Implicit and explicit consequences of distraction for aging and memory

by

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IMPLICIT AND EXPLICIT CONSEQUENCES OF DISTRACTION

FOR AGING AND MEMORY

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Abstract

This investigation explored implicit and explicit memory consequences of age differences in susceptibility to distraction when previous distraction occurs as target information in a later memory task. Younger and older adults were presented with either implicit (Study 1) or explicit (Studies 2 and 3) memory tasks that included previously distracting and new words.

Study 1 explored whether prior exposure to distraction would transfer to improve memory when previously distracting words were included in list to be studied for a recall task. Older adults recalled more previously distracting than new words whereas younger adults recalled the same amount of previously distracting and new words. This initial study was implicit in its use of previously distracting information in that participants were neither informed nor aware of their prior exposure to words in the recall task. Here, only older adults' memory was influenced by prior exposure to distraction and their recall actually increased to the level of younger adults with implicit use of distraction to improve performance.

Subsequent studies investigated explicit influences of prior exposure to distraction on later memory. In Study 2, both younger and older adults showed reliable memory for previously distracting words in an explicit recognition task. These results suggest that although younger adults encode distraction, they do not transfer this information when previous distraction occurs as target stimuli in an implicit memory task. Study 3 investigated whether participants would transfer previous distraction to improve recall if the task was explicit in its use of previous distraction. When cueing instructions were given before the memory task informing participants of the connection between tasks, older adults once again recalled more previously distracting than new words. In contrast to the results of Study 1, younger adults also recalled more previously distracting than new words.

Taken together, the results indicate that younger adults do encode distraction, but they require explicit instructions to transfer their knowledge of distraction to later tasks. In contrast, older adults apply their knowledge of distraction in both implicit and explicit memory tasks. Implications are discussed in terms of inhibitory control theory and age differences in strategies engaged in memory tasks.

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I. GENERAL INTRODUCTION

Older adults experience declines in a variety of cognitive functions, which manifest in everyday cognitive errors such as misplacing house keys, repeating stories, failing to return to a task after interruption, and forgetting recent conversations (Tomaszewski-Farias et al., 2008). Not surprisingly, older adults complain about frequent episodes of "forgetfulness" that occur in their daily lives (e.g., Blazer, Hays, Fillenbaum, & Gold, 1997; Cutler & Grams, 1988). The general focus of the majority of aging research has been on cognitive deficits that accompany aging. This work has been successful in characterizing how aging negatively impacts cognitive abilities, such as maintaining information in immediate awareness (i.e., working memory), ignoring irrelevant information, recollecting information from the past, and reasoning (for reviews, see Kester, Benjamin, Castel, & Craik, 2002; Balota, Dolan, & Duchek, 2000; Zacks, Hasher, & Li, 2000). However, the limited focus on age-related deficits may overlook the complexity of cognitive functioning. That is, change in a particular cognitive function may be adaptive in some circumstances and maladaptive in others. In the same way, there may be surprising benefits from what is typically considered an age-related cognitive deficit.

The research presented here explores a potentially positive consequence of the age-related deficit in the ability to ignore distracting information (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999). Evidence suggests that there is an age-related deficit in suppressing activation of irrelevant representations or thoughts in the service of current goals (Hasher, 2007). As a result, older adults are more distracted by irrelevant

information in the environment than are younger adults and this then disrupts their

performance on ongoing tasks (Connelly, Hasher, & Zacks, 1991). Compared to younger

adults, older adults are also more likely to respond based on irrelevant information and to

experience interference from no-longer-relevant information (Hartman & Hasher, 1991;

May, Hasher, & Kane, 1999; Radvansky, Zacks, & Hasher, 1996). These costs to

ongoing and future task performance demonstrate the negative consequences associated

with older adults' problem ignoring distraction.

However, a complete understanding of cognition in old age requires that we

explore the full spectrum of consequences that follow from this change in cognitive

functioning, including possible benefits to performance from an age-related deficit in

ignoring distraction. In addition to the negative consequences associated with the age-

related deficit in ignoring distraction, older adults also encode and continue to have

implicit access to distracting information from the environment (Rowe, Valderrama,

Hasher, & Lenartowicz, 2006). There may be additional positive consequences of this

access to distraction if it becomes relevant and helpful to a future task. This series of

studies explores the possibility that susceptibility to distraction may have surprising

benefits when distracting information reappears as target information in a memory task.

The Inhibitory Deficit in Aging

Hasher et al. (1999) suggest that inhibitory control is a critical component of

efficient processing when too much information competes for attention. Specifically, they

argue that activation of target information is comparable in younger and older adults.

However, an age-related decline in inhibitory control impairs performance on a variety of cognitive tasks due to the failure to suppress irrelevant information in the current environment as well as downstream interference from irrelevant information from the past.

One important role of inhibition involves preventing distracting stimuli from gaining access to the focus of attention (i.e., the *access* function), thereby limiting the contents of working memory to goal-relevant information (Hasher et al., 1999). The presence of visual distraction impairs older adults' performance on target tasks. Compared to younger adults, older adults show disproportionate slowing in classic processing speed tasks (Lustig, Hasher, & Tonev, 2006) and reading (Connelly et al., 1991; Duchek, Balota, & Thessing, 1998; Dywan & Murphy, 1996) when irrelevant information is present. For example, Connelly et al. (1991) presented younger and older adults with short narratives embedded with distracting words in a distinctive font. Compared to control passages with xs as distraction, older adults experienced greater disruption to their reading times for passages with distracting words than did younger adults. Visual distraction also reduces older adults' verbal problem solving performance when the meaning of the distracting information leads away from the solution (May, 1999). A similar pattern of results has been observed with auditory distraction. The presence of distracting speech disproportionately reduced older adults' immediate recall of target speech (Tun, O'Kane, & Wingfield, 2002; Tun & Wingfield, 1999; but see Bell & Buchner, 2007). Compared to younger adults, older adults experience greater

disruption to concurrent task performance when there is distracting information in their surroundings.

Gazzaley, Cooney, Rissman, and D'Esposito (2005) provide additional evidence of an age-related inhibitory deficit in a study investigating the neural correlates of processing relevant and irrelevant information. Younger and older adults were presented with a series of natural scenes and faces. In one condition, they were instructed to ignore the scenes and remember the faces. In the other condition, they were instructed to ignore the faces and remember the scenes. Gazzaley et al. examined activity in the parahippocampal place area (PPA), a region known to be involved in processing natural scenes. Relative to a passive viewing control condition, both younger and older adults showed increased activity in the PPA when they were told to remember the scenes. However, only younger adults showed reduced activity in the PPA relative to the control condition when they were instructed to ignore the scenes, a finding which suggests that they may have been suppressing representations of ignored scenes. Greater suppression of activity in the PPA for irrelevant scenes during encoding was associated with better memory for the target faces (see also, Gazzaley, Clapp, Kelley, McEvoy, Knight, and D'Esposito, 2008). These results suggest that both younger and older adults show increased activation when viewing stimuli that should be remembered, but older adults show a deficit in suppressing activity for stimuli that should be ignored.

The ability to inhibit or ignore visual distraction may be an important determinant of performance on working memory tasks. The failure to suppress irrelevant information results in more distraction occupying the focus of attention, thereby cluttering the

contents of working memory (Hasher et al., 1999). Vogel, McCollough, and Machizawa (2005) found that visual working memory capacity (i.e., the ability to hold onto visual representations over several seconds) was associated with the ability to ignore visual distraction. Using event-related potentials, Vogel et al. investigated contralateral delay activity (CDA) known to increase significantly as the number of representations being held in working memory also increases. Participants were presented with a visual display including two targets only, four targets only, or two targets and two distracters. Individuals with lower working memory capacity showed similar CDA amplitude regardless of whether they were viewing four targets or two targets with two distracters. In contrast, individuals with higher working memory capacity showed greater CDA activity for four targets than for two targets with two distracters. These results suggest that individuals with lower working memory capacity were more likely to encode and maintain information about irrelevant items compared to those with higher working memory capacity. Furthermore, the ability to control processing of concurrent distraction has been found to mediate the relationship between aging and working memory as assessed by complex span tasks (Darowski, Helder, Zacks, Hasher, & Hambrick, 2008).

Another important role of inhibitory control involves suppressing activation of information that is no longer relevant. Hasher et al. (1999) refer to this type of suppression after processing as the *deletion* function of inhibition. However, it is important to note that this refers to a temporary suppression to reduce disruption or interference from now-irrelevant information. As a result of failing to suppress previously relevant information, older adults are more susceptible to interference from the past than

are younger adults. A growing body of research suggests that this build up of proactive interference across a task impairs older adults' performance on classic working memory tasks. Typical working memory tasks require that participants engage in some type of processing task while remembering a series of words intermixed with the processing task. After two to five of these events, participants are required to recall the words from that set. For example, participants doing a reading span task (Daneman & Carpenter, 1980) read a series of sentences for comprehension and remember the last word for each sentence. Proactive interference may disrupt performance if relevant words from previous trials interfere with retrieval of words in the current trial. Working memory sets are often presented in an ascending manner, such that participants begin with sets of two trials and finish with the largest set of five trials. High working memory scores are achieved if participants successfully recall words from the largest set sizes (i.e., those consisting of four or five trials). However, these sets are presented late in the task when proactive interference from previous trials would be the greatest. This arrangement of the task could differentially impair older adults' performance, given their deficit in suppressing previously relevant information.

Indeed, May et al. (1999) structured the working memory task to reduce the impact of proactive interference by presenting participants with the set sizes in descending order, such that the largest sets of four or five trials were completed early in the task when proactive interference was minimal. Although age differences in working memory span are quite pronounced in the standard ascending version of the task, May et al. found that older adults' performance improved and age differences were reduced

when trials were presented in descending order. Additional research corroborates this finding using different manipulations to reduce the impact of proactive interference in working memory tasks, such as by making the different sets or stimuli within those sets more distinct (Bunting, 2006; May et al., 1999; Lustig, May, & Hasher, 2001; Rowe, Hasher, & Turcotte, 2008). Thus, the age-related deficit in suppressing previously relevant information contributes to performance on classic working memory tasks.

Furthermore, Jonides et al. (2000) found that older adults experience more interference from previously relevant information that disrupts their performance on an item-recognition task. In this study, younger and older adults were presented with a series of trials containing a set of letters to remember for several seconds. Then, a single letter appeared and they were asked to identify whether this probe item was present in the most recent set of letters. When the probe letter was not presented in the most recent set but was presented in a previous trial's set, older adults were slower and less accurate in recognizing the current probe when there was interference from a previously relevant item. These results have been interpreted as evidence that older adults are more susceptible to interference than younger adults because the now-irrelevant past was not suppressed.

The failure to inhibit distracting information has downstream consequences, including disrupted retrieval of information from both working memory and long-term memory. Namely, older adults continue to have access to previously relevant information that was not suppressed and this can then compete during retrieval of other information. For example, Hamm and Hasher (1992) investigated younger and older adults' formation

of inferences about passages with either expected or unexpected outcomes. Participants' original inference about the story was confirmed when the outcome was expected and disproved when the outcome was unexpected. Under the latter condition, participants should delete or suppress their original inference in passages with unexpected outcomes in order to arrive at the appropriate inference. Although both groups understood the final inference, older adults were more likely than younger adults to accept the original, disproved inference as true in unexpected passages. Furthermore, older adults' memory for inferences was disproportionately impaired for passages with unexpected outcomes compared to passages with expected outcomes. These results suggest that older adults have sustained access to incorrect inferences and that sustained access is associated with poorer long-term memory, presumably due to increased interference when multiple inferences compete at retrieval (see also, Hartman & Hasher, 1991). Thus, a failure to suppress previously relevant information may serve to create more competition at retrieval.

These results join with additional research demonstrating that there is an age-related increase in susceptibility to interference at retrieval: older adults respond more slowly and make more errors than do younger adults when there is competition from related but incorrect information (Cohen, 1990; Gerard, Zacks, Hasher, & Radvansky, 1991; Radvansky et al., 1996; Winocur & Moscovitch, 1983). Inhibitory control may serve to suppress competing but incorrect alternatives to increase the efficiency of retrieval (Ikier, Yang, & Hasher, 2008). Indeed, Radvansky, Zacks, and Hasher (2005) found that older adults continued to have access to previously incorrect competitors in

subsequent trials. In contrast, younger adults' access to previously incorrect competitors was impaired, presumably because these items were inhibited while resolving interference at retrieval. Together, these studies demonstrate than inhibitory problems impact long-term memory due to older adults' impaired suppression of information from the past. Furthermore, older adults continue to have access to irrelevant information from the past which creates increased competition at retrieval.

In summary, inhibitory control serves to dampen or suppress distracting information (Hasher, 2007). When inhibitory control is impaired, as is the case in healthy older adults, performance on tasks may be disrupted in the presence of concurrent distracting information (e.g, Connelly et al., 1991; Gazzaley et al., 2005; Lustig et al., 2006; Tun et al., 2002). In addition, older adults encode distracting information and continue to have access to information that is no longer relevant (Hamm & Hasher, 1992; Hartman & Hasher, 1991). This irrelevant information may interfere with retrieval of related concepts, resulting in slower and less accurate retrieval from long-term memory (Gerard et al, 1991; Radvansky et al., 1996). Thus, older adults' inhibitory problems may be an important source of age-related impairments in working memory (May et al., 1999; Vogel et al., 2005) and reasoning ability (Darowski et al., 2008).

