BRIEF REPORT

Listwise Directed Forgetting is Present in Young-Old Adults, but is Absent in Old-Old Adults

Alp Aslan and Karl-Heinz T. Bäuml
Regensburg University

People can exert control over the contents of their memory and can intentionally forget information when cued to do so. The present study examined such intentional forgetting in older adults using the listwise directed forgetting (DF) task. We replicated prior work by finding intact forgetting in young-old adults (up to 75 years). Extending the prior work, we additionally found forgetting to decline gradually with individuals' age and to be inefficient in old-old adults (above 75 years). The results indicate that listwise DF is a late-declining capability, suggesting a deficit in very old adults' episodic memory control.

Keywords: cognitive aging, episodic memory, intentional forgetting directed forgetting, cognitive control

Older adults often complain about their poor memory, continually expressing concerns about the adverse effects of their forgetfulness. However, there may be situations in daily life in which older adults also would wish to forget previous experiences, be it because the experience was annoying, like an unpleasant stay in hospital, or because the experience was ugly, like a heated quarrel with a daughter. Laboratory work has shown that people can exert control over the contents of their episodic memory and can intentionally forget "unwanted" memories when cued to do so. Corresponding evidence has arisen from studies using the (listwise) directed forgetting (DF) task. In this task, subjects study a first list of items and, after study of the list, receive an unexpected cue to forget the list again. Following presentation of a second list and a retention interval, a recall test for both lists is conducted. The typical finding is that, compared with remember-cued subjects, forget-cued subjects show improved recall of the second list (List 2 enhancement); in particular, they show reduced recall of the first list (List 1 forgetting), that is, efficient intentional forgetting (for reviews, see Bäuml, Pastötter, & Hanslmayr, 2010; MacLeod, 1998).

Over the years, a number of suggestions of how people may exert control over their memory in listwise DF have been offered. For instance, it has been suggested that forget-cued participants may selectively rehearse (to-be-remembered) List 2 items at the expense of (to-be-forgotten) List 1 items (Bjork, 1970), or may engage in active inhibitory processes, reducing the accessibility of the to-be-forgotten list (Geiselman, Bjork, & Fishman, 1983).

Others have suggested that participants may engage in diversionary thinking in response to the forget cue; such strategy may lead to forgetting by inducing a change in mental context and increasing the mismatch between the study and retrieval context (Mulji & Bodner, 2010; Sahakyan & Kelley, 2002). Although the single accounts differ in detail, they all emphasize that DF reflects self-initiated and effortful processes that require executive control (Conway, Harries, Noyes, Racsmány, & Frankish, 2000; Delaney & Sahakyan, 2007). Consistently, previous work found the forgetting to be eliminated when individuals' attentional resources were detracted by a secondary task (Conway et al., 2000), reported a positive relationship between amount of forgetting and individuals' working memory capacity (WMC; Aslan, Zellner, & Bäuml, 2010; Delaney & Sahakyan, 2007), and found the forgetting to be associated with increased activity in prefrontal cortical areas (Hanslmayr et al., 2012). Also consistent with the executive control view on DF is the finding of reduced forgetting in individuals supposed to suffer from deficits in executive control. These individuals include various clinical samples (Conway & Fthenaki, 2003; Racsmány et al., 2008; White & Marks, 2004), and (healthy) young children (Aslan, Staudigl, Samenieh, & Bäuml, 2010; Harnishfeger & Pope, 1996).

It has been proposed that older adults also show deficits in self-initiated and effortful executive control processes, and thus should show poor performance in the DF task (Braver & West, 2008; Craik, 1986; Hasher & Zacks, 1979; Lustig, Hasher, & Zacks, 2007; Zacks, Radvansky, & Hasher, 1996). In line with this view, an initial study by Zacks et al. (1996) indeed reported reduced forgetting in older adults, compared with young controls, suggesting that older adults may not be capable of intentional forgetting. Because interpretation of these data was complicated by a potential floor effect (see Zellner & Bäuml, 2006, for a discussion), Zellner and Bäuml (2006) revisited the issue and, across three experiments, found significant forgetting in older adults that was indistinguishable in amount from that of young controls. Sego, Golding, and Gottlob (2006) confirmed the finding. Highlighting

---

the role of strategic/metacognitive processes, Sahakyan, Delaney, and Goodmon (2008) also found equivalent forgetting in younger and older adults, at least when older adults' motivation to engage in the DF task was ensured by downplaying their typical concerns about their poor memory. Complementing the picture, a recent meta-analysis by Titz and Verhaeghen (2010) revealed significant forgetting in older adults.[1] The previous findings thus converge on the view that older adults may not have major difficulty with listwise DF and may show the same pattern of efficient forgetting as young adults. On a theoretical level, these findings indicate that the control processes mediating listwise DF may not decline much with age but may be relatively age invariant. Such conclusion might be premature, however.

