Research Article

Implicit Proactive Interference, Age, and Automatic Versus Controlled Retrieval Strategies

Simay Ikier,[1] Lixia Yang,[2] and Lynn Hasher[3,4]

[1]*Yeditepe University,* [2]*Ryerson University,* [3]*University of Toronto, and* [4]*The Rotman Research Institute of Baycrest Centre*

ABSTRACT—*We assessed the extent to which implicit proactive interference results from automatic versus controlled retrieval among younger and older adults. During a study phase, targets (e.g., "ALLERGY") either were or were not preceded by nontarget competitors (e.g., "ANALOGY"). After a filled interval, the participants were asked to complete word fragments, some of which cued studied words (e.g., "A_L_ _GY"). Retrieval strategies were identified by the difference in response speed between a phase containing fragments that cued only new words and a phase that included a mix of fragments cuing old and new words. Previous results were replicated: Proactive interference was found in implicit memory, and the negative effects were greater for older than for younger adults. Novel findings demonstrate two retrieval processes that contribute to interference: an automatic one that is age invariant and a controlled process that can reduce the magnitude of the automatic interference effects. The controlled process, however, is used effectively only by younger adults. This pattern of findings potentially explains age differences in susceptibility to proactive interference.*

Several classic interference effects found in explicit memory (e.g., Crowder, 1976; Kintsch, 1977; Postman & Underwood, 1973) are also seen in implicit memory (Lustig & Hasher, 2001a). For example, the similarity and number of competing responses influence performance on both implicit and explicit memory tasks (e.g., Martens & Wolters, 2002; Nelson, Keelean, & Negrao, 1989; Winocur, Moscovitch, & Bruni, 1996). In addition, the time course of interference in implicit memory follows that seen in explicit memory, with both showing spontaneous recovery of initially suppressed information (Lustig, Konkel, & Jacoby, 2004). Finally, older adults exhibit heightened susceptibility to interference in both explicit and implicit memory (Ikier & Hasher, 2006), and both frontal-lobe patients and amnesics demonstrate interference effects despite evidence of their reduced efficiency in intentional retrieval (e.g., Mayes, Pickering, & Fairbairn, 1987; Shimamura, Jurica, Mangels, Gershberg, & Knight, 1995; Winocur et al., 1996). Thus, the literature suggests the possibility that interference can occur at an automatic level of processing. Our goal in the present study was to identify the contributions of automatic and controlled processes to interference in implicit memory.

We studied interference arising from competition between two similar candidates for response, a major source of disruption in proactive interference tasks (e.g., Crowder, 1976; Kintsch, 1977). To this end, we manipulated the potential for interference by presenting at encoding critical targets (e.g., "ALLERGY") that either were or were not preceded by structurally similar competitors (e.g., "ANALOGY"). The critical test fragments (e.g., "A_L_ _GY") could be completed only with targets. Interference was assessed by comparing completion rates for target words presented with competitors and completion rates for target words presented without competitors.

To separate automatic and controlled retrieval, we began the word-fragment-completion phases with a long series of fragments that could not be completed with items that were presented at study. Speed of generating responses in this phase was compared with speed of generating responses in the subsequent critical test phase, in which some fragments could be completed with presented items (participants were uninformed about the change in materials; Horton, Wilson, & Evans, 2001; Yang, Hasher, & Wilson, 2007). Given evidence that controlled retrieval takes longer than automatic retrieval (Richardson-

Address correspondence to Simay Ikier, Yeditepe University, Faculty of Arts and Sciences, Department of Psychology, 34755 Kayisdagi-Istanbul, Turkey, e-mail: ikier@yeditepe.edu.tr; to Lixia Yang, e-mail: lixiay@ryerson.ca; or to Lynn Hasher, e-mail: hasher@psych.utoronto.ca.

Klavehn & Gardiner, 1995; Yang et al., 2007), our working assumption was that participants who continued to rely on automatic processing as the materials switched to a mix of old and new fragments would continue to respond rapidly, whereas those who began to rely on controlled processing would slow down (see Yang et al., 2007). We note that controlled processes do not necessarily involve intentional retrieval; instead, they may include postretrieval checking or evaluation of candidates for response, and these can occur without explicit awareness of an item's status as old or new (for a discussion of how strategies can be used unconsciously and unintentionally, see Hassin, 2005).

