $t(70) = 4.09$, $p < .001$, $d = 0.96$, whereas the recall difference between the forget cue and the imagination task conditions was not significant, $t(70) < 1.0$, $p = .856$. After the 24-h delay, target recall was reduced in the forget cue condition, both relative to the remember cue condition (31.9% vs. 43.1%), $t(70) = 2.47$, $p = .016$, $d = 0.58$, and relative to the imagination task condition (31.9% vs. 42.4%), $t(70) = 2.23$, $p = .029$, $d = 0.53$. There was no difference in target recall between the imagination task and the remember cue conditions (42.4% vs. 43.1%), $t(70) < 1.0$, $p = .888$.

Additional analyses

Because proportion data as reported in Experiments 1 and 2 lie on a bounded scale and therefore are often not normally distributed, it can be inappropriate to run an ANOVA on this type of data. In response, it has repeatedly been recommended to transform proportion data before running an ANOVA and check whether such preceding transformations lead to the same ANOVA results as the analysis on the original proportion data. To address the issue, we reanalyzed our data using arcsin (McNicol, 1972; Sokal & Rohlf, 1981) and log-odds transformations (Johnson, 1949; Lesaffre, Rizopoulos, & Tsonaka, 2007; Winer, 1962) as well as a nonparametric method developed to examine interaction effects (the adjusted rank transform test, ART; for details, see Leys & Schumann, 2010). For all these analyses, we pooled the data of the two experiments to increase statistical power. The analyses showed that the critical interaction between instruction and delay did not only show up with the original proportion data, $F(2,354) = 6.63$, $MSE = .03$, $p = .001$, $\eta^2 = 0.04$, but was equally present when employing the arcsin transformation, $F(2,354) = 6.64$, $MSE = .04$, $p = .001$, $\eta^2 = 0.04$, the log-odds transformation, $F(2,354) = 6.50$, $MSE = .18$, $p = .002$, $\eta^2 = 0.04$, and the nonparametric ART test, $F(2,354) = 6.10$, $MSE = 10602.50$, $p = .002$, $\eta^2 = 0.03$. These results strongly support the results reported in the two single experiments above.

Discussion

The results replicate those of Experiment 1 by showing that, after a short retention interval, both the presentation of a forget cue and the engagement in an imagination task between study of two lists can induce forgetting of first list items. More important, the results also replicate those of Experiment 1 for the prolonged retention interval. Again, the forgetting as induced by the imagination task was absent after the longer delay, whereas the forgetting as induced by the forget cue was present. These findings again demonstrate that context-dependent forgetting is a relatively transient phenomenon, whereas directed forgetting can persist for quite a while. Like the results of Experiment 1, these findings indicate that directed forgetting and context-dependent forgetting can be nonequivalent.

General discussion

The results of this study dissociate forgetting as induced by a forget cue and forgetting as induced by mental context change. The forget cue caused forgetting that was present after both the two short retention intervals (30 s, 3 min) and the two prolonged retention intervals (20 min, 24 h), whereas the imagination task caused forgetting that was restricted to the two short delay conditions and did no longer arise after the prolonged retention intervals. Thus, while context-dependent forgetting was already absent after a delay of 20 min between study and test, directed forgetting emerged even after an interval of 24 h. This pattern arose although the two forms of forgetting were comparable in size 30 s and 3 min after study. These findings show that directed forgetting and context-dependent forgetting differ in the persistence of the induced forgetting, thus providing evidence that the two forms of forgetting are dissociable from each other.

