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Age Differences in Implicit Interference

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We assessed age differences in interference effects in priming by using fragment completion. In Experiment 1, noninterfering filler words preceded critical targets at study, and priming was age invariant. In Experiment 2, the same target items had interfering competitors at the beginning of the list, such that both the target and the competitor were legitimate solutions to a fragment. Having two responses to a cue was disruptive for older adults, but not for younger adults. Younger and older adults differ in their susceptibility to interference in implicit tasks, and interference may play a role in influencing the magnitude of age differences in priming.

INTERFERENCE, or disrupted retrieval of target information as a result of exposure to related information either before or after target information, is a major source of forgetting (Crowder, 1976; Kintsch, 1977). Explicit memory tests typically reveal age differences between younger and older adults (Balota, Dolan, & Duchek, 2000; Craik, 2000; Zacks, Hasher, & Li, 2000), and the greater susceptibility of older adults than younger adults to the disruptive effects of interference is accepted as a major factor in these age differences (e.g., Kausler, 1994).

The study of age differences in interference has mainly been limited to explicit memory tasks (Lustig & Hasher, 2001a). The role of age differences in interference in implicit tasks, in which people are likely to be unaware of the connection between the retrieval event and prior experience, has not been extensively investigated. To a large degree, this is because implicit memory was thought to be immune to the effects of interference (Graf & Schacter, 1987; Jacoby, 1983; Sloman, Hayman, Ohta, Law, & Tulving, 1988). Recently, a review of the implicit memory literature (Lustig & Hasher, 2001b), as well as studies specifically designed to test for interference in implicit memory tasks (e.g., Lustig & Hasher, 2001c, Martens & Wolters, 2002), concluded that such tasks, like explicit ones, are vulnerable to interference. Indeed, some of the same variables operate in both implicit and explicit tasks, including the similarity between targets and competing responses and the number of competing responses. In fact, there is evidence that studying an alternative that is similar to the target can reduce memory performance for the target below baseline (McKoon & Ratcliff, 1996; Ratcliff & McKoon, 1996, 1997).

Several studies now report substantial proactive interference in tests of implicit memory. For example, proactive interference (the disruptive effects of learning prior to a target task) has been reported in a semantic priming paradigm (Winocur, Moscovitch, & Bruni, 1996, Experiment 2) in which a cue word (e.g., *eat*) was first associated with one response (e.g., *food*) and then with another (e.g., *drink*) on a second list. At test, the production of second-list target responses was reduced with substantial intrusions from the first learned association. In another study, a fragment-completion task was used in which a target (e.g., *allergy*) either was or was not preceded by a structurally similar nontarget competitor (e.g., *analogy*) at study. At test, a single-solution word fragment was presented that could only be completed by the target (e.g., *a _ l _ _ gy*). Young adults who studied the nontarget competitors before the critical items showed less priming for the critical items, and they had more intrusions of the nontarget items than did participants who received the critical items without the interfering nontargets (Lustig & Hasher, 2001b).

There is also evidence for retroactive interference (the disruptive effects of learning that follows a target task) in implicit memory. Martens and Wolters (2002) used a word-stem completion task. In this task, one or more competitors (e.g., *electricity, elephant*) that shared the same stem (e.g., *ele____*) as the previously studied target word (*element*) were presented after the study phase. Compared to a condition in which the competitors did not share the same word stem (e.g., *giraffe*), the young adult participants in the interference condition produced significantly fewer target words, calculating only the original response as correct. In addition, increasing the number of competing items interpolated between study and test increased the disruptive effects of interference.

These findings, along with the argument that susceptibility to interference is an individual-difference variable that leads to age differences in memory (e.g., Kane & Hasher, 1995; Lustig & Hasher, 2001a; May, Hasher, & Kane, 1999), raise the question of whether older adults are differentially vulnerable to interference in implicit tasks, as they seem to be in explicit memory tasks. To explore this question, we use an implicit memory task in which study lists do or do not have direct competitors for the same test cue. The findings suggest that interference can play a role in age differences in implicit memory.

EXPERIMENT 1

PRIMING WITHOUT INTERFERENCE

Experiment 1 compares older and younger adults on an implicit memory task when no interference is present. We used materials that could easily be altered, as they were for the second study, to create interference. To this end, we created a list of target words and their structurally similar paired competitors (e.g., *bells–bills*) and presented one member of each pair *without* its paired competitor at study. On the basis of a meta-analysis and review of age differences in implicit memory (Light, Prull, La Voie, & Healy, 2000), we expected age differences, if any, to be small because there is no opportunity for interference among items in the task, although there is opportunity for interference from semantic memory because the test fragments had multiple solutions.