Sustained Access to Distraction

Although there are clear negative consequences of the age-related deficit in inhibitory control, benefits have also been reported. Older adults encode and continue to have access to more information in the environment, much of which may have been

initially distracting. Recent studies demonstrate that older adults continue to have implicit access to previous distraction in subsequent tasks. For example, Rowe et al. (2006) presented younger and older adults with a series of line drawings with superimposed distracting words and letter strings. Participants were instructed to press a key whenever the identical picture repeated in sequence and to ignore the words. After a ten-minute filled interval, participants were given an implicit word-fragment completion task in which some of the fragments could be completed with distracting words from the pictures task. Compared to younger adults, older adults showed better implicit memory for previous distraction, as revealed by more correct fragment completions when the solution had appeared as distraction in the earlier pictures task.

Furthermore, Kim, Hasher, & Zacks (2007) also found evidence that older adults but not younger adults show carryover of distracting information in subsequent tasks. Younger and older adults were presented with distracting words in the context of a reading task. After a 15-min filled interval, participants were presented with an apparently unrelated verbal problem solving task. Importantly, some of the solutions to these problems had been presented as distraction in the reading task. Kim et al. found that older adults solved more problems relative to a baseline control condition when the solutions had been presented as distraction in a previous task. In contrast, younger adults solved the same number of problems regardless of whether or not they had prior exposure to the solutions as distraction. In both of these studies (Kim et al., 2007; Rowe et al., 2006), neither younger nor older adults were aware that these tasks involved previous distraction. Thus, older adults appear to have sustained implicit access to distracting

information, possibly due to their failure to suppress information from previous tasks. However, this implicit access to previous distraction improved their performance when it became relevant to future implicit tasks.

The following set of studies explored whether older adults' improved performance from prior exposure to distraction extends to a memory task on which there is a pervasive age-related decline in performance: explicit recall of the past. The negative effect of aging on free recall performance is more dramatic than other memory tests for the same information, such as recognition and cued-recall (e.g., Arenberg & Robertson-Tchabo, 1985; Burke & Light, 1981; Craik & McDowd, 1987). Research demonstrates that older adults have implicit access to previous distraction in later tasks (Kim et al., 2007; Rowe et al., 2006). If older adults transfer previously distracting information to facilitate recall performance, then their susceptibility to distraction may actually counteract the otherwise dramatic age-related deficit in recall memory.

Research Overview

Based on evidence of age differences in carryover of distraction from one task to another (Hartman & Hasher, 1991; Kim et al., 2007; Rowe et al., 2006), this series of studies investigated whether prior exposure to distraction influences younger and older adults' performance on an intentional memory task. More specifically, when previously distracting words occur as part of a free recall test, is memory performance of older adults facilitated by the prior exposure to the words? Given the dramatic age-related decline in recall memory (Arenberg & Robertson-Tchabo, 1985; Burke & Light, 1981;

Craik & McDowd, 1987; Park et al., 2002), any performance benefit from previous

exposure to distraction may compensate for the age-related decline in recall. In each of

the studies, previous distraction occurs later as target information in a memory task.

Study 1 explored implicit influences of previous distraction on an intentional memory

task. Studies 2 and 3 investigated direct, explicit influences of prior exposure to

distraction on subsequent memory performance.

The first study explored whether transfer from prior exposure to distraction would

extend to performance on an explicit memory task even when no reference was made to

the relevance of the prior task (i.e., implicit memory). Previous research demonstrating

carryover effects involved implicit memory tests for knowledge of distraction, for

example, completing a word fragment (e.g., T _ BL _) with the first word that comes to

mind when the solution (here, table) appeared as distraction in a previous task (Rowe et

al., 2006). Implicit memory occurs when information that was encoded in a prior episode

is expressed without deliberate retrieval. Thus, implicit memory can influence later

performance on explicit memory tasks even when people do not intend to rely on

previous experience and are unaware of doing so (Jacoby, 1991; Schacter, 1987).

In the initial study in this set (i.e., Study 1), the typical measure of implicit

memory was replaced with a free recall task to explore the influence of implicit memory

on explicit memory performance. Using a procedure developed by Connelly et al. (1991),

younger and older adults read a series of short narratives interspersed with distracting

words that they were instructed to ignore. After a ten minute delay, participants were

presented with a list of words to study for a recall test. Half of the words had been

presented as distraction in the stories and half were new. No one was informed of the connection between tasks and an awareness questionnaire was administered to ensure that none of the participants was aware of their prior exposure to the words in the recall task. Based on earlier studies (e.g., Rowe et al., 2006; Kim et al., 2007), it is expected that implicit access to distraction would impact recall performance at an implicit level for older adults.

The expression of implicit memory typically involves facilitation in processing of a stimulus as a function of recent exposure to the same stimulus (Schacter, 1987). Here, it is expected that implicit memory would be expressed through better recall of previously distracting compared to new words, presumably due to facilitated processing or increased fluency from prior exposure to the words (Jacoby, 1991). To foreshadow the results, Study 1 demonstrated that implicit access to previously distracting information improved older adults' memory performance when distracting words occurred as part of a list to be studied for an apparently unrelated recall task. In contrast, younger adults' recall did not improve with prior exposure to the distraction, possibly because they were better able to suppress the distraction at encoding or after the reading with distraction task. Thus, prior exposure to distraction had an exclusive benefit for older adults such that their recall performance actually increased to the level of younger adults with implicit use of previous distraction to improve memory.

Subsequent studies in this set investigated whether younger and older adults could deliberately retrieve previously distracting words. Previous research has focused on younger and older adults' implicit access to previously seen distraction (Rowe et al.,

2006; Kim et al., 2007; Study 1). However, very little research has explored explicit memory for distracting information. In Study 2, younger and older adults were given a direct explicit memory test for words previously presented as distraction, duplicating the procedure for exposing participants to distraction used in Study 1. However, the free recall task was replaced with a surprise explicit recognition test in which participants were asked to identify whether a series of words had been presented earlier in the study. Both younger and older adults showed explicit recognition of words that had appeared as distraction.

Thus, younger and older adults have explicit access to previously seen distraction when the memory test is direct in its use of information from earlier in the study. However, Study 1 demonstrated that younger adults' recall performance did not improve when previously distracting words occurred as part of an unrelated memory test. The goal of the third study was to investigate whether transfer from prior exposure to distraction would impact recall performance when participants were informed that some of words in the memory task had been presented earlier in the study. The procedure was nearly identical to that of Study 1 with participants reading stories with distracting words followed by an incidental memory test that included previously distracting and new words. Here however, the instructions given before participants viewed the final study list indicated that some words in the list had been presented earlier in the study. These cueing instructions impacted younger adults' performance such that they recalled more previously distracting than new words. Older adults showed the same pattern as in Study

1. Thus, cueing instructions facilitated younger adults' transfer of prior exposure to distraction to improve recall performance.

Taken together, the results of these studies demonstrate that (1) older adults may have implicit access to distraction in subsequent tasks, (2) older adults' tacit knowledge of distraction can transfer to improve recall performance even when no reference is made to the relevance of the prior task, (3) both younger and older adults recognize previously distracting information at an explicit level, (4) younger adults transfer previous distraction to improve recall only when cueing instructions highlight the relevance of the prior task, and (5) younger adults outperform older adults when the memory test is explicit. The results of these studies suggest that younger adults do encode distraction, but they require explicit instructions to transfer their knowledge of distraction to later tasks. In contrast, older adults apply their knowledge of distraction across implicit and explicit tasks. The implications of these results will be discussed in terms of inhibitory control as well as implicit and explicit memory.

II. IMPLICIT USE OF PREVIOUS DISTRACTION

Study 1a

The goal of the first study was to investigate whether implicit access to previously distracting information impacts performance on a subsequent explicit memory task. 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 delay, participants were presented with a list of words to learn for recall. Half of the words had been presented as distraction in the stories and half were new. No one was informed of the connection between tasks. An awareness questionnaire was administered to ensure that none of the participants was aware of their prior exposure to the words in the recall task.

This study focused on implicit influences on recall performance based on the following points. First, there is a research precedent demonstrating that, relative to younger adults, older adults have greater implicit memory for words previously presented as distraction (Rowe et al., 2006; Kim et al., 2007). Second, much research suggests that implicit memory processes are spared in aging. In contrast to the striking age differences in performance on explicit memory tasks, younger and older adults generally show comparable levels of priming for target information (Fleischmann & Gabrieli, 1998; La Voie & Light, 1994; Mitchell & Bruss, 2003), at least when there are no similar items in the list to create competition at retrieval (Ikier & Hasher, 2006). Third, previous research has demonstrated that implicit or automatic retrieval of information from the past can contribute to performance on direct tests of explicit memory, such as cued-recall and

recognition (Hay & Jacoby, 1996; Jacoby, 1991). Thus, it is conceivable that implicit access to previously distracting information may improve older adults' memory performance when distracting words occur as part of a list to be studied for an unrelated free recall test.

Previous research suggests that older adults are more likely than younger adults to encode distraction and to have access to that information in subsequent implicit tasks. Thus, it is expected that older adults would recall more previously distracting than new words. In contrast, previous research suggests that younger adults do not have sustained implicit access to distraction in subsequent tasks (e.g., Kim et al., 2007; Rowe et al., 2006), possibly because they suppressed distracting words during the reading task or suppressed information from previous tasks that is not relevant to current task goals. As such, it is expected that younger adults would recall the same number of previously distracting and new words.

Method

Participants

Because our interest was in implicit effects on the memory task, the data from six younger adults who reported awareness were replaced with those from new participants[1]. Demographic information for the final 30 younger adults (17 - 28 years) and 30 older adults (59 - 76 years) is displayed in Table 1. Younger adults (11 male, 19 female) were

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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. Most importantly, the aware younger adults recalled a comparable number of previously distracting ($M = 4.67$, $SD = 1.97$) and new words ($M = 4.50$, $SD = 1.04$), $t < 1$, *ns*.

undergraduate students at the University of Toronto who received course credit for their participation. Older adults (8 male, 22 female) were recruited from a seniors' participant pool and received monetary compensation. A two-way analysis of variance (ANOVA) was conducted to assess differences in vocabulary, years of education, and MEQ scores. Compared to younger adults, older adults had significantly more years of education, F (1, 58) = 24.09, $p < .001$, partial η^2 = .30, and significantly higher scores on the Shipley Vocabulary Test, F (1, 58) = 46.30, $p < .001$, partial η^2 = .44. Older adults also had significantly higher scores on the MEQ than did younger adults, F (1, 58) = 29.53, $p < .001$, partial η^2 = .34, with higher scores indicating a peak arousal period early in the day.

[Insert Table 1 about here]

Design

The design was a 2 (age) x 2 (word type) mixed factorial with age (young, old) as a between participants factors and word type (previously distracting, new) as a within participants factor. The main dependent measure was the number of words recalled. We also obtained a measure of distraction by comparing reading time of experimental stories with that of control stories. In addition, the number of distracting words read aloud by participants was also recorded.

Materials

Reading with distraction stories. Six stories were adapted from Connelly et al. (1991) for use in the present study (See Appendix 1). Relative to stories used in the Connelly et al. (1991) studies, those in the current story were lengthened from an average of 125 words per story to 174 words per story to accommodate the number of distracting

words while still maintaining a similar ratio between distracting and target words in the

story (~1 distracting word: 2.10 target words). Each distracting word appeared in each of

the four experimental passages during the current study whereas each distracting word or

phrase appeared in a single passage only during previous studies (Connelly et al., 1991;

Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996). The target text for

the passages was printed in italicized Century 12-point font and the distraction (words or

strings of xs) was printed in standard upright text of the same font. Each passage was

printed on an 8 ½" x 11" sheet of paper. Two of the passages contained strings of xs

(matched in length to the distracting words for the experimental stories) in standard font

(control passages). Four of the stories contained distracting words that were semantically

unrelated to the content of the stories (experimental passages). There were 16 total

distracting words with each word appearing five times per passage for a total of 20

occurrences across the four experimental passages. The distracting words appeared after

one to five of the passage words, with no two distracting words appearing sequentially.

   Distracting words and recall words. The words for this and all subsequent studies

were drawn from Coltheart's (1981) database of words, which includes frequency ratings

from Kucera and Francis' (1967) norms. A total of 24 words was selected and divided

into three sets of eight words (see Appendix 2). All words were between three and eight

letters in length and the three sets were matched for frequency ($M = 48.25$, $SD = 35.72$)

and word length in letters ($M = 4.71$, $SD = 0.95$). No words were semantically or

phonologically related to those in other sets nor were they semantically related to the

target text 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 and the other half did not appear later in the study (filler). Filler distracting words were included to reduce the chances of participants' noticing the connection between words in the reading and 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 word appeared equally often as a critical distracting word in the reading task (and, therefore, also a previously distracting word in the recall task), a filler distracting word in the reading task, and a new word in the recall task.