Previous studies reporting age invariance in the DF task compared one (undifferentiated) group of older adults above 60 years (with a mean age of about 70 years) with one group of young adults, typically students in their early 20s (e.g., Sego et al., 2006; Zellner & Bäuml, 2006). Although such an approach is common in cognitive aging research, and may be appropriate for evaluating relatively "early-onsetting" cognitive changes that occur between young and old adulthood, it is not well suited for detecting changes that may emerge only later in life. Evidence for the existence of fairly "late-onsetting" cognitive declines comes from studies that, using a variety of cognitive tasks, reported only small or nonexistent differences between so-called "young-olds" (up to 75 years) and young controls, but often larger and significant differences between "young-old" and "old-old" adults (above 75 years; e.g., Bäckman & Karlsson, 1986; Kliegel & Jäger, 2006; Kvavilashvili, Kornbrot, Mash, Cockburn, & Milne, 2009; Persad, Abeles, Zacks, & Denburg, 2002; Schnitzspahn & Kliegel, 2009; Sullivan, 1999).

Intriguingly, there is evidence that (at least some) executive control processes may fall into this category of "late-declining" capabilities. For instance, Schooler, Neumann, Caplan, and Roberts (1997) found no difference in negative-priming performance between young adults and older adults with a mean age of about 70 years, and Kieley and Hartley (1997) reported similar results using the Stroop task. In the memory domain, Murray, Muscatell, and Kensinger (2011), across four experiments, found intact memory control in young-old adults using the think/no-think task, a task that measures an individual's capability to prevent unwanted memories from coming to mind (e.g., Anderson & Green, 2001; but see Anderson, Reinholz, Kuhl, & Mayr, 2011). In particular, Aslan and Bäuml (in press) replicated the previous finding of intact memory control in young-old adults' retrieval-induced forgetting (Aslan, Bäuml, & Pastötter, 2007; Moulin et al., 2002), a finding often attributed to executive control processes operating during selective memory retrieval (e.g., Anderson, 2003; Bäuml et al., 2010), but found no such forgetting for old-old adults. Together, these findings provide evidence for control processes that remain intact for most of the life span and decline only at a relatively advanced age, if at all. In particular, the findings raise the possibility that previous DF work examining mostly young-old adults might have missed a possibly present deficit in older adults' memory control.

This study reports the results of an experiment designed to reexamine whether or not (listwise) DF declines with advancing age. To address the issue, we employed a more fine-grained design than the previous DF studies, and examined DF performance in both young-old and old-old participants. We expected to replicate

previous work by finding intact forgetting in young-old participants (e.g., Sego et al., 2006; Zellner & Bäuml, 2006). In contrast, on the basis of the young-old/old-old distinction and the results from prior work indicating that (at least some) control processes decline relatively late in life span (e.g., Aslan & Bäuml, in press), an age-related decline in DF efficiency might arise, with largely reduced, if not eliminated, forgetting in the group of old-old participants.

Method

Participants

Thirty-two young-old (21 females; 60 to 74 years; $M = 68.1$) and 32 old-old (27 females; 75 to 96 years; $M = 84.2$) participants took part in the experiment. They were recruited from the community and tested individually. The two age groups performed comparably on the *Mehrfachwahl Wortschatz Intelligenztest* (MWT-B; Multiple Choice Vocabulary Intelligence Test; Lehrl, 2005), a German vocabulary test that measures crystallized intelligence (young-olds, 30.0; old-olds, 28.8; $p = .061$). The two age groups did also not differ on the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), which screens for cognitive impairment (young-olds, 29.2; old-olds, 28.6; $p = .247$) and their self-reported health status, as measured on a 6-point Likert scale (from $1 = very\ good$ to $6 = very\ poor$; young-olds, 2.6; old-olds, 2.6; $t(62) < 1$). However, there was the expected difference in the two age groups' WMC (Craik, Anderson, Kerr, & Li, 1995), with old-old participants showing significantly lower operation span scores (Turner & Engle, 1989) than young-old participants (12.6 vs. 19.3, $p = .002$, $d = .79$).

