Journal of Experimental Psychology:
Learning, Memory, and Cognition
2012, Vol. 38, No. 5, 1309–1324

0278-7393/12/$12.00 DOI: 10.1037/a0027868

Metacognition Influences Item-Method Directed Forgetting

Nathaniel L. Foster and Lili Sahakyan
University of North Carolina at Greensboro

In 4 experiments, we examined whether metacognitive beliefs about item memorability influence item-method directed forgetting. In Experiment 1, participants studied loud and quiet items, which were subsequently cued as to-be-remembered (TBR) or to-be-forgotten (TBF). Typically, the volume of stimuli does not influence recall, although loud items are judged as more memorable than quiet items (Rhodes & Castel, 2009). In contrast, we found a recall advantage for loud items in directed forgetting, although this was observed for TBR items but not TBF items. The loud item advantage disappeared in Experiment 2, when we eliminated all TBF trials and instead inserted additional trials during which participants could engage in extra rehearsal of earlier presented items. In Experiments 3 and 4, a recall advantage for loud items was observed again when items were assigned a mixture of positive and negative values, but it did not emerge when items were assigned graded positive values. Overall, the results showed that the recall advantage for loud items emerges only in response to the need to forget some items. We propose 2 mechanisms to account for these results—either participants select to rehearse loud items as a controlled strategy that allows them to forget some items, or they have an unconscious preference for loud items that emerges only in response to the need to forget.

Keywords: metacognition, control processes, directed forgetting

Performance in many memory experiments is governed by the goal of retaining information for a future memory test. The ability to determine how well one has learned something and to use that information to inform future study decisions is a crucial part of an adaptive memory system (e.g., Dunlosky & Bjork, 2008; Metcalfe & Finn, 2008; Nelson & Narens, 1990; Son & Metcalfe, 2000). A wealth of research on study time allocation examined how people regulate their remembering by analyzing either the length of time people spend studying items, or examining which items people chose to restudy again in a second study session (see Metcalfe & Kornell, 2005; Son & Kornell, 2008). Many theories explain how people regulate their remembering, including the discrepancy-reduction account (Dunlosky & Hertzog, 1998; Dunlosky & Thiede, 2004; Mazzoni & Cornoldi, 1993; Thiede, 1999; Thiede & Dunlosky, 1999), the region-of-proximal-learning model (Kornell & Metcalfe, 2006; Metcalfe & Kornell, 2005; Son & Metcalfe, 2000), and the agenda-based model of regulation (Ariel, Dunlosky, & Bailey, 2009).

Similar to research on regulation of learning, there has been a wealth of research examining how people exert control over forgetting. One such phenomenon that received extensive attention is directed forgetting, which typically shows that people can make themselves forget recently learned information when instructed by an experimenter (e.g., R. A. Bjork, LeBerge, & Lagrand, 1968). Directed forgetting has been studied with a variety of stimuli; under many conditions of traditional memory paradigms of cognitive psychology; in different settings, including clinical, social, and legal environments; both with humans and with animals (for an integrative review, see Golding & MacLeod, 1998). Despite nearly four decades of research on this topic, the examination of metacognitive factors in directed forgetting is in its infancy. Recently, Friedman and Castel (2011) examined the role of monitoring in directed forgetting and showed that people estimate that they will be less likely to remember an item following an instruction to forget compared with an instruction to remember that item, suggesting that they are aware of the detrimental effect of a forget cue. We suspect that not only can people monitor the consequences of the forget cue but that they also engage monitoring and *control* processes when they attempt the directed forgetting task, including determining whether to engage in directed forgetting in the first place. Forgetting deserves to be examined as a process separate from remembering (or failures of remembering), because framing instructions in terms of forgetting influences the way people approach a metacognitive judgment task (Finn, 2008; Koriat, Bjork, Sheffer, Bar, 2004). Thus, the metacognition research may overlook important mechanisms if it focuses strictly on remembering or if it treats forgetting as the opposite of remembering.

Directed forgetting is one form of forgetting, but unlike unintentional forgetting, which happens most of the time without much

This article was published Online First April 2, 2012.

Nathaniel L. Foster and Lili Sahakyan, Department of Psychology, University of North Carolina at Greensboro.

The reported studies are based on the four experiments of Nathaniel L. Foster's dissertation. We thank Peter Delaney, Mike Kane, Stuart Marcovitch, Dayna Touron, Doug Levine, and David Frank for their constructive comments during the presentations of this work. We also thank Jacob Negley, Kendra Gray, Gary Styles, Josh Perkins, Casey Kelly, Corey Nowlin, Simran Kaur, Paige Henline, Jason May, Mindy Sharpe, Nick Hiatt, Kia Vaughn, Beatrice Campbell, Kirstie Stefonik, Jackie Palmer, Ron Barron, and Sarah Moore for their assistance with data collection and scoring.

Correspondence concerning this article should be addressed to Nathaniel L. Foster, Department of Psychology, 296 Eberhart Building, P.O. Box 26170, University of North Carolina at Greensboro, Greensboro, NC 27402-6170. E-mail: nlfoster@uncg.edu

conscious control, directed forgetting requires the engagement of control mechanisms. In this article, we approach the directed forgetting task from the metacognitive framework of monitoring and control (e.g., Koriat, 2007; Koriat & Goldsmith, 1996; Nelson & Narens, 1990, 1994). We focus primarily on the item-method directed forgetting procedure, whereby participants are shown a series of items that are subsequently cued as to-be-remembered (TBR) or to-be-forgotten (TBF) on an item-by-item basis. This procedure produces a memory impairment of TBF items in recall and recognition tests, as well as implicit memory tests (for reviews, see Basden & Basden, 1998; E. L. Bjork, Bjork, & Anderson, 1998; MacLeod, 1998). It is generally agreed upon that directed forgetting in the item-method arises from processes operating during encoding (Basden, Basden, & Gargano, 1993; R. A. Bjork & Woodward, 1973; MacLeod, 1999; Taylor, 2005; Woodward & Bjork, 1971). When an item is presented, participants start to rehearse that item, and they will continue to rehearse it if a TBR cue follows it, but they will stop rehearsing the item if a TBF cue follows it. Thus, forgetting arises from terminating the rehearsal of TBF items. Some researchers have recently challenged this passive view of directed forgetting and have shown that the actual process of stopping rehearsal of TBF items involves the recruitment of inhibitory mechanisms (Fawcett & Taylor, 2008,2010; Hourihan & Taylor, 2006; Taylor, 2005; see also Zacks, Radvansky, & Hasher, 1996). For example, following the TBF cues, participants are slower to detect a secondary visual or auditory probe (e.g., Fawcett & Taylor, 2008, 2010), and they show a larger inhibition of return after the TBF cues (e.g., Fawcett & Taylor, 2010; Taylor, 2005), suggesting that active attentional mechanisms are recruited in item-method directed forgetting. Consistent with this claim, neuroimaging work has shown that intentional forgetting relies on a distinct network of brain regions compared with the forgetting that occurs simply from a lack of remembering (Wylie, Fox, & Taylor, 2008; see also Ullsperger, Mecklinger, & Muller, 2000).

Regardless of the mechanism responsible for item-method directed forgetting, we approach this task by considering the importance of two different goals that it simultaneously invokes—remembering of TBR items and forgetting of TBF items. We suggest that how people accomplish those two goals likely involves metacognitive processes. To accomplish the *goal of remembering* TBR items, people may use the TBF trials as an opportunity to engage in further processing of TBR items, and they do so for the sake of enhancing their memory of TBR items later on during the test. Examining which items people select to rehearse during the TBF trials could be informative for understanding control processes aimed at remembering. For example, will people be more likely to rehearse the items they believe are less memorable and therefore require additional rehearsal, or will they be more likely to rehearse the items that they believe are more memorable, because they think they will gain more by focusing their effort and energy on already memorable items? Thus, the process of deciding which items to rehearse during the TBF trials shares conceptual similarities with the study-time allocation decisions, and therefore, the models of self-regulation of learning might explain how people allocate their rehearsal to accomplish the goal of remembering TBR items.

In contrast, to accomplish the *goal of forgetting* TBF items, people may engage in selective rehearsal of other items during the TBF trials out of a desire to distract themselves from the item they are trying to forget. In other words, they may be rehearsing earlier TBR items during the TBF trials for the sake of ensuring the forgetting of the items they are told to forget (rather than for the sake of remembering those TBR items). This would imply that people engage in controlled process aimed at forgetting, and the type of items they select to distract themselves during the TBF trials could be influenced by beliefs regarding which items are better "blockers" of unwanted information.

Thus, the process of selective rehearsal invoked by the directed forgetting procedure can serve two different goals, which may be influenced by different metacognitive biases and beliefs. Behaviorally, however, this may lead to a distinction without a difference, because examining performance only in the directed forgetting group makes it difficult to disentangle the remembering component from the forgetting component, making it impossible to evaluate which goal was affected by metacognitive influences. Sahakyan and Foster (2009) recommended including a baseline group in the experiment, where all items are followed by TBR cues, and therefore, performance in this condition could only be governed by the remembering goal. Comparing the directed forgetting group and the baseline group would allow isolating the metacognitive influences on the forgetting goal separately from the remembering goal.

In addition to the control processes involved in the directed forgetting task, how well people monitor the status of their memory during the experiment could, in turn, influence how they exert control in directed forgetting. There is recent evidence showing reduced judgments of the likelihood of later recall (i.e., judgments of learning [JOLs]) following TBF trials compared with TBR trials, suggesting metacognitive sensitivity in the item method (Friedman & Castel, 2011). However, we suspect that if participants feel that they have not learned an item they are told to forget, they may be less likely to engage in directed forgetting because they do not think they will remember it to begin with. Thus, the degree to which people's monitoring captures how well they have mastered the information should have implications for directed forgetting performance.