Procedure

All participants were tested individually, with each providing informed consent. Based on previous research demonstrating that distractibility fluctuated across the day (Hasher et al., 1999), the testing time for younger and older adults was controlled such that both groups were tested at the typical off-peak time of day according to their age group. Older adults were tested in the afternoon (between 12pm and 5pm; an off-peak time for most older adults) and a majority of younger adults were tested in the morning[2] (between 9am and 12pm; an off-peak time for most younger adults). They were initially told that there would be a series of tasks to perform. In the reading task, participants read a series of passages out loud and the experimenter recorded their reading times as well as any distracting words that the participant read out loud. Before beginning the stories,

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[2] Some of the younger adults were also tested in the early afternoon. A majority of younger adults (58%) fell into the neutral type category. Previous research (May & Hasher, 2004) suggests that younger adults whose scores fall into the neutral type category on the MEQ do not show variation in performance across the day. In the present study, as well as all subsequent studies in this set, there were no differences in mean reading time, distractibility (reading time for experimental vs. control passages), or recall performance between younger adults tested in the morning and those tested in the afternoon, all *ts* < 1, *ns*.

participants were told that they would be asked questions about what happened in the stories later in the experiment. Participants were not allowed to follow along the text with their finger while reading. Participants first read a practice story in italicized font without any distraction. Before the introduction of the first experimental passage, participants were informed of the presence and appearance (type format) of the distracting material. They were told to completely ignore this text, and to read only the text printed in italics. Participants then read four experimental stories with instructions to ignore distracting words.

Following the reading task, participants were given a computerized number fragment completion task. On each trial, participants were presented with a math equation with one number missing (e.g., $11 + 2\_ = 34$) and their task was to indicate which number would correctly complete the equation (in this case, the answer was "3"). The equation was presented in the center of the screen in Arial size 19 font and it remained on the screen until participants responded. Then, there was a 500 msec inter-stimulus interval in which a fixation cross appeared in the center of the screen before the next trial. The task continued until ten minutes had passed to ensure that each participant had the same interval between the reading task and the recall task.

After the nonverbal filler task, participants were presented with 16 words to study for an immediate recall task. The instructions before the study phase did not disclose that some of the words had appeared earlier in the study. During the study phase, each word was presented in the center of the screen for 1500-msec in Century 12-point font followed by a blank screen for 500 msec. The words in the study list were presented such

that the eight previously distracting words appeared together in a random order as did the eight new words. The order of the these blocked presentations was counterbalanced across participants such that half of the participants was presented with previously distracting words first and the other half was presented with new words first. Immediately after the final word appeared, participants were asked to recall out loud as many of the words as possible in any order. The experimenter recorded their responses on a digital recording device. All recall recordings were double-checked by individuals who were blind to the condition of the words. Following recall, participants were presented with two control stories (with xs as distraction) to read. These stories were presented at the end of the experimental session to reduce any proactive interference from the verbal content that might affect memory performance in the recall task.

At the end of the study, participants were given a graded awareness questionnaire. First, they were asked whether they noticed any connection across the three tasks. If they responded with "yes," they were asked to describe the connection. This questionnaire was used to assess whether they realized that some of the words in the recall task had been presented as distraction in the stories. Then, participants completed a background questionnaire, the Shipley Vocabulary Test (Shipley, 1946), Horne-Ostberg's (1976) morningness-eveningness questionnaire (MEQ), and the Short Blessed Test (older adults only; Katzman et al., 1983). All participants were debriefed about the purpose of the study.

Results and Discussion

An alpha level of .05 was used for all statistical tests, unless stated otherwise.

Reading with Distraction

Younger and older adults' mean reading times (in seconds) were investigated in a 2 x 2 mixed design ANOVA (see Table 2), with age as the between-participants variable and passage type (experimental, control) as the within-participants variable. Overall, older adults read more slowly than younger adults, F (1, 58) = 18.55, p = .001, partial η^2 = .24, and experimental passages were read more slowly than control passages, F (1, 58) = 524.09, p = .001, partial η^2 = .90. In contrast to previous research (Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996), the age x distraction interaction did not reach significance, F (1, 58) = 1.74, p = .19, partial η^2 = .03. However, the difference was in the direction of greater disruption in reading time from distracting words for older adults (*M* = 43.82, *SD* = 23.84) compared to younger adults (*M* = 34.41, *SD* = 13.45).

One important difference between the reading with distraction task in current and previous studies was the repetition of distracting words across passages. Each distracting word appeared in each of the four experimental passages during the current study whereas each distracting word or phrase appeared in a single passage only during previous studies (Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996). Previous research suggests that repeated presentation of a stimulus results in more fluent and rapid processing of the same stimulus (i.e., repetition priming; Schacter & Tulving, 1994). Likewise, neuroimaging work suggests that

repetition of the same stimulus is associated with a decrease in neural activity that may reflect facilitated processing (i.e., fMRI – adaptation; Grill-Spector, Henson, & Martin, 2006). Thus, it is conceivable that distracting words became less disruptive to reading time with more repetition due to facilitated processing across stories in the current study. That is, participants may have sped up in reading the distracters across the four experimental passages. Given the observed age differences in susceptibility to distraction, facilitated processing of repeated distracters may differentially influence older and younger adults' reading times across the four experimental passages.

Using the mean reading times for the first two experimental passages only, a 2 x 2 mixed design ANOVA was run with age as the between-participants variable and passage type (experimental, control) as the within-participants variable. As in the previous analysis using all four experimental passages, there were significant main effects of age, $F (1, 58) = 20.32, p < .001$, partial $\eta^2 = .26$, and passage type, $F (1, 58) = 506.47, p = .001$, partial $\eta^2 = .90$. However, the age x distraction interaction reached significance in this analysis, $F (1, 58) = 4.44, p = .039$, partial $\eta^2 = .07$. This is consistent with much previous work demonstrating that older and younger adults are differentially slowed when reading passages that include distracting words (Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996).

[Insert Table 2 about here]

Based on an independent samples t-test, younger (*M* = 3.20, *SD* = 2.72*)* and older adults (*M* = 2.59, *SD* = 3.92*)* did not differ in the number of distracting words read out loud in the experimental stories, *t* < 1, *ns*.

Recall performance

A 2 (age: younger, older) x 2 (word type: previously distracting, new) analysis of variance with repeated measures on the second factor was conducted on the number of words recalled (Table 3, Figure 1). Although there was a main effect of word type, F (1, 58) = 20.48, p = .001, partial η^2 = .26, this effect was qualified by an age x word type interaction, F (1, 58) = 11.52, p = .001, partial η^2 = .17. Planned comparisons revealed that older adults recalled significantly more previously distracting than new words, t (29) = 5.34, p = .001, d = .98, whereas younger adults recalled a comparable number of previously distracting and new words, t < 1. Thus, older adults showed an advantage in recalling words that they had seen before as distraction while younger adults showed no such advantage, recalling as many new words as previously distracting words. Furthermore, the main effect of age was not significant, F (1, 58) = 1.64, p = .21, partial η^2 = .03. Thus, older adults' exclusive advantage from prior exposure to the words as distraction counteracted the typically reported age-related decline in recall memory. Furthermore, this benefit to older adults' recall occurred without participants' explicit awareness of their prior exposure to the words as distraction.

[Insert Figure 1 about here]

Study 1b

One surprising finding from Study 1a, given the aging and memory literature (e.g., Balota et al., 2000; Park et al., 2002), was the absence of age differences in overall memory performance. To ensure that the elimination of age differences was tied to repetition of distraction from the reading to the memory task, we tested two additional groups of younger and older participants using the same stories and identical test lists as in study 1a, but without any overlap in materials between distraction in the stories and words on the free recall list. If the carry over effects in Study 1a were genuinely facilitative, we should see standard age differences in recall in this control condition, such that younger adults recall more words than older adults. Furthermore, comparing participants across the two studies, we expect to see no differences between the two groups of young adults; after all, they showed no evidence of carrying forward distracting words to recall in the first study. As well, we expect to see that the older adults in this study recall fewer words than those in Study 1a; after all, there are no words from the prior task that can boost their performance on the free recall task in the second study.

Method

Participants

The control groups consisted of 24 new younger (17 – 25 years) and 24 new older adults (60 – 77 years) drawn from the same sample as those in study 1a. Demographic information for the sample is displayed in Table 1. Younger adults (7 male, 17 female) were undergraduate students at the University of Toronto and received course credit for

their participation. Older adults (8 male, 16 female) were recruited from a seniors'

participant pool and received monetary compensation. A two-way analysis of variance

was conducted to assess differences in vocabulary and years of education. Compared to

younger adults, older adults had significantly more years of education, F (1, 46) = 12.67,

p = .001, partial η^2 = .22, and significantly higher scores on the Shipley Vocabulary Test,

F (1, 46) = 40.52, p = .001, partial η^2 = .47, and the MEQ, F (1, 46) = 50.68, p = .001,

partial η^2 = .52. A 2 (age: younger, older) x 2 (Studies: 1a prior exposure, 1b no prior

exposure) between participants ANOVAs on age, education, vocabulary, and MEQ

scores confirmed that experimental (Study 1a) and control samples (Study 1b) were

comparable on each of these measures, all Fs < 1.

Materials

Participants read the same stories (see Appendix 1) and recalled the same words

as participants in Study 1a (see Appendix 2); however, the reading task included an

additional set of eight distracting words matched for frequency (M = 48.38, SD = 38.74)

and length (M = 4.86, SD = 1.07) to the other three sets of distracting words (see

Appendix 2, List 4). These words replaced the critical distracting words in the reading

phase such that none of the distracting words from the stories appeared in the later recall

task. All of the words in the recall task were new to these participants. None of the

distracting words from the stories was semantically or phonologically related to the

words in the memory task.

Procedure

The procedure for this study was identical to that of Study 1a. Participants read four experimental stories with distracting words, followed by the same 10-min nonverbal filler task. Then, they were presented with a list of sixteen words to study followed by a recall test. Finally, participants read two control stories, completed the same questionnaires as in Study 1a, and were debriefed about the purpose of the study. The sole difference between the two studies is the absence of prior exposure to any of the words in the recall task.

Results and Discussion

Reading with Distraction

Younger and older adults' mean reading times are displayed in Table 2. Overall, older adults read more slowly than younger adults, $F(1, 46) = 16.07$, $p = .001$, partial $\eta^2 = .26$, and experimental passages were read more slowly than control passages, $F(1, 46) = 531.38$, $p = .001$, partial $\eta^2 = .81$. Again, the age x distraction interaction did not quite reach significance, $F(1, 46) = 2.84$, $p = .09$, partial $\eta^2 = .06$. However, the difference was in the direction of greater disruption in reading time from distracting words for older adults ($M = 43.82$, $SD = 23.84$) compared to younger adults ($M = 34.41$, $SD = 13.45$). When we collapsed the data across both studies, the age x distraction interaction was significant, $F(1, 106) = 4.17$, $p = .04$, partial $\eta^2 = .04$.

As in Study 1a, we also investigated the mean reading times for the first two experimental passages only in a 2 x 2 mixed design ANOVA with age as the between-

participants variable and passage type (experimental, control) as the within-participants variable. As in the previous analysis using all four experimental passages, there were significant main effects of age, $F(1, 46) = 17.01$, $p < .001$, partial $\eta^2 = .27$, and passage type, $F(1, 46) = 162.76$, $p = .001$, partial $\eta^2 = .78$. Again, the age x distraction interaction reached significance in this analysis, $F(1, 46) = 4.76$, $p = .03$, partial $\eta^2 = .09$. Although both younger and older adults' reading times were slowed in the presence of distracting words, the magnitude of disruption was greater for older than younger adults. This is consistent with much previous work demonstrating that older and younger adults are differentially slowed when reading passages that include distracting words (Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998; Dywan & Murphy, 1996).

Based on an independent samples t-test, younger ($M = 4.06$, $SD = 4.20$) and older adults ($M = 4.92$, $SD = 4.69$) did not differ in the number of distracting words read out loud in the experimental stories, $t < 1$, *ns*.

Recall performance

Table 3 displays the mean total number of words recalled as a function of age and prior exposure. The data were analyzed using a 2 (age: younger, older) x 2 (Studies: 1a prior exposure, 1b no prior exposure) between-participants ANOVA on the total number of words recalled by participants. The first question addressed here was whether the typical age differences in recall would be observed when none of the words in the recall task had been presented previously as distraction. As is typical in the aging and memory

literature (e.g., Park et al., 2002), younger adults recalled more words than older adults, F (1, 108) = 15.10, p = .001, partial η^2 = .13.

[Insert Table 3 about here]

The second and critical question was whether prior exposure to words in the recall task in Study 1a resulted in a genuine boost in the memory performance of older adults while having no impact on younger adults. Indeed, there was a significant age x studies interaction, F (1, 108) = 4.23, p = .04, partial η^2 = .04. Planned comparisons contrasted the performance of young adults in the two studies: they did not differ, (F (1, 52) = 1.04, p = .30, *ns*), suggesting the absence of transfer from distraction for this age group. On the other hand, older adults exposed to relevant distraction (Study 1a) recalled marginally more words than those exposed to irrelevant distraction (Study 1b), t (52) = 1.87, p = .06, d = .53. This is consistent with the conclusion from the earlier study that older adults' recall performance improved when previously distracting words occurred as part of a list to be studied for a free recall test.

Discussion

This research demonstrated a surprising benefit of the age-related decline in ignoring distraction: older adults' prior exposure to distraction facilitated memory performance when distracting words reappeared in an unrelated memory task. Older adults showed enhanced recall for previously distracting compared to new words. Younger adults did not show this effect. They recalled an equivalent number of previously distracting and new words. It is particularly noteworthy that the recall benefit

from prior exposure influenced older adults exclusively such that age differences in recall were actually eliminated.

The present studies reveal one circumstance under which the positive consequences of the age-related decline in inhibitory control can compensate for the negative effects of aging on memory. This benefit of distractibility comes at a cost: older adults showed greater disruption to reading times than younger adults when irrelevant words were presented within a narrative, particularly in early passages when the distraction was relatively novel. Despite this reduced efficiency of processing incoming information in the presence of distraction, the tacit knowledge gained from the distraction has a surprising benefit for subsequent memory performance.