Materials

Four study lists were constructed, each list consisting of six unrelated common nouns drawn from the CELEX database (Duyck, Desmet, Verbeke, & Brysbaert, 2004).

Design and Procedure

The experiment had a mixed design with the between-participants factor *of age group* (young-old, old-old), and the within-participants factor of *cue condition* (remember, forget). For each participant, the experiment consisted of two blocks that differed in the cue that was provided. In each of the two blocks, participants studied two lists of items. The items of each list were presented on index cards at a 5-s rate in random order. Following presentation of the first list, the interlist cue was provided. In the remember condition, subjects were told that the preceding items were the first part of the study list and should be kept in mind while studying the second part. To ensure task engagement in the critical forget condition, we used a forget instruction that provided

---

[1] Titz and Verhaeghen (2010) reported significant forgetting in older adults, with the magnitude of the effect being slightly reduced compared with young adults ($p = .08$). Because the analysis included the Zacks et al. (1996) results, which showed reduced forgetting for older adults but suffered from a floor effect (see previous discussion), it may have overestimated the age-related difference.

a comprehensible rationale for the (unexpected) forget cue and placed high emphasis on the need to forget (the so-called "whoops" instruction; see Aslan, Staudigl, et al., 2010). Specifically, after presentation of List 1, the experimenter became flustered and pretended that she had made a mistake and presented a wrong list. She apologized and asked the participant emphatically to try his or her best to forget those "incorrect" items and to concentrate on the following list of items, which would be the correct one. After presentation of the second list and a 1-min irrelevant distractor task, a recall test for both lists was conducted. Participants were asked to recall List 1 first and List 2 second. They were given 1 min per list but were provided extra time when needed. The verbal responses were noted by the experimenter. After a short break, the second part of the experiment with the second cue condition started. The order of the remember and forget conditions was counterbalanced across participants, as was the assignment of the four lists to these two conditions (see also Bäuml & Samenieh, 2010, 2012; Zellner & Bäuml, 2006).

Results

Preliminary analyses revealed that counterbalancing did not affect the present pattern of results. Indeed, neither in the young-olds nor in the old-olds did order of cue condition (remember first vs. forget first) show a main effect or interaction effect with any of the other variables (all $ps > .170$), which is consistent with previous work (e.g., Aslan, Zellner, et al., 2010; Bäuml, Hanslmayr, Pastötter, & Klimesch, 2008).

Regarding List 1 recall (see Figure 1A), a 2×2 ANOVA revealed significant main effects of age group, $F(1, 62) = 4.084$, $MSE = 0.073$, $p = .048$, $\eta_p^2 = .062$, and cue condition, $F(1, 62) = 26.605$, $MSE = 0.034$, $p < .001$, $\eta_p^2 = .300$. These main effects reflect higher recall in the young-olds than the old-olds (43.8% vs. 34.1%), and impaired recall in the forget condition compared with the remember condition (30.5% vs. 47.4%). Importantly, there was a significant interaction between the two factors, $F(1, 62) = 7.714$, $MSE = 0.034$, $p = .007$, $\eta_p^2 = .111$, reflecting the fact that significant forgetting was present in the young-olds (26.0%, $p < .001$, $d = .99$) but not the old-olds (7.8%, $p = .100$, $d = .30$). Consistently, continuous-variable analyses revealed a significant negative correlation between (all) individuals' age and forgetting scores (List 1 remember − List 1 forget; $r = -.324$, $p = .009$).[2]

Regarding List 2 recall (see Figure 1B), an analogous 2×2 ANOVA revealed significant main effects of age group, $F(1, 62) = 7.037$, $MSE = 0.087$, $p = .010$, $\eta_p^2 = .102$, and cue condition, $F(1, 62) = 9.487$, $MSE = 0.059$, $p = .003$, $\eta_p^2 = .133$. These main effects reflect higher recall in the young-olds than the old-olds (40.9% vs. 27.1%), and enhanced recall in the forget condition compared with the remember condition (40.6% vs. 27.3%). There was no interaction between the two factors, $F(1, 62) < 1$, reflecting the fact that the enhancement effect was comparable in the two age groups (young-olds, 15.1%, $p = .035$; old-olds, 11.5%, $p = .037$). Consistently, correlational analyses revealed no relationship between (all) individuals' age and enhancement scores (List 2 forget − List 2 remember; $r = -.123$, $p = .334$).

