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Reflections of Distraction in Memory: Transfer of Previous Distraction Improves Recall in Younger and Older Adults

Ruthann C. Thomas
Washington University in St. Louis

Lynn Hasher
University of Toronto and the Rotman Research Institute of
Baycrest Centre, Toronto, Ontario, Canada

Three studies explored whether younger and older adults' free recall performance can benefit from prior exposure to distraction that becomes relevant in a memory task. Participants initially read stories that included distracting text. Later, they studied a list of words for free recall, with half of the list consisting of previously distracting words. When the memory task was indirect in its use of distraction (Study 1), only older adults showed transfer, with better recall of previously distracting compared with new words, which increased their recall to match that of younger adults. However, younger adults showed transfer when cued about the relevance of previous distraction both before studying the words (Study 2) and before recalling the words (Study 3) in the memory test. Results suggest that both younger and older adults encode distraction, but younger adults require explicit cueing to use their knowledge of distraction. In contrast, older adults transfer knowledge of distraction in both explicitly cued and indirect memory tasks. Results are discussed in terms of age differences in inhibition and source-constrained retrieval.

Keywords: aging, memory, inhibition, transfer, retrieval constraint

Distractions, whether they are the small pop-ups from an e-mail program or conversations at a coffee shop, are everywhere and can be disruptive to performance on a critical task. However, what appears to be "noise" in the current situation may actually become relevant in the future. For example, conversations overheard in a coffee shop or outside an office door may contain information about road closures or an important research finding. As a result, there may be unforeseen benefits to encoding current distractions if they become relevant later. This series of studies explored the possibility that encoding distraction at one point in time, although disruptive to the current task, may have surprising benefits when this information reappears as target information in a later memory task.

Studies investigating the influence of distraction have focused on its negative consequences for ongoing tasks, which have been found to be greater for older than for younger adults (see e.g., Rabbitt, 1965). For example, when irrelevant information was present, older adults showed greater slowing than younger adults did in reading tasks (Connelly, Hasher, & Zacks, 1991; Darowski, Helder, Zacks, Hasher, & Hambrick, 2008; Duchek, Balota, & Thessing, 1998; Dywan & Murphy, 1996) as well as in classic perceptual speed tasks (Lustig, Hasher, & Tonev, 2006). Further, older adults showed worse performance on a problem-solving task than did younger adults when distracting information misled them from the correct solution (May, 1999).

According to the inhibitory deficit hypothesis (Hasher & Zacks, 1988), older adults' increased susceptibility to distraction is due to an age-related reduction in their ability to suppress irrelevant information. Consistent with this theoretical view, Gazzaley, Cooney, Rissman, and D'Esposito (2005) observed age differences in the neural correlates associated with initial processing of irrelevant information. Younger and older adults saw a series of pictures, alternating between scenes and faces. When instructed to remember target scenes and ignore faces, both age groups showed comparable activity in the parahippocampal place area (PPA), a region known to be involved in processing natural scenes. However, when instructed to ignore scenes and remember faces, younger adults, but not older adults, showed reduced activity in the PPA. These results suggest that younger adults suppressed processing of the distracting scenes (see de Fockert, Ramchurn, van Velzen, Bergstrom, & Bunce, 2009; Gazzaley et al., 2008, for converging evidence with event-related potentials). Further, compared with younger adults, older adults also gave higher ratings of familiarity to these irrelevant scenes in a later incidental memory task. These findings converge with additional evidence of age differences in suppression of auditory distraction (Fabiani, Low, Wee, Sable, & Gratton, 2006; Stevens, Hasher, Chiew, & Grady, 2008; but see Guerreiro, Murphy, & Van Gerven, 2010) to suggest that younger and older adults differ in their initial encoding of irrelevant information.

Ruthann C. Thomas, Department of Psychology, Washington University in St. Louis; Lynn Hasher, Department of Psychology, University of Toronto, Toronto, Ontario, Canada, and the Rotman Research Institute of Baycrest Centre, Toronto, Ontario, Canada.

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Correspondence concerning this article should be addressed to Ruthann C. Thomas, Department of Psychology, Washington University in St. Louis, Campus Box 1125, St. Louis, MO 63130, or to Lynn Hasher, Department of Psychology, University of Toronto, 100 St. George Street, Toronto, Ontario M5R 3G3, Canada. E-mail: thomas@artsci.wustl.edu or hasher@psych.utoronto.ca

In addition to distraction from current surroundings, irrelevant information can also have downstream consequences when it interferes with performance on subsequent tasks. Younger and older adults differ in their continued access to information from previous tasks, possibly due to age-related deficits in cognitive control processes that suppress old information in the face of new goals (see e.g., Hasher, Zacks, & May, 1999). For example, older adults experience more proactive interference than do younger adults in both verbal and spatial working memory tasks (Jonides et al., 2000; Lustig, May, & Hasher, 2001; May, Hasher, & Kane, 1999; Rowe, Hasher, & Turcotte, 2008), as well as in long-term memory tasks (Gazzaley et al., 2005; Gerard, Zacks, Hasher, & Radvansky, 1991; Hamm & Hasher, 1992; Hay & Jacoby, 1996, 1999).

These negative effects from carrying over information from the irrelevant past are complemented by positive effects of previous distraction seen in a number of recent implicit memory tasks (see Healey, Campbell, & Hasher, 2008). For example, older adults correctly completed more word fragments than did younger adults when the solutions had appeared as distraction in an earlier task (Rowe, Valderrama, Hasher, & Lenartowicz, 2006). Older adults also used no longer relevant words from an earlier task to complete sentence fragments, whereas younger adults used new words (May & Hasher, 1998). Likewise, older adults solved more remote associate verbal problems relative to a baseline condition when solutions had been presented as distraction in a previous task. In contrast, younger adults solved the same number of problems regardless of their prior exposure to the solutions as distraction (Kim, Hasher, & Zacks, 2007).