Theoretical implications for LMDF accounts

The present findings challenge the context-change account of LMDF. According to this account, the forget cue in LMDF creates mental context change, enhancing contextual fluctuation between the two studied lists and thus impairing recall of the first list items, at least when testing occurs shortly after study. When the retention interval between study and test is increased, however, the context can be changed sufficiently far away from the list contexts that the difference between the two list contexts becomes relatively small and recall of the first list items does no longer depend much on the induced context change, i.e., the forgetting of first-list items disappears (Divis & Benjamin, 2014; Mensink & Raaijmakers, 1988; Sahakyan & Kelley, 2002). The present results on the effects of an imagination task on recall of first list items are consistent with this account, showing that the effect of induced mental context change can be present after short delay but be eliminated 20 min later. Critically, however, the results on the effects of the forget cue clearly challenge the account, showing that the effect of the forget cue differs from the effect of the imagination task and can be present with retention intervals of up to 24 h.

On a more general level, the present results also challenge *all* theoretical accounts that attribute LMDF and forgetting as induced by imagination tasks to a common single mechanism. In consequence, the results do not only challenge the context-change account of LMDF, but they also challenge a proposal made by Anderson (2005), according to which a common inhibitory mechanism may underlie the two types of forgetting. On the basis of the inhibitory account of LMDF, which claims that forget-cued participants engage in inhibitory control processes on the list-1 context and thus impair access to the list-1 items (Geiselman et al., 1983), Anderson suggested that inhibitory processes might also be recruited when participants engage in imagination tasks, which may occur when a new mental context is constructed in order to suppress interference from the preceding mental context. If so, LMDF and context-dependent forgetting should be equivalent, which, however, is not what the present results show.

With the challenge to all accounts that attribute LMDF and forgetting as induced by imagination tasks to a common single mechanism, the suggestion may arise that LMDF and context-dependent forgetting are mediated by different mechanisms and, for instance, the forgetting as induced by the imagination task is mediated by noninhibitory context change mechanisms, whereas the LMDF results are mediated by inhibition. Because the inhibition account is silent on the possible role of retention interval between study and test for first list forgetting, as emphasized above, such claim would need support from the literature on RIF, a form of forgetting that, like LMDF, has been suggested to rely on inhibition (e.g., Anderson, 2003) and, like LMDF in the present study, was found to persist across delays of several hours or even days (e.g., Murayama et al., 2014). However, although some prior work stressed both possible theoretical and empirical parallels between the two forms of forgetting (e.g., Conway et al., 2000), other studies pointed to important differences between LMDF and RIF, in both theory and findings (e.g., Anderson, 2005; Bäuml et al., 2010; Bjork et al., 1998; Raaijmakers & Jakab, 2013). Thus, to evaluate the suggested dual-mechanism account, more conceptual work on the inhibitory account of LMDF would be required in order to come up with a clearcut prediction on whether LMDF should be transient or lasting.

Another dual-mechanism explanation of the present results might be that the forgetting as induced by the imagination task is mediated by noninhibitory context change mechanisms, whereas the LMDF results are mediated by selective rehearsal. According to this older account of LMDF, participants stop rehearsal of list 1 items when they receive a forget cue, but keep on rehearsing these items if a remember cue is provided (Bjork, 1970, 1972). Although selective rehearsal has proven inconsistent with a number of results in the LMDF literature (see Bäuml et al., 2010; MacLeod, 1998; Sahakyan et al., 2013), it is consistent with the basic finding of list-1 forgetting in LMDF. Because effects of differential encoding typically persist over time (e.g., Abel & Bäuml, 2013b; Slamecka & McElree, 1983), the account may also explain the persistence of the forgetting effect in this study. Moreover, there is reason to expect that the forgetting effect may increase with delay (see MacLeod et al., 2003). In fact, whereas participants in the remember condition may rehearse list-2 and list-1 items during the retention interval, participants in the forget condition may selectively rehearse the list-2 items, anticipating that only those items will be tested later. Such strategy would be detrimental to recall of list-1 items in the forget condition, causing an increase in amount of forgetting when the retention interval is increased. With regard to the present experiments, however, only the results of Experiment 1 show a tendency for such an increase in forgetting, with proportional forgetting rates of 34% and 28% in the forget and remember conditions, whereas no such tendency arises in Experiment 2 (26% and 29%).[3]