Additional Data and Analyses

In this study, we used shorter lists than in previous work reporting intact DF in young-old adults (e.g., Sego et al., 2006;

Zellner & Bäuml, 2006). This was done deliberately to avoid potential floor effects, especially in the group of old-olds. To examine whether the previous finding of intact DF in young-old adults generalizes to short lists, we repeated the experiment with 24 young adults (18 females; 19 to 29 years, $M = 22.8$ years), mostly undergraduates from Regensburg University. This young control group showed the standard pattern of DF, with significant forgetting of List 1 (remember, 86.8%; forget, 66.0%; $p < .001$, $d = 1.09$) and significant enhancement of List 2 (remember, 72.2%; forget, 83.3%; $p < .001$, $d = .95$). In particular, although overall recall rates were higher in the young than the young-old adults, the two age groups showed equivalent List 1 forgetting (20.8% vs. 26.0%, $p = .418$) and equivalent List-2 enhancement (11.1% vs. 15.1%, $p = .627$). These analyses confirm that, also when using short lists, young-old adults show DF comparable with that of young adults.

Discussion

Examining participants with a mean age of about 70 years, previous studies on listwise DF repeatedly reported intact forgetting in older adults (Sahakyan et al., 2008; Sego et al., 2006; Zellner & Bäuml, 2006). In the present study, we replicated this previous work by finding efficient forgetting in a group of young-old participants (up to 75 years) that was indistinguishable in amount from that of a young adult control group. Because the prior work used much longer study lists than were employed in the present work, the replication also indicates that intactness of older adults' DF does not vary much with length of study lists. More importantly, we additionally found the forgetting to decline gradually with individuals' age and to be inefficient in a group of old-old participants (above 75 years). These results indicate that listwise DF is a late-declining capability, with young-old adults showing intact and old-old adults showing deficient memory control.

The present findings support the view that (at least some) executive control processes fall into the category of "late-declining" capabilities. In particular, the findings are consistent with the previous result of intact control processes in young-old (though not old-old) adults' retrieval-induced forgetting and think/no-think impairment (Aslan & Bäuml, in press; Murray et al., 2011), and findings outside the memory domain reporting evidence for control processes that remain intact for the bigger part of the life span (e.g., Kieley & Hartley, 1997; Schooler et al., 1997). In a recent series of meta-analyses, Verhaeghen (2011) searched for a specific age-related deficit in (undifferentiated) older adults' executive functioning, employing tasks tapping local task-shifting costs, inhibition of return, negative priming, and Stroop. No evidence for a specific age-related deficit arose. Together, these findings indicate that the purported decline in executive control

---

[2] Further analyses revealed that entering WMC and a WMC $\times$ Age interaction term into a stepwise regression did not explain more DF variance than the initial model with age as the only variable ($\Delta R^2 = .058$, $p = .134$). Consistently, although there was a weak positive correlation between WMC and forgetting scores ($r = .249$, $p = .047$), this correlation disappeared once age was partialed out ($r = .088$, $p = .493$), indicating that WMC decline cannot (fully) account for age-related declines in DF efficiency, and that factors other than WMC play the critical role for old-old adults' poor DF.
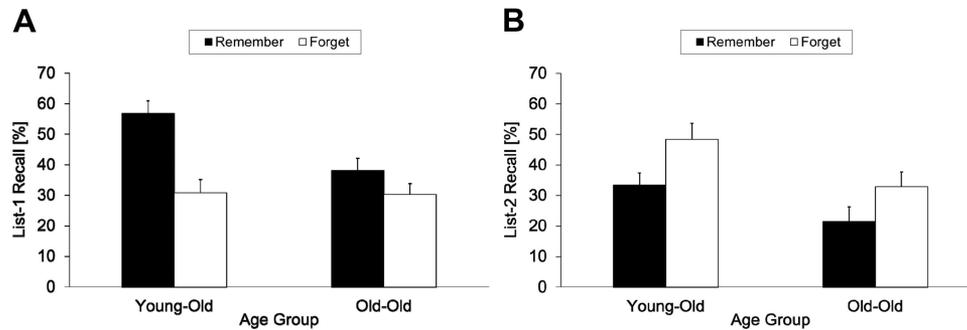
A

B

Figure 1. Mean recall of List 1 items (A) and List 2 items (B) as a function of cue condition (remember, forget) and age group (young-olds, old-olds). The error bars represent standard errors.

with advancing age may be exaggerated, and may not be as grave and general as has been traditionally believed (see also Verhaeghen, 2011).

