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Errorless learning and elaborative self-generation in healthy older adults and individuals with amnestic mild cognitive impairment: Mnemonic benefits and mechanisms

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Abstract

Errorless learning is an intervention that benefits memory performance in healthy older adults and a variety of clinical populations. A limitation of the errorless learning technique is that it is passive and does not involve elaborative processing. We report two studies investigating the added benefits of elaborative, self-generated learning to the errorless learning advantage. We also explored the mnemonic mechanisms of the errorless learning advantage. In both studies, older adults and individuals with amnestic mild cognitive impairment (aMCI) completed four encoding conditions representing the crossing of errorless/errorful learning and self-generated/experimenter-provided learning. Self-generation enhanced the errorless learning benefit in cued recall and cued recognition, but not in free recall or item recognition. An errorless learning advantage was observed for priming of target words, and this effect was amplified for participants with aMCI after self-generated learning. Moreover, the aMCI group showed significant priming of prior self-generated errors. These results demonstrate that self-generation enhances the errorless learning advantage when study and test conditions match. The data also support the argument that errorless learning eliminates the misleading implicit influence of prior errors, as well as the need for explicit memory processes to distinguish targets from errors. (*JINS*, 2009, *15*, 704–716.)

Keywords: Generation, Learning, Implicit memory, Cued recall, Recognition memory, Neuropsychological tests

INTRODUCTION

People with amnestic mild cognitive impairment (aMCI) have a decline in memory function that is both reported by themselves or an informant and indicated by performance on objective cognitive tests. It is important to develop interventions that improve memory functioning of individuals with aMCI, because they have a substantially elevated risk of developing Alzheimer's disease (Petersen, 2004).

Recent research has emphasized the value of errorless learning in facilitating memory functioning. In an early study by Baddeley and Wilson (1994), individuals with amnesia and younger and older healthy adults were presented with stems (e.g., "QU___") that had numerous potential completions. Participants either guessed the correct target word, which elicited several erroneous guesses before the target word was provided (the errorful condition), or were immediately provided with the target word (the errorless condition). All three groups, but particularly the amnesiac group, showed better cued-recall performance following errorless than errorful learning. This robust effect has been replicated in people with brain injury (e.g., Parkin, Hunkin, & Squires, 1998; Tailby & Haslam, 2003) and Alzheimer's disease (Clare, Wilson, Carter, Roth, & Hodges, 2002).

One limitation of the way errorless learning is typically administered is that target information is provided in full by the experimenter without active involvement of the participant. This procedure ignores the wealth of evidence that participant involvement in learning benefits later memory (i.e., the generation effect; Slamecka & Graf, 1978), especially when it entails semantic processing (Craik & Tulving, 1975). Our first goal was to test the hypothesis that semantic generation of targets during errorless encoding would enhance recall beyond the normal advantage of

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experimenter-provided errorless learning. Previous studies provide some evidence that active elaboration enhances the errorless learning effect (e.g., Clare & Wilson, 2004; Evans et al., 2000; Tailby & Haslam, 2003; but see Dunn & Clare, 2007). However, these studies did not employ a factorial design needed to assess the interactive effects of errorless *versus* errorful learning and passive *versus* elaborative encoding separate from their individual effects. We report two studies to test our primary hypothesis that semantically guided errorless generation would lead to better memory performance than either effect alone. We also expected that self-generation of errors in an errorful encoding condition would actually hinder later retrieval of target memoranda, relative to experimenter-provided errors (Roediger & Marsh, 2005). In both studies we compared the effects of errorless *versus* errorful learning and experimenter-provided *versus* self-generated learning on later memory performance.

Our predictions were further qualified by the multifactor view of generation effects (Hirshman & Bjork, 1988; McDaniel, Rigler, & Waddill, 1990), drawn from transfer-appropriate processing theory (c.f. Morris, Brandsford, & Franks, 1977), which states that memory is best when processing engaged at study is recapitulated at test. According to this view, providing participants with a cue word and requiring generation of a semantically associated target word enhances the processing of the semantic cue-target relation and results in generation advantages in cued recall, relative to simply reading words. At the same time, this sort of associative generation hinders processing of relationships among targets (inter-item processing) and of the specific features of the targets themselves (intra-item processing). Therefore, encoding based on semantically cued generation typically does not lead to generation advantages on subsequent free recall (which relies on inter-item processing) or recognition (which relies on intra-item processing) testing. We thus predicted that the added benefit of self-generation to the errorless learning advantage might be evident only during cued recall. To test this hypothesis, memory was tested using free recall, cued recall, and recognition in both studies. Study 1 included a yes/no item recognition test, whereas Study 2 employed a sentence-fragment cued recognition test. Given that the former emphasizes processing of item-specific target features and the latter emphasizes processing of the cue-target relationships, we expected errorless, semantic generation to enhance recognition performance in Study 2 but not in Study 1.