One approach to implicating the role of metacognitive factors in directed forgetting is to find manipulations that affect people's beliefs about memory without objectively influencing memory. If greater directed forgetting is obtained in some conditions than in others, it could be directly traced to metamemory rather than objective memory differences. Rhodes and Castel (2009) had participants study a mixed list of items presented in loud and quiet volumes. Although people rated loud items as more memorable than quiet items by assigning them higher JOLs, they recalled both types of items equally well. Importantly, the mechanisms driving this illusion were shown to have an effect on control processes by influencing participants' future study decisions. When asked to select which items participants wished they could restudy, they were more likely to select quiet items than loud items.

Current Experiments

Borrowing the volume illusion reported by Rhodes and Castel (2009), we aimed to examine how beliefs in item memorability influence intentional forgetting. In Experiment 1 we exposed participants to a mixture of loud and quiet items, which were subsequently cued as TBR or TBF items. In the baseline group, all items received TBR cues. To preview the results, the directed forgetting group showed the same magnitude of impairment for both quiet and loud TBF items relative to the baseline group. In other words, there was no difference in recall of loud and quiet TBF items. Importantly, the directed forgetting group remembered a greater proportion of loud and quiet TBR items compared with the baseline group, but the enhancement was larger for loud TBR items. This finding implies that directed forgetting group selectively rehearsed earlier presented loud TBR items to a greater extent than quiet TBR items. We proposed two hypotheses to explain these findings. Either the participants were rehearsing loud TBR items in service of the remembering goal, or they were rehearsing loud TBR items as a strategy aimed at forgetting. The next three experiments were aimed at testing these hypotheses. Experiment 2 eliminated all TBF trials, and it contained additional trials during which participants could engage in extra rehearsal of earlier presented items. If we observe a loud item recall advantage in this condition, it would suggest that participants focus rehearsal on loud items in service of a remembering goal. However, if we fail to observe the effect, it would suggest that forgetting goal is critical in observing a recall advantage for loud items. Experiments 3 and 4 used a point value manipulation to test whether a forgetting goal or a prioritized remembering goal causes people to remember more loud items. Items were assigned either graded positive values or a combination of positive and negative values. After four experiments, we present the analyses of the output dynamics and conclude with the analyses of the verbal reports from all experiments.

Experiment 1

The purpose of Experiment 1 was to explore how a volume manipulation affects the directed forgetting task versus the remembering-only task. Although loud and quiet items should be remembered equally well when the instructions mainly emphasize remembering (e.g., Rhodes & Castel, 2009), instructions to forget may affect TBR and TBF items differently, depending on the mechanism underlying item-method directed forgetting and how metacognition interacts with this mechanism. If forgetting arises from a passive process of stopping rehearsal, loud and quiet TBF items should suffer equally. At the same time, recall of loud and quiet TBR items should not be different, because people should be rehearsing them equally, just like in a remembering-only task. If an active inhibitory mechanism targets individual items in directed forgetting, then loud TBF items might be forgotten more because they are perceived to be more memorable and thus might require more inhibitory efforts. In this case, recall of loud and quiet TBR items should be equal because the inhibitory mechanism will operate on loud TBF items only. Finally, a third possibility is that participants engage in an active forgetting process, but they do so by focusing rehearsal on the TBR items that they believe are more memorable as a strategy aimed at preventing encoding of TBF items. This should produce enhanced memory for loud TBR items compared with quiet TBR items, because participants may select to devote their rehearsal to items they believe are more memorable (i.e., loud TBR items) as a way of preventing encoding of TBF items. Recall of TBF items, however, should remain unaffected by volume because rehearsal will be focusing on loud TBR items only.

Method

Participants. Participants were 96 University of North Carolina at Greensboro (UNCG) undergraduates who participated for course credit.

Materials and design. The study list consisted of 32 medium-frequency unrelated nouns. Each item was assigned equally often to the TBF and TBR cue. It was also presented equally often in a quiet volume and in a loud volume. During the presentation, items within each list were randomized with the constraint that no more than three cues of the same type and no more than three items of the same volume could follow in a row.

List items were recorded using Audacity (http://audacity.sourceforge.net/). Each item was recorded once, and then two versions of each recording were created—a quiet version and a loud version. Each quiet item produced 50 dB of sound (e.g., a word spoken across a room), whereas each loud version produced 55 dB of sound (e.g., a word spoken in at point blank). The 5-dB increase is equivalent to an increase in the power ratio by a factor of 3.16, and it follows the three-factor increase in volume reported by Rhodes and Castel (2009).

The design of the directed forgetting group involved a Volume (quiet vs. loud) × Cue (TBF vs. TBR) repeated-measures design. In addition to the directed forgetting group, we also included a baseline group in which all quiet and loud words were followed by TBR cues (there were no TBF cues). The dependent measure of interest was the proportion of items correctly recalled, although we also collected and analyzed immediate JOLs. The primary reason for including the JOL stage was to ensure we replicate the findings of Rhodes and Castel (2009); however, the main goals concerned evaluating how the volume manipulation would influence recall.

Procedure. Participants were told they would be presented with a list of words to study for a later memory test. Before the study session, however, they listened to a practice trial of a single nonword spoken at the quiet and loud volumes. The volume levels were preset, and adjustments were made if a participant reported difficulty with hearing the quiet nonword. No participant reported difficulty hearing the quiet practice item. Participants then studied a list of 32 words presented over headphones at a rate of 5 s per word. A speaker icon appeared on the monitor for the entire 5 s to signify the study trial. Participants were then instructed to provide a JOL by indicating how likely they would be to recall that word later on, using a scale from 0 (*not likely at all that I will remember the word*) to 100 (*very likely that I will remember the word*). Participants were given 3 s to type each JOL into the computer, and they were encouraged to use the entire range of scale. The JOL entry appeared on the screen as it was entered and could be edited if a mistake was made. Next, a TBR or TBF cue appeared for 4 s. The TBR cues appeared in green-colored font and had a plus sign on either side of the word, whereas the TBF cues were in red-colored font and were flanked by minus signs. Sixteen items were followed by TBR cues, whereas the remaining 16 were followed by TBF cues. Participants were told from the outset of the experiment that their memory would be later tested only for TBR items but that they would not be tested for TBF items and that they could forget those words. Each item-JOL-cue trial was separated by a 1-s interstimulus interval.

A baseline group was included that followed the exact same procedures as the directed forgetting group, except that they never received the TBF cues. Like the directed forgetting group, the baseline group was told upfront that each word would receive either a TBR or TBF cue. In reality, however, only TBR cues followed each item's JOL trial.

After the study phase, participants engaged in a distractor task for 60 s, which involved writing down the names of as many United States that they could think of. Finally, a free recall test was administered in which participants were given 4 min to write down as many words from the list as they could remember. Participants were told to recall all studied words, including the ones they were told to forget. After recall, participants completed a brief post-experimental questionnaire designed to assess learning strategies, intentional forgetting strategies, and whether participants had a preference for rehearsing items of a certain volume. The two critical questions that we analyze in this article were the following: "What did you do during the time the forget cue (the word "forget" with the minus signs) was on the screen?" and "Did you try to remember (a) loud words more than quiet words, (b) quiet more than loud, or (c) did you try to remember the loud and quiet words to about the same extent?"

Results and Discussion

Recall. The recall rates for the baseline and directed forgetting groups across the volume and cue are displayed in Figure 1. Replicating Rhodes and Castel (2009), there was no difference in recall of loud and quiet items in the baseline group ($t < 1$).

To completely evaluate directed forgetting in the item-method directed forgetting design, we assessed the degree to which the TBF items suffered and the TBR items benefitted compared with an all-remember baseline group (see also, Sahakyan & Foster, 2009). We assessed these effects by comparing each item type in the directed forgetting group with the baseline group.

A mixed analysis of variance (ANOVA) on TBR items, using volume (quiet vs. loud) as the within-subject factor and group (directed forgetting vs. baseline) as the between-subjects factor, revealed that the directed forgetting group had greater recall (M = 0.47, SD = 0.15) than the baseline group (M = 0.32, SD = 0.15), $F(1, 94) = 24.59$, $MSE = 0.045$, $p < .001$. Additionally, there was a main effect of volume, $F(1, 94) = 10.06$, $MSE = 0.016$, $p < .01$, with better recall of loud items (M = 0.42, SD = 0.10) than quiet items (M = 0.36, SD = 0.19). Interestingly, there was a significant interaction, $F(1, 94) = 4.18$, $MSE = 0.016$, $p < .05$. Loud TBR items were recalled significantly better than quiet TBR items in the directed forgetting group, $t(47) = 3.29$, $p < .01$, but there was no difference between the loud and quiet items in the baseline group ($t < 1$). Therefore, compared with the baseline group, there was greater enhancement for loud TBR items (19%) than for quiet TBR items (11%) in the directed forgetting group.

We conducted similar analyses on TBF items to analyze the magnitude of directed forgetting impairment. The Volume (quiet vs. loud) × Group (directed forgetting vs. baseline) ANOVA on TBF items revealed that the directed forgetting group showed impaired recall of TBF items (M = 0.19, SD = 0.10) compared with the baseline group (M = 0.32, SD = 0.15), $F(1, 94) = 25.85$, $MSE = 0.031$, $p < .001$, for the main effect of group. The main effect of volume was not significant ($F < 1$), and neither was the Volume × Group interaction, $F(1, 94) = 1.03$, $p = .31$, suggesting that the magnitude of impairment was the same for the loud and quiet items.