The assumption of differential selective rehearsal during prolonged retention intervals may also motivate a third dual-mechanism explanation. According to this view, non-inhibitory context change may mediate both the forgetting that is induced by the forget cue and the forgetting that is induced by the imagination task, though only for short retention intervals. For prolonged retention intervals, additional first list rehearsal may arise in the imagination condition but not in the forget condition and thus cause the observed difference in the persistence of the forgetting effect.[4] However, because first list rehearsal should not be restricted to the imagination condition but arise also in the remember condition (Bjork, 1970, 1972), similar levels of time-dependent forgetting should arise in the two conditions. In contrast, the present results show time-dependent forgetting in the remember (and forget) condition(s) but hardly any time-dependent forgetting in the imagination condition, which challenges this dual-mechanism explanation of the present results. Future work is required to address the issue of possible dual-mechanism accounts in more detail and examine the possible contribution of rehearsal processes to the persistence of LMDF.

Relation to prior work on LMDF and imagination tasks

While the present results are the first to show that directed forgetting, but not context-dependent forgetting, persists for at least 24 h, single aspects of the results show agreement with other studies. For instance, the present finding that a forget cue and an imagination task cause comparable forgetting of first list items shortly after study agrees with the results of prior work reporting similar outcomes in the two types of tasks under such delay conditions (e.g., Delaney & Sahakyan, 2007; Pastötter & Bäuml, 2007; Sahakyan & Kelley, 2002). The present finding that the imagination task induces forgetting after a short delay but no longer after a 20-min delay parallels the recent finding that, in a multiple-list paradigm, the semantic generation of extra-list items between study of the lists induces forgetting in immediate recall but no longer when recall is delayed by 15 min (Divis & Benjamin, 2014). Finally, the finding of intact directed forgetting after a retention interval of 20 min agrees with a recent study, in which reliable forgetting of first list items was found after exactly the same retention interval (Abel & Bäuml, 2013a), and it also agrees with the conclusion drawn in other prior work that LMDF may persist with delay (Basden & Basden, 1998; Joslyn & Oakes, 2005; MacLeod et al., 2003; but see above). On a more general level, the present finding of a behavioral dissociation between directed forgetting and context-dependent forgetting also fits with the results from prior neurocognitive studies that indicated a neural dissociation between the two forms of forgetting (Bäuml et al., 2008; Pastötter et al., 2008).

While there is thus a lot of consistency of the present results with prior findings in the LMDF literature, there is also some disagreement. In particular, the present finding of lasting directed forgetting contrasts with the results of Shapiro et al.'s (2006) study. These researchers examined the role of LMDF for advertising, finding forgetting of first list items after a short delay of 3 min, but not after a delay of 18 min. In this study, participants studied a list of product attributes that could be used to evaluate and shop for notebook computers; they should then imagine that radical technology change had just occurred, try to forget the old attributes, and learn a list of new product attributes that supposedly were important to compare different brands of notebook computers in the future. A possible reason for the difference in results compared to the present study may be that the instruction that subjects should imagine radical technology change after first list study has induced mental context change on the side of the participants, making the additional forget instruction obsolete and the results mimic those from the present context change manipulation and the recent context change study by Divis and Benjamin (2014). Future work may thus repeat the experiments without any instructions to change mental context, to see whether directed forgetting in this type of situation is still transient in the absence of such an instruction (see also below). Applying regular word lists, the dissertation work by Liu (2001) also reported a numerical reduction of LMDF with delay and may therefore appear inconsistent with the present results. However, the reduction of LMDF with delay was nonsignificant in

[3] In their book chapter, MacLeod et al. (2003) mentioned results from a study in which they found numerically increased directed forgetting when the retention interval was increased. No exact recall rates and no statistical results were reported. Critically, there was no remember cue baseline condition in this study and directed forgetting was inferred from subtracting recall of (to-be-forgotten) list-1 items from recall of (to-be-remembered) list-2 items. As already mentioned above, this method includes possible effects of the forget cue on both list 1 and list 2 recall and thus leaves it open to what extent the cue influenced list-1 recall in the single retention interval conditions.