Further, a recent study using a cued-recall task showed that older adults have continued access to distraction (Campbell, Hasher, & Thomas, 2010). In the initial task, younger and older adults did a one-back task on pictures that were superimposed with distracting words. When the same picture–word pairs appeared 10 min later on a study list for a cued-recall memory task, only older adults showed enhanced recall for pairs from the earlier task compared with new pairs. These results suggest that older adults, but not younger adults, encoded distraction on the initial task and also formed associations between distraction and concurrently presented target information. Thus, several studies have shown differential transfer of distraction to new implicit memory tasks that facilitate performance of older adults but not younger adults (see also Gopie, Craik, & Hasher, 2011).

The present studies explored whether transfer of distraction would extend to a memory task on which there is a pervasive age-related decline in performance: explicit recall of the past.

Prior evidence of older adults' transfer of distraction was based on tasks that provide environmental support. For example, cued-recall (see e.g., Campbell et al., 2010) and word-fragment completion tasks (Rowe et al., 2006) provide additional retrieval cues that may compensate for older adults' deficit in self-initiated retrieval (Craik, 1986). In contrast, free recall tasks rely heavily on self-initiated retrieval from memory. As a result, age-related declines in performance on free recall tasks are widely found to be more dramatic than declines seen in other types of memory tests for the same information, such as recognition and cued recall (see e.g., Balota, Dolan, & Duchek, 2000; Craik, 1986; Park et al., 2002).

Our question in the first study was whether older adults would show positive transfer of distraction to a memory task that relies on self-initiated retrieval, free recall of unrelated words. Further, this study explored whether younger and older adults would differ in their transfer of distraction, such that only older adults' memory performance would benefit from prior exposure to the distraction. In each of the present studies, distracting words were initially presented in the context of a reading task. In a later memory task, some of these words occurred as part of a list to be studied for a free recall test. To foreshadow the results of Study 1, older adults, but not younger adults, implicitly used distraction from a previous task to improve their free recall performance. Only older adults showed positive transfer of previous distraction, which increased their memory performance such that they recalled as many words as did younger adults.

In subsequent studies, we examined the cognitive mechanisms underlying age differences in transfer of distraction. These differences in younger and older adults' positive transfer of distraction to free recall could be due to age differences in initial encoding of distraction, or rather to differences in their access to previous distraction at retrieval. We also examined whether there are some circumstances in which younger adults can remember distraction.

Study 1

The goal of the first study was to investigate whether implicit transfer of previously distracting information influences performance on a subsequent free recall test. In this study, younger and older adults read a series of short narratives interspersed with distracting words that they were instructed to ignore. After a 10-min delay, participants were presented with a list of words to study for a recall test. Half of the words on the list had been presented as distraction in the stories and half were new. Although the memory task itself was explicit, the use of previous distraction was indirect in that participants were not aware that the study list included information from a previous task.

If older adults are more likely than younger adults to encode and maintain access to irrelevant information (Campbell et al., 2010; Kim et al., 2007; Rowe et al., 2006), they might also show an advantage in recall for previously distracting compared with new words. In contrast, if younger adults do not have implicit access to distraction during the recall task, as suggested by previous research (see e.g., Kim et al., 2007; May & Hasher, 1998; Rowe et al., 2006), they should show equivalent recall for previously distracting and new words.

Method

Participants. Because our interest was in implicit effects on the memory task, we replaced data from six younger adults who reported awareness of the relationship between words in the reading task and those in the final recall task.[1] Demographic information for the 30 remaining younger adults (ages 17–28 years) and 30 older adults (59–76 years) is displayed in Table 1. Younger adults

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[1] The pattern of results from the six aware younger adults did not differ from that of the unaware younger adults in the final sample. The aware younger adults recalled a comparable number of previously distracting words ($M = 4.67$, $SD = 1.97$) and new words ($M = 4.50$, $SD = 1.04$; $t < 1$, *ns*). Further, when data from these participants were included in analyses, the pattern of results was identical to those reported for only unaware participants.

Table 1
Demographic Information for Younger and Older Participants in Studies 1 (N = 60), 2 (N = 48), and 3 (N = 48)

Group	Age (in years)		Education (in years)		Vocabulary	
	M	*SD*	*M*	*SD*	*M*	*SD*
Study 1						
Younger	19.5	2.5	13.2	2.3	29.8	3.2
Older	66.9	4.3	16.4	2.7	35.9	3.7
Study 2						
Younger	20.1	1.7	14.4	2.0	31.1	3.5
Older	68.4	5.8	18.3	2.9	35.2	3.2
Study 3						
Younger	20.9	3.3	14.5	1.6	34.2	3.9
Older	69.6	6.2	16.0	2.5	37.0	1.3

(11 male, 19 female) were undergraduate students at the University of Toronto and received course credit or monetary compensation for their participation. Older adults (8 male, 22 female) were recruited from a seniors participant pool and received monetary compensation. Older adults were screened for dementia using the Short Blessed Test (Katzman et al., 1983), with a threshold of six errors for inclusion in the sample. Compared with younger adults, older adults had significantly more years of education, $F(1, 58) = 24.09$, $\eta_p^2 = .30$, and significantly higher scores on the Shipley Vocabulary Test, $F(1, 58) = 46.30$, $\eta_p^2 = .44$, as is often the case in the aging and cognition literature.