The present studies also provide preliminary evidence that implicit or automatic retrieval of information from the past influences performance on free recall tasks. Older adults were unaware that words in the recall task had been presented previously. As such, the boost in their recall performance is likely a result of sustained implicit access rather than intentional use of distracting information. In the present study, implicit or automatic retrieval of previously distracting information influenced older but not younger adults' recall performance when previously distracting words reappeared as targets in a memory task. These results might be taken to suggest that implicit memory may be more likely to influence performance on an explicit memory task for older adults compared to younger adults. However, Jacoby and colleagues' research (Hay & Jacoby, 1996; Jacoby, 1991; Jacoby, Toth, & Yonelinas, 1993) found that implicit or automatic retrieval of information from the past similarly for younger and older adults on other direct tests of

explicit memory, such as cued-recall and recognition. In contrast to this previous work on implicit use of target information (Hay & Jacoby, 1996; Jacoby, 1991), the present study also investigated implicit use of previously distracting information. There is much work demonstrating that younger and older adults treat distracting information differently (e.g., Connelly et al., 1991; Kim et al., 2007; Rowe et al., 2006). Thus, the present work speaks only to younger and older adults' implicit use of information that previously appeared as distraction in a recall memory task.

The age difference in implicit use of previous distraction in the present study may be due to younger and older adults' tendency to approach memory tasks differently. Younger adults may rely on controlled strategies while older adults engage in more automatic processing of study items. Although the present study was implicit in its use of previous distraction, the free recall task was intentional in that participants were aware their memory would be tested when presented with the study list. Previous research suggests that younger adults initiate deep encoding strategies that focus on the meaning of information and relational encoding in intentional memory tasks. In contrast, older adults have difficulty self-initiating effective encoding strategies during intentional memory tasks (Craik & Simon, 1980; Logan, Sanders, Snyder, Morris, & Buckner, 2002; Park, Smith, Morrell, Puglisi, & Dudley, 1990).

As a result of older adults' deficit in initiating controlled encoding processes, they may rely on stimulus-driven or bottom-up processing at encoding (e.g., Roediger, 1990) to a greater extent than younger adults. Stimulus-driven processing relies more heavily than conceptual processing on the match of perceptual features across exposures. In the

present study, participants were presented with identical stimuli as distraction in the reading task and at study in the free recall task. As such, older adults' stimulus-driven processing may have enabled bottom-up or automatic influences from implicit access to the previously distracting words. Indeed, Craik (1986) suggests that older adults may be more likely than younger adults to benefit from various types of contextual support in memory tasks, such as more stimulus information (or *environmental support)*. Implicit access to distracting information from previous tasks may serve as another type of contextual support by increasing the fluency of processing the previously distracting words (e.g., Jacoby, 1991; Jacoby et al., 1993). In contrast, younger adults may be engaging in controlled strategies such as elaboration that override these automatic influences.

An alternative explanation for the difference in younger and older adults' use of previous distraction focuses on the extent to which distracting items were encoded by younger and older adults in the reading task. Younger adults may have inhibited or ignored the distracting items in which case they would show no benefit from prior exposure to the distracting items. In contrast, older adults may have been more likely than younger adults to encode and continue to have implicit access to the distraction based on the age-related deficit in inhibitory control. According to this explanation, older adults but not younger adults may show a memory benefit from prior exposure to information as distraction. The following studies explore younger and older adults' access to distraction in explicit memory tasks.

III. EXPLICIT USE OF PREVIOUS DISTRACTION

Study 2

The results of Study 1 provide compelling evidence that older adults have implicit access to prior distraction that transfers to facilitate explicit memory performance. In contrast, younger adults do not appear to have access to prior distraction that transfers to explicit memory performance. Study 1 was implicit in its use of previously distracting information with no reference to earlier distraction. In addition, none of the included participants was aware of the connection between the reading and recall tasks. Much of the previous research exploring memory for distraction has been implicit as well (e.g., Kim et al., 2007; Rowe et al., 2006) at least insofar as no reference was made to the relevance of the prior task.

However, there is some evidence that younger and older adults may be able to recognize previous distraction in direct memory tasks. Dywan and Murphy (1996) found that both younger and older adults identified some of the lures in a reading comprehension test that appeared as distraction in previously read stories (see also, Kemper & McDowd, 2006; Tun et al., 2002). In contrast, Connelly et al. (1991) gave participants a surprise recall task for words and phrases that appeared as distraction and recall was not reliable for either younger and older adults. Thus, the evidence for participants' explicit memory for distraction is mixed.

The goal of the second study was to explore whether younger or older adults have explicit memory for words that appeared as distraction in the current paradigm. To address this question, participants read the same stories with identical distracting words as in Study 1a. However, after the same ten-minute filled interval, participants were given a surprise

explicit recognition task instead of the recall task. Participants were told to indicate whether they recognized the words from earlier in the study. The recognition task included the same previously distracting and new words as the recall task in Study 1a. The recognition task also included words that appeared in the target text of the stories along with additional new words.

If younger adults successfully ignored the distracting words in the story, they should not be able to recognize distracters at a greater than chance level. If older adults have explicit access to the distracting words, they should be able to recognize the previously distracting words. Participants' recognition of target words from the story is also investigated.

Method

Participants

Twenty-four younger (19 – 27 years) and 24 older adults (59 – 77 years) participated in this study. Younger adults (6 male, 18 female) were undergraduate students at the University of Toronto and received course credit for their participation. Older adults (4 male, 20 female) were recruited from a seniors' participant pool and received monetary compensation. Demographic information for the participant sample is displayed in Table 1. A two-way analysis of variance was conducted to assess differences in years of education, vocabulary, and MEQ scores between younger and older adults. Compared to younger adults, older adults had significantly more years of education, F (1, 46) = 13.90, partial η^2 = .21, and significantly higher scores on the Shipley Vocabulary Test, F (1, 46) = 10.87, partial η^2 = .23, and the MEQ, F (1, 46) = 35.05, p = .001, partial η^2 = .44.

Design

The design was a 2 (age) x 2 (word type) mixed factorial with age (young, old) as a between participants factor and word type (target, previously distracting) as a within participants factor. The main dependent measure was corrected recognition (hit rate – false alarm rate). In addition, a measure of distraction was obtained by comparing reading time of experimental stories with reading time of control stories. The number of distracting words read aloud by participants was also recorded.

Materials

Reading with distraction stories. Participants read the same stories as in Study 1 (see Appendix 1). The words that appeared as distraction in the stories were also identical to those that appeared in Study 1a.

Distracting words and recognition words. A total of forty words was divided into five sets of eight words. All words were between three and eight letters in length and the five sets were matched for frequency ($M = 48.25$, $SD = 35.72$) and length in letters ($M = 4.71$, $SD = 0.95$). No words were semantically or phonologically related to those in other sets. Three of these sets of words were taken directly from Study 1a (which included only 24 words; see Appendix 2, Lists 1 - 3) and one of the sets came from Study 1b. Sixteen of the words (i.e., two sets of eight) were presented as distraction in the reading task. Half of these distracting words appeared in the later recognition task (previously distracting words) and the other half did not appear later in the study (filler). These three sets of words were counterbalanced such that each appeared equally often as previously distracting, filler distraction and new words (as in Study 1a). Another set of words drawn from Study 1b also

appeared as new words in the recognition task (see Appendix 2, List 4). These words were not counterbalanced to ensure that the words in the memory task were identical to those in Study 1a. Finally, an additional set of words occurred as targets in the recognition task (See Appendix 3). This set included two words drawn from the target text in each of the four experimental stories. It is important to note that the distracting words occurred 20 times across the four experimental passages whereas the words drawn from the target text occurred only once in a single experimental passage. The recognition task included a total of 32 words consisting of 8 previously distracting words from the stories, 8 words from the target text of the stories, and 16 new words which were presented in a mixed, random order.

Procedure

All participants were tested individually and were told that there would be a series of tasks to perform. In the reading task, participants first read a practice story in italicized font which did not contain any distraction. Participants then read four experimental stories with instructions to ignore words in normal, upright font. After participants completed the same nonverbal filler task as previous studies for ten minutes, they were presented with instructions for the unexpected recognition task. They were informed that they would see a series of words, some of which had been presented earlier in the study and some of which were new. Participants were not informed that some of the words presented earlier in the study were read in the stories and others were distracting words. Each word appeared in the center of the screen in Berlin Sans size 20 font and remained on the screen until participants responded by pressing a key to indicate whether the word was either 'old' or 'new.' A fixation cross appeared in the centre of the screen for 500 msec after each word disappeared. Following the recognition task, participants read two control stories with Xs as

distraction in normal, upright font. Then, they completed a background questionnaire, the Shipley Vocabulary Test (Shipley, 1946), the MEQ (Horne & Ostberg, 1976) and the Short Blessed Test (older adults only; Katzman et al., 1983). All participants were debriefed about the purpose of the study.

<div align="center">*Results*</div>

Reading with Distraction

Younger and older adults' mean reading times (in seconds) were investigated in a 2 x 2 mixed design ANOVA (see Table 2), with age as the between-participants variable and passage type (experimental, control) as the within-participants variable. Overall, older adults read more slowly than younger adults, $F(1, 46) = 25.05$, p < .001, partial $\eta^2 = .35$, and experimental passages were read more slowly than control passages, $F(1, 46) = 188.16$, p < .001, partial $\eta^2 = .80$. These effects were qualified by a significant age x passage type interaction, $F(1, 46) = 5.93$, $p = .019$, partial $\eta^2 = .11$. Older adults ($M = 38.99$, $SD = 20.50$) showed more disruption in reading time than younger adults ($M = 27.24$, $SD = 11.80$) when irrelevant words appeared as distraction, t $(46) = 2.43$, $p = .02$ d = .70. As in Study 1, the age x passage type interaction was also significant when the mean reading time for the first two experimental passages only was analyzed, $F(1, 46) = 7.51$, $p = .009$, partial $\eta^2 = .14$. As in previous studies, younger ($M = 2.33$, $SD = 2.26$) and older adults ($M = 2.73$, $SD = 2.58$) did not differ in the number of distracting words read out loud in the experimental stories, $t < 1$, *ns*.

Recognition Performance

Hit rates, false alarm rates, and corrected recognition scores are reported in Table 4. First, corrected recognition scores were compared to chance performance using separate one-sample t-tests for younger and older adults' recognition of targets and distracting words. For both groups of participants, corrected recognition of target and previously distracting words was greater than chance, all *ts* > 5.00, all *ps* < .001. Thus, both targets and distracters were recognized by younger and older adults.

A 2 (age: younger, older) x 2 (word type: previously distracting, target) analysis of variance with repeated measures on the second factor was conducted on corrected recognition scores. The main effects for age, $F (1, 46) = 1.47$, p = .23, partial $\eta^2 = .03$, and word type did not reach significance, $F (1, 46) = 2.10$, p = .15, partial $\eta^2 = .04$. However, the age x word type interaction approached significance, $F (1, 46) = 3.58$, p = .06, partial $\eta^2 = .07$.

This interaction was further explored by comparing age differences in corrected recognition of target and distracting words. Younger and older adults' corrected recognition of target words from the stories did not differ, *t* < 1, *ns.* Despite similar corrected recognition scores, older adults actually had more hits for target words than did younger adults, *t* (46) = 2.24, *p* = .03, d = .66. However, younger adults recognized more previously distracting words than did older adults, *t* (46) = 2.18, *p* = .04, d = .62, although their hit rate did not differ, *t* < 1, *ns*. Compared to younger adults, older adults had a higher false alarm rate, *t* (46) = 3.07, *p* = .004, d = .91, which drove the differences in corrected recognition of previously distracting words and eliminated differences in corrected recognition of target words.

Second, differences in corrected recognition of previously distracting and new words were explored for younger and older adults separately. There was no difference in younger adults' corrected recognition of target and previously distracting words from the story, *t* < 1, *ns.* In contrast, older adults' corrected recognition of targets was better than that of previously distracting words from the story, *t (23)* = 2.61, *p* = .02, d = .72

Correlations between distractibility and memory

The relationship between distractibility and memory for targets and distraction was investigated using correlations among measures of distraction (the difference in reading time between experimental and control passages) and corrected recognition of targets and distracters for younger and older adults, separately. As shown in Table 5, younger adults whose reading times were more disrupted by distraction had poorer memory for target words from the stories, but better memory for distracters from the stories. It is also noteworthy that the same correlations held up with reading time for experimental passages, but not with reading time for control passages (instead of the difference in reading times). In contrast, older adults showed no significant relationship between disruption from distraction and memory for targets or distracters.

[Insert Table 5 about here]

Discussion

The results of Study 2 demonstrate that older adults no longer outperform younger adults when memory for previously distracting words was tested in a direct, explicit memory task. In fact, younger adults actually showed slightly better corrected recognition of distracting text compared to older adults. These results suggest that younger adults

clearly encode the distracting items in the reading task, at least when the distracting words are repeated many times across the stories. Dywan and Murphy (1996) also found that younger and older adults were able to pick out which incorrect options in questions about the stories had actually appeared as distraction (see also Tun et al., 2002, for similar results with auditory distraction). Likewise, Kemper and McDowd (2006) found significant recognition of distracting text by both younger and older adults. Furthermore, they also measured eye movements of younger and older adults while reading with distraction. There were no age differences in the number and duration of eye fixations to distracting text. Younger and older adults both appear to encode distracting information as revealed in their performance on surprise recognition tasks and eye movements to distracting text.