[4] This account was suggested to us by one of the reviewers.

this study, so that eventually the results are not inconsistent with the present findings.

At first glance, the present result that directed forgetting is observable after a retention interval of 24 h may also be interpreted as a contradiction to Abel and Bäuml's (2013a) report that directed forgetting is eliminated after a delay of 12 h when the delay is filled with nocturnal sleep. Since a 24-h delay typically includes some period of sleep, the present finding of intact forgetting after such a 24-h delay seems to disagree with the previous result. However, prior work on sleep-associated memory consolidation has shown that the sequence of sleep and wake intervals may be critical here, and that sleep effects emerge primarily if sleep follows closely upon encoding (e.g., Benson & Feinberg, 1977; Gais, Lucas, & Born, 2006; Talamini, Nieuwenhuis, Takashima, & Jensen, 2008). In Experiment 2, we controlled for this factor by asking participants to complete the study phase during the first half of the day (before 2 p.m.), thus making it unlikely that participants would go to sleep soon after encoding. Possible sleep effects on the forgetting should therefore not have played a major role in the present experiments, which reconciles the previous finding with the present results.

When comparing results across the prolonged retention interval conditions of Experiments 1 and 2, it becomes evident that there was only little additional time-dependent forgetting from the 20-min delay in Experiment 1 to the 24-h delay in Experiment 2, a finding we recently replicated in a different research context. Such pattern may appear surprising, because there is reason to expect a longer delay of 24 h to induce more context change than a shorter delay of 20 min, thus leading to poorer recall rates after the longer delay. At least two factors may have contributed to this surprising pattern. The first factor may be that subjects in the 20-min condition were simply fatigued at the end of a long session, which included a number of different cognitive tests (see Method of Experiment 1), compared to the subjects in the 24-h condition, who may have been relatively refreshed one day later. The second factor may be that, in the 20-min condition of Experiment 1, the test followed immediately upon the single distractor tasks, thus leaving not much room for preceding study context reinstatement. In contrast, in the 24-h condition, some opportunity for study context reinstatement may have arisen before the test started, for instance, when subjects were on their way back to the lab, mentally preparing for the (expected) final memory test. Like the possible difference in degree of cognitive fatigue, the possible difference in context reinstatement may have reduced the effect of retention interval, making recall rates after 24 h look similar to recall rates after 20 min. Future studies may examine the issue in more depth, trying to control possible effects of cognitive fatigue and differential reinstatement effects across different delay conditions.

Generalizability of results and directions for future research

LMDF experiments are often conducted with word lists, using single study cycles during learning and free recall at test, and employing both a remember and a forget condition (e.g., Sahakyan et al., 2013). Like most of the previous studies on the role of retention interval in LMDF (e.g., Basden & Basden, 1998; Joslyn & Oakes, 2005; MacLeod et al., 2003; Shapiro et al., 2006), the present study differed in single aspects from this "standard" LMDF task. Indeed, here we used two study cycles, rather than a single study cycle, during learning to avoid floor effects with prolonged retention intervals, and employed (selective) initial-letter cued recall, rather than (nonselective) free recall, to get relatively pure measures of the forgetting effects (see Method section of Experiment 1). Arguably, both deviations from the "standard" task may have influenced the results. For instance, mental context change may cause more durable forgetting if participants receive single study cycles only, because further study cycles may add new context features to the items and thus reduce the amount of context-dependent forgetting. Similarly, the free recall task may rely more strongly on context than does the initial-letter cued recall task and therefore enhance the forgetting effect.