Our second goal was to further explore the contribution of explicit and implicit memory to the errorless learning advantage. According to Baddeley and Wilson (1994), implicit memory elicits the strongest item in response to a cue, irrespective of the item's accuracy, whereas one of the major functions of explicit memory is to eliminate learning errors. Given that individuals with aMCI have impaired explicit memory but intact implicit memory (Anderson et al., 2008), we reasoned that they would have difficulty eliminating learning errors. How might this affect memory performance? Tailby and Haslam (2003) argued that if the errorless learning advantage is mediated by implicit memory, then controls and individuals with explicit memory deficits should demonstrate equivalent explicit memory performance under errorless learning conditions. We disagree, however, because although errorless learning would eliminate the implicit influence of prior errors, it would not compensate for the poorer explicit memory for target words. Instead, we argue that if the errorless learning advantage is mediated by implicit memory, then the effects would only be evident on indirect tests; namely, relative to errorful learning, errorless learning should lead to greater priming of target words, because only the targets are experienced and not the competing prior errors.[a] This should be true for both healthy individuals and individuals with aMCI, given that they do not differ in their implicit memory abilities (Anderson et al., 2008).

We also expected greater priming of previous learning errors in the aMCI than in the healthy control group, given the former groups' reduced ability to eliminate these errors. To date, no studies have examined implicit memory for learning errors.[b] To test this, in Study 1 we included an indirect priming test in which participants completed word stems with the first word that came to mind. The word stems could be completed by target words, prior errors, or new unstudied words. Finally, we also explored false positive responses to prior errors on the recognition tests in the two studies. False alarms to prior errors, if occurring at a higher rate than false alarms to new words, would reveal the implicit influence of memory unopposed by explicit information that the prior error is not a target word, despite being familiar.

To summarize, we report two studies conducted to identify the learning and retrieval conditions most conducive to memory performance in healthy older adults and those with aMCI, and to explore the cognitive mechanisms of these effects. Including two groups of otherwise matched older adults who differ only in terms of their explicit memory functioning facilitates examination of the contributions of explicit *versus* implicit memory to the errorless learning advantage. In both studies, errorless *versus* errorful learning was crossed with experimenter-provided *versus* self-generated learning, followed by free recall, cued recall, and recognition measures of memory. We hypothesized that (a) Errorless learning and semantic generation advantages would be super-additive for both healthy older adults and those with aMCI, but only on cued recall and cued recognition tests in which the cue-target relational processes encouraged by encoding are recapitulated at retrieval; and (b) The errorless learning advantage is mediated primarily by implicit memory. We expected this to be revealed by greater priming of target words after errorless than errorful learning for both groups, and by greater priming of and greater recognition false alarms to prior errors in the aMCI than healthy control group, given the former group's relatively greater reliance on implicit memory processes.

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[a] Hunkin et al. (1998) found that priming of target words was numerically higher after errorless than errorful learning, but the difference was not reliable, likely because of their sample size ($n = 8$).

[b] Hasher and her colleagues (Ikier & Hasher, 2006; Kim, Hasher, & Zacks, 2007; Rowe, Valderrama, Hasher, & Lenartowicz, 2006) reported reliable priming of *task-irrelevant* information in older, but not younger adults.

STUDY 1

We compared the effects of errorless (EL) *versus* errorful (EF) learning and experimenter-provided (EP) *versus* self-generated (SG) learning on free recall, cued recall, and recognition performance, as well as on indirect word stem completion.

METHOD

Participants

Independently living older adults were recruited from a research participant pool at Baycrest and talks given at senior centers. Exclusion criteria for participants in both studies included a history of head injury with loss of consciousness, major neurologic or psychiatric disorder, learning disability, systemic medical disease, or a score > 11 on either measure of the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983). Two potential participants were excluded following phone screening because of medical conditions.

A neuropsychological test battery was administered subsequently to participants at Baycrest or in their homes. A consensus judgment of two neuropsychologists was used for group assignment, using published criteria for aMCI (Petersen, 2004; Winblad et al., 2004). Specifically, each participant: (a) reported a *memory complaint* during interview or on the Memory Assessment Clinics Self-Rating Scale (MAC-S; Crook & Larrabee, 1990), a measure of subjective memory abilities and frequency of memory failures; (b) exhibited *objective memory impairment for age* on at least two memory measures, including immediate and delayed Logical Memory and Verbal Paired Associates subtests of the Wechsler Memory Scale-Revised (WMS-R; Ivnik et al., 1992a; Wechsler, 1987), the Memory subscale of the Dementia Rating Scale-2 (DRS-2; Lucas et al., 1998; Mattis, 2001), and immediate and delayed production of the Rey-Osterrieth Complex Figure Test (ROCFT; Fastenau, Denburg, & Hufford, 1999; Lezak, Howieson, & Loring, 2004); (c) demonstrated *normal mental status* for age and education on the DRS-2 and scores > 30/50 on the modified Telephone Interview of Cognitive Status (m-TICS; Welsh, Breitner, & Hagruder, 1993); (d) demonstrated *normal nonmemory abilities* as measured by the Boston Naming Test (Ivnik, Malec, Smith, Tangalos, & Petersen, 1996; Kaplan, Goodglass, & Weintraub, 1983), the Block Design subtest of the WAIS-R (Ivnik et al., 1992b; Wechsler, 1981), and copy of the ROCFT; and (e) reported no substantial interference with *normal daily activities* (e.g., personal banking, grocery shopping). In the end, 19 individuals diagnosed with aMCI and 19 healthy older controls, who performed in the normal range on all neuropsychological measures, were included in the study. All participants gave informed consent and were paid $30. Both studies were approved by the Research Ethics Board at Baycrest.