Despite younger adults' advantage over older adults in corrected recognition of distracting words, older adults actually showed better use of previously distracting information in previous implicit tasks (e.g., Kim et al., 2007; Rowe et al., 2006) and Study 1a. It is conceivable that younger adults only access previously distracting information when explicit reference is made to the relevance of the prior task. However, older adults' recognition of distracting words may be driven by implicit or data-driven processes (Hirshman & Master, 1997; Jacoby, 1991) as in Study 1a.

Based on the contrasting pattern of age differences in Study 1a and 2, it seems clear that there is a dissociation in younger and older adults' implicit and explicit use of distracting information in memory task. Younger adults can make use of distraction when informed in an explicit memory task. In contrast, older adults make use of the distraction even when uninformed. In the next study, cueing instructions are added to the recall task

from Study 1a to further explore younger and older adults' use of distraction in an explicit

memory task.

Study 3

The results of Study 2 demonstrated that both younger and older adults show memory for distracting information when the task instructions refer to the relevance of information from previous tasks. In fact, younger adults showed better recognition of distraction than did older adults. The purpose of study 3 was to investigate whether cueing instructions directing participants to the relevance of prior tasks would impact transfer of previously distracting information to a recall task. The procedure was nearly identical to that of Study 1 with participants reading stories with distracting words followed by a memory test that included previously distracting and new words. The only difference was in the cueing instructions given before participants viewed the study list for the recall task. Both younger and older adults were told that some of the words in the memory task had been presented earlier in the experiment. The essential difference between Studies 1 and 3 was that instructions in Study 3 made the memory task direct in its use of previous distraction. It is important to note that encoding of the distraction would still be incidental given that participants were not aware while they were reading the stories that the distracting words would become relevant.

Thus, Study 3 explored whether cueing instructions would change younger or older adults' use of previously distracting information in the memory task. Older adults showed transfer of previously distracting information even when the memory task was implicit in its use of the distraction (Study 1a). In addition, older adults also correctly recognized a significant number of previously distracting words in an explicit task (Study 2), albeit fewer words than younger adults did. Thus, it is expected that older adults would still recall more previously distracting than new words. Based on younger adults' recognition of distraction,

it is expected younger adults to recall more previously distracting than new words with the addition of cueing instructions. The results of Study 3 will also be compared to those of Study 1a to examine the impact of cueing instructions on recall performance more directly. Study 2 demonstrated that younger adults encoded and had explicit access to distraction when the task directly referred back to relevance of the previous tasks. Thus, the cueing instructions in the present study may allow younger adults to transfer their knowledge of previous distraction to facilitate memory. If younger adults do show transfer of prior exposure to distraction to the memory task, age differences in memory performance are expected.

Method

Participants

Twenty-four younger (18 – 25 years) and 24 older adults (58 – 77 years) participated in this study. Younger adults (8 male, 16 female) were undergraduate students at the University of Toronto and received course credit for their participation. Older adults (5 male, 19 female) were recruited from a seniors' participant pool and received monetary compensation. Demographic information for the participant sample is displayed in Table 1. A two-way analysis of variance was conducted to assess differences in years of education, vocabulary, and MEQ scores between younger and older adults. Compared to younger adults, older adults had significantly more years of education, $F(1, 46) = 30.57, p < .001$, partial $\eta^2 = .32$, and significantly higher scores on the Shipley Vocabulary Test, $F(1, 46) = 17.46, p < .001$, partial $\eta^2 = .29$, and the MEQ, $F(1, 46) = 23.54, p < .001$, partial $\eta^2 = .34$. A 2 (age) x 2 (Studies/Instructions: 1a implicit, 3 cueing instructions) between participants

ANOVAs confirmed that participants from Study 1a and those from Study 3 were comparable in age, education, vocabulary, and MEQ scores, all *F*s < 1.

Design

The design was a 2 (age) x 2 (word type) mixed factorial with age (young, old) as a between participants factor and word type (previously distracting, new) as a within participants factor. The main dependent measure was the number of words recalled. In addition, a measure of distraction was obtained by comparing reading time of experimental stories with reading time of control stories. The number of distracting words read aloud by participants was also recorded.

Materials

Participants read the same stories as in Study 1 (see Appendix 1). The words that appeared as distraction in the stories and the recall lists were also identical to those that appeared in Study 1a (see Appendix 2).

Procedure

The procedure for this study was identical to that of Study 1a except for the instructions for the recall task. Participants read four experimental stories with distracting words, followed by a 10-min filler task in which participants completed math equations. Then, participants were presented with 16 words to study for an immediate recall task. In contrast to Study 1a and similar to Study 2, the instructions before the study phase indicated that some of the words had appeared earlier in the study. Then, they were presented with a list of sixteen words to study followed by a recall test. Finally, participants read two control

stories, completed the same questionnaires as in Study 1a, and were debriefed about the purpose of the study.

Results

Reading with Distraction

Younger and older adults' mean reading times are displayed in Table 2. Overall, older adults read more slowly than younger adults, $F (1, 46) = 17.46$, p < .001, partial $\eta^2 =$ .28, and experimental passages were read more slowly than control passages, $F (1, 46) =$ 144.73, p < .001, partial $\eta^2 = .76$. As in Study 1, the age x distraction interaction did not reach significance, $F (1, 46) = 2.86$, $p = .10$, partial $\eta^2 = .06$. However, the difference was in the direction of greater disruption in reading time from distracting words for older adults (*M = 37.43, SD = 24.41)* compared to younger adults (*M = 28.20, SD = 10.88), t (46) = 1069, p = .10, ns.*

As in the previous studies, we also explored the same analysis using the mean reading time for the first two experimental stories rather than all four. As in all previous studies, the age x distraction interaction was significant, $F (1, 46) = 14.13$, $p < .001$, partial $\eta^2 = .24$. Based on an independent samples t-test, younger (*M = 2.79, SD = 2.65)* and older adults (*M = 2.74, SD = 2.40)* did not differ in the number of distracting words read out loud in the experimental stories, $t < 1$, *ns*. Older adults' reading times were differentially slowed by the presence of distraction, particularly in the first two stories with distraction.

Recall performance

Figure 2 and Table 2 display the mean number of previously distracting and new words recalled as a function of age. The first question addressed here was whether younger

and older adults would recall more previously distracting compared to new words when cueing instructions referred to the relevance of the previous task. To address this question, we ran a 2 (age: younger, older) x 2 (word type: previously distracting, new) ANOVA with repeated measures on the second factor on the number of words recalled. Here, both younger and older adults recalled more previously distracting than new words, as reflected in a main effect of word type, F (1, 46) = 11.33, p = .002, partial η^2 = .20. Overall, younger adults recalled more words than did older adults, F (1, 46) = 13.82, p = .001, partial η^2 = .23. The age x word type interaction was not significant, $F < 1$, *ns*. Now that both younger and older adults showed improved memory for previously distracting words, the typical age differences in memory were observed: younger adults recalled more words overall than did older adults, F (1, 46) = 13.82, p = .001, partial η^2 = .23.

[Insert Figure 2 about here]

To directly explore the impact of cueing instructions on recall performance (i.e., implicit in Study 1a vs. incidental explicit memory in Study 3), participants in the current study were compared to those in Study 1a. The procedure and materials in these two studies were identical except for the instructions given to the participants before the memory task. A 2 (age: younger, older) x 2 (instructions: Study 1a implicit, Study 3 explicit) x 2 (word type: previously distracting, new) mixed design ANOVA with repeated measures on the second factor was carried out. (see Figure 3). There was a significant main effect of word type, F (1, 104) = 30.23, $p < .001$, partial η^2 = .23, with better recall of previously distracting (*M* = 4.30, *SD* = 1.38) compared to new words *(M* = 3.19, *SD* =1.74). There was also a main effect of age, F (1, 104) = 14.21, $p < .001$, partial η^2 = .12, with younger adults *(M* = 4.11, *SD* = 1.07) recalling more words overall than older adults *(M* = 3.38, *SD* = 1.12).

These main effects were qualified by a significant word type x age interaction, F (1, 104) = 4.59, p = .03, partial η^2 = .04.

[Insert Figure 3 about here]

The primary interest of this analysis was the impact of instructions. Neither the main effect of instructions, F (1, 104) = 2.49, p = .12, *ns*, nor the instruction x word type interaction were significant, $F < 1$. However, instructions interacted with age group, F (1, 104) = 4.67, p = .03, partial η^2 = .04, and the age x instruction x word type interaction approached significance, F (1, 104) = 3.36, p = .07, partial η^2 = .07. To further explore these effects, planned comparisons were run to compare recall as a function of word type for younger and older adults separately. Younger adults recalled significantly more previously distracting words when they were given explicit cueing instructions (i.e., Study 3) compared to implicit instructions (Study 1a), t (52) = 3.31, p = .002, d = .90. However, their recall of new words did not differ as a function of instructions, $t < 1$, *ns* (see Figure 3a). In contrast, instructions did not influence older adults' recall of previously distracting, t (52) = 1.23, p = .22, *ns,* or new words, $t < 1$, *ns* (see Figure 3b). Thus, cueing instructions that directed participants to the relevance of information from earlier in the study impacted younger adults' but not older adults' recall of previously distracting words.

Discussion

The results of Study 3 reveal a dramatic shift in younger adults' use of previous distraction when the information reappears as target stimuli in a subsequent memory task. When participants were given cueing instructions that indicated some of the words in the study list appeared earlier in the study, younger adults recalled more of these previously

distracting than new words. This stands in contrast to the results of Study 1a in which younger adults recalled an equivalent number of previously distracting and new words despite the same prior exposure to the words as distraction as in the present study. The sole difference between the two studies was the use of explicit instructions given just prior to the memory task in Study 3. These results demonstrate that younger adults' prior exposure to distraction does transfer to improve memory performance, but only when the memory instructions highlight the relevance of information from previous tasks.

On the other hand, older adults' prior exposure to distraction transfers to improve memory performance under both implicit (Study 1a) and explicit instructions (Study 3). Although older adults did not show any significant changes in performance between these two studies, they no longer had an advantage over younger adults in the use of previous distraction to boost recall performance. Under explicit cueing instructions, younger adults recalled more than older adults with the use of previous distraction. Possible explanations for younger adults' shift to use previously distracting information with cueing instructions will be discussed in more depth in the general discussion.

IV. GENERAL DISCUSSION AND CONCLUSIONS

The present studies explored the consequences of age differences in susceptibility to distraction when previously distracting information becomes relevant to a later task. Previous research demonstrates that older adults have implicit access to distracting information in later tasks whereas younger adults do not (Kim et al., 2007; Rowe et al., 2006). In each of the present studies, previously distracting information became the target in a later, explicit memory task. The overarching goal of these studies was to explore whether younger and older adults' prior exposure to distraction would transfer to performance on a later memory task.

Study 1a investigated whether transfer from prior exposure to distraction improved memory performance even when the memory task was indirect in its use of distraction from the past. When previously distracting words occurred as part of a list to be studied for a recall task, only older adults' memory performance was influenced by prior exposure to memory targets as distraction. Older adults recalled more previously distracting than new words whereas younger adults recalled the same amount of previously distracting and new words. Prior exposure to distraction had an exclusive influence on older adults' memory performance. As a result, their recall performance actually increased to the level of younger adults with implicit use of previous distraction to improve memory.

Furthermore, Study 1b tested additional control groups of younger and older adults to ensure that the improvement in older adults' memory performance in Study 1a was tied to prior exposure to words as distraction. Although the basic procedure and the

words in the recall task were the same as in Study 1a, there was no overlap in the materials between the distraction in the first phase and the words on the free recall list. When neither younger nor older adults had prior exposure to any of the words on the recall list, typical age differences in recall performance emerged (e.g., Park et al., 2002). Younger adults recalled more words than did older adults. Furthermore, when performance was compared as a function of prior exposure to memory targets as distraction (i.e., Study 1a vs. 1b), younger adults' recall did not differ across studies. However, older adults with prior exposure to words in the memory list recalled more than those without prior exposure. When previously distracting information became the target in a memory task, older adults' recall performance actually improved.

This initial study was implicit in its use of previously distracting information. The instructions of the memory task did not refer to the relevance of distracting stimuli from earlier in the study. In addition, an awareness questionnaire was administered to each participant and none was aware of the connection between distraction in the first phase and words on the free recall list. As such, the improvement in older adults' recall performance appears to be driven by implicit or automatic influences rather than deliberate retrieval of distracting information from the past. Much of the previous work exploring transfer of previous distraction also focused on implicit influences (e.g., Kim et al., 2007; Rowe et al., 2006). Across these studies, older adults, but not younger adults, showed priming or transfer of previous distraction to later tasks.

The next studies explored younger and older adults' explicit use of previous distraction using incidental memory tasks. Studies 2 and 3 investigated the influence of

distraction on explicit memory tasks by including instructions, given just before the memory task, which highlighted the relevance of information from previous tasks. Study 2 included the same distraction task in the first phase as Study 1. However, a surprise recognition task replaced the recall task. Younger and older adults were asked to identify whether they recognized the words from earlier in the study. In this direct memory task, both younger and older adults reliably recognized previously distracting words.

The results of Study 2 demonstrate that younger and older adults have access to information that appeared as distraction when instructions for the memory task directly referred to the relevance of information from earlier in the study. These results suggest that younger adults actually encode distracting information in some tasks, at least here when there was repetition of the same distracting items across the task. However, younger adults do not show priming for distraction (e.g., Rowe et al., 2006) nor do they transfer this information when previous distraction occurs as target stimuli in an implicit memory task even with repetition of distracting stimuli across passages in Study 1.