In this study, we intended to replicate two recent findings: (a) that implicit memory shows interference effects (e.g., Lustig & Hasher, 2001b), and (b) that the magnitude of these effects is greater for older than for younger adults (Ikier & Hasher, 2006). In addition, the procedure we adopted allowed us to address two novel questions about interference: (a) Does interference in implicit memory result from automatic processes, controlled processes, or both? (b) Are age-related differences in interference due to automatic processes, controlled processes, or both?

METHOD

Participants

Twenty-seven younger adults (13 females, 14 males; 18–27 years old, $M = 21.07$, $SD = 2.24$) and 27 older adults (17 females, 10 males; 59–75 years old, $M = 65.15$, $SD = 4.95$) participated in the study. The younger adults were university students who received course credit or monetary compensation for their participation; the older adults were community dwelling and received monetary compensation. Participants had normal or corrected-to-normal vision and no serious health problems. All participants scored above 24 on the Shipley Vocabulary Test (Shipley, 1940), and the older participants scored below 6 on a cognitive-impairment assessment, the Short Blessed Test (Katzman et al., 1983). Four younger and 2 older adults who reported some awareness of the connection between the study and test phases of the experiment and 4 older adults with serious health problems were replaced. In addition, a younger adult who scored poorly on the vocabulary test was replaced, as was a younger adult whose data could not be used because of technical problems. The older adults had significantly higher vocabulary scores ($M = 35.00$, $SD = 3.5$) than the younger adults ($M = 31.96$, $SD = 3.41$), $F(1, 53) = 10.33$, $p < .05$.

Design

We used a 2 × 2 mixed design, with age (younger vs. older) as a between-participants variable and condition (interference vs. no interference) as a within-participants variable.

Materials

Thirty target items (e.g., "ALLERGY"), their corresponding fragments (e.g., "A _ L _ _ GY"), and their structurally similar nontarget competitors (e.g., "ANALOGY") were taken from two previous studies (Kinoshita & Towgood, 2001; Smith & Tindell, 1997). The targets were divided into three sets having equal baseline fragment-completion rates, according to the baseline measures provided by Kinoshita and Towgood (2001). To counterbalance assignment of items to conditions, we created three study lists such that each set of targets occurred once in each of the three conditions: interference (both the target and the competitor were presented at study), no interference (only the target was presented at study), and baseline control (neither the target nor the competitor was presented at study; this condition was used to calculate priming effects).

Each study list consisted of 46 seven- and eight-letter words: 20 targets, 10 competitors, 10 fillers, and 6 buffers (3 at the beginning and 3 at the end of the list). After the initial buffers, the competitors and fillers were presented in alternating order. Finally, the target items were presented; those that had and those that had not been preceded by their competitors were interleaved.

For each of two practice phases (1 and 2), we developed a list of 20 word fragments corresponding to seven- and eight-letter words that were structurally, phonologically, and semantically unrelated to any words presented in the study phase. These were later used for response time (RT) analysis. Materials for the test phase were 50 word fragments: 20 cues for targets that had been presented at study (10 that had been presented with their competitors and 10 that had been presented without competitors), 20 cues for new words (i.e., used for RT analysis), and 10 cues for targets that had not been presented at study (i.e., baseline items). Twelve of the fragments corresponding to new words served as buffer items (6 at the beginning and 6 at the end of the list); the remaining 8 were interspersed among the fragments for targets with competitors, targets without competitors, and baseline fragments. Fragments of the same type never appeared consecutively.

Critical items for the RT analyses used to assess individuals' retrieval strategies were the new items (fragments) presented in the two practice phases and the test phase. To counterbalance assignment of these items to the phases, we created three practice-test lists such that each of three sets of 20 critical items occurred once in each of these three phases. Each practice-test list was combined with each study list to produce a total of nine lists, each used equally often across participants and conditions.

Procedure

All items appeared in black font against a white background and were displayed at the center of a computer screen.

Study Phase

In the study phase, the words were presented one at a time for 1,800 ms each, and participants were asked to count the number of vowels in each word. The interstimulus interval was 1,000 ms.