JOLs. Table 1 shows the JOL values for quiet and loud items across directed forgetting and baseline conditions. Because TBR and TBF cues were presented after each JOL trial, they could not have influenced JOLs, and therefore, we left the cue factor out of the analysis. We included group as a factor in the analyses,

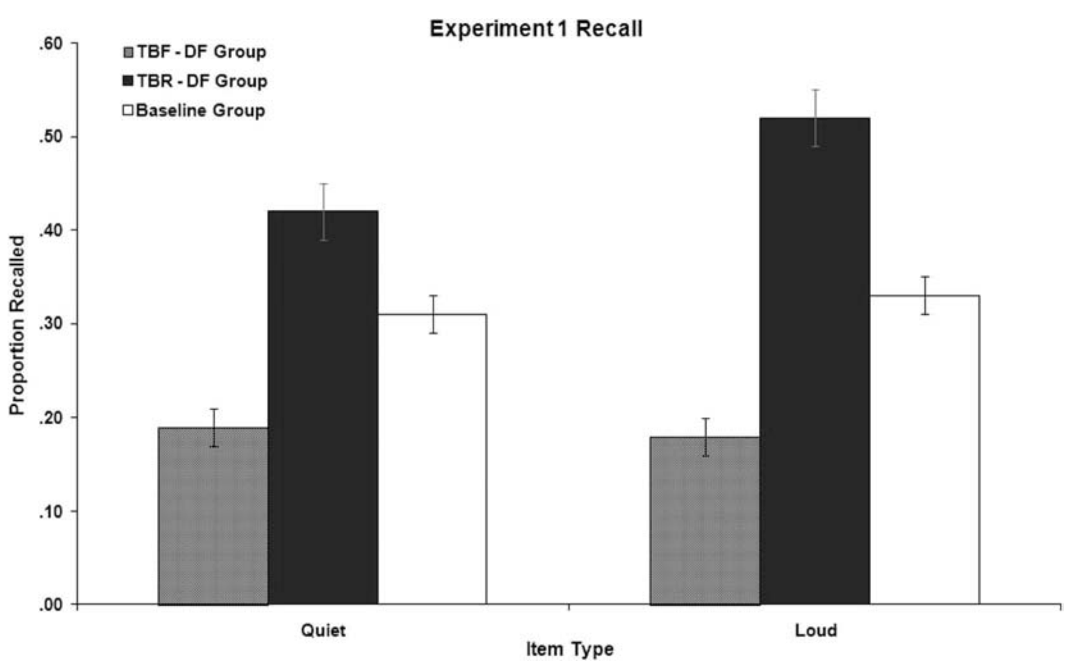

Figure 1. Mean proportion recalled as a function of group, cue, and volume in Experiment 1. TBF = to-be-forgotten; TBR = to-be-remembered; directed forgetting = directed forgetting. The error bars represent ± *SEM*.

Table 1
Mean Judgments of Learning by Experiment, Condition, and Volume

Volume	directed forgetting group	Baseline group
	Experiment 1	
QUIET	55.35 (2.55)	49.10 (2.69)
LOUD	65.10 (2.10)	60.93 (2.59)

Volume	Extra-rehearsal	Rehearse loud	Rehearse quiet	No-instruction
	Experiment 2			
QUIET	52.84 (3.32)	48.79 (3.26)	57.57 (3.73)	56.24 (3.28)
LOUD	60.40 (3.47)	68.37 (2.81)	58.84 (3.78)	62.64 (3.27)

	Experiment 3			
	Forgetting group		Prioritized remembering	
Volume	−5 items	+10 items	+5 items	+10 items
QUIET	47.10 (3.06)	47.48 (3.49)	47.08 (2.70)	47.03 (2.60)
LOUD	64.22 (3.57)	61.26 (3.29)	56.10 (3.14)	59.43 (2.91)

	Experiment 4			
	Forgetting group		Prioritized remembering	
Volume	−5 items	+10 items	+0 items	+10 items
QUIET	44.62 (2.76)	48.64 (2.67)	45.63 (2.47)	49.36 (2.83)
LOUD	59.40 (2.82)	61.90 (2.76)	62.49 (2.67)	63.44 (2.70)

Note. directed forgetting = directed forgetting. *SEM* appears in parentheses.

because the mere presence of the TBF and TBR cues may have changed the basis of JOLs and could have influenced the magnitude of the JOL effect compared with the baseline group. A Volume (quiet vs. loud) × Group (directed forgetting vs. baseline) mixed ANOVA on JOLs revealed only a significant effect of volume, $F(1, 94) = 53.65$, $MSE = 104.20$, $p < .001$. Loud items received higher JOLs ($M = 63.02$, $SD = 16.41$) than quiet items ($M = 52.23$, $SD = 18.35$). The effect of group was not significant, $F(1, 94) = 2.63$, $p = .11$, and neither was the interaction ($F < 1$). Thus, loud items were judged as being more memorable than quiet items, replicating the findings of Rhodes and Castel (2009), and this bias was unaffected by whether participants received a mixture of TBR and TBF cues or if they only received TBR cues.

Discussion. The baseline group remembered quiet and loud words equally well, replicating Rhodes and Castel (2009). In contrast, volume influenced recall in the directed forgetting group in unique ways. Although the recall of TBF items in the directed forgetting group suffered compared with the recall in the baseline group, quiet and loud items suffered to the same extent from directed forgetting. In contrast, whereas the recall of TBR items in the directed forgetting group was enhanced compared with the baseline group, loud TBR items were remembered better than quiet TBR items. Equivalent impairment of quiet and loud TBF items seems to suggest that forgetting was either caused by simply ignoring all TBF items or by engaging some active mechanism via rehearsing loud TBR items, which helped facilitate the forgetting of TBF items. We come back to the distinction between "ignoring to forget" and "actively rehearsing to forget" in Experiment 4.

The volume effect in TBR items in the directed forgetting group suggests two possibilities. Perhaps participants were using the TBF trials to selectively rehearse loud TBR items because they thought that loud items were easier to remember, and they therefore selected to devote their rehearsal to easy items (Dunlosky & Thiede, 2004; Nelson & Leonesio, 1988; Son & Metcalfe, 2000). Thus, the presence of TBF trials simply enabled them to engage in additional rehearsal. This implies that selective rehearsal of loud items was used as a strategy aimed at remembering as many TBR items as possible during the later test. Alternatively, participants in the directed forgetting group may have selected to rehearse loud items to a greater extent because they might have perceived loud items are better "blockers" of unwanted information. In other words, they engaged in selective rehearsal of loud items as a strategy aimed at forgetting TBF items. Experiment 2 was conducted to examine these hypotheses.

Experiment 2

If participants in the directed forgetting group engaged in selective rehearsal of loud items as a strategy aimed at remembering as many TBR items as possible, then why did we fail to observe a similar effect in the baseline group, which contained only TBR trials? The absence of this effect in the baseline group suggests that engaging in intentional forgetting is critical to producing a loud item advantage. However, the baseline group had twice as many items to keep in mind, compared with the directed forgetting group, which could use the TBF trials as an opportunity to rehearse earlier TBR items. Thus, it is possible that the observed effects in the directed forgetting group may have had nothing to do with intentional forgetting per se and may have been driven by the goal to remember as many TBR items as possible (just like in the baseline group); however, conditions for additional rehearsal may have been more ripe in the directed forgetting group.

If engaging in intentional forgetting is not critical in producing the loud item advantage, then we should observe a similar effect if we reduce the number of items participants had to remember for a later test, while also creating opportunities for additional rehearsal during study. Therefore, in Experiment 2, all TBF trials were replaced with an irrelevant task that did not involve memorizing. Participants were exposed to 16 TBR trials intermixed with 16 visual search trials (i.e., there was no directed forgetting manipulation in this experiment).

There were four groups, which differed with respect to the type of rehearsal instruction they received at the start of the experiment. The no-instruction group was not given any rehearsal instructions in order to evaluate if, in the absence of TBF trials, people would spontaneously choose to rehearse loud items provided they had opportunities to engage in additional rehearsal. Observing loud item advantage in the no-instruction group would confirm that intentional forgetting is not critical in producing this effect.

The second group was instructed to strategically rehearse those words that they think would improve their memory performance later (termed *extra-rehearsal group*). No mention was made which type of items they should rehearse. The extra-rehearsal group would provide even a stronger test of whether intentional forgetting is critical in producing loud item advantage. This group is meant to simulate the directed forgetting group because it is told to engage in rehearsal of earlier items without being told which items to rehearse; the main difference is that it has no TBF trials. If participants elect to rehearse loud items more, then we should see a loud item advantage in the extra-rehearsal group. Note that we might actually observe a quiet item advantage, implying that participants prefer to devote their rehearsal to more difficult items (e.g., quiet items). This prediction follows the results of Rhodes and Castel (2009), who found that participants indicated a preference to restudy quiet items more than loud items if given an opportunity to restudy.

The third group was told to rehearse the loud items during spare time in the experiment to see if people could actually distinguish between loud and quiet words during rehearsal (termed *rehearse-loud group*). We expected to observe loud item advantage in this group, pending people could differentiate between the two types of items during rehearsal. Finally, the fourth group was told to rehearse quiet items during spare time in the experiment (termed *rehearse-quiet group*). If we observe a quiet item advantage in this group, it would imply that participants could have selectively rehearsed quiet items in the directed forgetting group of Experiment 1 if they wanted to. However, it is possible that even if participants are told to rehearse quiet items, they might not be able to rehearse them as effectively because during rehearsal, loud items might come to mind more fluently than quiet items, making it more difficult to rehearse the quiet items. Thus, the rehearse-quiet group might not show a quiet item advantage, and such findings would constrain the interpretations of the directed forgetting effect obtained in Experiment 1.