Methods

Participants

Thirty-two younger (11 male, 21 female; 17–25 years old, $M = 19.5$, $SD = 1.8$) and 32 older adults (9 male, 23 female; 60–75 years old, $M = 67.3$, $SD = 4.8$) participated. Younger participants received course credit or payment. Older participants received payment. All participants had normal or corrected to normal vision, and all had a vocabulary score of 10 or more on the Extended Range Vocabulary Test (Educational Testing Service, 1976). Older adults had significantly higher vocabulary scores, $t(63) = 5.0$, $p < .05$; M (older) = 28, SD = 8.5, versus M (younger) = 17.2, SD = 6.8.

Materials

In preparation for the second experiment, we created two lists (List 1, List 2) of 20 word pairs by finding structurally similar but semantically unrelated items (e.g., *bells* and *bills*; see Appendix), coupled with fragments that could be completed by both members of a pair (e.g., *b _ _ l _*). Participants saw only one word from each pair, with the particular items counterbalanced across participants.

For the study session, we created a list of 90 words, 20 of which were targets for the implicit memory task. There were 10 buffer items at the beginning and 10 at the end of the list. The buffers at the beginning of the list were followed by one of two sets of 10 noninterfering items, which were the same length as the target items but were semantically, structurally, and phonemically unrelated to them. In addition to the 20 buffers, 10 noninterfering words, and 20 targets, there were also 40 filler items interspersed between the sets of buffers that we included to reduce awareness of the connection between the presentation and test items. Target items never appeared consecutively.

For testing, we created word fragments such that each had its first letter present, had no more than two blanks in a row, and the ratio of blanks to letters in each was either 2:3 or 3:2. Each fragment could be completed by at least five English words; however, within the experiment, only one word was presented that could complete it. We created a word-fragment-completion list of 70 items, 50 new and 20 targets, for the test session of the experiment. Twenty of those new fragments tested for target items that a particular participant did not see; this was a counterbalancing procedure that enabled us to collect baseline completion rates. Five of the new fragments served as buffer items at the beginning and five at the end of the series, and we included 20 filler fragments to reduce the likelihood of participants' becoming aware of the connection between the input and test tasks. Target fragments never appeared consecutively.

A number-fragment-completion task of 120 items served as a filler task in which the participants were asked to provide the missing numbers in mathematical operations (e.g., $10 + \_\ 0 = 20$). The task was similar in kind but not in content to the subsequent word-fragment-completion task, and we included it to reduce awareness of the connection between the final critical test task and the presentation phase (adapted and revised from Lustig & Hasher, 2001c).

Table 1. Target Completion and Error Rates for Younger and Older Adults: Experiment 1

Completion Type	Younger (%)	Older (%)
Target completion	9.1 (2.0)	7.8 (2.4)
Omission error	58.9 (4.0)	53.5 (4.1)
Intrusion error	33.2 (3.8)	37.7 (3.3)
Baseline completion[a]	2.0 (0.2)	2.2 (0.3)

Note: Standard errors are given in parentheses.
[a]These are guessing rates for participants who did not see the target items.

An awareness questionnaire assessed whether participants noticed the connection between the study and test sessions.

Procedure

We computerized and programmed all tasks under E-prime (Psychology Software Tools, 2001). Items appeared in the middle of the screen in black font over white background, to provide high contrast. In all tasks, a fixation cross appeared for 1,000 ms before the presentation of the first item, in order to indicate where the participant should fixate, and the interstimulus interval was 1,000 ms for all tasks. During presentation, participants saw 90 words, at a rate of 1,500 ms per word. Participants were instructed to count the number of vowels in each word, and to press the corresponding key (1–4). They were told that they could respond anytime before the next word appeared.

Following the study session, participants were told about a pair of completion tasks, with the first one being a number-fragment-completion task. The math problems were presented at a rate of 2,000 ms per item for a total of 6 min, and participants could respond anytime before the next item appeared. The experimenter recorded responses.

Participants were then told that the second completion task was a word-fragment-completion task, and they were asked to fill the fragments with the first word that came to mind that also fit the fragment perfectly. Each word fragment was presented for 3,000 ms, and the participants could respond any time before the next item appeared. The experimenter recorded responses.