Filler Task
Next, participants were told that a series of completion tasks would be presented, and that the first one would involve numbers. In this task, which served as a 6-min nonverbal filler task, participants completed a series of simple equations (e.g., responding "0" to the problem "2_ + 15 = 35").

Practice Phases and Test Phase
In the practice and test phases, each fragment was presented until a response was given or 5,000 ms had elapsed, whichever came sooner. The interval from response to onset of the next stimulus was 500 ms. Participants were instructed to respond as quickly as possible to each fragment. To encourage participants to give answers quickly, we provided feedback, telling each participant his or her mean RT at the end of each practice phase. RTs were recorded using a voice key, and verbal responses were recorded by the experimenter.

Following the test phase, all participants were questioned about their awareness of the relationship among the phases. They were first asked whether they noticed any connection among the phases of the experiment, and if they did, they were asked what they noticed. Participants who reported that some words from the study phase were repeated in the test phase were replaced. All participants then completed a questionnaire asking about their demographic background (e.g., age, gender, race-ethnicity), health, and activities (e.g., caffeine consumption, daily activities) before they took the vocabulary test. Older adults were administered the Short Blessed Test, and all participants were debriefed and compensated.

RESULTS

We first present priming data to assess interference effects in implicit memory and evidence of age differences in these effects. We then report interference effects for participants who relied on different retrieval strategies (i.e., more automatic vs. more controlled retrieval).

Priming Scores
Priming scores were calculated by subtracting the proportion of never-presented, baseline items completed with target words from the proportion of target fragments that were completed with target words (see Table 1). The percentage of baseline items completed with target words did not differ between younger adults (M = 42.2%, SE = 3%) and older adults (M = 41.9%, SE = 2.8%), $F < 1$. Priming was greater for targets in the no-interference condition than for targets in the interference condition, $F(1, 52) = 50.08, p < .001, p_{\text{rep}} = .986$, a finding consistent with interference in implicit memory. No main effect of age was detected, $F(1, 52) = 2.20, p = .14$; however, the critical Age × Condition (interference vs. no interference) interaction was reliable, $F(1, 52) = 3.93, p = .05, p_{\text{rep}} = .873$. Post hoc analyses confirmed that there were substantial age differences in priming for targets in the interference condition, $F(1, 52) = 4.93, p < .05, p_{\text{rep}} = .908$, but no age differences in priming for targets in the no-interference condition, $F < 1$. Together, these results demonstrate greater interference for older than for younger adults, as we found in a previous study (Ikier & Hasher, 2006).

TABLE 1
Mean Percentage of Priming for Targets in the Interference and No-Interference Conditions

	Age group			
	Younger		Older	
Condition	Mean	*SE*	Mean	*SE*
Both subgroups combined				
No interference	19.63	3.87	17.78	3.67
Interference	6.30	3.70	−5.93	4.07
More-automatic subgroup				
No interference	24.29	4.16	16.43	4.52
Interference	2.86	4.50	−5.00	7.01
More-controlled subgroup				
No interference	14.62	6.56	19.23	6.04
Interference	10.00	5.99	−6.92	4.14

Retrieval Strategy and Interference

Response Times
To determine retrieval strategies, we calculated each participant's median RT for the 20 critical items in each practice phase and for the 20 critical items in the test phase (Yang et al., 2007). These RT scores were entered into an analysis of variance with age (younger vs. older) as a between-participants variable and phase (Practice 1 vs. Practice 2 vs. test) as a within-participants variable. Although there was no main effect of age and no Age × Phase interaction, a test of age differences during the test phase, in which controlled processes could be engaged, showed that younger adults were reliably slower (M = 1,264 ms, SE = 55 ms) than older adults (M = 1,088 ms, SE = 60 ms), $F(1, 52) = 6.26, p < .05, p_{\text{rep}} = .935$. Thus, younger adults' slower performance on new items in the test phase suggests that younger adults were more likely than older adults to use controlled retrieval, an observation confirmed in subsequent analyses.