Design. The design was a 2 (age group) × 2 (word type) mixed factorial with age group (young, old) as a between-participants factor and word type (previously distracting, new) as a within-participant factor. The main dependent measure was the number of words recalled. We also obtained a measure of the degree of disruption from the presence of distraction by comparing reading times for distraction stories and control stories.

Materials.

Reading with distraction stories. Six stories, averaging 174 words in length, were adapted from Connelly et al. (1991) for use in the present study (see Figure 1 for an example). The stories were each presented on a sheet of paper with target text in italicized Century 12-point font and distracting words (words in distraction stories or strings of *x*s in control stories) in standard, upright text of the same font. This version of the reading with distraction task differed from that of previous studies in its use of the same distracting words in each of the four distraction stories. In previous studies, each distracting word or phrase appeared 10 to 15 times in a single distraction story only (Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996). In the current studies, each of the four distraction stories contained 16 distracting words that each appeared five times per story after one to five intervening target words in an unpredictable format. Each distracting word appeared a total of 20 times across the four distraction stories. The two control stories contained strings of *x*s (matched in length to distracting words from distraction stories) distributed within the target text in the same locations as the words in the distraction stories.

Distracting words and recall words. A total of 24 words from Coltheart's (1981) database was selected and divided into three sets of eight words. All words were between three and eight letters in length, and the three sets were matched for frequency ($M = 48.25$, $SD = 35.72$), concreteness ($M = 5.87$, $SD = 0.43$), and length ($M = 4.71$, $SD = 0.95$). No words were semantically[2] or phonologically related to those in other sets, nor were they semantically related to the stories in which they were embedded. Sixteen of the words (i.e., two sets of eight) were presented as distraction in the reading task. Half of the distracting words appeared in the later recall task (target), and the other half did not appear later in the experiment (filler). The filler distracting words were included to reduce the chances of participants noticing the connection between the words in the initial reading and final recall tasks. The additional set of eight words appeared in the recall task as new words. The sets of words were counterbalanced such that each appeared equally often as target distraction in the reading task (and, therefore, also a previously distracting word in the recall task), filler distraction in the reading task, and new words in the recall task.

Procedure. Participants were told that there would be a series of tasks to perform and that they would be tested individually. In the reading task, they were instructed to read a series of stories out loud and were told that later in the experiment they would be asked questions about what happened in the stories. Participants first read a practice story in italicized font without any distraction. Then they were informed of the presence and appearance (type format) of the distracting material. They were told to completely ignore this text and to read out loud only the text printed in italics. They were also instructed not to follow along the text with their finger while reading. Participants then read four distraction stories, and the experimenter recorded their reading times as well as any distracting words that they read out loud.

Following the reading task, participants were given a computerized math task to provide a 10-min delay between the reading and recall tasks. After the filler task, participants were given 16 words to study for recall. The memory instructions did not inform participants that some of the words had appeared earlier, constituting an indirect test of memory. Participants were told to study the words for an upcoming recall test. During the study phase, each word was presented in the center of the screen for 1,500 ms in Century 12-point font, followed by a blank screen for 500 ms. After the final word appeared, participants were asked to recall as many words as possible, in any order, from the list they had just studied. Following recall, participants were presented with two control stories (with *x*s as distraction) to read.

At the end of the study, participants were given a graded awareness questionnaire to assess whether they realized that some of the words in the recall task had been presented as distraction in the stories. First, they were asked whether they noticed any connection across the three tasks and if so, to describe the connection. Then participants completed a background questionnaire and the Shipley Vocabulary Test (Shipley, 1946). Older adults also com-

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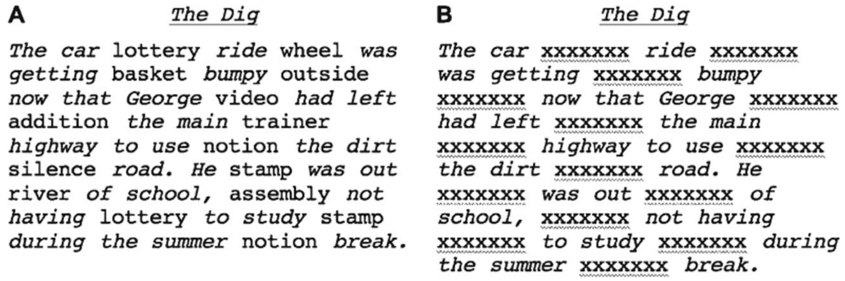
[2] On the basis of a latent semantic analysis, the semantic similarity of words was matched both within and between words in a set (the range of scores was .056 to .098, with 1.0 representing maximum semantic similarity) with relatively low semantic similarity overall (possible range of scores was –1.0 to 1.0).



A *The Dig*

The car lottery *ride* wheel *was*
getting basket *bumpy* outside
now that George video *had left*
addition *the main* trainer
highway to use notion *the dirt*
silence *road. He* stamp *was out*
river *of school,* assembly *not*
having lottery *to study* stamp
during the summer notion *break.*

B *The Dig*

The car xxxxxxx *ride* xxxxxxx
was getting xxxxxxx *bumpy*
xxxxxxx *now that George* xxxxxxx
had left xxxxxxx *the main*
xxxxxxx *highway to use* xxxxxxx
the dirt xxxxxxx *road. He*
xxxxxxx *was out* xxxxxxx *of*
school, xxxxxxx *not having*
xxxxxxx *to study* xxxxxxx *during*
the summer xxxxxxx *break.*

Figure 1. Examples of the reading with distraction task, displaying a distracting story (Panel A) and a control story (Panel B).

pleted the Short Blessed Test (Katzman et al., 1983) to screen for dementia.