Method

Participants. Participants were 128 UNCG undergraduates, who participated for course credit. None of these participants had been in the previous studies.

Materials. The materials were the same as in the prior experiments. The most important change involved replacing the TBF trials from the previous experiment with a visual search task that involved a conjunction search of colors and shapes. During the visual search trials, participants were shown a 6×6 matrix of 35 distractors and a single target item. The distractors consisted of a mixture of blue squares and red triangles, whereas the target was a red square. Participants were told to click on the red square as soon as they located it amidst the distractors. The arrangement of distractors and the position of the target among the distractors were randomized for each participant.

Procedure. Participants were told that they would hear words through their headphones and that they should attempt to remember them for a later memory test. Additionally, they were told that on some trials, they would not hear any words but would instead perform a visual search task. Two practice trials familiarized participants with the steps and procedures of the experiment.

At the start of the experiment some participants were told that whenever they had spare time during the experiment, they should engage in one of the following activities. Participants in the extra-rehearsal condition were told to "strategically rehearse those specific words presented earlier that you think will increase the number of words you will remember during the test." Participants in the rehearse-loud condition were told to "think back to the loud words that you heard from earlier and rehearse to yourself those loud items." Participants in the rehearse-quiet condition were told the same thing except that any mention of loud items in the instruction was replaced with quiet items. Finally, the no-instruction condition was simply told that there may be spare time between the trials and that they should get ready for the next trial.

The presentation order of word trials and visual search trials was randomized with the constraint that no more than three presentations of each trial type (word vs. visual search), and no more than two presentations of each item type (loud vs. quiet) occurred in a row. During the word trials, a loud or a quiet word was presented via headphone at a rate of 5 s following the procedures described in Experiment 1. Afterward, participants were given 3 s to type in their JOL response. A 4-s blank interval followed the JOL trials (in lieu of the TBR cue) to facilitate potential additional rehearsal. During the visual search trials, a matrix of shapes was presented for 5 s, and participants had to identify and click on the target. Following each visual search trial, just like in the word-trials, there was a 4-s blank interval to facilitate potential additional rehearsal. After all 32 trials, participants engaged in the same filler task and free recall tasks as those described in Experiment 1.

Finally, participants in the no-instruction group were asked the following: "After studying each word, you made a judgment about it and then there was a blank screen for about 4 seconds. What did you do during the period when the screen was blank?" In addition, both the no-instruction group and the extra-rehearsal group was given the second question from the questionnaire: "Did you try to remember (a) loud words more than quiet words, (b) quiet more than loud, or (c) did you try to remember the loud and quiet words to about the same extent?"

Design. The design involved a Volume (quiet vs. loud) × Instruction (rehearse-loud vs. rehearse-quiet vs. extra-rehearsal vs. no instruction) mixed factorial, where volume was varied within-subject and instruction was varied between subjects.

Results and Discussion

Recall. A Volume (quiet vs. loud) × Instruction (no-instruction, extra-rehearsal, rehearse-loud, rehearse-quiet) mixed-factorial ANOVA was performed on recall. The results are summarized in Figure 2. Neither the main effect of instruction, $F(1, 124) = 1.17$, $MSE = 0.048$, $p = .33$, nor the main effect of volume was significant, $F(1, 124) = 2.46$, $MSE = 0.038$, $p = .12$. However, there was a significant Volume × Instruction interaction, $F(3, 124) = 13.05$, $MSE = 0.038$, $p < .001$. Comparing the recall of loud and quiet items in each of the four conditions revealed that there was no difference in the no-instruction condition ($t < 1$), indicating that although participants had opportunities to go back and rehearse earlier presented items, they did not show any preference for either type of item. The same pattern emerged also in the extra-rehearsal group, where the recall of loud and quiet items was equivalent ($t < 1$). Although this group was instructed to rehearse earlier presented items during the spare time, it showed a 7% recall advantage compared with the no-instruction group (collapsed across volume), but the improvement was not statistically significant ($p = .11$). Because there was no significant difference in overall recall between the no-instruction group and the extra-rehearsal group, it suggests that the no-instruction group was most likely already rehearsing items during the spare time in the experiment even without being explicitly prompted to do so. Indeed, the verbal reports from the no-instruction condition revealed that 66% of the participants indicated rehearsing earlier presented items during the blank periods of the experiment (in response to the first question of the post-experimental questionnaire). In response to the second question of the questionnaire, only 6% of participants in the extra-rehearsal group reported preferring to rehearse loud items, with 13% reporting preference for quiet items, and the majority of participants (81%) reporting having "no preference for any type of item," $\chi^2(1, N = 32) = 33.25$, $p < .001$. These findings are informative because they suggest that people did not interpret the instruction to "rehearse the words that you think will help you remember the most" as an instruction recommending rehearsal of loud items. Because a large majority of people had no volume preference, it suggests that people do not choose to rehearse loud items as a way to help them remember the most.

In contrast to the no-instruction group and the extra-rehearsal group, the remaining two groups showed advantage on those specific items that they were instructed to rehearse. Specifically, loud items were recalled better than quiet items in the rehearse-loud condition, $t(31) = 5.25$, $p < .001$, whereas quiet items were recalled better than loud items in the rehearse-quiet condition, $t(31) = 2.64$, $p < .05$. Furthermore, in the rehearse-loud condition, loud item recall was significantly enhanced compared with the no-instruction group, $t(62) = 3.37$, $p < .01$, whereas the recall of quiet items went down numerically compared with the no-instruction group, although this effect was not significant, $t(62) = 1.79$, $p < .08$. Instructions to rehearse loud items may have led participants to somewhat neglect the quiet items during encoding,

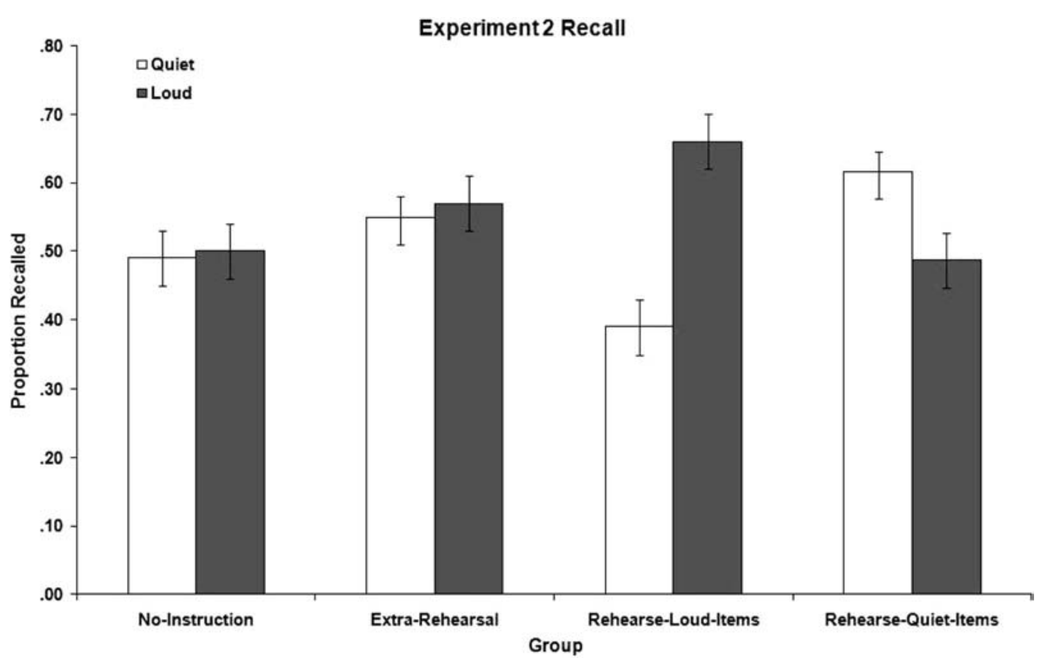

Figure 2. Mean proportion recalled as a function of group and volume in Experiment 2. The error bars represent ± *SEM*.

and there may have been a tendency to rehearse loud items at the expense of quiet items. However, caution is warranted with this conclusion, because the decline in quiet item recall was not statistically significant. Finally, in the rehearse-quiet condition, quiet item recall was significantly enhanced compared with the no-instruction condition, $t(32) = 2.50$, $p < .05$, whereas loud item recall did not suffer ($t < 1$). This effect suggests that participants benefited from rehearsing quiet items and that this did not come at the expense of loud items.

JOLs. A Volume × Instruction mixed-factorial ANOVA was conducted on JOLs. The results are shown in Table 1. There was a significant Volume × Instruction interaction, $F(3, 123) = 8.65$, $p < .001$. Separate comparisons of quiet versus loud JOLs in each instruction group revealed that the extra-rehearsal group gave higher JOLs for loud items than quiet items, $t(31) = 3.60$, $p < .01$, as did the rehearse-loud group, $t(31) = 5.36$, $p < .001$, and the no-instruction group, $t(31) = 3.00$, $p < .01$. The only group that did not show this effect was the rehearse-quiet group ($t < 1$), which rated the loud and quiet items as equally memorable. The lack of the volume effect in the rehearse-quiet group is more meaningful in light of the magnitude of the same effect in the rehearse-loud group (20%), which was substantially larger than in the no-instruction group (6%) and the extra-rehearsal group (8%). Thus, an instruction to rehearse loud items enhanced the volume effect, whereas instructions to rehearse quiet items eliminated this effect.