As in a previous study (Yang et al., 2007), inspection of individual participants' RTs revealed that some participants slowed down between Practice 2 and test, and others did not. It has been argued that controlled strategies take longer than automatic ones (e.g., Richardson-Klavehn & Gardiner, 1995). Thus, slowing in the test phase can be taken as evidence that participants changed their retrieval strategy from an automatic one to a more controlled one when fragments cued both new and old items. To explore the impact of response strategy on priming and interference, we determined for each person the difference between median RT for new items in Practice 2 and median RT for new items at test. We also calculated the median RT for each age group and then assigned participants in each age group to

TABLE 2

Average Median Response Time (RT; in Milliseconds) in the Practice 2 and Test Phases in the More-Automatic and More-Controlled Subgroups

	Age group			
	Younger		Older	
Subgroup and phase	Mean	*SE*	Mean	*SE*
More-automatic subgroup				
Practice 2	1,239	124	1,156	133
Test	1,123	84	968	53
RT increase	−116	66	−188	91
More-controlled subgroup				
Practice 2	949	67	920	45
Test	1,264	55	1,088	60
RT increase	315	34	168	40

Note. In the more-automatic retrieval group, $n = 14$ for both younger and older adults; in the more-controlled retrieval group, $n = 13$ for both younger and older adults.

two subgroups: those above the median ($n = 13$), referred to as the *more-controlled subgroup*, and those below the median ($n = 14$), referred to as the *more-automatic subgroup* (see Table 2).[1]

Younger adults in the more-controlled subgroup slowed down by an average of 315 ms (*SE* = 34 ms), whereas older adults in the more-controlled subgroup slowed down by an average of 168 ms (*SE* = 40 ms). Both increases in RT were reliable, *p*s < .001, p_{rep}s = .986, and younger adults slowed more than older adults, $F(1, 24) = 7.83$, $p < .05$, $p_{rep} = .950$. Participants in the more-automatic subgroups sped up from Practice 2 to the test phase, but younger and older adults in these subgroups did not differ in how much their responses sped up, $F < 1$; younger adults sped up by 116 ms (*SE* = 66 ms), $p = .11$, and older adults sped up by 188 ms (*SE* = 91 ms), $p = .06$.

Priming Scores

Priming scores were analyzed separately for the more-automatic and more-controlled subgroups (see Table 1). For the more-automatic subgroup, a mixed analysis of variance using age as a between-participants variable and condition as a within-participants variable showed only a main effect of condition, $F(1, 26) = 34.31$, $p < .001$, $p_{rep} = .986$; both age groups showed greater priming for targets in the no-interference condition than for those in the interference condition. Post hoc analyses suggested that both age groups showed reliable priming (*p*s < .01, p_{rep}s ≥ .974) for targets in the no-interference condition, and that priming in this condition did not differ with age, $F(1, 26) = 1.64$, $p = .21$. For targets in the interference condition, neither younger adults, $t(13) = 0.64$, $p = .54$, nor older adults, $t(13) = 0.71$, $p = .49$, showed reliable priming, and there was no age-related difference in priming scores, $F < 1$. Clearly, the presence of a highly similar competitor eliminated priming for a target to an equal extent among older and younger adults who relied on more automatic retrieval.

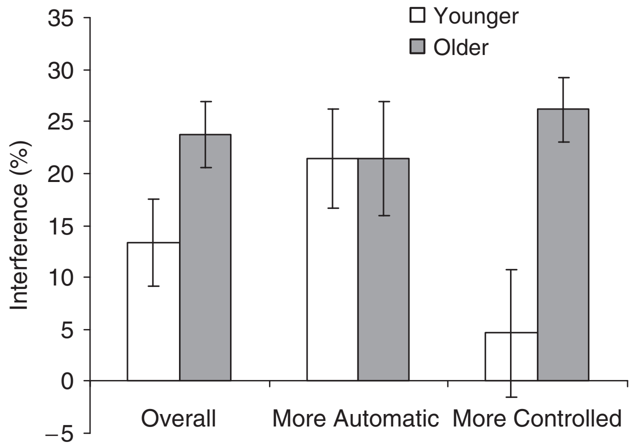

Fig. 1. Percentage of interference (overall and separated by retrieval strategy) for younger and older adults. Error bars indicate standard errors.