Results

Across all studies, younger and older adults' mean reading times (in seconds) were investigated in a 2 (age group: younger, older) × 2 (story type: distraction, control) analysis of variance (ANOVA), with repeated measures on story type. Recall performance was analyzed using a 2 (age group: younger, older) × 2 (word type: previously distracting, new) ANOVA with repeated measures on word type. Planned comparisons followed each ANOVA. The significance level for all statistical tests was $p < .05$.

Reading times. Mean reading times are displayed in Table 2. Overall, older adults read more slowly than did younger adults, $F(1, 58) = 18.55$, $\eta_p^2 = .24$, and distraction stories were read more slowly than control stories, $F(1, 58) = 524.09$, $\eta_p^2 = .90$. In contrast to previous research (see e.g., Connelly et al., 1991), the Age Group × Story Type interaction did not reach significance, $F(1, 58) = 1.74$, $p = .19$, $\eta_p^2 = .03$. As noted earlier, this version of the reading with distraction task differed from that of Connelly et al. (1991) and Darowski et al. (2008) in its repetition of the same distracting words in each of the four distraction stories. This repeated presentation of the distracting stimulus may result in more rapid processing of the distraction (i.e., repetition priming; Schacter & Tulving, 1994). As a result, we also explored disruption from distraction for the first two distraction stories only (see Table 2), when the distraction was still relatively novel. As in the analysis including all four stories, there were main effects of both age group, $F(1, 58) = 20.32$, $\eta_p^2 = .26$, and story type, $F(1, 58) = 506.47$, $\eta_p^2 = .90$. However, in this analysis, the Age Group × Story Type interaction reached significance, $F(1, 58) = 4.44$, $\eta_p^2 = .07$, consistent with previous work demonstrating that older and younger adults are differentially slowed when reading stories that include distracting words (Connelly et al., 1991; Duchek et al., 1998; Dywan & Murphy, 1996). An independent samples *t* test revealed that younger ($M = 3.20$, $SD = 2.72$) and older ($M = 2.59$, $SD = 3.92$) adults did not differ in the number of distracting words read out loud in distraction stories ($t < 1$, *ns*).

Recall performance. Figure 2A displays the mean number of previously distracting and new words recalled by younger and older adults.[3] Most important, there was an Age Group × Word Type interaction, $F(1, 58) = 11.52$, $\eta_p^2 = .17$, which revealed transfer of previous distraction for older adults but not younger adults. Although older adults recalled significantly more previously distracting than new words, $t(29) = 5.34$, $d = 0.98$, younger adults recalled a comparable number of previously distracting and new words ($t < 1$, *ns*). Older adults, but not younger adults, showed transfer of previous distraction that enhanced their free recall performance.[4]

Younger adults recalled more new words than did older adults, $t(58) = 2.93$, $d = 0.75$, which is consistent with the widely reported age-related decline in memory as measured by free re-

Table 2
Reading Times (in Seconds) for Younger and Older Adults as a Function of Story Type in Studies 1 (N = 60), 2 (N = 48), and 3 (N = 48)

	Distraction stories					
	All four stories		First two stories		Control stories	
Age group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study 1						
Younger	94.6	16.8	99.6	18.4	66.2	10.3
Older	113.3	21.5	121.6	23.7	81.3	13.3
Study 2						
Younger	93.3	18.9	96.5	19.0	65.1	12.6
Older	119.2	28.7	130.9	31.8	81.7	16.2
Study 3						
Younger	78.2	12.4	81.6	13.4	54.7	7.7
Older	114.7	23.6	123.7	31.0	74.2	12.4

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[3] Overall, participants produced few extralist intrusions during recall. The mean number of extralist intrusions ranged from 0.04 to 0.25 words across studies and age groups, and this number did not significantly differ between younger and older adults in any of the studies (all *t*s < 1.20, *ns*).

[4] This pattern of differential transfer of distraction by younger and older adults was also observed in a pilot study. We tested 12 younger and 12 older adults in a procedure identical to that used in Study 1, except that distracting words in the reading task and words in the memory task were more abstract (e.g., *rarity, essence, impulse*) than those used in the studies reported here (e.g., *king, flower, pepper*). Younger adults did not differ in their recall of previously distracting and new words (3.2 vs. 2.8, respectively; $t < 1$, *ns*). However, older adults recalled more previously distracting than new words (2.8 vs. 1.4, respectively), $t(11) = 3.14$, $p < .009$, $d = 1.20$. We took these data to be promising but changed the materials to concrete words in Study 1 to increase older adults' overall memory performance.