Participants were then given the awareness questionnaire, a demographic questionnaire, and the Extended Range Vocabulary Test (Educational Testing Service, 1976). All participants were debriefed.

Results and Discussion

No participants reported noticing the connection between the study and the test sessions of the experiment.

Target Completion and Errors

We calculated the target completion for each participant as a percentage of target test fragments. When participants did not produce the target item, they could produce omissions or intrusions. The latter consisted of words (or, a nonword on rare occasions) that either did or did not fit the fragment. We also report these scores as percentages of target fragments; and we present them in Table 1. Younger and older adults did not differ in their omission or intrusion error rates (Fs < 1). Intrusion rates in Table 1 include the production of the potential competitor created for Experiment 2 (see Appendix). Although the competitor was not presented at the study session of this experiment, the competitor was produced 0.3% of the time by younger and 1.4% of the time by older adults, and this difference was reliable; $t(1, 62) = 2.1, p < .05$.

Priming Scores

We calculated separate baselines (the probability of completing a fragment with the target when it was not presented) as a percentage of critical fragments for younger and older participants. The baselines did not show an age difference, $F < 1$; M (younger) = 2.0%, $SE = 0.2$, versus M (older) = 2.2%, $SE = 0.3$. We calculated priming scores by subtracting the baseline score from target-completion scores. The priming scores for younger and older adults did not differ reliably, $F < 1$, although there was a small advantage for younger adults; M (younger) = 7.1%, $SE = 2.0$, versus M (older) = 5.7%, $SE = 2.4$.

Effect Sizes

We calculated effect sizes for age differences as in the meta-analyses by La Voie and Light (1994), Light and La Voie (1993), and Light and colleagues (2000), using formulas from Hedges and Olkin (1985). The effect size (d) for the difference between younger and older adults was small at 0.2. (The value d refers to the corrected effect size. An effect size of 0.2 is considered as small, 0.5 as medium, and 0.8 as large; see Cohen, 1988.)

Replicating the findings of others using word-fragment completion (e.g., Jelicic, Craik, & Moscovitch, 1996; Light, Singh, & Capps, 1986; but see Karlsson, Adolfsson, Borjesson, & Nilsson, 2003 for a report of age differences in fragment completion,[1] and Light, Kennison, & Healy, 2002 for mixed results), we did not detect age differences in priming. In addition, the effect size for age differences was small, as has been reported for implicit word-fragment completion in meta-analyses (La Voie & Light, 1994; Light & La Voie, 1993; Light et al., 2000). Thus, with no source of interference internal to the experiment, younger and older adults showed similar patterns of performance.

Experiment 2
Priming with Interference

To address the question of whether older adults are differentially vulnerable to interference in implicit memory tasks, we compared fragment completion for the same target items as in Experiment 1, except that half of the critical target words were now preceded in the list by orthographically similar words (e.g., *bells* and *bills*) for the interference condition and half were not for the no-interference condition. The critical test cues remained the same (e.g., *b _ _ l _*); however, now each could be completed by two words in the interference condition, but by a single item in the no-interference condition. In the interference condition, we had the competitor items presented early in the list in a block that included filler items. Each item served as a competitor in one counterbalance condition and as a target in another counterbalance condition. In addition, each item appearing as an item in the interference condition also appeared as an item in the no-interference condition in another counterbalance.

The paradigm used in this study constitutes a proactive interference situation as seen in the explicit memory literature (see e.g., Kintsch, 1977). Proactive interference typically occurs when, for example, more than one response is paired to a single cue. When the cue occurs, it triggers those responses and they compete with each other, resulting in reduced retrieval, as has been found in the classic paired-associate literature using two successive pairs of lists that share the same cue words but have different response terms (A-B, A-D; Postman & Underwood, 1973) as well as in the cue-overload effect (e.g., Watkins & Watkins, 1975). Competition among responses to a cue also induces slowed and inaccurate retrieval, as has been found in the "fan effect" in the explicit memory literature (Anderson & Bower, 1973; Radvansky & Zacks, 1991; Watkins & Watkins). Throughout this literature, competition effects are thought to occur at retrieval (e.g., Watkins & Watkins) and to underlie much of proactive interference (Postman & Underwood).

There is empirical evidence supporting the idea that older adults are more likely to be affected by the presentation of competitors in explicit tasks (Gerard, Zacks, Hasher, & Radvansky, 1991; Kausler, 1994; Radvansky, Zacks, & Hasher, 1996). We anticipated that, in the interference condition, older adults would show greater interference effects than would younger adults.