Discussion. Overall, the recall findings suggest that loud items have a recall advantage only when participants were explicitly told to rehearse the loud items. However, when left to their own devices, participants did not spontaneously engage in rehearsal of loud items. Furthermore, even when they were instructed to engage in extra rehearsal without specifying which type of items to rehearse, they still did not prefer to rehearse loud items. Interestingly, the rehearse-quiet group showed enhanced memory for quiet items, suggesting that participants' ability to rehearse quiet items was not thwarted by the fluency of loud items. Therefore, if participants wanted to rehearse quiet items during spare time, they could have done so in the remaining conditions. However, we never observed a quiet item advantage without specifically instructing participants to rehearse quiet items.

The JOL findings, with an exception of the rehearse-quiet group, all showed that participants thought that loud items would be remembered better than quiet items, replicating Rhodes and Castel (2009). Upon closer inspection, the volume effect in the rehearse-loud condition was greater than in the other conditions, suggesting that instructing participants to rehearse loud items had a reactive effect on their JOLs. Both loud and quiet items JOLs were affected by the rehearse-loud instruction, with loud items being judged as more memorable and quiet items being judged as less memorable compared with the no-instruction condition. In contrast, the rehearse-quiet condition rated the two types of items as equally memorable, and this was driven by the decrease of loud item JOLs, whereas quiet item JOLs were unaffected compared with the no-instruction group. This implies that the perception that loud items are more memorable is so robust that even the instruction to rehearse-quiet items cannot reverse this effect in favor of quiet items; it can, at most, eliminate it but not reverse it. Although JOLs were not the primary focus of investigation, the finding that the volume effect can be influenced by experimental instructions is intriguing and deserves to be examined in future research.

Overall, the results of Experiment 2 suggest that providing participants with extra rehearsal opportunities is not sufficient to produce a memory advantage for any type of item without directly instructing participants to rehearse either loud items or quiet items. This implies that when participants only have the goal to remember items (without the competing forgetting goal), they do not spontaneously rehearse loud items to a greater extent than quiet items even when opportunities to engage in rehearsal are created throughout the experiment.

Experiment 3

The results of the experiments presented thus far suggest that the forgetting component is important for producing the loud item advantage (Experiment 1), aside from explicitly instructing participants to rehearse loud items (Experiment 2). In Experiment 3, we aimed to rule out an additional alternative interpretation of the data that does not require an intentional forgetting component. Specifically, directed forgetting cues may stress the importance of some items over others, with participants perceiving TBR items as more important than TBF items. If this is the case, then they may adopt a rehearsal strategy that capitalizes on metacognitive cues, like volume, to help them perform the task of remembering the more important items. That is, people might rehearse loud volume items not as a way to perform intentional forgetting per se but, rather, as a way to help them focus on items that they believe to be more important, like TBR items. Therefore, we might observe a memory advantage for loud items even in a list where some items are deemed more important than others, without involving directed forgetting cues.

In Experiment 3, all TBR and TBF cues were replaced with point values, and participants were told that they would earn or lose points by remembering words. Half of the participants received only positive value points (+5 and +10), where +10 words signified the "more important" words and +5 words signified the "less important" words. We refer to this condition as the *prioritized remembering group*, because the goal of this group is only to remember the words, but some words are more important than others because they are worth more points. The point value manipulation was crossed with the volume manipulation. If importance is the critical variable driving the loud item advantage, then +10 loud words should be better recalled than +10 quiet words in the prioritized remembering group. This is because +10 items are more important items than the +5 items, and participants may selectively rehearse the loud important words to a greater extent.

The remaining half of the participants were assigned to the forgetting group, where they received a mixture of positive and negative value points (–5 and +10) crossed with volume manipulation. The +10 words in this condition signified the "more important" words, but –5 words were not merely "less important," they were actually detrimental to performance. Thus, participants would be better off forgetting the –5 words and remembering only +10 words, even though they were never explicitly told to forget the –5 point words. Functionally, the forgetting group in the current experiment resembles the directed forgetting group employed in Experiment 1, with –5 items being analogous to TBF items, and +10 items being analogous to TBR items. Therefore, we expected to obtain higher recall of +10 loud words over +10 quiet words in the forgetting group, similar to what we observed in Experiment 1. The critical predictions concern whether this effect should emerge only in the forgetting group or whether it would emerge also in the prioritized remembering group. If importance is the critical variable driving this effect and intentional forgetting is irrelevant, then +10 loud words should be better recalled than +10 quiet words in both groups. In contrast, if having to engage in intentional forgetting is critical, then +10 loud words should be better recalled than +10 quiet words only in the forgetting group, and there should be no such effect in the prioritized remembering group.

Method

Participants. Participants were 64 UNCG undergraduates, who participated for course credit. None of them had participated in previous experiments.

Materials. The materials were the same as in the prior experiments. Items were rotated through the different volume and value conditions. Presentation order of items was randomized with the constraint that no more than three items of the same volume occurred in a row, and no more than three values of the same type appeared in a row.

Procedure. The procedure was very similar to Experiment 1, except that instead of TBR/TBF cues, participants saw value points. They first studied items through headphones for 5 s and then performed a JOL for that word for 3 s. They were told that after making a JOL, a number would appear indicating how many points that word is worth if it is recalled during the test. Participants in the prioritized remembering group were told that, during study, words would receive point values of +5 and +10. Recalling a +5 word later on would add five points to their score, and recalling a +10 word would add 10 points to their score. Participants in the forgetting group were told the same thing about the +10 words. However, they were also told that some words would be followed by a –5 value cue and that if these words were recalled later on, five points would be subtracted from their final score. None of the participants in the forgetting group were explicitly told to forget –5 words. It was made clear to all participants that their goal was to earn as many points during the test as possible. Two practice trials familiarized participants with the steps and procedures of the experiment.

After studying the list, participants engaged in the same distractor and free recall tasks used in prior experiments. Importantly, before the test, the experimenter unexpectedly canceled the implications of point values (as is often done in directed forgetting procedure). All participants were told that every item would be worth +10 points and that they should try to recall all items regardless of the original value assigned to that item.

Finally, the post-experimental questionnaire was administered. All participants were asked the following: "What did you do when the +10 values would appear on the screen?" "What did you do when the –5 (or +5) values appeared on the screen?" and "Did you try to remember (a) loud words more than quiet words, (b) quiet more than loud, or (c) did you try to remember the loud and quiet words to about the same extent?"

Results and Discussion

Recall. The recall was analyzed following the same format as in Experiment 1. Our critical predictions concerned the recall of +10 items (i.e., important items) across the forgetting group and prioritized remembering group, and therefore, we focus our analyses on these items first. This analysis is functionally equivalent to the analyses on TBR items performed in Experiment 1. Critical for our hypothesis is whether we would obtain a recall advantage for +10 loud words over +10 quiet words in the forgetting group only or whether a similar effect would emerge also in the prioritized remembering group.

A mixed ANOVA on the recall of +10 items, using volume (quiet vs. loud) and group (forgetting vs. prioritized remembering) revealed a significant interaction, $F(1, 62) = 5.10$, $MSE = 0.023$, $p < .05$ (see Figure 3, right side). The group effect was not significant, $F(1, 62) = 2.37$, $p = .13$, and neither was the volume effect, $F(1, 62) = 1.20$, $p = .28$. To follow up the interaction, we compared the recall of loud and quiet items in each group. There was a recall advantage for loud +10 items over quiet +10 items that emerged only in the forgetting group, $t(31) = 2.15$, $p < .05$. There was no such difference in the prioritized remembering group ($t < 1$).

For completeness, we also analyzed the recall of +5/−5 items (i.e., less important/detrimental items) using mixed ANOVA, with volume and group as factors (see Figure 3, left side). This analysis is functionally similar to the analyses on TBF items performed in Experiment 1. It allows evaluating the extent to which recall of detrimental words (i.e., –5) in the forgetting group suffered compared with less important words (i.e., +5) in the prioritized remembering group. A Volume (quiet vs. loud) × Group (forgetting vs. prioritized remembering) mixed ANOVA on recall of –5/+5 items revealed neither a volume effect, nor an interaction effect (both Fs < 1). The overall recall was lower in the forgetting group ($M = 0.26$, $SD = 0.12$) than in the prioritized remembering group ($M = 0.32$, $SD = 0.14$); however, the main effect of group did not reach conventional significance, $F(1, 62) = 3.50$, $p = .07$.

JOLs. Table 1 shows JOLs for each group across the point value and volume manipulation. A Volume × Group mixed ANOVA on JOLs showed only a significant main effect of volume, $F(1, 62) = 65.82$, $MSE = 0.83.26$, $p < .001$. The group effect was not significant ($F < 1$), and neither was the interaction, $F(1, 62) = 2.18$, $p = .15$. Overall, loud items were given higher JOLs ($M = 60.26$, $SD = 16.71$) than quiet items ($M = 47.17$, $SD = 16.04$), replicating previous research.

Discussion. To summarize, the critical finding of Experiment 3 was that the recall advantage for loud items emerged only for +10 items and only in contexts where participants had to engage in intentional forgetting of half of the items. A loud item advantage was not observed in the prioritized remembering group where +10 items were intermixed with +5 items. Overall, the results in the forgetting group replicated previous findings of Experiment 1 in obtaining loud item memory advantage for important items.