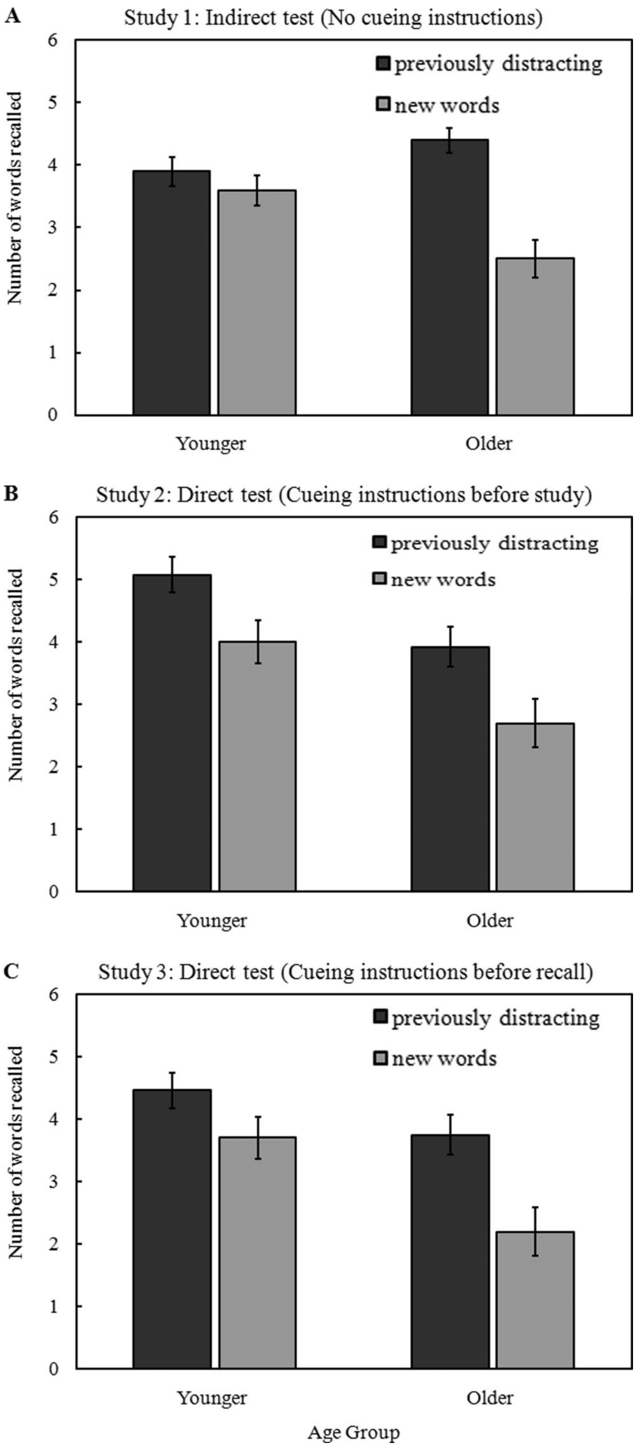

Figure 2. Mean recall of previously distracting and new words as a function of age group in Studies 1–3 (Panels A–C, respectively). Error bars represent standard errors of the mean.

call.[5] However, younger and older adults' recall of previously distracting words did not differ, *t*(58) = 1.50, *p* = .14, *ns*. As a result of these age differences in transfer of distraction, older adults' exclusive transfer of distraction improved their recall, such that there was also no significant difference in younger (*M* = 7.53, *SD* = 1.93) and older (*M* = 6.87, *SD* = 2.10) adults' total recall, *F*(1, 58) = 1.64, *p* = .20, *ns*.

Discussion

These results support our key hypothesis that older adults' prior exposure to distraction can improve recall when distracting words reappear in a seemingly unrelated memory task. However, the benefit of distractibility to recall came at a cost: Older adults showed greater disruption to reading times than did younger adults when irrelevant words were presented within a narrative, particularly in early stories, when the distraction was relatively new to participants. Although processing of incoming information was slowed in the presence of distraction, the tacit knowledge gained from encoding this distraction had a surprising benefit for older adults' later memory performance. In contrast, prior exposure to the same distraction had no impact on younger adults' recall performance. As a result of these age differences in transfer of distraction, older adults actually recalled as many words as did younger adults, despite the age-related decline in free recall performance that is widely observed in the literature (Arenberg & Robertson-Tchabo, 1985; Burke & Light, 1981; Craik & McDowd, 1987; Park et al., 2002; see also footnote 5). In sum, these results converge with previous studies to show age differences in implicit transfer of distraction to future implicit tasks (Campbell et al., 2010; Kim et al., 2007; Rowe et al., 2006). Further, the results extend previous work to show that implicit transfer of distraction can improve older adults' memory performance in a free recall task that is known to rely heavily on self-initiated retrieval (Craik, 1986).

A critical question is whether the difference in younger and older adults' transfer of distraction seen here and elsewhere (Campbell et al., 2010; Kim et al., 2007; Rowe et al., 2006) is due to differences in their initial encoding of distraction or to differences in their access to distraction in later tasks. With respect to initial encoding, younger adults may effectively inhibit or ignore distraction by quickly suppressing it (de Fockert et al., 2009; Gazzaley et al., 2005), consistent with the access function of regulating distraction (Hasher et al., 1999). In contrast, older adults may have difficulty suppressing distraction, resulting in additional processing of this irrelevant information.

Alternatively, both younger and older adults may encode distraction in the initial reading task, but only older adults continue to have access to distraction in subsequent tasks (as seen in Kim et al., 2007; Rowe et al., 2006). This interpretation is consistent with research suggesting that older adults have more difficulty than younger adults in suppressing previous information in order to switch to new information (Jonides et al., 2000; Lustig et al., 2001;

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[5] We also tested two additional groups of 24 younger and 24 older participants to show typical age differences in free recall when the distraction in the reading task was unrelated to words in the memory task. The procedure was identical to that in Study 1, with the same stories and identical free recall test list, but without any overlap in materials between the distraction in the first phase and the words on the free recall list. As expected, we found that younger adults (*M* = 8.08, *SD* = 1.90) recalled more words than did older adults (*M* = 5.91, *SD* = 1.47), *t*(46) = 4.40, *d* = 1.28.

May et al., 1999). From this perspective, younger adults may encode distraction, at least under some circumstances. However, younger adults may successfully suppress information from a previous task when they move on to the next one. As a result, information from previous tasks may be temporarily inaccessible, as suggested by work in the classic retroactive interference paradigm (Postman & Underwood, 1973).