Although LMDF research with short retention intervals does not provide evidence for a critical role of study cycles or recall format for the forgetting effect (Bäuml & Samenieh, 2012a; Sahakyan, Delaney, & Waldum, 2008), it may be hypothesized that such role may emerge after prolonged retention interval, when context features can play a more dominant role for recall. In such case, single study cycles together with free recall testing might enhance reliance on context features and thus, in contrast to the present study, may induce forgetting even after longer retention interval. However, there is no direct support for this hypothesis currently. Rather, Divis and Benjamin (2014) found no context-dependent forgetting after a delay of 15 min when using single study cycles and free recall at test, which is similar to the findings of the present Experiment 1 and may indicate that the present results do not depend much on the present study and recall conditions.

Future work on LMDF should nonetheless examine how general the findings reported in the present study are. Particularly useful information may emerge from research that simultaneously examined generalizability of the present results and generalizability of the partly conflicting results reported in Shapiro et al. (2006, see above). Such research may provide critical information on which factors eventually influence persistence of directed forgetting and thus inform researchers about how to revise current theories of LMDF in order to explain LMDF not only after short but also after prolonged retention interval. Above all, the present finding of a first behavioral dissociation between directed forgetting and context-dependent forgetting together with the recent evidence for a neural dissociation between the two forms of forgetting may motivate a more intense search for further dissociations, eventually leading to a more detailed picture of the possible similarities and differences between the two forms of forgetting.

Conclusions

This study is the first to show that directed forgetting can be behaviorally dissociated from context-dependent forgetting. Whereas LMDF was found to persist for retention intervals of up to 24 h, the forgetting as induced by mental context change did not even last for 20 min. These dissociations arose while both forms of forgetting were present and comparable in size for retention intervals of up to 3 min. The finding that directed forgetting remains intact with longer delay challenges the context-change account of LMDF (as well as all other current accounts of LMDF) and suggests that the effect of a forget cue and the effect of induced mental context change can be nonequivalent.

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Appendix A

A.1. Results for list-1 recall when target and nontarget items are included in the analysis

Mean recall performance for *all* list-1 items can be found in Table A1, separately for each condition of Experiments 1 and 2. For reasons of completeness, recall rates for list-1 targets (the half of the list that was always tested first and that constitutes the basis for all analyses in the main text) as well as list-1 nontargets (the second half of the list, not included in the main analyses) are provided.

For Experiment 1, a $3 \times 2 \times 2$ ANOVA with the factors of INSTRUCTION (remember cue, forget cue, induced context change), DELAY (30 s vs. 20 min) and LIST HALF (target recall, nontarget recall) revealed significant main effects of DELAY, $F(1,138) = 16.99,\ MSE = .07,\ p < .001,\ \eta^2 = 0.11$, and INSTRUCTION, $F(2,138) = 9.33,\ MSE = .07,\ p < .001,\ \eta^2 = 0.12$, but no interaction between the two factors, $F(2,138) = 2.13,\ MSE = .07,\ p = .122,\ \eta^2 = 0.03$. The ANOVA also showed a significant main effect of LIST HALF, $F(1,138) = 19.04,\ MSE = .02,\ p < .001,\ \eta^2 = 0.002$, reflecting generally lower recall of nontargets compared to targets (41.1% vs. 49.1%). No other interactions reached significance, $Fs < 1.0$, which shows that LIST HALF did not modulate the overall pattern of results.

A corresponding ANOVA for Experiment 2 revealed similar results, with significant main effects of DELAY, $F(1,210) = 20.77,\ MSE = .05,\ p < .001,\ \eta^2 = 0.09$, and INSTRUCTION, $F(2,210) = 11.42,\ MSE = .05,\ p < .001,\ \eta^2 = 0.10$, but no significant interaction between the two factors, $F(2,210) = 2.01,\ MSE = .05,\ p = .137,\ \eta^2 = 0.02$. As for Experiment 1, there was a significant main effect of LIST HALF, $F(1,138) = 36.90,\ MSE = .03,\ p < .001,\ \eta^2 = 0.15$, that again arose due to lower recall of nontargets compared to targets (34.2% vs. 44.1%). No other interactions were significant, $Fs \leqslant 1.38,\ ps \geqslant .254,\ \eta^2 \leqslant 0.01$, which again suggests that LIST HALF did not affect the overall pattern of results.