The present result of an age-related decline in DF efficiency complements previous developmental work reporting reduced listwise DF in young children. For instance, Harnishfeger and Pope (1996) found intact (adult-like) DF in fifth graders, while the forgetting was reduced in third graders and completely absent in first graders. Similarly, Zellner and Bäuml (2004) found significant DF in fourth graders but no effects of the forget cue in second graders. These previous studies, together with the present one, reveal a comprehensive life span picture of listwise DF, indicating that the control processes involved in this task develop during middle childhood, remain intact for most of the life span, and become inefficient again not until very old age.

Recent work highlighted the role of strategic and/or metacognitive processes in listwise DF, suggesting that whether individuals show forgetting, or not, can depend on whether they engage in deliberate attempts to forget at all (Aslan, Staudigl, et al., 2010; Sahakyan et al., 2008). Sahakyan et al. (2008), for instance, found reduced forgetting in older adults who felt that efforts to forget were needless because they forgot the information anyway. When the forget instruction was modified to emphasize the need to engage in forgetting attempts, older adults showed the same pattern of DF as young controls. Similarly, although previous work suggested inefficient forgetting in young elementary schoolchildren, Aslan, Staudigl, et al. (2010) recently found that first graders (but not kindergartners) may show intact forgetting when a comprehensible rationale for the forget cue is provided and high emphasis on the need to forget is placed. In the present study, we used the same forget instruction as in Aslan, Staudigl, et al.'s high-emphasis condition (the "whoops" instruction). The finding that old-old, but not young-old, participants failed to show successful forgetting under such instruction indicates that old-olds' poor DF cannot be attributed to a mere reluctance to follow task instruction. This conclusion is also supported by the fact that old-old adults showed intact List 2 enhancement in the present study, which indicates that they did not simply ignore the forget instruction, but rather showed task engagement comparable with that of young-old adults.

The latter finding is also theoretically interesting. Indeed, standard accounts of listwise DF, like selective rehearsal, inhibition, or context change, assume that the two effects of the forget cue are mediated by the same mechanism, and thus should always behave concordantly. The present finding that age affected the forgetting, but not the enhancement effect, thus challenges such single-mechanism accounts (for further challenges, see Bäuml et al., 2008; Pastötter & Bäuml, 2010; Sahakyan & Delaney, 2003). However, the finding agrees with recent two-mechanism accounts, according to which the forgetting effect is caused by a retrieval-based mechanism, like context change (Sahakyan & Delaney, 2003) or inhibition (Pastötter & Bäuml, 2010), but the enhancement effect is caused by an (additional) encoding-based mechanism, like a change in encoding strategy (Sahakyan & Delaney, 2003) or a reset of encoding processes (Pastötter & Bäuml, 2010). On the basis of such two-mechanism accounts, the present results suggest that the retrieval-based mechanism mediating the forgetting effect is more age-sensitive than the encoding-based mechanism mediating the enhancement effect.[3]

The present results on listwise DF relate to research using a variant of the DF task, called itemwise DF. In itemwise DF, participants study a single list of items, and each item is followed closely by a cue to either remember or forget the item. The typical finding is that memory for to-be-remembered items is better than memory for to-be-forgotten items, a finding generally attributed to differential encoding (Basden & Basden, 1998). In contrast to the present results, previous work consistently reported poor performance in itemwise DF already in young-old adults (for a review, see Titz & Verhaeghen, 2010). Because the encoding-based mechanism involved in itemwise DF supposedly differs in nature from the encoding-based mechanism involved in listwise DF (see MacLeod, 1998, or Bäuml, 2008), the arising conclusion that one of the two mechanisms is more age-sensitive than the other is not in conflict with the DF literature. Rather, the two DF tasks provide direct evidence for the view that not necessarily all types of control processes fall into the category of "late-declining" capabilities, a conclusion that is supported by aging research from both inside and outside the memory domain (e.g., Mayr, 2001; Park, Smith,

---

[3] In this study, we focused on the forgetting effect, and thus always tested List 1 prior to List 2. Because recall order may affect DF performance (Golding & Gottlob, 2005; Pastötter, Kliegl, & Bäuml, 2012), the present indication that the enhancement effect is fairly age-invariant needs verification using the "optimal" recall order to examine the effect, that is, testing List 2 first.

Dudley, & Lafronza, 1989; Van der Linden, Brédart, & Beerten, 1994).