In the more-controlled subgroups, there was also greater priming for targets in the no-interference condition than for targets in the interference condition, $F(1, 24) = 19.88$, $p < .01$. In addition, there was a reliable Age × Condition interaction, $F(1, 24) = 9.74$, $p < .01$, $p_{rep} = .966$. The main effect of age was not reliable for targets in the no-interference condition, $F < 1$. However, the effect of age was reliable for targets in the interference condition, $F(1, 24) = 5.40$, $p < .05$, $p_{rep} = .910$, with younger adults showing greater priming (*M* = 10%, *SE* = 5.99%) than older adults (*M* = −6.92%, *SE* = 4.14%).[2]

Interference Effects

Figure 1 presents interference scores (priming in the no-interference condition minus priming in the interference condition) for both age groups. Statistical analyses confirmed the pattern seen in the figure: First, overall interference effects were greater for older than for younger adults, $F(1, 52) = 3.93$, $p = .05$, $p_{rep} = .873$. Second, there were no age-related differences in interference for participants who used more automatic retrieval, $F < 1$. Third, participants who used more controlled retrieval showed reliable age-related differences in interference, $F(1, 24) = 9.74$, $p < .01$, $p_{rep} = .966$. It is particularly noteworthy that the younger adults in the more-controlled subgroup showed less interference than those in the more-automatic subgroup, *F*(1,

[1]No conclusions were altered when we used having zero RT difference as the criterion for being included in the more-automatic group, but a median split provided a more balanced sample size across conditions.

[2]Selecting participants from a counterbalanced design raises the possibility that the pattern of results was due to participants in different subgroups being in different counterbalancing conditions. To rule out this possibility, we separated participants into retrieval-strategy groups based on the median RT change from Practice 2 to test, within each of the three counterbalancing conditions used for the RT analyses. The analysis based on this separation showed the same pattern, suggesting the effects reported here are robust across different counterbalancing conditions.

25) = 4.72, $p < .05$, $p_{rep} = .892$. Thus, younger adults who slowed down in the test phase were able to reduce automatic interference effects, whereas the older adults who slowed down were not, $F < 1$.[3,4]

If controlled strategies reduce interference, and if strategies require some exposure to the materials in order to develop, their benefits would be expected to build up during a test series. To test this possibility, we assessed interference effects in the first and second halves of the test list. For younger adults in the more-controlled subgroup, the interference effect was 9.23% (*SE* = 6.65%) for the first half of the list and 0.00% (*SE* = 8.47%) for the second half of the list; thus, controlled retrieval appears to have built up gradually throughout the test phase. For younger adults in the more-automatic subgroup and for older adults in both retrieval-strategy groups, interference effects increased from the first to the second half of the list (average interference effects were between 17% and 29%). These results suggest that some younger adults can reduce interference by engaging in controlled retrieval strategies. There is no evidence, however, that older adults are able to reduce interference by slowing their RTs.

GENERAL DISCUSSION

This experiment reconfirms the existence of proactive interference in implicit memory (Lustig & Hasher, 2001b), as well as the greater susceptibility of older adults to that interference (Ikier & Hasher, 2006). The novel and critical findings are that (a) interference occurs at an automatic level in both younger and older adults and (b) younger adults, but not older adults, can resolve this automatic interference by using a controlled strategy. Thus, the overall extent of interference can be seen as reflecting both automatic and controlled components, with the controlled component largely responsible for age-related differences.

From the perspective of the classic interference-theory literature (e.g., Crowder, 1976; Kintsch, 1977; Postman & Underwood, 1973), simultaneous competition between two candidates for response is a major mechanism that produces interference. In this study, either only one (e.g., "ALLERGY") or two (e.g., "ALLERGY" and "ANALOGY") words could be cued by a particular fragment (e.g., "A _ L _ _ GY"). When only one word had been presented, younger and older adults produced that word in response to the cue at approximately equivalent rates. When two similar words had been presented, performance declined, and to a greater extent among older than younger adults. Clearly, older adults were less able to resolve the conflict between competing responses than were younger adults.

Under automatic-retrieval circumstances, older and younger adults appear to be equally vulnerable to interference effects. Younger adults who engaged in more controlled processing were able to reduce or even eliminate interference, whereas older adults were unable to do so. The present study does not provide direct evidence regarding the nature of the controlled processes engaged by younger adults. Given that our participants appeared to have access to target words presented without competitors, it seems conceivable that when a competitor had been presented, both the target and the competitor solutions occurred to participants, and those who slowed down used a careful, fragment-checking strategy and, in doing so, selected the matching item, perhaps via suppression of the nonmatching item. This checking-selection strategy does not entail intentional retrieval, as all participants were unaware that some of the fragments at test cued study items.