While no significant interaction between INSTRUCTION and DELAY arose in either of the two experiments when list 1 was analyzed as a whole, the numerical pattern was nevertheless very similar to the one reported for target items only in the main text. In Experiment 1, after the short 30-s delay, recall of (all) list-1 items was reduced after the forget cue (45.1%) and the imagination task (48.2%), as compared to the remember cue condition (60.7%), all $ts \geqslant 2.29$, all $ps \leqslant .028$. In contrast, after the longer 20-min delay, recall was reduced after the forget cue (27.9%) compared to the remember cue (44.0%), $t(46) = 3.19,\ p = .003$, but not after the imagination task (44.5%), $t(46) < 1.0$. Similar to Experiment 1, in Experiment 2, after the short 3-min delay, recall was lower in the forget cue (37.7%) and imagination task conditions (41.0%), as compared to the remember cue condition (53.5%), all $ts \geqslant 3.70$, all $ps < .001$. In contrast, after the

Table A1
Mean recall (and standard deviations) of *all* List-1 items in Experiments 1 and 2 as a function of between-list instruction (remember cue, forget cue, imagination task), and delay (short delay, long delay). Targets refer to the first tested half of list 1 (see also main text); nontargets refer to the second tested half of list 1 (not included in the main text); overall recall is collapsed across targets and nontargets of list 1.

	Experiment 1			Experiment 2		
	Remember cue	Forget cue	Imagination task	Remember cue	Forget cue	Imagination task
Targets						
Short delay	66.2%	49.0%	50.0%	60.4%	43.1%	43.8%
	(20.4)	(16.9)	(13.8)	(17.8)	(15.7)	(16.8)
Long delay	47.4%	32.3%	49.5%	43.1%	31.9%	42.4%
	(23.3)	(18.0)	(18.6)	(20.1)	(18.0)	(21.4)
Nontargets						
Short delay	55.2%	41.2%	46.4%	46.5%	32.3%	38.2%
	(28.3)	(22.3)	(21.0)	(20.4)	(21.6)	(20.5)
Long delay	40.6%	23.4%	39.6%	33.0%	25.7%	29.5%
	(24.8)	(16.2)	(26.5)	(22.6)	(20.5)	(21.0)
Overall						
Short delay	60.7%	45.1%	48.2%	53.5%	37.7%	41.0%
	(23.2)	(16.5)	(13.2)	(14.8)	(14.8)	(13.8)
Long delay	44.0%	27.9%	44.5%	38.0%	28.8%	35.9%
	(20.5)	(14.0)	(19.6)	(18.1)	(14.4)	(18.1)

Table B1
Mean list 2 recall (and standard deviations) in Experiments 1 and 2 as a function of between-list instruction (remember cue, forget cue, imagination task), and delay (short delay, long delay).

	Experiment 1			Experiment 2		
	Remember cue	Forget cue	Imagination task	Remember cue	Forget cue	Imagination task
Short delay	54.2% (25.8)	52.1% (20.8)	46.4% (20.9)	46.7% (18.5)	45.0% (20.9)	35.6% (25.3)
Long delay	39.3% (23.4)	35.4% (16.4)	37.8% (23.1)	32.5% (18.2)	31.3% (21.1)	30.2% (20.1)

24-h delay, recall was lower in the forget cue (28.8%) compared to the remember cue condition (38.0%), $t(46) = 2.39,\ p = .020$, but was not reduced in the imagination task condition (35.9%), $t(70) < 1.0$.