In sum, we found that listwise DF is a late-declining capability that is largely preserved in young-old adults but inefficient in old-old adults. The finding is in line with previous aging research, indicating that the group of "older adults" is not as homogeneous as it has often (implicitly) been assumed, and considerable decline in cognitive functioning may occur *within* old age. The previous and present findings thus validate the distinction between young-olds and old-olds, highlighting the importance of employing more fine-grained experimental designs in cognitive aging research.

References

Anderson, M. C. (2003). Rethinking interference theory: Executive control and the mechanism of forgetting. *Journal of Memory and Language, 49,* 415–445. doi:10.1016/j.jml.2003.08.006

Anderson, M. C., & Green, C. (2001). Suppressing unwanted memories by executive control. *Nature, 410,* 366–369. doi:10.1038/35066572

Anderson, M. C., Reinholz, J., Kuhl, B. A., & Mayr, U. (2011). Intentional suppression of unwanted memories grows more difficult as we age. *Psychology and Aging, 26,* 397–405. doi:10.1037/a0022505

Aslan, A., & Bäuml, K.-H. T. (in press). Retrieval-induced forgetting in old and very old age. *Psychology and Aging.* doi:10.1037/a0028379

Aslan, A., Bäuml, K.-H., & Pastötter, B. (2007). No inhibitory deficit in older adults' episodic memory. *Psychological Science, 18,* 72–78. doi:10.1111/j.1467-9280.2007.01851.x

Aslan, A., Staudigl, T., Samenieh, A., & Bäuml, K.-H. T. (2010). Directed forgetting in young children: Evidence for a production deficiency. *Psychonomic Bulletin & Review, 17,* 784–789. doi:10.3758/PBR.17.6.784

Aslan, A., Zellner, M., & Bäuml, K.-H. T. (2010). Working memory capacity predicts listwise directed forgetting in adults and children. *Memory, 18,* 442–450. doi:10.1080/09658211003742698

Bäckman, L., & Karlsson, T. (1986). Episodic remembering in young adults, 73-year-olds, and 82-year-olds. *Scandinavian Journal of Psychology, 27,* 320–325. doi:10.1111/j.1467-9450.1986.tb01210.x

Basden, B. H., & Basden, D. R. (1998). Directed forgetting: A contrast of methods and interpretations. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 139–172). Mahwah, NJ: Erlbaum.

Bäuml, K.-H. (2008). Inhibitory processes. In H. L. Roediger, III (Ed.), *Cognitive psychology of memory. Vol. 2 of Learning and memory: A comprehensive reference* (pp. 195–220). Oxford, UK: Elsevier.

Bäuml, K.-H., Hanslmayr, S., Pastötter, B., & Klimesch, W. (2008). Oscillatory correlates of intentional updating in episodic memory. *NeuroImage, 41,* 596–604. doi:10.1016/j.neuroimage.2008.02.053

Bäuml, K.-H. T., Pastötter, B., & Hanslmayr, S. (2010). Binding and inhibition in episodic memory: Cognitive, emotional, and neural processes. *Neuroscience and Biobehavioral Reviews, 34,* 1047–1054. doi:10.1016/j.neubiorev.2009.04.005

Bäuml, K.-H. T., & Samenieh, A. (2010). The two faces of memory retrieval. *Psychological Science, 21,* 793–795. doi:10.1177/0956797610370162

Bäuml, K.-H. T., & Samenieh, A. (2012). Selective memory retrieval can impair and improve retrieval of other memories. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 488–494. doi:10.1037/a0025683

Bjork, R. A. (1970). Positive forgetting: The noninterference of items intentionally forgotten. *Journal of Verbal Learning & Verbal Behavior, 9,* 255–268. doi:10.1016/S0022-5371(70)80059-7

Braver, T. S., & West, R. L. (2008). Working memory, executive processes, and aging. In F. I. M. Craik & T. L. Salthouse (Eds.), *Handbook of aging and cognition* (pp. 311–372). New York, NY: Erlbaum.

Conway, M. A., & Fthenaki, A. (2003). Disruption of inhibitory control of memory following lesions to the frontal and temporal lobes. *Cortex: A Journal Devoted to the Study of the Nervous System and Behavior, 39,* 667–686. doi:10.1016/S0010-9452(08)70859-1

Conway, M. A., Harries, K., Noyes, J., Racsmány, M., & Frankish, C. (2000). The disruption and dissolution of directed forgetting: Inhibitory control of memory. *Journal of Memory and Language, 43,* 409–430. doi:10.1006/jmla.2000.2706

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. Klix and H. Hagendorf (Eds.), *Human memory and cognitive capabilities: Mechanisms and performances* (pp. 409–422). Amsterdam, The Netherlands: Elsevier.