Methods

Participants

Thirty-two younger (11 male, 21 female; 18–33 years old, $M = 20.5$, $SD = 3.0$) and 32 older adults (9 male, 23 female; 61–79 years old, $M = 67$, $SD = 4.5$) participated. Younger participants either received course credit or payment. Older participants received payment. All participants had normal or corrected to normal vision and all had a vocabulary score of 10 or more on the Extended Range Vocabulary Test (Educational Testing Service, 1976). Older adults had significantly higher vocabulary scores, $t(62) = 5.2$, $p < .05$; M (older) = 30.0, $SD = 8.6$, versus M (younger) = 20.6, $SD = 5.6$. We replace the data from 6 participants, because they indicated some degree of awareness of the connection between the study and test phases of the experiment (1 older and 2 younger adults), because of a serious health problem (1 older participant), or because of a performance that was more than 3 SD above their age group's mean (1 older and 1 younger adult).

Design

We used a 2 × 2 mixed design with presence of interference (interference vs no interference) as a within-participant variable and age (younger vs older) as a between-participant variable.

Materials and Procedure

Materials and procedure were the same as Experiment 1, except that we replaced the set of 10 noninterfering items that preceded the targets in Experiment 1 with 10 competitors, creating a study list consisting of 10 competitors, 10 targets with competitors, and 10 targets without competitors, plus the fillers and buffers used in the first experiment. We fully counterbalanced lists (List 1, List 2), item type (competitors, targets with competitors, targets without competitors, and baseline),

Table 2. Target Completion and Error Rates for Younger and Older Adults: Experiment 2

Condition	Completion Type	Younger	Older
No interference	Target completion	6.0 (1.3)	8.8 (1.4)
	Omission error	50.3 (4.5)	46.0 (4.1)
	Intrusion error	44.0 (4.8)	45.3 (3.7)
	Baseline completion[a]	3.2 (0.2)	3.1 (0.2)
Interference	Target completion	7.4 (1.6)	4.8 (1.1)
	Competitor completion	5.8 (1.2)	4.2 (1.0)
	Omission error	52.4 (4.1)	43.9 (4.4)
	Intrusion error	34.4 (4.0)	46.9 (4.1)
	Baseline completion[a]	3.2 (0.2)	3.1 (0.2)

Note: Standard errors are given in parentheses.

[a]These are guessing rates for participants who did not see the target or the competitor items. The baseline rate is the same for both targets and competitors, because the same items serve as targets in one condition and as competitors in the other.

and order of presentation of the targets with and without competitors.

Results and Discussion

In the interference condition, we refer to the orthographically similar items that appear in the beginning of the list as competitors. We refer to targets that share the same test cue as the competitors as targets with competitors. In the no-interference condition, we refer to the targets as targets without competitors.

Target Completion and Errors

We calculated target completion in both conditions and competitor completion in the interference condition as in Experiment 1, along with errors (see Table 2). In the no-interference condition, omissions and intrusions for younger and older adults did not differ (Fs < 1), similar to Experiment 1. Intrusion rates in the no-interference condition include the production of the unpresented competitor (see Appendix 1). Both older and younger participants produced the potential competitor 2.5% of the time.

In the interference condition, when the target word was not produced, older adults were more likely to generate an intrusion error than were younger adults, $F(1, 62) = 4.8$, $p < .05$; however, the two groups did not differ in the likelihood of omitting a response, $F(1, 62) = 2.0$, $p = .2$.

Priming Scores

Younger and older adults did not differ in percentage of baseline items generated for critical items, $F < 1$; M (younger) = 3.2%, $SE = 0.2$ versus M (older) = 3.1%, $SE = 0.2$. We calculated priming scores for the two target types (with and without competitors; see Figure 1 for means and standard errors[2]) as before, by subtracting the baseline score from target-completion scores. An analysis of variance using target type as a within-participant variable and age as a between-participant variable showed a significant Age × Target Type interaction, $F(1, 62) = 4.7$, $p < .05$, with no main effects (Fs ≤ 1). Paired comparisons within each age group showed that the occurrence of competitors reduced target priming for older adults, with a reliable difference between targets with and without competitors, $t(31) = 2.2$, $p < .05$. In contrast, younger adults did not show evidence of disrupted retrieval for the targets with competitors, compared with those without; $t(31) = 0.8$, $p = .4$.