The absence of this effect in the prioritized remembering group suggests that engaging in intentional forgetting is critical to producing a loud item recall advantage. However, a closer examination of recall in the prioritized remembering group suggests that participants may not have treated +10 words as more important

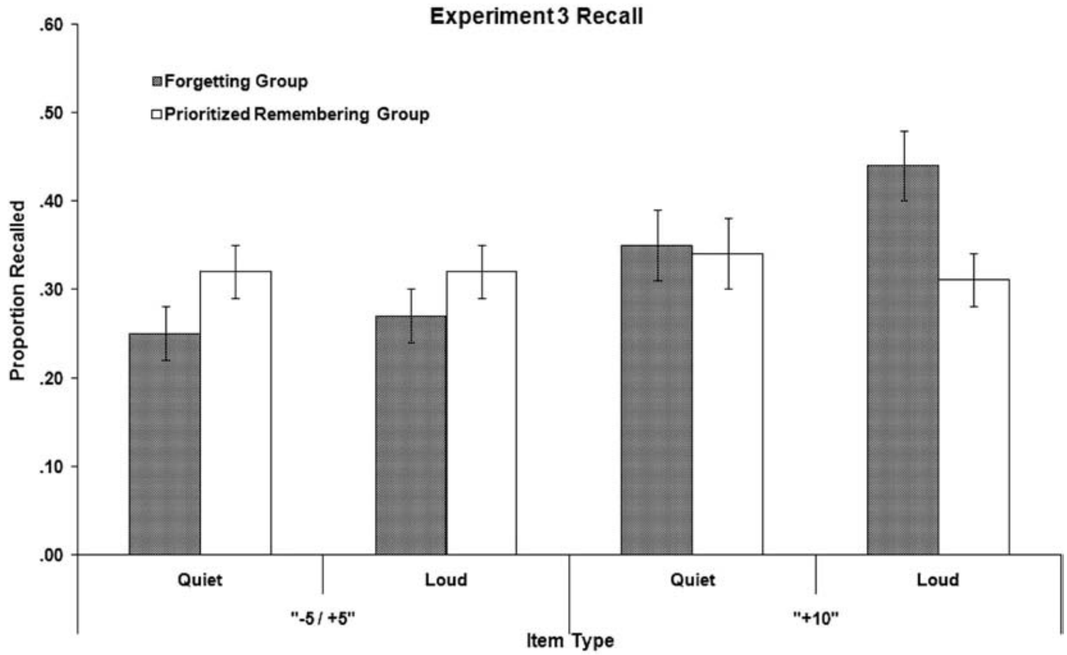

Figure 3. Mean proportion recalled as a function of group, item type, and volume in Experiment 3. The error bars represent ± *SEM*.

than +5 words because they remembered +5 and +10 words equally well. If the prioritized remembering group is analyzed by itself using a repeated-measures ANOVA, it does not show significant effect of value (all Fs < 1). Thus, the manipulation of item importance in the prioritized remembering group was less successful than in the forgetting group, where +10 items were recalled better than –5 items. Equivalent recall of +10 and +5 items in the prioritized remembering group is interesting considering that in previous studies, intermixing +5 and +10 values led to recall differences between the two types of items (e.g., Castel, Benjamin, Craik, & Watkins, 2002; Castel, Farb, & Craik, 2007; Friedman & Castel, 2011). One reason for the absence of the value effect in our experiment may have been crossing the positive value manipulation with the volume manipulation (in contrast to previous studies, where positive values were manipulated in isolation). The item's volume feature could have offset the influence of the positive value manipulation (e.g., a loud item followed by +5 points may appear as important as a quiet item assigned +10 points). Interestingly, research by Golding, Roper, and Hauselt (1996) found that people will often adopt a "betting" strategy when presented with an ambiguous cue. For example, when told that an item will have a 100% chance of being tested, participants will be more likely to devote additional processing efforts to that item. When an item has a 50% likelihood of being tested, participants do not devote half as much processing compared with a 100% item but, rather, make a decision to process that item all the way or not at all. It is possible, then, that participants in Experiment 3 tried to devote equal amounts of rehearsal efforts to +5 items as well as +10 items with the intention of maximizing the amount of points they could earn.

Experiment 4

The goal of Experiment 4 was to use a wider range of value points to more successfully manipulate importance in the prioritized remembering group. The experiment was similar to Experiment 3, except that we introduced a new point value manipulation. Specifically, in the prioritized remembering group, items were followed either by +10 points or +0 points; in the forgetting group, we used +10 and –5 points, as before. The selected +10/+0 values not only employ a wider range but they also create a situation where participants should neither forget the less important items (i.e., the +0 items) nor try to remember +0 items to the same extent as +10 words. Participants should try to rehearse +10 items to a greater extent than +0 point items, because they have no reason to do any further processing on the +0 items. Note that a +0 cue is not the same as a forget cue, because there is no penalty for remembering a +0 item. In contrast, the forgetting group should not only try to remember +10 items more than –5 items, but they should also try to forget the –5 items.

The predictions regarding this experiment are similar to Experiment 3. In addition, we anticipated obtaining a value effect in the prioritized remembering group, which should make the interpretation of results in the forgetting group even stronger.

Method

Participants. Ninety-six UNCG undergraduates participated for course credit. None of them had participated in previous experiments.

Materials and design. The materials, counterbalancing procedures, and the design were identical to those in Experiment 3.

Procedure. The procedures followed Experiment 3, except that in the prioritized remembering group, participants saw +0 value cues and +10 value cues. Finally, all participants completed the post-experimental questionnaire from Experiment 3, which was slightly adjusted to reflect the change in the point values used in Experiment 4.

Results and Discussion

Recall. We first analyzed the recall of +10 items (i.e., important items) using a Volume (quiet vs. loud) × Group (forgetting vs. prioritized remembering) mixed ANOVA, because our critical predictions concerned the recall of +10 items. The results are summarized in Figure 4. There was no main effect of volume ($F < 1$), but there was a significant main effect of group, $F(1, 94) = 5.24$, $MSE = 0.060$, $p < .05$, and a significant Group × Volume interaction, $F(1, 94) = 4.72$, $MSE = 0.020$, $p < .05$. The forgetting group remembered loud +10 items better than quiet +10 items, $t(47) = 2.05$, $p < .05$, but this difference did not emerge in the prioritized remembering group ($t < 1$).

For completeness, we used the same ANOVA to analyze the recall of +0/−5 items (i.e., less important/detrimental items). The main effect of volume was not significant ($F < 1$), and neither was the interaction effect ($F < 1$). There was, however, a significant effect of group, $F(1, 94) = 5.41$, $MSE = 0.030$, $p < .05$, with the recall of the +0 items being greater in the prioritized remembering group ($M = 0.25$, $SD = 0.14$) than the recall of –5 items in the forgetting group ($M = 0.19$, $SD = 0.11$). In other words, the forgetting group attempted to forget the detrimental items (i.e., –5 items), compared with the prioritized remembering group, which had less important items (i.e., +0 items).

Unlike in the previous experiment, the value manipulation led to recall differences in the prioritized remembering group. A repeated-measures ANOVA in the prioritized remembering group, using value and volume as factors confirmed a significant effect of value, $F(1, 47) = 8.78$, $MSE = 0.043$, $p < .01$ (Fs < 1 for the remaining effects). This result shows that the prioritized remembering group differentiated between the +10 words and +0 words, implying a successful manipulation of item importance.

JOLs. Table 1 shows the JOLs for Experiment 4. One participant's JOL data were lost because of a computer error. A Group × Volume mixed ANOVA on JOLs showed only a significant effect of volume, $F(1, 93) = 70.15$, $MSE = 147.18$, $p < .001$. Neither the group effect nor the interaction was significant (Fs < 1). Overall, loud items received higher JOLs ($M = 61.80$, $SD = 18.22$) than quiet items ($M = 47.06$, $SD = 17.60$).

Discussion. In the current experiment, we obtained recall differences between +0 and +10 value items in the prioritized remembering group, suggesting that participants perceived +10 words as more important than +0 words and rehearsed those to a greater extent. In light of these findings, we again replicated the previous results in the forgetting group. Loud +10 recall was greater than quiet +10 recall in the forgetting group, suggesting that when participants have to forget some of the items (i.e., –5 items), they prefer to remember loud +10 items over quiet +10 items. Consistent with previous experiment, volume did not influence recall of "less important/detrimental" items—that is, loud and quiet items that received +0 or –5 point values were remembered the same. Finally, participants rated loud items as more memorable than quiet items in both groups.