Craik, F. I. M., Anderson, N. D., Kerr, S. A., & Li, K. Z. H. (1995). Memory changes in normal ageing. In A. D. Baddeley, B. A. Wilson, & F. N. Watts (Eds.), *Handbook of memory disorders* (pp. 211–241). Chichester, UK: Wiley.

Delaney, P. F., & Sahakyan, L. (2007). Unexpected costs of high working memory capacity following directed forgetting and contextual change manipulations. *Memory & Cognition, 35,* 1074–1082. doi:10.3758/BF03193479

Duyck, W., Desmet, T., Verbeke, L., & Brysbaert, M. (2004). Wordgen: A tool for word selection and non-word generation in Dutch, German, English, and French. *Behavior Research Methods, Instruments & Computers, 36,* 488–499. doi:10.3758/BF03195595

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-mental state: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12,* 189–198. doi:10.1016/0022-3956(75)90026-6

Geiselman, R. E., Bjork, R. A., & Fishman, D. (1983). Disrupted retrieval in directed forgetting: A link with posthypnotic amnesia. *Journal of Experimental Psychology: General, 112,* 58–72. doi:10.1037/0096-3445.112.1.58

Golding, J. M., & Gottlob, L. R. (2005). Recall order determines the magnitude of directed forgetting in the within-participants list method. *Memory & Cognition, 33,* 588–594. doi:10.3758/BF03195326

Hanslmayr, S., Volberg, G., Wimber, M., Oehler, N., Staudigl, T., Hartmann, T., . . . Bäuml, K.-H. T. (2012). Prefrontally driven down-regulation of neural synchrony mediates goal-directed forgetting. *The Journal of Neuroscience, 32,* 14742–14751. doi:10.1523/JNEUROSCI.1777-12.2012

Harnishfeger, K. K., & Pope, R. S. (1996). Intending to forget: The development of cognitive inhibition in directed forgetting. *Journal of Experimental Child Psychology, 62,* 292–315. doi:10.1006/jecp.1996.0032

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General, 108,* 356–388. doi:10.1037/0096-3445.108.3.356

Kieley, J. M., & Hartley, A. A. (1997). Age-related equivalence of identity suppression in the Stroop color-word task. *Psychology and Aging, 12,* 22–29. doi:10.1037/0882-7974.12.1.22

Kliegel, M., & Jäger, T. (2006). Delayed-execute prospective memory performance: The effects of age and working memory. *Developmental Neuropsychology, 30,* 819–843. doi:10.1207/s15326942dn3003_4

Kvavilashvili, L., Kornbrot, D. E., Mash, V., Cockburn, J., & Milne, A. (2009). Differential effects of age on prospective and retrospective memory tasks in young, young-old and old-old adults. *Memory, 17,* 180–196. doi:10.1080/09658210802194366

Lehrl, S. (2005). *Mehrfachwahl-Wortschatz-Intelligenztest MWT-B.* Balingen, Germany: Spitta Verlag.

Lustig, C., Hasher, L., & Zacks, R. T. (2007). Inhibitory deficit theory: Recent developments in a "new view". In D. S. Gorfein & C. M. MacLeod (Eds.), *The place of inhibition in cognition* (pp. 145–162). Washington, DC: American Psychological Association. doi:10.1037/11587-008

MacLeod, C. M. (1998). Directed forgetting. In J. M. Golding & C. M. MacLeod (Eds.), *Intentional forgetting: Interdisciplinary approaches* (pp. 1–57). Mahwah, NJ: Erlbaum.

Mayr, U. (2001). Age differences in the selection of mental sets: The role of inhibition, stimulus ambiguity, and response-set overlap. *Psychology and Aging, 16,* 96–109. doi:10.1037/0882-7974.16.1.96

Moulin, C. J. A., Perfect, T. J., Conway, M. A., North, A. S., Jones, R. W., & James, A. N. (2002). Retrieval-induced forgetting in Alzheimer's disease. *Neuropsychologia, 40,* 862–867. doi:10.1016/S0028-3932(01)00168-3

Mulji, R., & Bodner, G. E. (2010). Wiping out memories: New support for a mental context change account of directed forgetting. *Memory, 18,* 763–773. doi:10.1080/09658211.2010.510475

Murray, B. D., Muscatell, K. A., & Kensinger, E. A. (2011). Effects of emotion and age on performance during a think/no-think memory task. *Psychology and Aging, 26,* 940–955. doi:10.1037/a0023214