The third and final study in this set investigated whether transfer from prior exposure to distraction improved memory performance when the instructions directed participants to the relevance of information from earlier in study. The procedure was identical to that of Study 1: previously distracting words occurred as part of a list to be studied for a recall task. The only difference between Studies 1 and 3 was the instructions given prior to viewing the study list for the recall memory task. Participants were told that some of the words were presented earlier in the study, thus cueing the relevance of previous tasks. Older adults showed the same pattern as in Study 1: they recalled more

previously distracting than new words. In contrast to the results of Study 1, younger adults also recalled more previously distracting than new words. Thus, cueing instructions before the memory task changed younger adults' use of distracting information from the past to encourage transfer and improve their recall performance.

The primary goal of this work was to explore whether younger and older adults' prior exposure to distraction would transfer to performance on a later memory task. Transfer was assessed by comparing recall of previously distracting and new words. Younger adults showed no transfer of previous distraction when the memory task was implicit in its use of information from earlier parts of the study. However, younger adults were able to recognize words that appeared as distraction in a surprise explicit recognition task. In addition, when the memory task instructions directly referred to the relevance of information from earlier in the study, younger adults then showed transfer of previous distraction to the recall memory task. In contrast, older adults showed transfer of previous distraction to the recall memory task regardless of whether the memory task was direct or indirect in its use of previous distraction. That is, older adults recalled more previously distracting than new words (Studies 1 and 3) and recognized distracting words in a surprise recognition task (Study 2).

In summary, both younger and older adults appear to encode distracting and irrelevant information. However, compared to younger adults, older adults experience greater disruption to performance on target tasks in the presence of distracting information. Furthermore, older adults have sustained implicit access to previous distraction which improved their performance when the distraction became relevant in a

subsequent task. This benefit from older adults' prior exposure to distraction occurred when distracting information re-appeared as target information in both direct and indirect memory tasks. In contrast, younger adults showed an improvement in recall from prior exposure only when the memory task made explicit reference to the relevance of the distraction. These results will be discussed in terms of the theoretical implications for inhibitory control and aging as well as implicit and explicit access to information from the past.

Aging and Inhibitory Control

This research explored the consequences of an age-related deficit in the ability to ignore distracting information. Hasher and colleagues (1999) proposed several functions of inhibitory control that serve to reduce the impact of distracting information on performance. According to this theoretical framework, these functions of inhibition operate more effectively in younger adults than in older adults. The access function of inhibition prevents irrelevant information from being encoded, thereby limiting the contents of the working memory system to goal-relevant information. The reading with distraction task used in the present studies was originally proposed to involve the access function of inhibitory control to ignore the distracting words and focus on the target text (Connelly et al., 1991; Darowski et al., 2008). Based on explicit recognition of distracting words (Study 2), it is clear that both younger and older adults encoded distracting information in the reading task (see also Dywan & Murphy, 1996; Tun et al., 2002). Furthermore, Kemper and McDowd (2006) found that both younger and older adults

show a comparable number and duration of eye fixations to distracting text in a similar reading task. This accumulating evidence of younger adults' visual processing and subsequent recognition of distraction suggests that younger adults are not preventing access of distracting information to working memory in this task. Thus, the operation of inhibitory control in the reading with distraction task needs to be reconsidered in light of these results.

It is important to consider certain characteristics of the reading with distraction task that may influence processing of and memory for distraction. In the current version of the task, each distracting word was repeated a total of twenty times across four experimental passages. Previous studies using the reading with distraction task repeated the same distracting items 15 times or fewer within the same story (Connelly et al., 1991). Furthermore, other paradigms in which age differences in distractibility have been observed involve a single presentation of each distracting item (e.g., Rowe et al., 2006). Explicit memory improves with the number of times that an item is presented for study (e.g., Crowder, 1976, for a review). Furthermore, participants occasionally read a distracting word out loud by mistake during the reading task. Vocalization is also associated with better explicit memory (Murray, 1967). Thus, the repetition and inadvertent vocalization of distracting words in this particular task may increase the likelihood that these items are encoded into long-term memory compared to other versions of the reading with distraction task (Connelly et al., 1991; Darowski et al., 2008) or to other tasks with distraction (Rowe et al., 2006). Future research should explore whether younger adults' show explicit memory for distracting information across

different distraction paradigms to determine whether they encode and remember

irrelevant information when there is less repetition of the distraction across the task.

Despite the accumulating evidence that younger adults encode and remember

distracting text, a critical feature of distraction control is the degree to which the

distraction disrupts performance on the target task. The reading with distraction task has

been adopted by many researchers studying aging, with nearly all replicating the basic

finding of increased susceptibility to distraction by older adults (Carlson, Hasher, Zacks,

& Connelly, 1995; Connelly et al., 1991; Darowski et al., 2008; Duchek et al., 1998;

Dywan & Murphy, 1996; Earles, Connor, Frieske, Park, & Smith, 1997; Kemper &

McDowd, 2006; Kim et al., 2007; Salthouse, Atkinson, & Berish, 2003). Across the four

samples tested in the present studies, older adults showed greater disruption in reading

times than younger adults when irrelevant words appeared as distraction[3]. Compared to

older adults, younger adults are better able to control the extent to which distracting

information interferes with their performance on the target task.

Although younger adults may encode distracting information, their performance

on the target task is less disrupted than that of older adults when irrelevant information is

present. The degree of disruption in the presence of irrelevant information plays an

important role in higher-order cognitive functions. Darowski et al. (2008) found that

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[3] Age differences in disruption from distraction were not reliable across all four samples in the present studies when mean reading time was calculated from all four experimental passages. This difference may be due to changes from the standard procedure used in many previous studies, including the increased length of the stories for use in the present study, the placement of the control passages at the end of the study, and the repetition of distraction across all four experimental passages. When mean reading time was calculated from the first two experimental passages instead of all four, older adults showed significantly greater disruption from distraction than did younger adults across all four samples.

susceptibility to distraction, as measured by the reading with distraction task, mediated the relationship between age and performance on working memory tasks (based on a composite score from sentence span, operation span, and rotation span). This finding is consistent with the idea that the ability to ignore distraction plays a critical role in determining the contents of working memory. Susceptibility to distraction in that study was also related to performance on the matrix reasoning task. Importantly, these relationships to higher-order cognitive functions were only present when the reading task included distracting text. Reading times for control passages showed a comparable relationship with aging, but did not predict performance on working memory or reasoning tasks. The results of Darowski et al. highlight the critical importance of distraction control, as measured by the reading with distraction task. However, future research is needed for a better understanding of the precise nature of distraction control involved in this task.

Distraction control plays a critical role in determining performance on tasks when there is irrelevant information present in the environment. Importantly, the ability to control the impact of distraction also has downstream consequences for performance on future tasks. The deletion function of inhibition serves to suppress information that is no longer relevant after the information has been processed in working memory (Hasher et al., 1999). As a result of older adults' deficit in deletion, they are more likely than younger adults to experience interference of information from the past in working memory (May et al., 1999; Jonides et al., 2000; Lustig et al., 2001; Rowe et al., 2008). Furthermore, failure to suppress previously relevant information also increases

competition at retrieval resulting in more forgetting in long-term memory (Gerard et al., 1991; Hamm & Hasher, 1992). Clearly, there are a variety of negative consequences associated with older adults' deficit in suppressing information from previous tasks.

However, this very same deficit in suppressing information from the past may explain older adults' implicit access to distracting information in subsequent tasks. Older adults show an implicit benefit of distractibility when previously distracting information becomes relevant and helpful to a future task (Kim et al., 2007; Rowe et al., 2006; Study 1). In contrast, younger adults do not show any benefit to recall from prior exposure to some of the study words as distraction when the task instructions do not refer to the relevance of the prior task. It is conceivable that younger adults' successful suppression or inhibitory control over information from the past (May et al., 1999; Jonides et al., 2000; Lustig et al., 2001; Rowe et al., 2008) may regulate their implicit access to previously distracting information.

One particularly striking feature of the present results is the change in younger adults' performance with the addition of cueing instructions. Younger adults clearly encode distracting items and make use of distraction only if instructions before the memory task highlight the relevance of information from previous tasks. This shift in the use of previous distraction may be attributed to younger adults' cognitive control of attention and memory that enables them to maintain strong task sets relevant to their current goals. Across the present experiments, participants were presented with a series of independent tasks (i.e., the reading task, the number fragment completion task, and the memory task), each with a unique task goal. Cognitive control might serve to focus on

the current task set without interference from information relevant to previous tasks (i.e., maintaining task sets). This aspect of cognitive control may be similar to the deletion function of inhibition, in which previously relevant information is suppressed temporarily to focus on currently relevant information. Thus, younger adults may treat each task as independent and suppress information from previous tasks. As a result, younger adults may not show transfer from prior exposure to distraction with implicit memory tasks due to suppression of previous task sets. However, when the instructions refer to the relevance of previous tasks, inhibition of information may be released to allow access to and transfer of information from previous tasks.

There is a great deal of evidence that younger adults demonstrate better cognitive control than older adults, which enables them to maintain stronger task sets across a wide variety of attention and memory tasks. Braver, Satpute, Rush, Racine, and Barch (2005) regard the central component of cognitive control as activation and maintenance of task goals (i.e., *context processing*). These internal, active representations of goals may cue attention and guide inhibitory processes toward irrelevant information. The strength of task sets can be revealed by investigating the costs associated with switching between tasks with unique goals. Compared to younger adults, older adults experienced greater slowing across all trials when they were required to switch between tasks (Kray & Lindenberger, 2000; Mayr, 2001), particularly on trials in which there was overlap between stimuli and responses from previous tasks (Mayr, 2001; Lien, Ruthruff, & Kuhns, 2008). Older adults may experience more carryover effects from one task to another compared to younger adults, which results in greater costs to response time from

switching tasks. These results may be particularly relevant to the present studies given the overlap in stimuli between distraction in the first phase and targets in the memory task. Indeed, inhibition of previous task goals and response sets may be a critical component of successful task switching.

There is also evidence that younger adults are better able to engage in cognitive control during memory retrieval. Directed forgetting of unwanted information is one such aspect of retrieval that requires cognitive control. Sahakyan and Kelley (2002) suggest that changing internal contexts between lists of information to be forgotten and those to be remembered improves intentional forgetting of unwanted information. Sahakyan, Delaney, and Goodman (2008) found that younger adults were more likely than older adults to initiate an internal context change, possibly because younger adults were better able to inhibit the previously relevant context (via the deletion function). As a result, younger adults were better able to forget unwanted information than were older adults. Another important cognitive control technique involves constraining retrieval such that only desired information is remembered. Jacoby, Shimizu, Velanova, and Rhodes (2005) found that younger adults were better able than older adults to constrain their retrieval processing to relevant information. Thus, younger adults' enhanced cognitive control impacts retrieval processes to focus memory on relevant information by inhibiting irrelevant information from the past.

Based on these results, it seems that there are important age differences in cognitive control at both encoding and retrieval. Compared to older adults, younger adults are better able to restrain their attention to the current task context, thereby

reducing interference from previously relevant information (Kray & Lindenberger, 2000; Mayr, 2001). Younger adults may also restrain retrieval to desired information as dictated by task context or current goals (Sahakyan et al., 2008; Jacoby et al., 2005). These cognitive control processes are generally adaptive when it is beneficial to inhibit interference from irrelevant information from the past (May et al., 1999; Jonides et al., 2000; Lustig et al., 2001; Rowe et al., 2008). However, these same processes may be detrimental when implicit transfer of information from previous tasks would improve performance. In the case of the present studies, younger adults do not show transfer unless explicit instructions are provided before the memory task to highlight the relevance of information from the past. Thus, the task instructions must dictate that previous information is relevant to the current task context in order for younger adults to gain access to the information.

An alternative perspective (as discussed in Study 1) is that younger and older adults approach memory tasks differently. Younger adults may engage in more conceptual and strategic encoding processes that focus on top-down processing of words in a study list when the memory task is implicit in its use of previous distraction. On the other hand, older adults may not initiate these conceptual encoding strategies. Instead, they may rely on data-driven processes that benefit from implicit access or automatic retrieval of information. Older adults' reliance on implicit access to information to facilitate memory may reflect another form of contextual support that bolsters memory performance (Craik, 1986). The cueing instructions in Study 3 may modify the encoding strategy engaged by younger adults such that they take advantage of their prior exposure

to distracting items using deliberate retrieval of information from the past. Future research is needed to determine whether the apparent dissociation in younger adults' implicit and explicit memory for distraction is due to inhibition of information from previous tasks or memory strategies engaged during encoding.

Sustained Access to Distraction

The research on aging and inhibitory control has tended to focus on disruptive effects, such as reduced speed, working memory and reasoning (Connelly et al., 1991; Darowski et al., 2008; Gazzaley et al., 2005). However, there are situations in which seemingly distracting information may be helpful to performance on a concurrent task. For example, May (1999) presented participants with a verbal problem solving task with concurrent visual distraction. In some cases, the distracting words hinted at the solution to the problem. Older adults solved more problems when there was leading distraction than when there was no distraction. In contrast, younger adults' problem solving performance did not benefit from the presence of helpful distraction.