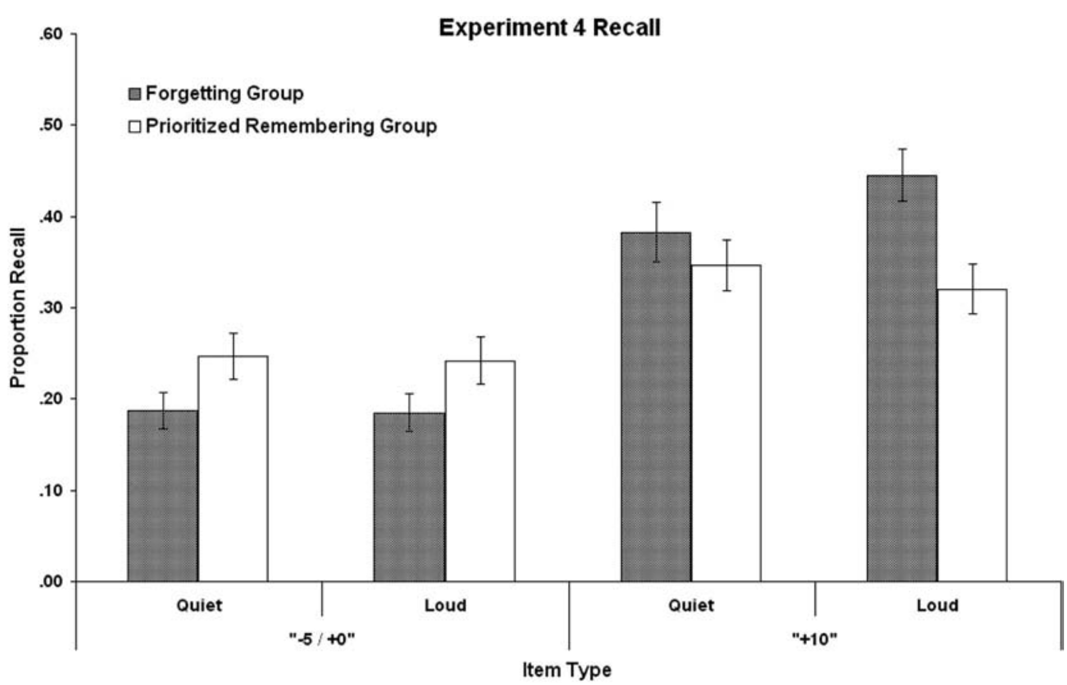

Figure 4. Mean proportion recalled as a function of group, item type, and volume in Experiment 4. The error bars represent ± *SEM*.

Another important finding of Experiment 4 is that when people engaged in intentional forgetting of –5 items, recall for those items was impaired compared with recall of +0 items in the prioritized remembering group. This finding has theoretical implications for item-method directed forgetting. If people performed directed forgetting by simply ignoring TBF items, then we would expect recall for –5 items to be comparable to +0 items, because people would ignore –5 items the same way they would ignore +0 items. However, we obtained impaired recall for –5 items compared with 0 items. It could be that the forgetting group participants were more rigorous in monitoring the source of each item during encoding in order to exclude –5 items from the rehearsal set. In contrast, participants in the prioritized remembering group may have accidentally rehearsed +0 items because there was no cost to remembering these items. Thus, differences in the quality of monitoring across the two groups might account for impaired recall of "detrimental" items. It could also be that intentional forgetting recruits more active inhibitory processes that are different from passive ignoring of TBF items (e.g., Fawcett & Taylor, 2008; Taylor, 2005).

Analyses of Output Dynamics

Thus far, we have interpreted the recall advantage of loud items over quiet items by evoking better encoding of loud items over quiet items in the intentional forgetting groups of Experiments 1, 3, and 4. However, it is possible that the disadvantage of quiet items reflects the influence of certain retrieval dynamics that favors loud items. For example, if loud items were processed more fluently in directed forgetting groups, then during free recall these items might be recalled first, causing output interference on the quiet items.

To test the output interference explanation, we evaluated whether the first recalled item was a loud item or a quiet item across the directed forgetting and baseline/remembering groups in Experiments 1, 3, and 4. The results are summarized in Table 2. In Experiment 1, the proportion of participants in the baseline group who output a loud item first was not different from chance ($t < 1$). The same pattern was observed for the directed forgetting group ($t < 1$). These results suggest that loud and quiet items were equally likely to be output first in both groups.[1] The same analysis conducted on Experiment 3 showed no difference between the loud and quiet items in the prioritized remembering group ($t < 1$) or in the forgetting group ($t < 1$). Finally, the same pattern was found in Experiment 4, where there was neither a tendency to output loud items first in the prioritized remembering group, $t(46) = 1.02$, $p = .31$, nor in the forgetting group, $t(46) = 1.32$, $p = .19$. Overall, people were just as likely to initiate recall with a quiet item as with a loud item, suggesting that the recall pattern in the directed forgetting conditions was not driven by the output interference.

Table 2
Percentage of Participants Initiating Recall With Loud Item in Experiments 1, 3, and 4

Group	Experiment 1	Experiment 3	Experiment 4
Intentional forgetting	55%	55%	60%
Baseline/remembering	56%	52%	58%

Analysis of Post-Experimental Questionnaire

The intentional forgetting participants recalled more loud TBR items than quiet TBR items, suggesting that they rehearsed loud items to a greater extent than the baseline conditions. Therefore, we expected to find a greater percentage of participants reporting rehearsal of earlier items in the directed forgetting groups than the remembering groups in response to the first question of the post-experimental questionnaire.

All forgetting groups across Experiments 1, 3, and 4 were combined to form a global-directed forgetting group ($N = 128$), and the prioritized remembering groups from Experiment 3 and Experiment 4 were combined to form a global-baseline group ($N = 80$). All of these participants had to indicate what they did during the time when the TBF cue (or –5 cue) appeared on the screen. Participants that reported rehearsing previously studied TBR (or +10) items were coded as using a rehearsal strategy, whereas those that provided any other type of response were coded as using a nonrehearsal strategy. The coding of the responses into the two strategy groups was done by the experimenters, and it was unambiguous (i.e., 100% agreement rate). The percentage of participants reporting a rehearsal strategy for Experiments 1, 3, and 4 is presented in Table 3. Below we report the combined analyses across all experiments.

Consistent with the predictions, a chi-square analysis revealed that more participants in the global-directed forgetting group (80%) reported rehearsing previous TBR items during TBF trials than did participants in the global-baseline group (43%), $\chi^2(1, N = 208) = 31.57$, $p < .001$. We also compared the global-directed forgetting group against the no-instruction group of Experiment 2. Because the no-instruction group had fewer items to keep in mind than the global-baseline groups, it had more conducive conditions for selective rehearsal. This group was asked to indicate what they did during the blank interval that was inserted after the JOL trial in lieu of the TBR cue. More participants in the global-directed forgetting reported rehearsing previous items compared with the no-instruction group (66%), $\chi^2(1, N = 160) = 3.24$, $p = .066$. The results may have fallen short of conventional significance because of the small size of the no-instruction group ($N = 32$). Overall, these findings suggest that the intentional forgetting groups engaged in the selective rehearsal of earlier items to a greater extent than did the remembering groups.

In the next step, we examined which type of items participants reported rehearsing more during the experiment in response to the second question of the post-experimental questionnaire. We evaluated both the frequency of responses across the global-directed forgetting and global-baseline groups and also how those re-

[1] In addition to analyzing the first response data, we also examined the output percentile scores, which were calculated following the procedures described by R. A. Bjork and Whitten (1974). The average output percentile score for loud items was not different from that of quiet items either in the directed forgetting group ($t < 1$) or in the baseline group, $t(47) = 1.44$, $p = .16$. This analysis reveals the same pattern as the first response analysis, and we therefore report the first response analysis for the remaining experiments.

Table 3
Percentage of Participants Who Reported Rehearsing Previous TBR Items During TBF Trials (Experiment 1), or Rehearsing +10 Items During −5/+5 Trials (Experiment 3) or −5/+0 Trials (Experiment 4)

Group	Experiment 1	Experiment 3	Experiment 4
Directed forgetting	94%	69%	75%
Prioritized remembering		22%	46%

Note. TBR = to-be-remembered; TBF = to-be-forgotten.

sponses compared against the actual recall. The global-directed forgetting group consisted of the same participants as in the previous analyses, but the global-baseline group included more participants, because with an exception of rehearse-quiet and rehearse-loud groups, all remaining participants were administered a volume-preference question in their questionnaire.

First, we calculated the difference between the recall of loud TBR/+10 items and the quiet TBR/+10 items, because these items showed significant volume effect in our experiments. Then we plotted the recall difference score by the type of reported volume preference (e.g., rehearsed loud items more, rehearsed quiet items more, or no preference) across the global-directed forgetting and global-baseline conditions. Figure 5 summarizes the findings. Positive scores on the vertical axis indicate recall advantage for loud items, whereas a score of 0 indicates equivalent recall of loud and quiet items. We statistically evaluated all of the six conditions by comparing the recall difference score with zero (to determine whether there was a significant loud item advantage), but we report only the significant findings in the text.

More participants in the global-directed forgetting group (28%) reported "rehearsing loud items more often" compared with the global-baseline group (15%), $\chi^2(1, N = 320) = 8.81$, $p < .01$. These reports were confirmed by the actual recall data, which showed that the global-directed forgetting participants had a significant recall advantage for loud items, $t(35) = 5.42$, $p < .001$. In addition, fewer participants in the global-directed forgetting group (59%) reported "no preference between loud and quiet items" compared with global-baseline participants (72%), $\chi^2(1, N = 320) = 5.42$, $p < .05$. Interestingly, despite indicating "no preference," the global-directed forgetting participants also showed significant recall advantage for loud items, $t(75) = 2.74$, $p < .01$, suggesting that they were not necessarily aware that they were rehearsing loud items to a greater extent. However, the recall advantage for loud items was much smaller among those indicating "no preference" compared with those reporting "preference for loud items," $t(110) = 2.21$, $p < .05$. Finally, there was no difference in the proportion of responses indicating "rehearsing quiet items more often" across the two global groups ($\chi^2 < 1$; 13% in global-directed forgetting group and 14% in global-baseline group).

General Discussion

Across four experiments we demonstrated a unique case of preferential remembering that occurred only under conditions of intentional forgetting or when participants were given explicit instructions to rehearse loud items. In Experiment 1, TBR recall in the directed forgetting group was greater than overall recall in the baseline group, but the effect was larger for loud items than for quiet items, implicating a metacognitive influence on recall of TBR items. Although the TBF recall in the directed forgetting group was lower compared with the recall in the baseline group, the magnitude of impairment was identical across quiet and loud items.