Consistent with this latter view, there is some evidence that younger adults may also encode information that initially appeared as distraction. Kemper and McDowd (2006) measured eye movements of younger and older adults while reading with distraction and found no age differences in the number and duration of eye fixations to distracting text. Likewise, Williams, Zacks, and Henderson (2009) found that younger and older adults showed comparable eye movements to distracting stimuli in a visual search task as well as comparable recognition of distractors in a surprise memory test. Further, in explicit memory tasks, both younger and older adults showed significant recognition of previously distracting stimuli (Kemper & McDowd, 2006; Williams et al., 2009). Likewise, in previous studies using tasks that involve reading target text amid distraction, both age groups were able to select incorrect alternatives from multiple-choice questions about the stories that had actually appeared as distraction (Dywan & Murphy, 1996; see also Tun, O'Kane, & Wingfield, 2002, for similar results with auditory distraction).

The next studies attempt to disentangle these two alternative explanations for age differences in transfer of distraction to later memory tasks. In particular, the differential transfer observed in Study 1 could be due to age differences either in initial encoding of distraction or in subsequent accessibility of the distraction in new tasks.

Study 2

We addressed the question of whether younger adults encode distraction but need explicit cues to use it in new situations. The procedure here differed from Study 1 only in that the memory test was now direct, such that participants were informed that words on the to-be-learned list had occurred previously in the experiment. These cueing instructions were given immediately before presenting the words to study. Although the memory task was now a direct measure of distraction, the encoding of distraction would still be incidental given that participants were not aware while they were reading the stories that the distracting words would become relevant.

If encoding of distraction does not differ for younger and older adults (see e.g., Dywan & Murphy, 1996; Kemper & McDowd, 2006; Williams et al., 2009), cueing instructions should encourage younger adults to access information from the previous task by highlighting its relevance to current task goals. In an explicit memory task, younger adults may be able to access their knowledge of previous distraction to improve their recall of previously distracting words. This finding would also be consistent with previous research demonstrating that younger adults are more likely than older adults to constrain retrieval to what is seen as the relevant source (B. A. Anderson, Jacoby, Thomas, & Balota, 2011; Jacoby, Shimizu, Velanova, & Rhodes, 2005). In Study 1, younger adults may have constrained memory retrieval to words from the study list. If cueing instructions indicate that some of the words that will be studied were presented earlier in the experiment, then younger adults may relax their constraint over retrieval to gain access to distraction from previous tasks. If younger adults do show transfer of distraction to the memory task, this would suggest that, like older adults, they had encoded the distraction initially.

Method

Twenty-four younger (18–25 years) and 24 older (58–77 years) adults participated in this study. The younger (8 male, 16 female) and older (5 male, 19 female) adults were recruited from the same participant pools as before. Table 1 displays demographic information for the participant sample. Compared with younger adults, older adults had significantly more years of education, $F(1, 46) = 30.57$, $\eta_p^2 = .32$, and significantly higher scores on the Shipley Vocabulary Test, $F(1, 46) = 17.46$, $\eta_p^2 = .29$. The materials and procedures were identical to those of Study 1 with the exception of instructions given just prior to the exposure of the study list (in which half the items had occurred as distractors in the initial reading task). As in Study 1, participants were told that they should study the words for an upcoming recall test. In contrast to Study 1, here participants were also presented with an onscreen cueing instruction informing them that "some of the words in the study list were presented earlier in the experiment."

Results and Discussion

Reading times. Younger and older adults' mean reading times are displayed in Table 2. Overall, older adults read more slowly than did younger adults, $F(1, 46) = 17.46$, $\eta_p^2 = .28$, and distraction stories were read more slowly than were control stories, $F(1, 46) = 144.73$, $\eta_p^2 = .76$. As in Study 1, the Age Group × Story Type interaction did not reach significance when all the stories were considered, $F(1, 46) = 2.86$, $p = .10$, $\eta_p^2 = .06$, but did when only the first two stories were compared with the control stories, $F(1, 46) = 14.13$, $\eta_p^2 = .24$. On the basis of an independent samples *t* test, younger ($M = 2.79$, $SD = 2.65$) and older ($M = 2.74$, $SD = 2.40$) adults did not differ in the number of distracting words read out loud in the distraction stories ($t < 1$, *ns*).

Recall performance. Figure 2B displays the mean number of previously distracting and new words recalled as a function of age. As in Study 1, there was a main effect of word type, $F(1, 46) = 11.33$, $\eta_p^2 = .20$. However, there was no Age Group × Word Type interaction ($F < 1$, *ns*). Both younger and older adults recalled more previously distracting than new words when cueing instructions referred to the relevance of the previous task, $t(23) = 2.43$, $d = 0.71$, and $t(23) = 2.35$, $d = 0.69$, for younger and older adults, respectively. Under these direct cueing instructions, both groups benefited from prior exposure to distraction and typical age differences were observed, with younger adults ($M = 9.08$, $SD = 2.10$) recalling more words than did older adults ($M = 6.63$, $SD = 2.46$), $F(1, 46) = 13.82$, $\eta_p^2 = .23$.

The addition of cueing instructions promoted a striking change in younger adults' use of previous distraction when it was relevant to a subsequent memory task. When cueing instructions indicated that some words in the study list appeared earlier in the experiment, younger adults recalled more previously distracting than new words. Young adults clearly encoded the distraction initially; they simply did not use it to improve free recall performance in the indirect memory task used in Study 1 (see also Gopie et al., 2011). In contrast, older adults' prior exposure to distraction transferred to improve free recall performance with both indirect (Study 1) and explicitly cued (Study 2) memory tasks.