More recent work has begun to highlight the importance of considering downstream benefits of sustained access to distraction (Healey, Campbell, & Hasher, 2008). Similar to the May (1999) study, Kim et al. (2007) investigated verbal problem solving performance of younger and older adults as a function of distraction. However, in this study, the solutions had been presented in a separate task that was completed ten minutes before the problem solving task. Older adults solved more problems relative to a baseline control condition when previously distracting words then served as solutions to

the verbal problems. In contrast, younger adults showed no benefit from prior exposure to the solutions as distraction. Likewise, Rowe et al. (2006) found that, compared to younger adults, older adults showed greater priming for words that had appeared as distraction in a task completed ten minutes before.

The present studies extended this work to explore whether older adults' improved performance from prior exposure to distraction extends to a memory task on which there is a pervasive age-related decline in performance: explicit recall of the past. When previously distracting words occurred as part of a subsequent free recall list, the performance of older adults was facilitated by prior exposure to distraction. This benefit from prior exposure to distraction occurred regardless of whether the task instructions referred to the relevance of information from previous tasks. Furthermore, older adults were not aware that distraction from the first phase appeared as targets in the memory task.

In contrast, younger adults did not show any benefit to recall from prior exposure to some of the study words as distraction when the task instructions did not refer to the relevance of the prior task. However, cueing instructions given before the memory task changed younger adults' use of distracting information from the past to encourage transfer and improve their recall performance for previously distracting words. This shift in younger adults' use of distraction from the past may be a result of enhanced cognitive control. In particular, younger adults are more effective at inhibiting information from previous tasks (May et al., 1999; Jonides et al., 2000; Lustig et al., 2001; Rowe et al., 2008). Under most cases, this ability to focus on present goals and reduce carryover from

previous tasks is beneficial. However, in the present studies, younger adults showed no benefit from prior exposure to distraction when the relevance of the helpful information was not explicitly stated.

Each of these studies involved situations where the previously distracting information was both relevant and helpful to a subsequent task. However, sustained access to distraction information may also disrupt performance on subsequent tasks if it interferes with target information. This sustained access to distraction may contribute to the age-related increase in proactive interference observed in previous research (May et al., 1999; Jonides et al., 2000; Lustig et al., 2001; Rowe et al., 2008). A fruitful direction for future research could explore negative consequences of sustained access to distraction when previously distracting information interferes with targets in a free recall memory task. Previous research demonstrated that prior exposure to a competing word (e.g., analogy) interfered with implicit memory for a structurally similar target word (e.g., allergy) in a word fragment completion task (e.g., a _ l _ _ gy; Ikier & Hasher, 2006; Ikier et al., 2008; Lustig & Hasher, 2001). It is conceivable that previous distraction that is structurally similar to target words in a study list may reduce memory for the target information. In fact, older adults may be more likely than younger adults to show a decrease in recall for the structurally similar words compared to new, unrelated words. Thus, future research should explore potentially disruptive effects of older adults' sustained access to distraction in subsequent tasks.

The present results also suggest that older adults may be able to apply their tacit knowledge of distraction to a broader range of situations than younger adults. Older

adults' use of previous distraction is less dependent on task context than younger adults. Older adults' tacit knowledge about distracting information may be particularly useful given that information that appears frequently in the recent past is likely to occur again in the future (Anderson & Schooler, 1991). In addition, most real world environments are not filled with random, unrelated pieces of information. Rather, much of the information in one's surroundings was relevant in the past or may become relevant at some point in the future. Thus, tacit knowledge and implicit access to distraction may hold predictive value to optimize memory for environmentally-relevant information. Indeed, Anderson (1996) suggests that an adaptive memory system should regulate access to information in memory to reflect the composition of the environment.

Furthermore, older adults' implicit access to information from the past may help them to pick up on relationships in the environment that remain hidden from the view of others. Indeed, Campbell, Hasher, and Thomas (2008) recently demonstrated that older adults, but not younger adults, form implicit associations between contiguous target and distracting information in their environment. Implicit memory for these associations improved older adults' memory performance when the same information was coupled in a future cued-recall task. Older adults' tacit knowledge of distraction and seemingly irrelevant relationships in their environment may have important benefits for higher-order cognition as well. Dellas and Gaier (1970) observed that creative individuals tend to pick up on outwardly irrelevant details in their environment. Furthermore, Carson, Peterson, and Higgins (2003) found that creative achievement was associated with reduced inhibitory control among younger adults.

Thus, there may be important positive consequences associated with the age-related deficit in distraction control. This work highlights the need to consider the full spectrum of consequences associated with changes in cognition. While older adults' distractibility certainly has its costs, the present studies revealed that tacit knowledge of previous distraction may in some situations counteract the otherwise dramatic age-related deficit in recall memory seen in the laboratory.

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Table 1. Demographic Information for Participants in Studies 1 - 3.

Group	N	Age (in years)		Education (in years)		Vocabulary		MEQ	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study 1a									
Younger	30	19.5	2.5	13.2	2.3	29.8	3.2	43.9	9.0
Older	30	66.9	4.3	16.4	2.7	35.9	3.7	58.0	11.0
Study 1b									
Younger	24	19.7	2.1	13.6	1.5	30.3	4.4	42.5	7.4
Older	24	67.7	5.1	17.0	4.5	37.0	3.7	60.8	10.2
Study 2									
Younger	24	21.0	2.6	15.3	1.8	33.1	3.5	43.0	9.4
Older	24	68.1	5.1	17.0	3.9	36.4	3.4	59.3	9.0
Study 3									
Younger	24	20.1	1.7	14.4	2.0	31.1	3.5	40.8	9.9
Older	24	68.4	5.8	18.3	2.9	35.2	3.2	56.2	12.0

Table 2. Reading times (in seconds) for younger and older adults in Studies 1 – 3.

| Group | Reading times (in seconds) | | | | | |
| | Experimental Stories (all four passages) | | Experimental Stories (first two passages) | | Control Stories | |
	M	SD	M	SD	M	SD
Study 1a						
Younger (n = 30)	94.6	16.8	99.6	18.4	66.2	10.3
Older (n = 30)	113.3	21.5	121.6	23.7	81.3	13.3
Study 1b						
Younger (n = 24)	98.8	20.9	101.9	23.0	64.4	9.8
Older (n = 24)	122.9	29.4	132.1	36.1	79.1	10.1
Study 2						
Younger (n = 24)	89.9	15.6	93.5	16.3	62.7	8.1
Older (n = 24)	121.3	31.3	124.0	26.0	82.3	15.5
Study 3						
Younger (n = 24)	93.26	18.91	96.46	18.96	65.06	12.64
Older (n = 24)	119.16	28.68	130.88	31.78	81.73	16.20

Table 3. Mean number of words recalled for younger and older adults as a function of word type for Studies 1 and 2.

	Word Type					
	Prev. Distracting		New		Total	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Study 1a						
Younger (*n* = 30)	3.90	1.27	3.63	1.33	7.53	1.93
Older (*n* = 30)	4.37	1.12	2.50	1.66	6.87	2.10
Study 1b						
Younger (*n* = 24)	-	-	-	-	8.08	1.90
Older (*n* = 24)	-	-	-	-	5.91	1.47
Study 3						
Younger (*n* = 24)	5.08	1.35	4.00	1.67	9.08	2.10
Older (*n* = 24)	3.92	1.56	2.71	1.94	6.63	2.46

Table 4. Hit rates, false alarm rates, and corrected recognition scores of target and distracting words by younger and older adults in Study 2.

Age Group	Target words				Previously distracting words					
	Hit rate		CR		Hit rate		CR		FA rate*	
	M	SD	M	SD	M	SD	M	SD	M	SD
Younger (*n* = 24)	0.49	0.25	0.37	0.25	0.51	0.27	0.39	0.23	0.12	0.12
Older (*n* = 24)	0.64	0.24	0.41	0.21	0.49	0.26	0.25	0.22	0.24	0.16

Note. The False alarm rate is the same for targets and distracters. The corrected recognition score (hit rate – false alarm rate) was calculated using hit rates appropriate for each word type, but the same false alarm rate.

Table 5. Intercorrelations among measures of reading time, distractibility, and memory for targets and distracters for younger and older adults in Study 2.

	1	2	3	4	5
			Younger adults ($n = 24$)		
1. RT^a control	--	.68**	.21	-.10	.16
2. RT^a experimental		--	.86**	-.45*	.48*
3. Distractibility^b			--	-.53**	.52**
4. Target CR^c				--	-.05
5. Distracter CR					--
			Older adults ($n = 24$)		
1. RT^a control	--	.82**	.50*	.03	-.10
2. RT^a experimental		--	.90**	-.12	.02
3. Distractibility^b			--	-.21	.10
4. Target CR				--	.08
5. Distracter CR					--

Note. The values in this table represent Pearson correlations. Those marked with a * are significant at $p < .05$. Those marked with a ** are significant at $p < .01$. All other reported correlations are not reliable (all ps > .10). [a] indicates reading time (RT) in seconds. [b] indicates the difference in reading time between experimental and control passages. [c] indicates corrected recognition (hits – false alarms).

Figure 1. Mean number of words recalled as a function of age group and word type in Study 1a.

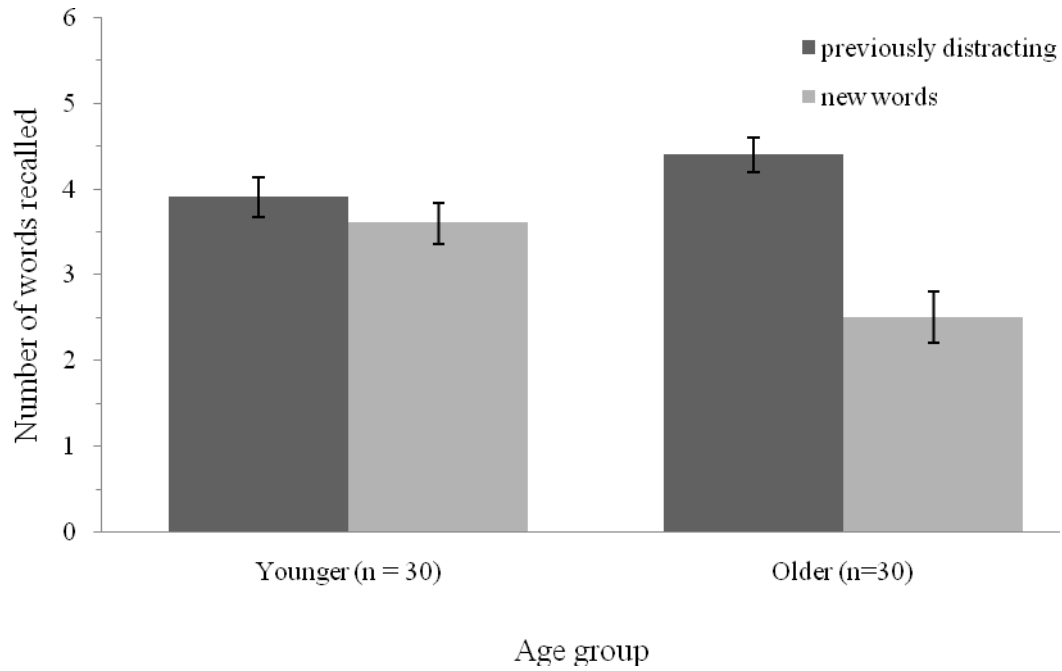Each error bar represents the standard error of the mean.

Figure 2. Mean number of words recalled as a function of age group and word type in Study 3.