What would prevent older adults from engaging in such a checking strategy? It is not likely that either lack of motivation or lack of verbal skill is an issue, given the widely reported pleasure that older adults take in doing crossword puzzles and anagram problems. And it is not likely that vocabulary is the problem, as the older participants in this study appeared to have richer vocabularies than the younger adults. Given that production of a target that had no competitor did not differ between the age groups, but production of that same target was substantially reduced among older adults when a similar item had occurred in the study list, the findings suggest that older adults' difficulties may be tied to the failure of a suppression process that enables one option to be selected from among competitors. At least one body of behavioral work suggests that older adults are far less able to suppress activated representations in memory than younger adults are (Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Lustig, Hasher, & Zacks, 2007) and that this difficulty contributes to a wide range of cognitive deficits, including deficits in working memory (e.g., Lustig, May, & Hasher, 2001) and greater susceptibility to proactive interference.

Recent research using functional magnetic resonance imaging also suggests that older adults have particular difficulty suppressing activated representations. In a study by Gazzaley, Cooney, Rissman, and D'Esposito (2005), participants viewed alternating pictures of faces and scenes, under instructions to remember only one category. In younger adults, the magnitude of neural response to to-be-ignored scenes was reduced to a below-baseline level. Older adults, however, showed no suppression of neural response to such stimuli. This finding suggests that older adults are less able to modulate neural activity associated with irrelevant information. Other researchers have suggested that areas of the frontal lobes are responsible for the resolution of interference between conflicting candidates for response (e.g., Hazeltine, Poldrack, & Gabrieli, 2000; Jonides & Nee, 2006),

[3]The reduced priming of more-controlled younger adults, compared with more-automatic younger adults, in the no-interference condition cannot be attributed to an increase in response threshold. Such an increase would also have eliminated incorrect responses, but the number of intrusions was the same for the more-automatic and the more-controlled subgroups of both younger adults (more-automatic group: $M = 25.71\%$, $SE = 3.43$; more-controlled group: $M = 23.08\%$, $SE = 3.82$), $F < 1$, and older adults (more-automatic group: $M = 27.14\%$, $SE = 3.04$; more-controlled group: $M = 30.77\%$, $SE = 4.15$), $F < 1$.

[4]Among the participants who slowed down, the majority of the younger adults showed reduced interference, whereas only 1 older adult did so.

and, indeed, frontal-lobe patients have shown increased susceptibility to interference (e.g., Shimamura et al., 1995). These findings suggest that age-related reductions in underlying frontal functions that serve suppression may be a critical factor leading to higher levels of interference at retrieval for older than for younger adults.

Whatever the ultimate source of age differences in the successful use of selection is, the present findings clearly suggest that interference from competition between candidates for response occurs at an automatic level and that younger adults are able to control that interference, perhaps by downregulating the activation of the nonrelevant candidate. At least under the circumstances tested in this study, older adults are far less able than younger adults to select the correct option when a strong competitor is available (Balota, Dolan, & Duchek, 2000).

Acknowledgments—This study was supported by National Institute on Aging Grant R37 AGO4306. The authors thank Ji-A Min, Grace Leung, Yaroslav Konar, Betty Luk, and Ursula Wiprzycka for their help in data collection and Sachiko Kinoshita for providing the lists of word fragments and their original baseline completion rates.

REFERENCES

Balota, D.A., Dolan, P.O., & Duchek, J.M. (2000). Memory changes in healthy older adults. In F.I.M. Craik (Ed.), *The Oxford handbook of memory* (pp. 395–409). London: Oxford University Press.

Crowder, R.G. (1976). *Principles of learning and memory*. Hillsdale, NJ: Erlbaum.

Gazzaley, A., Cooney, J.W., Rissman, J., & D'Esposito, M. (2005). Top-down suppression deficit underlies working memory impairment in normal aging. *Nature Neuroscience*, *8*, 1298–1300.

Hasher, L., & Zacks, R.T. (1988). Working memory, comprehension, and aging: A review and a new view. In G.H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory, Vol. 22* (pp. 193–225). San Diego, CA: Academic Press.