Study 3

The results of the previous studies suggest that both younger and older adults encoded distraction during the reading task but that younger adults transferred this information only when given explicit cueing instructions that highlighted its relevance (Study 2). Given that cueing instructions in Study 2 occurred before participants studied the words, the accessibility of previous distraction may facilitate either encoding or retrieval processes (or both) in the free recall task. The goal of this study was to isolate when in learning younger adults need the cueing instructions in order to transfer information from previous tasks. In Study 3, the same explicit cueing instructions used in Study 2 were relocated to occur after studying the words but before recall.

If younger adults show transfer of previous distraction when cueing instructions occur after study, these results would suggest that accessibility of previous distraction facilitates retrieval. This finding would be consistent with the possibility that younger and older adults differ in their ability to control what information is retrieved in a memory task. Indeed, Healey, Campbell, Hasher, and Ossher (2010) found that younger adults suppress competing responses at retrieval. In contrast, a subsequent study found that older adults actually showed facilitation of the competing responses at retrieval, consistent with the suggestion that aging is associated with a failure of suppression at the time of output (Healey, Ngo, & Hasher, 2011). Accordingly, information from previous tasks may be suppressed during retrieval unless its relevance is highlighted. Likewise, Jacoby and colleagues found that younger adults constrain retrieval to a relevant source during explicit memory (B. A. Anderson et al., 2011; Jacoby, Shimizu, Velanova, & Rhodes, 2005). Cueing instructions before recall would point to the prior reading task as an additional relevant source, thus encouraging younger adults to access distracting information from previous tasks.

Method

Twenty-four younger (18–35 years) and 24 older (60–82 years) adults participated in this study. Younger adults (10 male, 14 female) were undergraduate students at Washington University in St. Louis and received course credit or monetary compensation for participation. Older adults (7 male, 17 female) were recruited from a seniors participant pool in the St. Louis community and received monetary compensation. Table 1 displays demographic information for the participant sample, excluding one older adult who did not complete education information. Compared with younger adults, older adults had significantly more years of education, $F(1, 45) = 5.96$, $\eta_p^2 = .12$, and significantly higher scores on the Shipley Vocabulary Test, $F(1, 46) = 11.38$, $\eta_p^2 = .20$. The materials and procedures were identical to those of Study 2 except that the cueing instructions were now given after exposure to the study list and before participants began to recall the words. As in Study 1, participants were told that they should study the list of words for an upcoming recall test. Following the final word in the study list, participants were presented with an onscreen cueing instruction read out loud by the experimenter to inform them that "some of the words in the study list were presented earlier in the experiment." Then, as in previous studies, participants recalled out loud and experimenters recorded their responses.

Results and Discussion

Reading times. Younger and older adults' mean reading times (in seconds) are displayed in Table 2. Overall, older adults read more slowly than did younger adults, $F(1, 46) = 49.35$, $\eta_p^2 = .52$, and distraction stories were read more slowly than were stories without distraction, $F(1, 46) = 337.01$, $\eta_p^2 = .88$. Further, the Age Group × Story Type interaction was significant when all the stories were considered, $F(1, 46) = 23.65$, $\eta_p^2 = .34$, revealing that older adults showed greater slowing than did younger adults when they read stories that contained distracting text. The same pattern emerged when we compared reading times for only the first two distraction stories with those for the stories without distraction, $F(1, 46) = 21.15$, $\eta_p^2 = .32$, for the Age Group × Story Type interaction. Compared with younger adults ($M = 1.85$, $SD = 1.42$), older adults ($M = 3.73$, $SD = 2.70$) also read more distracting words out loud in the distraction stories, $t(46) = 2.91$, $d = 0.24$.

Recall performance. Figure 2C displays the mean number of previously distracting and new words recalled as a function of age group. These results replicate the pattern observed in Study 2. Participants recalled more previously distracting than new words, $F(1, 46) = 22.23$, $\eta_p^2 = .33$. Further, younger adults recalled more words overall than did older adults, $F(1, 46) = 8.01$, $\eta_p^2 = .15$. There was no Age Group × Word Type interaction ($F < 1$, *ns*). Both younger and older adults recalled significantly more previously distracting than new words when cueing instructions referred to the relevance of the previous task before recall, $t(23) = 2.61$, $d = 0.46$, and $t(23) = 4.21$, $d = 0.86$, for younger and older adults, respectively. Under these direct cueing instructions, both groups benefited from prior exposure to distraction, and typical age differences were observed, with younger adults ($M = 8.13$, $SD = 3.10$) recalling more words than did older adults ($M = 5.96$, $SD = 2.12$). These results suggest that cueing instructions facilitate retrieval of distraction from previous tasks.

General Discussion

A series of three studies reported here demonstrate that encoding distraction has surprising benefits when this information becomes relevant to a future memory task. Older adults showed transfer of previous distraction that improved recall performance regardless of whether the memory task was direct or indirect in its use of information that had appeared previously as distraction. Moreover, older adults' transfer of previously distracting information improved their performance and, at least under indirect testing conditions (Study 1), counteracted the widely reported reduced recall that older adults ordinarily show in explicit memory tests (see e.g., Balota et al., 2000; Park et al., 2002). In contrast, younger adults showed no transfer from prior exposure to distraction when the memory task was indirect in its use of distracting information from previous tasks (Study 1). However, when memory instructions directly referred to the relevance of information from previous tasks, younger adults then showed transfer of previous distraction, resulting in increased recall for those items they had seen before (Studies 2 and 3). The transfer effects observed in the current studies suggest that exposure to distracting information in earlier tasks can transfer to improve memory performance on future tasks. However, these memory benefits for previously distracting information depended both on the nature of the final test task (i.e., indirect vs. direct instructions) and on the age of the participants.