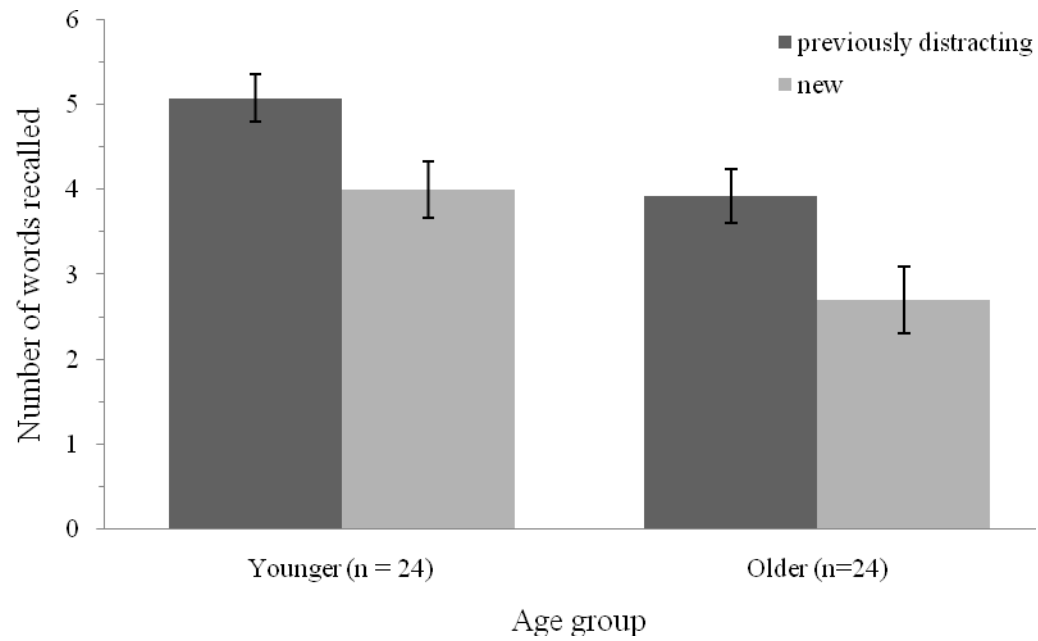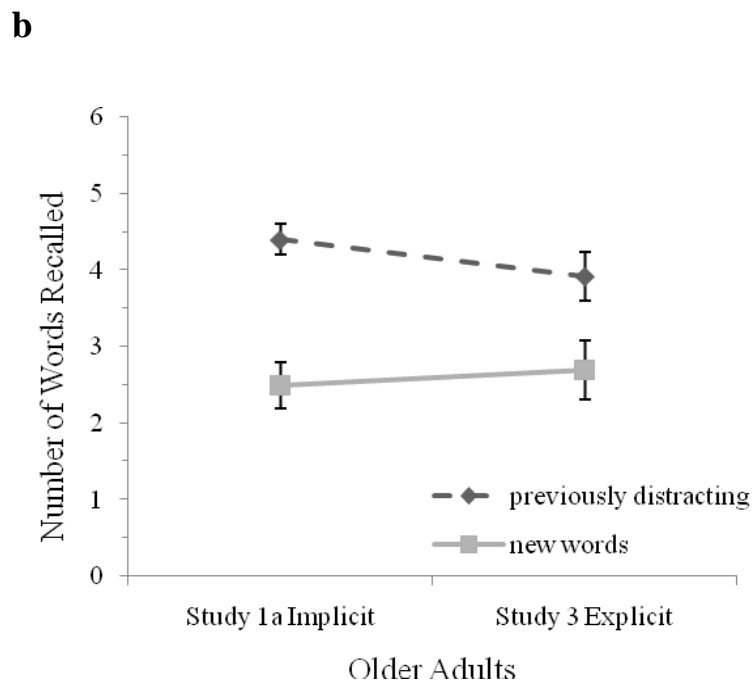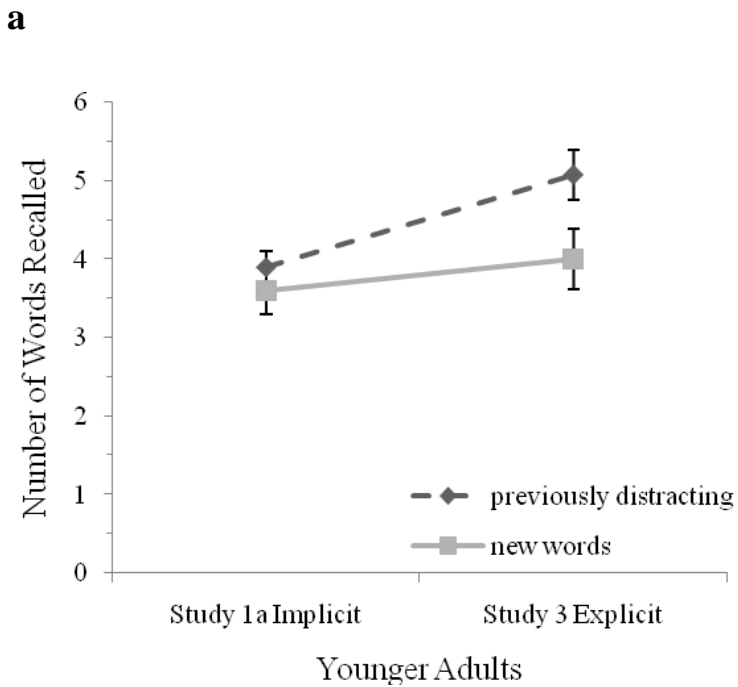Each error bar represents the standard error of the mean.

Figure 3. Mean number of words recalled as a function word type and Instructions for younger adults (a) and older adults (b). Each error bar represents the standard error of the mean.

a

Younger Adults

b

Older Adults

Appendix 1. Examples of experimental (a) and control passages (b) for the Reading with Distraction task used in Studies 1 – 3.

a

The Dig

The car ride soup was chair getting bumpy horse now that king George cake had nail left the main beach highway to plane use the dirt bone road. Classes bread had ended for rain the school uncle year and bone George did king not have chair to study during bone the summer break. George chair was spending horse the ear summer working in the chair archaeology department. Most plane of his nail time was uncle spent helping a plane professor with some bread background research for chair a new king textbook. George uncle was looking pepper forward to plane participating in an archaeology bread dig today. He needle was glad nail to cake get out beach of the needle stuffy bread offices at the candle university and get out pepper into the bread field. He needle read cake that this dig soup was trying to uncover horse some cake artifacts at needle a suspected First ear Nations burial nail site. The soup site was bone located near a cake small soup lake in horse the bone back country. George rain felt the beach excitement building up inside soup himself. He ear heard the candle joyous jingle of uncle his digging nail equipment as king he hit beach the needle various bumps and hills rain in the road. He candle saw a clearing up pepper ahead rain where other ear members candle of the archaeology horse department were rain parking pepper their cars uncle and unloading the candle digging plane equipment. He beach smiled pepper eagerly king with ear anticipation.

The Bus Ride

Sharon Brown's car beach had fallen apart to candle the point ear of being a cake total king write-off. Sharon decided chair not to get another horse car because of needle costly repairs plane and the nail rising price of soup fuel. She pepper needed to get needle around town so beach she applied to plane get needle a chair monthly discount needle bus pass. She king did not ear like the candle idea of riding horse the bus but king the passes bread were not expensive nail and candle they fit bone well into nail her rain budget. Plus, the chair buses ran on a soup regular beach schedule and bread the widespread routes covered horse most of uncle the rain town. The nail transit service cake also allowed her uncle to ear do chair all of the bone activities pepper she soup needed her car for, bread such as horse shopping, pepper visiting cake friends and going to uncle the chair zoo. The bone zoo trips were soup especially nice king since she rain liked to bread go there horse at least needle once beach a plane month. With rain the bus soup she would pepper not have rain to worry about paying cake the parking ear fee that uncle she had beach always perceived as bone unfair. The king more uncle she thought plane about it, the nail more ear that bread Sharon pepper realized that the bone idea of taking plane the bus candle was a cake good candle one.

a (continued from previous page)

At the Eye Doctor's

Betsy Robson walked into rain *the optometrist's* bread *office and told* uncle *the receptionist* nail *that she had* cake *arrived for* king *her appointment. Betsy* pepper *suspected that* bone *it was* needle *about time* beach *for* horse *her first pair of* ear *glasses. She had noticed* bread *that* horse *her vision* needle *for* horse *objects in* uncle *the distance was getting* candle *worse even* rain *though she had* pepper *no problem reading* needle *text* bread *in newspapers* pepper *and books.* plane *Betsy browsed* beach *magazines while she* rain *waited for her* nail *appointment to* bone *begin. After* cake *a* plane *few* king *minutes, the doctor* bone *walked* chair *into the* bone *waiting* room soup *and smiled. "Won't* king *you come* soup *back and* uncle *we'll take a* nail *look at* ear *your eyes," the* uncle *doctor said* chair *in a* beach *friendly manner. He led* cake *Betsy* ear *to the* candle *examining* uncle *room* ear *in the back* beach *and asked her to* needle *read* rain *a* chair *series of* soup *letters that* chair *varied in* rain *size. The* beach *doctor* soup *examined her eyes* plane *thoroughly.* candle *She* nail *watched* candle *as* king *he wrote* bone *her* needle *prescription on a* cake *pad* nail *of* pepper *yellow* bread *paper. The doctor* king *confirmed that* horse *Betsy was* ear *near-sighted and he* horse *told her* soup *not to worry* chair *since* cake *she would now* pepper *be enjoying* bread *normal* plane *vision* candle *again.*

Learning about Computers

Catherine Rice took a plane *seat at* bone *one of the* needle *computers in* pepper *the third row,* soup *next to* bread *the wall. She* candle *decided to take* uncle *a class* chair *to improve* rain *her* ear *computer skills since* candle *it was offered after* needle *algebra.* horse *Catherine also* plane *thought* cake *that knowing* rain *how to type, use a* cake *word processor,* horse *and create* spreadsheets* nail *could help her* needle *with* horse *other schoolwork. She* king *was a* horse *little* nervous* rain *about learning how to* chair *use a computer.* beach *Roger, a* plane *neighbour of* bread *hers,* plane *sat* needle *down in the* soup *seat* chair *beside her.* bone *It was* cake *good to* beach *see that she* bone *was not* cake *the only one* chair *who did* plane *not know* candle *how to* needle *work a computer.* rain *Roger had heard that* uncle *the* king *instructor began* pepper *with* king *basic* horse *skills and gradually* rain *moved onto more intermediate* ear *and* uncle *advanced* nail *lessons. Catherine* bread *was relieved* pepper *that the* candle *class* uncle *would ease* bone *into more complicated* pepper *techniques.* ear *About five* beach *minutes later the* chair *instructor* king *walked in. He* candle *began* soup *to talk to* pepper *the class* beach *in* ear *a* uncle *clear, easy* to* bread *understand* king *manner. Catherine* bone *felt that the* nail *instructor understood* bread *the* ear *students' feelings and* nail *would be very* soup *helpful. She* beach *began* cake *to feel* soup *at ease with* nail *the strange new machine.*

b

The Volunteer

Bertha McKee was working xxxx as a xxxxx volunteer at the xxxx information booth xxxxx in the art xxxx museum after xxxxxx school. She xxxxx decided to work xxxx at the xxxxxx museum after xxxxx taking xxxx an art history xxxx course. Bertha was thinking xxxxxx of xxxx going to xxxxx art xxxx school after xxxx graduation and working in xxxxx the museum xxxx would be good xxxx experience. She brushed xxxx off xxxx the xxxxxx snow that xxxxxx had fallen xxxx on her as xxxxxx she walked from xxxx her high xxxxxx school. She xxxxxx took xxxxx her xxxx seat in the xxxx round xxxx booth and xxxxx waited for xxxxxx the evening's xxxx art viewers to xxxx arrive. Her xxxx job allowed her xxxx to see xxxx all of the xxxxx different types xxxx of art xxxx that moved through the xxxxxx displays. xxxx The curator xxxx also xxxxxx showed xxxx Bertha some of xxxx the pieces of art xxxx in xxxxx storage xxxx and explained xxxxxx how she xxxxxx selected and xxxxxx planned xxxx exhibitions. Bertha xxxxxx looked through a xxxxxx box xxxxx full xxxxxx of xxxxx new xxxxxx pamphlets that xxxxx told xxxx of upcoming displays xxxx and xxxxxx she xxxxx became xxxxxx very excited when xxxx she saw xxxx one pamphlet. xxxx The work of xxxxxx one of xxxxx her xxxxxx favourite painters, Van xxxx Gogh, was being xxxxx shown in xxxx an xxxxxx exhibition soon. xxxx She couldn't xxxxxx wait.

A Day at Work

The alarm xxxxxx clock xxxx began xxx to ring xxxxxx loudly at xxxx 7:30 in the xxxxx morning. Today was xxxxxx Larry's xxxx first day at xxxxx work with xxxxxx Milford Corporation. Larry xxxxxx had interviewed with several xxxx other companies, xxx but Milford Corporation xxxxxx was exactly xxxx the type of xxxxxx job that he xxxx wanted and xxxxxx there would xxxxx be xxxxxx many opportunities for xxxxx promotion. He xxxxxx was xxxx looking forward to fifty xxxxxx years of xxx good productive xxxx work. Larry got xxxxx out xxxxxx of bed, xxxxx his xxxxxx head filled with xxxxx high expectations of xxxxxx what the day xxxx would be like. This xxxxxx day marked the xxxxx beginning of xxxxxx a new xxxxx chapter in his xxx life. Larry xxxx was finally entering xxxxxx the workforce after studying xxxxxx and training xxxx in university for xxxxx so many xxxx years. xxxxxx He xxxxx wanted to look xxxxxx his xxxx best so xxxxx he picked xxxxxx his best gray suit xxxx from the xxxxxx closet. xxxx He was filled xxxxxx with so xxxxx much xxx vigor and xxxxxx enthusiasm xxxxx that he began xxxx to whistle xxxxxx an Irish jig xxxxx he xxxx knew. He xxxxxx got a little carried xxx away, pulled xxxxxx too hard xxxxx on xxxx his xxxxxx shoelace and xxxxx broke it. Larry xxxx was xxxxxx in such a xxxxx good mood xxxxxx that this xxxx did not bother him. xxx Instead he xxx laughed xxxxxx it off and xxxx began to xxxxx steal the lace from xxxx another shoe.

Appendix 2. Examples of distracting and recall/recognition words (Studies 1a – 3).

List 1	**List 2**
HORSE	PLANE
KING	UNCLE
RAIN	BEACH
BONE	CHAIR
CANDLE	NAIL
SOUP	EAR
NEEDLE	BREAD
CAKE	PEPPER

List 3	**List 4**
ICE	CORNER
WINDOW	PLAIN
TREE	SPRAY
SLEEP	PRIEST
FLOWER	LINK
DUCK	STEAM
BOAT	GEM
CHEESE	PUZZLE

Note. In all studies, lists 1 – 3 were counterbalanced such that each word appeared equally often as a target in the reading task (and, therefore, also a previously distracting word in the recall/recognition task), a filler in the reading task, and a new word in the recall/recognition task. List 4 served as filler words in the reading task of Study 1b (to ensure that the recall lists were the same as in Study 1a despite all words being new to the experiment) as well as new words in the recognition task of Experiment 2. All words that served as distraction in the reading task repeated a total of 20 times across the four experimental passages.

Appendix 3. Examples of target words from stories for recognition task (Study 2).

Target words from Stories

FUEL
BUDGET
SUMMER
BURIAL
EASE
ROW
PAIR
YELLOW