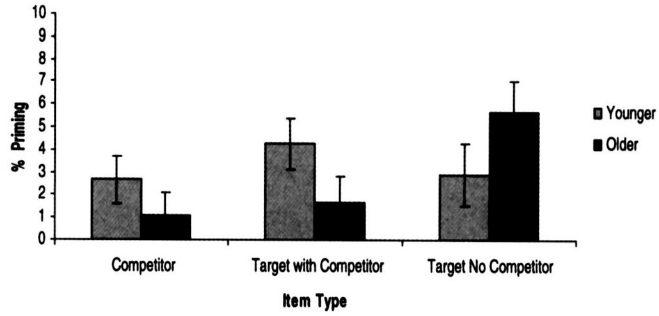

Figure 1. Percentage of priming for competitor, target with competitor, and target without competitor for younger and older adults (Experiment 2).

Because of the minimal priming that older adults showed for targets in the interference condition, we conducted t tests to see whether each priming score differed from zero. For older adults, priming was only reliable for targets without competitors, with $t(31) = 4.2$, $p < .05$. For younger adults, priming was reliable for both types of targets, as it was for the competitor, with ts ≥ 2.2.

Note that, in the interference condition, both the target and the competitor were presented at study and both were legitimate completions of the critical fragments. We created a priming score for the competitor itself (using the same methods as before; see Figure 1). We then created a total priming score for cues with two presented responses, composed of priming for target solutions (target completion minus baseline) plus competitor solutions (competitor completion minus baseline) for items in the interference condition; we compared this score with priming for the target without the competitor. An analysis of variance once more indicated a significant Age × Item Type interaction, $F(1, 62) = 7.1$, $p < .05$, but no main effects of age or item type (Fs < 1). This interaction is the result of different patterns of priming for younger and older adults.

Paired comparisons within each age group showed the same pattern for older adults as we saw when only target completions were considered, that is, greater priming when no competitor was presented ($M = 5.7$ %) than when there was a competitor presented ($M = 2.8$ %), although this difference did not reach significance, $t(31) = 1.6$, $p = .1$. In fact, even when we added the priming scores for the two critical cues ($M = 2.8$ %), older adults did not show reliable, above-baseline priming, $t(31) = 1.5$, $p = .2$. Older adults showed disruption for two-solution fragments compared with single-solution fragments, and younger adults did not. In contrast, younger adults actually showed more priming in the interference condition, when the two solutions were summed ($M = 6.8$ %), than in the no-interference condition ($M = 2.8$ %); $t(31) = 2.2$, $p < .05$.

Priming scores in general indicated that older adults were negatively affected by the presence of two completions for a single item.

Interference Effects

Interference effects in the explicit memory literature are typically defined as difference scores between control and experimental conditions, and here we calculated them by

Table 3. Effect Sizes for the Age Differences in Priming and for Interference Effects: Experiment 2

Priming and Interference	*d*	Effect Size
Priming for competitor	0.3	S–M
Priming for target with competitor	0.3	S–M
Priming for target with competitor + competitor	0.6	M–L
Priming for target without competitor	0.4	S–M
Interference (target with competitor)	0.5	M–L
Interference (target with competitor + competitor)	0.7	M–L

Note: For effect size, S = small, M = medium, L = large.

subtracting priming for targets without competitors (no-interference condition) from priming for targets with competitors (interference condition). We did this once with just the target-completion priming score and a second time with the combined target and competitor score as measures of priming in the interference condition. For target-completion score, younger adults showed a nonreliable facilitation of 1.4%, $t < 1$ ($SE = 1.7$), whereas older adults showed a reliable interference effect of 4.0%, $t(31) = 2.2$ ($SE = 1.8$). These scores were reliably different from each other, $F(1, 63) = 4.7$, $p < .05$.

Using the combined target and competitor score, we found that younger adults showed a reliable facilitation of 4.1%, $t(31) = 2.2$ ($SE = 1.8$), and older adults showed a nonreliable interference effect of 2.9%, $t(31) = 1.6$, $p = .1$ ($SE = 1.9$). The age difference was reliable, $F(1, 63) = 7.1$, $p < .05$. Thus, by either measure of interference, the patterns for younger and older adults were different, with only older adults showing disrupted retrieval in the face of two potential solutions to a fragment.