In memory tasks, cognitive control processes operate at encoding, at the time that tasks switch, and at retrieval. The differences in younger and older adults' use of prior distraction may be accounted for by age-related changes in the efficiency of these cognitive control processes.

During encoding, control processes are thought to limit the focus of attention to relevant information, as suggested by the access function of inhibitory theory (Hasher et al., 1999; Lustig, Hasher, & Zacks, 2007). However, age differences in initial processing of irrelevant information cannot account for the differences reported here in younger and older adults' transfer of prior distraction. Both younger and older adults encode irrelevant information, at least under the present circumstances, in which distracting words occurred many times amid a set of target materials. The distracting information must be encoded in order to transfer to later tasks. Indeed, there is other evidence of encoding irrelevant information in the environment by young adults in both visual search (see e.g., Chun & Jiang, 1999; Williams et al., 2009) and working memory research (see e.g., Serences, Ester, Vogel, & Awh, 2009; Vogel, McCollough, & Machizawa, 2005). Likewise, evidence from eye-tracking studies (Kemper & McDowd, 2006) shows that both younger and older adults show comparable visual fixation on irrelevant information. Although younger adults are better able than older adults to control the influence of the distraction on concurrent task performance, these findings converge on the possibility that both younger and older adults encode distracting information.

There is also evidence to suggest that older adults have difficulty switching tasks, resulting in greater carryover of item representations, goals, and response sets from one task to another (see e.g., Jonides et al., 2000; Kray & Lindenberger, 2000; Lien, Ruthruff, & Kuhns, 2008; Lustig et al., 2001; May et al., 1999; Mayr, 2001). Indeed, information from previous tasks that is no longer relevant may be an important source of distractibility. Hasher et al. (1999) proposed that suppression was required to diminish activation of no longer relevant information, a mechanism that is far less efficient for older adults compared with younger adults. This same deficit in suppressing no longer relevant information from the past may explain older adults' implicit access to distracting information in subsequent tasks. By contrast, younger adults' successful suppression as tasks change (Jonides et al., 2000; Lustig et al., 2001; May et al., 1999) may underlie their failure to transfer previous distraction to improve their free recall when the memory task is indirect. As in previous work (see e.g., Kim et al., 2007; Rowe et al., 2006), those previously distracting items are not accessible under indirect testing conditions, at least when the task goals seem different. Suppression of irrelevant information from previous tasks may enable younger adults to focus on current task content without interference or facilitation from information presented in the past.

Older adults have also shown a deficit in cognitive control that operates during retrieval. Source-constrained retrieval regulates the memory search such that only desired information is retrieved (Jacoby, Shimizu, Daniels, & Rhodes, 2005). Further, there is evidence that young adults are better able to constrain retrieval than are older adults (B. A. Anderson et al., 2011; Jacoby, Shimizu, Velanova, & Rhodes, 2005). Age-related differences in source-constrained retrieval, coupled with age-related differences in suppressing information from previous tasks (Healey et al., 2010, 2011), explain why information from previous tasks is more likely to influence memory performance of older adults than that of younger adults. In the current studies, younger adults may limit retrieval to the studied list of words, unless memory instructions directly encourage them to consider information from previous tasks. Then, given that younger adults have encoded the distracting items, their enhanced cognitive control and retrieval constraint ability enables them to access the earlier set of words and to benefit from them when recalling the final list of words in this study. Indeed, the results of Study 3 demonstrate that younger adults transfer previous distraction to improve memory even when they are informed of the relevance of this information only before recall. Thus, age differences in retrieval constraint ability may also play a critical role in transfer of distraction from previous tasks.

This view of age differences in cognitive control would suggest that there may be many situations in which seemingly distracting information in one situation can enhance performance when it becomes relevant in a new situation. This transfer of information from previous tasks may depend on the extent to which participants suppress information from previous tasks (see e.g., Healey et al., 2010; Jonides et al., 2000; Lustig et al., 2001; May et al., 1999) and constrain retrieval to a relevant source at recall (Jacoby, Shimizu, Daniels, & Rhodes, 2005). These downstream effects of encoding distraction may be beneficial when previous distraction becomes relevant to future tasks, as has been seen in tasks that rely on implicit retrieval such as word-fragment completion (Rowe et al., 2006) and verbal problem solving (Kim et al., 2007). Further, Campbell et al. (2010) recently found that older adults, but not younger adults, form implicit associations between contiguous target and distracting information in their environment. Implicit access to seemingly irrelevant information from the past may also help individuals to pick up on relationships in the environment that are not necessarily encoded or obvious to others.

The results of the present studies have important implications for the way that younger and older adults apply their knowledge of distraction. Both younger and older adults encode distraction, at least under some circumstances. As a result, both groups can benefit from prior distraction when it becomes relevant in a future task. This knowledge of distracting information may be particularly useful given that information that appears frequently in the recent past is likely to occur again in the near future (J. R. Anderson & Schooler, 1991). J. R. Anderson (1996) suggested that an adaptive memory system should regulate access to information in memory to reflect what might be relevant in one's current environment. As an example, if a person overheard a colleague discussing some exciting new research findings outside his or her office door, he or she might be more likely to attend to and remember the details when these findings are described at a later conference. Further, older adults are more likely than younger adults to benefit from prior distraction when its relevance in the current environment is not obvious (i.e., in the absence of strong cues). Although older adults are particularly susceptible to the negative consequences of processing distraction in the environment, tacit knowledge of prior distraction may hold predictive value to optimize memory for previous distraction that becomes relevant in a new context.

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