If participants in the directed forgetting groups were rehearsing loud items to a greater extent because they wanted to

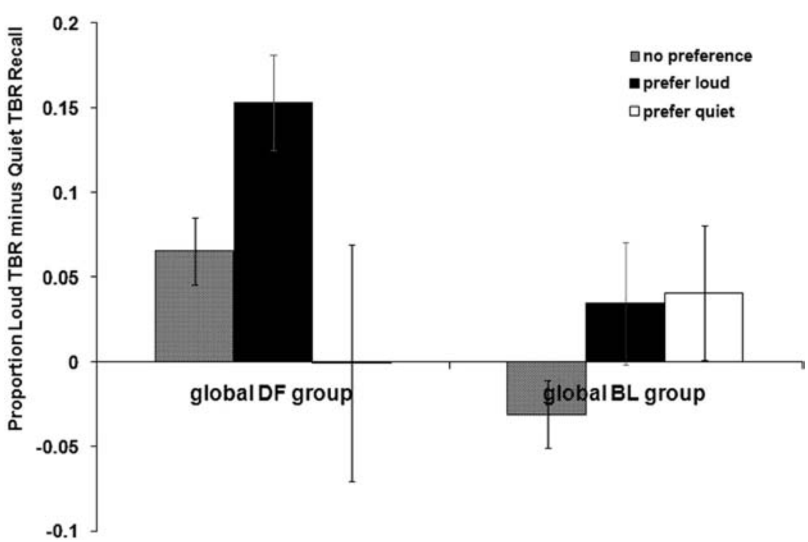

Figure 5. Recall difference between the loud and quiet TBR (or +10) words from Experiments 1, 3, and 4, plotted as a function of reported volume preference in post-experimental questionnaire in forgetting and remembering conditions. TBR = to-be-remembered; directed forgetting = directed forgetting. The error bars represent ± *SEM*.

improve overall recall of TBR items and therefore chose to focus their energy on the items that they thought were easier to remember (i.e., loud items), then the directed forgetting condition was more conducive for this type of strategy, because the TBF trials should have provided more opportunities to rehearse previous items. The baseline condition, on the other hand, had to remember twice as many items, and there were no TBF trials to help them do this. Experiment 2 demonstrated that when the TBF trials were replaced with an unrelated task, thus giving participants the opportunity to selectively rehearse earlier items, there was no memory advantage for loud items. Participants remember more loud items, however, when instructed to rehearse loud items at certain times during the study phase. These findings suggest that, aside from explicit instructions to rehearse loud items, engaging in directed forgetting is the only condition that produces the loud item advantage. Even still, when we instructed participants to strategically rehearse earlier items to enhance overall memory (without specifying which type of item), we still did not observe a loud item advantage, suggesting furthermore that participants do not selectively rehearse loud items as a way to help them remember the most items.

Experiments 3 and 4 provided additional evidence that engaging in intentional forgetting was necessary for obtaining a selective advantage of loud items. The loud item advantage was observed when positive value items were intermixed with negative value items but not when graded positive values were used. Specifically, loud +10 items were better recalled than quiet +10 items, but only when those +10 items were intermixed with –5 items in the list. We did not observe the same effect when +10 items were intermixed with +5 items (Experiment 3) or with +0 items (Experiment 4). These results suggest that if experimental manipulations merely emphasize some items over others in the context of remembering (without involving intentional forgetting), then the loud item advantage is not observed. Engaging in intentional forgetting of some items is critical for observing the loud item advantage.

Our analyses of output dynamics suggest that a loud item was just as likely to be recalled first during the test as a quiet item, and this was equally true in directed forgetting conditions and in baseline conditions. This suggests that the quiet item disadvantage in directed forgetting groups was not a result of output interference.

The verbal reports analyses revealed that during the experiment, directed forgetting participants tended to rehearse previous TBR items more frequently than did baseline participants. Importantly, more directed forgetting participants reported a preference for rehearsing loud items than baseline participants. Among those who reported a preference for rehearsing loud items, only directed forgetting participants actually nonetheless showed a significant loud item advantage, whereas the baseline participants did not. Finally, the majority of participants reported having no particular preference for either type of item, but the rates of such strategy were higher in the baseline groups than in the directed forgetting groups. Interestingly, despite reporting no preference for either type of item, the directed forgetting participants nonetheless showed a significant loud item advantage, whereas the baseline participants did not. To summarize, throughout all experiments and across all participants, only two subgroups of directed forgetting participants showed a loud item advantage in recall—those who reported rehearsing loud items during the experiment and those who reported no preference for either type of item in their rehearsal. Importantly, the loud item advantage was much greater among directed forgetting participants who reported a preference for rehearsing loud items, compared with directed forgetting participants who reported no preference for either type of item.

The verbal reports analyses suggest that there may be two different mechanisms contributing to the loud item advantage in directed forgetting. The first mechanism may indicate engagement of a controlled strategy aimed at forgetting. Many directed forgetting participants reported rehearsing loud items during the experiment, and they indeed showed the greatest loud item advantage. Thus, we propose that some directed forgetting participants could have selected to rehearse items that they rated as more memorable (i.e., loud items) as a deliberate strategy to help them engage in directed forgetting. Conceptually, this mechanism shares similarities with the mechanisms used to explain the list method of directed forgetting (Sahakyan & Kelley, 2002). In list method studies, participants often retrieve extra-experimental distracting thoughts in response to the forget cue as a strategy to help them forget the unwanted items (Foster & Sahakyan, 2011; Sahakyan & Kelley, 2002). The forget cue in the list method is presented only once after an entire list has been presented, and participants must forget all the items they have studied until that point. Thus, the list-method participants are more likely to retrieve other, unrelated thoughts from episodes prior to the experiment to forget unwanted items. In contrast, in the item-method studies, participants could retrieve the TBR items presented earlier as a way to prevent encoding of TBF items.

The second mechanism underlying the loud item advantage in the directed forgetting group could involve some type of unconscious priming favoring loud items. The verbal reports analyses showed that a subgroup of directed forgetting participants showed some disconnect between what they reported and what the actual recall data showed. Specifically, 59% of the directed forgetting participants reported rehearsing both types of items equally well, but the recall findings from those participants indicated that they remembered loud items better than quiet items. This suggests that some directed forgetting participants were not aware that they rehearsed loud items to a greater extent than quiet items during the experiment. The TBF cues may have unconsciously primed participants to prefer loud items. The exact reasons for such preference remain elusive and require further investigation. It could be that the notion of forgetting primes the idea of intensity because people may associate intense events with successful instances of intentional forgetting. For example, when people try to get something out of their mind, they may automatically seek environments full of intense energy, loud music, and bright lights, because such a highly intense atmosphere allows for good distraction, as it makes it hard to ruminate on the "problem" that one is trying to put out of mind. Loud items are more perceptually intense and salient, and people might prefer to rehearse those items because they tend to associate them with forgetting. Another possibility is that if loud items are processed more fluently during encoding, then perhaps people have a preference to rehearse more fluent items during the TBF trials. Why forgetting could unconsciously prime the preference for loud items among some participants remains to be investigated in future research. However, it is important to note that in our experiments, the unconscious priming mechanism did not lead to nearly as large of an effect as did the deliberate strategy to rehearse loud items. The verbal reports indicated that the loud item advantage was twice larger among those directed forgetting participants who reported preference for rehearsing loud items, compared with those who indicated no preference for rehearsing either type of item. This implies that the controlled strategy aimed at forgetting is more likely to produce a robust advantage for loud items than the unconscious priming mechanism.

Results of the current study have implications for theories of item-method directed forgetting. Prior research using the item method suggests that forgetting is guided by a rehearsal process where an item is first processed and rehearsed upon presentation. Rehearsal then continues for items that receive a TBR cue but stops for items that receive a TBF cue. Intentional forgetting was mostly believed to arise from a passive process of not rehearsing TBF information (e.g., R. A. Bjork, 1972; MacLeod, 1999). In contrast, Taylor (2005) and colleagues (Fawcett & Taylor, 2008, 2010; Hourihan & Taylor, 2006) have argued that forgetting arises from an active process that operates by inhibiting rehearsal of the TBF item. Wylie, Fox, and Taylor (2008) have identified brain regions that are active during trials associated with successful intentional forgetting later on, and they have shown that these areas are distinct from the areas associated with accidental/unintentional forgetting. We agree with the notion that forgetting of TBF items requires an active process that is different from merely ignoring TBF items during encoding. Indeed, the results of Experiment 4 showed that recall for –5 items was worse than that for +0 items, suggesting that a more active process is contributing to intentional forgetting than the passive ignoring of +0 items. Furthermore, recall in the directed forgetting groups was influenced by volume manipulation, whereas the same metamemorial information had no effect in the baseline groups. Overall, our findings highlight the role of an active forgetting process in the item method and suggest that this process may, ironically, be driven by selective remembering of earlier presented items.

The results of the reported experiments suggest that the agenda-based model of metacognitive control that was previously invoked to explain self-regulation of remembering can also be used to explain the self-regulation of forgetting. The efficiency of goal attainment has been emphasized as an important component of the self-regulation of learning (see Ariel et al., 2009; Thiede & Dunlosky, 1999). It may also be an important component in the self-regulation of forgetting. The role of an agenda in selective rehearsal could be to help determine what types of items should be rehearsed to meet the demands of the current task. When the goal is to remember all the items, rehearsal is allocated equally to both quiet and loud items. On the other hand, when a goal to forget is introduced, rehearsal efforts will focus on items that are perceived to be more memorable. These studies provide the first evidence for the role of metacognitive control in directed forgetting.

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Received June 9, 2011
Revision received February 14, 2012
Accepted February 16, 2012 ■