Effect Sizes

We calculated effect sizes and interpreted them as in Experiment 1 (see Table 3). Effect sizes for age differences in priming for different item types were characterized by small to medium magnitudes, whereas effect sizes in the interference condition when both completions for the target fragment are taken into account (target with competitor + competitor), as well as the interference effects, calculated with or without collapsing target priming with competitor priming, were characterized by medium to large effects sizes. These are substantially larger than the effect sizes obtained for age differences in implicit word-fragment-completion studies in which competitors did not occur (La Voie & Light, 1994; Light & La Voie, 1993; Light et al., 2000).

The results of Experiment 2 suggest that response competition is differentially disruptive to older adults in implicit tasks, as it is in explicit tasks. In the interference condition, older adults rarely generate either the target or the competitor, a pattern that is parallel to classic response competition as discussed in the explicit memory literature (e.g., Kintsch, 1977). In contrast, younger adults look quite different, because when a cue has two potential responses, younger adults frequently generated either the target or its competitor; they actually showed no interference effect relative to the single-item cue condition.

We note that there are some discrepancies between the results of the first and second experiments. For example, priming in the no-competitor condition in Experiment 2 is reduced relative to priming in Experiment 1. Such discrepancies may be due to different samples of participants across the two studies or possibly to effects associated with using within- versus between-subject designs, as is not infrequently found in the cognitive literature (e.g., McDaniel & Einstein, 1986). In any event, although the extent of priming differs across the two studies, the general finding of no age differences in the absence of experimentally presented interfering items is seen in both studies.

General Discussion

The major findings across these two implicit memory studies are as follows. First, there was an absence of detectable age differences in priming when no competitors for a cue were presented, a finding that is generally consistent with the literature on age differences in implicit memory (e.g., Light et al., 2000). Second, older adults show susceptibility interference in an implicit memory task in which two legitimate completions for a fragment were presented. For older adults, simply having two potential solutions to the same fragment appeared to be sufficient to reduce access to both the target item and its competitor to their semantic memory baseline. Third, under conditions in which older adults' performance is reduced to a semantic memory level, younger adults showed facilitation relative to a condition in which only one completion was presented for each critical cue. This latter finding, although initially unexpected, is actually similar to those of Martens and Wolters (2002), in which interfering items (e.g., *electricity, elephant*) shared the same word stem (e.g., *ele*____) as the target response (e.g., *element*). Although the authors only compared priming for the target in the presence versus absence of the competing items, younger adults showed higher total priming scores when there were alternative items present, indicating that they produced those as well.

The facilitation shown by young adults when two response candidates are presented is worth noting—because one might have otherwise expected a disruption in retrieval caused by the mere presence of competitors. The unusual aspect of this study, and of the Martens and Wolters study (2002) as well, is that either experimentally presented response was a legitimate solution to a critical cue; no analysis of the appropriateness of the response was needed. This is in contrast with many studies assessing competition effects in which only one of two or more possible responses is correct (e.g., Lustig & Hasher, 2001c), a situation that potentially requires a postretrieval analysis of response candidates.

In sharp contrast to the performance of younger adults, older adults in the same situation show disrupted retrieval, even though careful analysis of the appropriateness of a response candidate is not required. One speculative, retrieval-based interpretation of this pattern assumes that selection between responses is difficult because of a reduced ability to suppress one or another alternative, as Hasher, Zacks, and May (1999) might suggest. Age-related selection or decision problems have been reported in the literature using event-related potentials as a measure of processing (Bashore, van der Molen, Ridderinkhof, & Wylie, 1997), as well as elsewhere in the aging literature (Kausler, 1991; Salthouse, 1996).

An alternative interpretation of the patterns of priming for younger and older adults in the presence of competitors might focus on events at encoding. For example, during presentation, when a similar item occurs (e.g., *bells* preceded some items before *bills*), the second item might trigger retrieval of its antecedent. For younger adults, this distributed retrieval process results in greater accessibility of one or the other or both responses at the time of the implicit test. Such an interpretation can clearly account for the facilitation effects seen here. How might this encoding argument be extended to account for the absence of detectable priming shown by older adults when they also show above-baseline priming if only one such item is presented? If retrieval at encoding were automatically triggered by the second item for older adults as for younger adults, then something like a "competition at encoding" mechanism would have to be introduced in which the activation of the two similar items is reduced to baseline, but only for older adults. We are unaware of any relevant evidence on this point and, clearly, more empirical work is needed before a definitive interpretation of the "silencing" seen here for older adults can be offered. Our own inclination, influenced by the explicit memory literature (e.g., Kintsch, 1977), is to favor a retrieval explanation that includes an age-related reduction in the ability to suppress or control one candidate for response in order to produce another.