Thus, variance was enhanced and interaction effects were reduced in size by including the nontarget items of list 1 in the analyses, but the overall pattern remained the same. This reasoning is further supported by an additional analysis, in which statistical power was enhanced by pooling the data of Experiments 1 and 2. Doing so, the critical interaction between INSTRUCTION and DELAY became significant for *complete* list-1 recall as well, $F(2,354) = 3.56,\ MSE = .03,\ p = .029,\ \eta^2 = 0.02$. Moreover, the interaction effect stayed significant when log-odds or arcsin transformations were applied on the data or when employing the nonparametric ART test. The results from this analysis confirm the view that one may get more pure measures of LMDF and context-dependent forgetting when restricting analysis to the first half of tested items (see Method of Experiment 1 above).

Finally, notice that the smaller recall rates for (tested-last) nontarget items compared to (tested-first) target items likely reflect an effect of material rather than an effect of output interference. In fact, if there had been measurable effects of output order in the present experiments, they should have been different for the single instruction conditions, showing reduced recall for nontargets in the remember condition but enhanced recall of nontargets in the forget and imagination conditions (e.g., Abel & Bäuml, 2015; Bäuml & Samenieh, 2010, 2012b; Schlichting, Aslan, Holterman, & Bäuml, 2015). Typically, output order effects arise fairly gradually and depend on preceding retrieval of quite a number of items (e.g., Bäuml & Samenieh, 2010). Therefore, due to the relatively low number of successfully recalled targets in the present experiments, preceding target recall may not have been sufficient to measurably influence subsequent recall of the nontarget items.

Appendix B

B.1. Results for list-2 recall

Mean recall performance for the list-2 items can be found in Table B1, separately for each condition of Experiments 1 and 2. For Experiment 1, a 2×2 ANOVA with the factors of INSTRUCTION (remember cue, forget cue, imagination task) and DELAY (30 s vs. 20 min) revealed a main effect of DELAY, $F(1,138) = 13.39,\ MSE = .05,\ p < .001,\ \eta^2 = 0.09$, but no main effect of INSTRUCTION, $F(2,138) < 1.0$, and no interaction between the two factors, $F(2,138) < 1.0$. List-2 recall in the short delay condition was numerically lowest when participants had engaged in the imagination task (see Table A1), but there was no reliable difference between the three instruction conditions, $F(2,69) < 1.0$.

For Experiment 2, corresponding ANOVAs showed parallel results. A 2×2 ANOVA with the factors of INSTRUCTION and DELAY showed a significant main effect of DELAY, $F(1,210) = 15.36,\ MSE = .04,\ p < .001,\ \eta^2 = 0.07$, but no main effect of INSTRUCTION, $F(2,210) = 2.05,\ MSE = .04,\ p = .132,\ \eta^2 = 0.02$, and no interaction between the two factors, $F(2,210) = 1.02,\ MSE = .04,\ p = .361,\ \eta^2 = 0.01$. Again, recall in the short delay condition was lowest in the imagination condition, but again the difference was nonsignificant, $F(2,105) = 2.72,\ MSE = .05,\ p = .071,\ \eta^2 = 0.05$. Importantly, the pattern of results in each of the two experiments remained the same when log-odds or arcsin transformations were applied on the data before running the statistical tests.

Overall, these results are consistent with prior work, showing that preceding recall of first-list items often eliminates possible effects of the forget cue on recall of second-list items (e.g., Golding & Gottlob, 2005; Pastötter & Bäuml, 2010; Pastötter et al., 2012; Sahakyan & Foster, 2009). Indeed, recalling list 1 items first may reinstate the list's interference potential in the forget and imagination conditions and thus reduce subsequent list 2 enhancement (see Pastötter et al., 2012). Thus, to examine possible effects of retention interval on list-2 recall performance in the two forms of forgetting, fresh experiments would be required in which list-2 items are recalled first at test.

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