Park, D. C., Smith, A. D., Dudley, W. N., & Lafronza, V. N. (1989). Effects of age and a divided attention task presented during encoding and retrieval on memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 1185–1191. doi:10.1037/0278-7393.15.6.1185

Pastötter, B., & Bäuml, K.-H. (2010). Amount of postcue encoding predicts amount of directed forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36,* 54–65. doi:10.1037/a0017406

Pastötter, B., Kliegl, O., & Bäuml, K.-H. T. (2012). List-method directed forgetting: The forget cue improves both encoding and retrieval of the postcue information. *Memory & Cognition, 40,* 861–873. doi:10.3758/s13421-012-0206-4

Persad, C. C., Abeles, N., Zacks, R. T., & Denburg, N. L. (2002). Inhibitory changes after age 60 and the relationship to measures of attention and memory. *The Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, 57,* P223–P232. doi:10.1093/geronb/57.3.P223

Racsmány, M., Conway, M. A., Garab, E. A., Cimmer, C., Janka, Z., Kurimay, T., . . . Szendi, I. (2008). Disrupted memory inhibition in schizophrenia. *Schizophrenia Research, 101,* 218–224. doi:10.1016/j.schres.2008.01.002

Sahakyan, L., & Delaney, P. F. (2003). Can encoding differences explain the benefits of directed forgetting in the list method paradigm? *Journal of Memory and Language, 48,* 195–206. doi:10.1016/S0749-596X(02)00524-7

Sahakyan, L., Delaney, P. F., & Goodmon, L. B. (2008). "Oh, honey, I already forgot that": Strategic control of directed forgetting in older and younger adults. *Psychology and Aging, 23,* 621–633. doi:10.1037/a0012766

Sahakyan, L., & Kelley, C. M. (2002). A contextual change account of the directed forgetting effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28,* 1064–1072. doi:10.1037/0278-7393.28.6.1064

Schnitzspahn, K. M., & Kliegel, M. (2009). Age effects in prospective memory performance within older adults: The paradoxical impact of implementation intentions. *European Journal of Ageing, 6,* 147–155. doi:10.1007/s10433-009-0116-x

Schooler, C., Neumann, E., Caplan, L. J., & Roberts, B. R. (1997). Continued inhibitory capacity throughout adulthood: Conceptual negative priming in younger and older adults. *Psychology and Aging, 12,* 667–674. doi:10.1037/0882-7974.12.4.667

Sego, S. A., Golding, J. M., & Gottlob, L. R. (2006). Directed forgetting in older adults using the item and list methods. *Aging, Neuropsychology, and Cognition, 13,* 95–114. doi:10.1080/138255890968682

Sullivan, M. P. (1999). The functional interaction of visual-perceptual and response mechanisms during selective attention in young adults, young-old adults, and old-old adults. *Perception & Psychophysics, 61,* 810–825. doi:10.3758/BF03206899

Titz, C., & Verhaeghen, P. (2010). Aging and directed forgetting in episodic memory: A meta-analysis. *Psychology and Aging, 25,* 405–411. doi:10.1037/a0017225

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28,* 127–154. doi:10.1016/0749-596X(89)90040-5

Van der Linden, M., Brédart, S., & Beerten, A. (1994). Age-related differences in updating working memory. *British Journal of Psychology, 85,* 145–152.

Verhaeghen, P. (2011). Aging and executive control: Reports of a demise greatly exaggerated. *Current Directions in Psychological Science, 20,* 174–180. doi:10.1177/0963721411408772

White, H. A., & Marks, W. (2004). Updating memory in list-method directed forgetting: Individual differences related to adult attention-deficit/hyperactivity disorder. *Personality and Individual Differences, 37,* 1453–1462. doi:10.1016/j.paid.2004.02.002

Zacks, R. T., Radvansky, G. A., & Hasher, L. (1996). Studies of directed forgetting in older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 143–156. doi:10.1037/0278-7393.22.1.143

Zellner, M., & Bäuml, K.-H. (2004). Retrieval inhibition in episodic recall. In A. Mecklinger, H. Zimmer, & U. Lindenberger (Eds.), *Bound in memory: Insights from behavioral and neuropsychological studies* (pp. 1–26). Aachen, Germany: Shaker Verlag.

Zellner, M., & Bäuml, K.-H. (2006). Inhibitory deficits in older adults – list-method directed forgetting revisited. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32,* 290–300. doi:10.1037/0278-7393.32.3.290