We note that populations such as individuals with amnesia and frontal and medial temporal lobe patients that are inefficient at using controlled processing show higher levels of interference than do normal controls (e.g., Mayes, Pickering, & Fairbairn, 1987; Shimamura, Jurica, Mangels, Gershberg, & Knight, 1995; Winocur et al., 1996). The presence of higher levels of interference in these populations suggests that interference may be reduced in populations that are efficient at using controlled processing. Compared with younger adults, older adults who show reduced volume (Raz, Gunning-Dixon, Head, Dupuis, & Acker, 1998; Raz et al., 2004) and less efficiency of frontal lobe functions (e.g., Moscovitch & Winocur, 1992) may be worse at the regulation of interference by the use of controlled processes. Such an interpretation is supported by other findings that illustrate the involvement of the frontal lobes in the resolution of interference (e.g., Hazeltine, Poldrack, & Gabrieli, 2000; Jonides et al., 2000; Nelson, Reuter-Lorenz, Sylvester, Jonides, & Smith, 2003).

It is worth nothing that the results of the present study suggest the need for researchers to be cautious when setting up implicit memory studies. The finding that older adults might be more susceptible to interference than are younger adults suggests the need for researchers to be particularly careful about materials selection. For example, tasks such as vocabulary tests completed in the laboratory prior to implicit memory experiments, interpolated verbal tasks used in order to reduce the number of participants that notice the connection between the study and the test sessions of the experiments, and the similarity of the materials in the study session of an experiment might all be factors that affect younger and older adults differently, and older adults more adversely, at least when more than one experimental item is the legitimate solution for a test cue.

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End Notes

1. Karlsson and colleagues (2003) followed the study session by two filler tasks, a word comprehension and a general knowledge test, both given before the priming test. Note that the filler tasks were verbal and so, on an entirely post hoc argument, may have provided items that could subsequently interfere with the studied target words.
2. We carried out a correction because of a mistake in the materials. The fragment *c _ _ ck*, which served as the target fragment for *chick* and *check*, could also be completed by the target word *crack*. We treated the fragment as a filler fragment and removed it from the analysis of both baselines and experimental items.

Appendix

Target Items and Fragments in Experiment 1

List 1			List 2		
Target 1	Target 2	Fragment	Target 1	Target 2	Fragment
Block 1	Block 2		Block 1	Block 2	
BELLS	BILLS	B _ _ L _	CARTS	CORES	C _ R _ _
LEARN	LEAST	L _ A _ _	FROST	FROSH	F _ O _ _
PLEAT	PREEN	P _ E _ _	ARENA	AREAS	A _ E _ _
CLASS	CRACK	C _ A _ _	POINT	PRIME	P _ I _ _
QUICK	QUILL	Q _ I _ _	SHINE	SPINE	S _ _ N _
TOTES	TOKEN	T _ _ E _	CRIME	CLIMB	C _ I _ _
AFTER	ACTOR	A _ T _ _	HEARD	HOARD	H _ A _ _
SWEET	SHEEP	S _ _ E _	THERE	THEME	T _ E _ _
THINK	THICK	T _ I _ _	SMILE	SMALL	S _ _ L _
CHICK	CHECK	C _ _ C K	BRAIL	BRAID	B _ _ I _
Block 3	Block 4		Block 3	Block 4	
PAPER	POWER	P _ _ E _	ROPES	RATES	R _ _ E _
BOOKS	BOOTS	B _ O _ _	ADOPT	ALOFT	A _ O _ T
DRINK	DRILL	D _ I _ _	FEELS	FALLS	F _ _ L _
SPEAR	SMEAR	S _ E A _	TRACE	TRADE	T _ A _ _
PLATE	PLANT	P _ A _ _	BRAND	BRINE	B _ _ N _
ABOVE	ABODE	A _ O _ E	GRADE	GRATE	G _ A _ _
TELLS	TALLY	T _ _ L _	WRITE	WHITE	W _ _ T _
SEATS	SUITS	S _ _ T _	GREET	GLEAM	G _ E _ _
BREAD	BREAK	B _ _ A _	SHAME	SHADE	S _ A _ E
FORCE	FORGE	F _ R _ _	MANIC	MUSIC	M _ _ I _