Hasher, L., Zacks, R.T., & May, C.P. (1999). Inhibitory control, circadian arousal, and age. In D. Gopher & A. Koriat (Eds.), *Attention and performance XVII* (pp. 653–675). Cambridge, MA: MIT Press.

Hassin, R.R. (2005). Non-conscious control and implicit working memory. In R.R. Hassin, J.S. Uleman, & J.A. Bargh (Eds.), *The new unconscious* (pp. 196–225). New York: Oxford University Press.

Hazeltine, E., Poldrack, R., & Gabrieli, J.D.E. (2000). Neural activation during response competition. *Journal of Cognitive Neuroscience*, *12*(Suppl. 2), 118–129.

Horton, K.D., Wilson, D.E., & Evans, M. (2001). Measuring automatic retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*, 958–966.

Ikier, S., & Hasher, L. (2006). Age differences in implicit interference. *Journal of Gerontology: Psychological Sciences*, *61B*, P278–P284.

Jonides, J., & Nee, D.E. (2006). Brain mechanisms of proactive interference in working memory. *Neuroscience*, *139*, 181–193.

Katzman, R., Brown, T., Fuld, P., Peck, A., Schechter, R., & Schimmel, H. (1983). Validation of a short Orientation-Memory-Concentration Test of cognitive impairment. *American Journal of Psychiatry*, *140*, 734–739.

Kinoshita, S., & Towgood, K. (2001). Effects of dividing attention on the memory-block effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*, 889–895.

Kintsch, W. (1977). *Memory and cognition*. New York: John Wiley & Sons.

Lustig, C., & Hasher, L. (2001a). Implicit memory is not immune to interference. *Psychological Bulletin*, *127*, 618–628.

Lustig, C., & Hasher, L. (2001b). Implicit memory is vulnerable to proactive interference. *Psychological Science*, *12*, 408–412.

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

Lustig, C., Konkel, A., & Jacoby, L.L. (2004). Which route to recovery? Controlled retrieval and accessibility bias in retroactive interference. *Psychological Science*, *15*, 729–735.

Lustig, C., May, C.P., & Hasher, L. (2001). Working memory span and the role of proactive interference. *Journal of Experimental Psychology: General*, *130*, 199–207.

Martens, S., & Wolters, G. (2002). Interference in implicit memory caused by processing of interpolated material. *American Journal of Psychology*, *115*, 169–185.

Mayes, A.R., Pickering, A., & Fairbairn, A. (1987). Amnesic sensitivity to proactive interference: Its relationship to priming and the causes of amnesia. *Neuropsychologia*, *25*, 211–220.

Nelson, D.L., Keelean, P.D., & Negrao, M. (1989). Word-fragment cuing: The lexical search hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 388–397.

Postman, L., & Underwood, B.J. (1973). Critical issues in interference theory. *Memory & Cognition*, *1*, 19–40.

Richardson-Klavehn, A., & Gardiner, J.M. (1995). Conjoint dissociations reveal involuntary "perceptual" priming from generating at study. *Consciousness & Cognition*, *8*, 271–284.

Shimamura, A.P., Jurica, P.J., Mangels, J.A., Gershberg, F.B., & Knight, R.T. (1995). Susceptibility to memory interference effects following frontal lobe damage: Findings from tests of paired-associate learning. *Journal of Cognitive Neuroscience*, *7*, 144–152.

Shipley, W.C. (1940). A self-administering scale for measuring intellectual impairment and deterioration. *Journal of Psychology*, *9*, 371–377.

Smith, S.M., & Tindell, D.R. (1997). Memory blocks in word fragment completion caused by involuntary retrieval of orthographically related primes. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*, 355–370.

Winocur, G., Moscovitch, M., & Bruni, J. (1996). Heightened interference on implicit, but not explicit, tests of negative transfer: Evidence from patients with unilateral temporal lobe lesions and normal old people. *Brain and Cognition*, *30*, 44–58.

Yang, L., Hasher, S., & Wilson, D.E. (2007). Synchrony effects in automatic and controlled retrieval. *Psychonomic Bulletin & Review*, *14*, 51–56.

(Received 6/8/07; Revision accepted 10/5/07)