The healthy control and aMCI groups did not differ in age, $t(36) = 1.49$, $p = .15$, education, $t(36) < 1$, or sex distribution, $\chi^2(1, N = 38) = .026$, *ns* (see Table 1). The aMCI group performed worse than the healthy controls on all measures of memory, $ts(36) > 2.2$, marginally so on Rey-Osterrieth Immediate Recall, $t(36) = 1.82$, $p = .08$. The two groups performed equally well on the nonmemory tasks, $ts(36) < 1$, except for a marginal difference on Rey-Osterrieth Copy, $t(36) = 1.81$, $p = .08$. The aMCI group reported poorer memory ability (MAC-S Ability), $t(35) = 2.89$, $p < .01$, and poorer memory relative to others their age (MAC-S Global), $t(35) = 3.17$, $p < .01$.[c]

Materials

Participants learned four lists of 12 words, one in each encoding condition. Each word began with a different three-letter word stem. Each stem was assigned four noun completions selected from Shaw (1997). The order of the noun completions was counterbalanced across stems within lists, so that completion frequency (Shaw), word frequency, and word length were equivalent across lists and across ordinal positions within lists, $Fs < 1$. The assignment of list to encoding condition, list order, and which of the four words was the target (termed the *word number*) were counterbalanced across all participants tested, rather than within group, because group assignment was determined after testing.

Procedure

In all four conditions, word stems were presented on card stock. Cues were always provided to ensure that participants received an equal amount of semantic information in each condition. These cues were used by participants to generate the target information in the EL-SG condition and were provided subsequent to presentation of the target word in the other conditions. After each target word was generated or provided, participants wrote it on a piece of paper and covered the previous words they had written.

In the EL-EP condition, the experimenter displayed a word stem and immediately displayed and read aloud the target word (e.g., "I am thinking of a word that begins with BAN___, and it is banana") and then the two semantic cues (e.g., "which is related to peel and fruit"). In the EL-SG condition, the experimenter displayed a word stem and immediately said the first cue. Participants were encouraged to say the target word only if they were sure of the correct response. If they did not respond, the second cue was provided ("it is also related to fruit"). In the rare case that a participant failed to generate the target word, the word stem was presented with three completions in a multiple-choice format, and the participant verbally selected the correct word. The choices included two nonwords and the target word (e.g., banafa, banana, banata), which ensured that the participant would generate the target word without error. The experimenter recorded the number of cue words provided.

[c] Due to an oversight, the MAC-S was not administered to one control participant.

Table 1. Demographic and neuropsychological data for subject groups in Study 1

	Healthy Controls ($n = 19$)		aMCI ($n = 19$)	
	Mean	*SD*	Mean	*SD*
Age	73.74	5.89	76.95	7.33
Education	14.00	3.42	14.11	3.09
Sex				
Male	9		10	
Female	10			9
m-TICS (raw scores)	37.37	4.04	35.00	4.46
Dementia Rating Scale (SSs)				
Attention	11.74	1.33	11.63	1.43
Initiation	10.74	1.73	11.31	1.38
Construction	9.84	0.68	10.00	0.00
Conceptualization	11.74	1.82	11.37	1.77
Memory*	11.58	2.19	8.53	3.27
Block Design (SS)	12.37	2.91	12.63	3.53
Boston Naming Test (SS)	11.79	2.76	10.89	2.71
ROCF Test (SSs)				
Copy	10.84	2.69	9.25	2.66
Immediate	10.89	2.87	8.75	4.09
Logical Memory I* (SS)	11.63	2.67	7.74	3.30
Logical Memory II* (SS)	11.32	2.61	7.88	3.76
Verbal PA I* (SS)	10.26	2.35	8.37	2.09
Verbal PA II* (SS)	12.11	1.52	10.79	2.12
HADS (raw scores)				
Anxiety	4.58	2.32	5.78	1.56
Depression	2.95	1.96	3.61	1.94
MAC-S (raw scores)				
Ability*	66.17	7.69	58.68	8.04
Frequency	73.17	10.52	68.42	8.67
Global Rating*	3.44	0.62	2.74	0.73

Note. SS = scaled scores; aMCI = amnestic mild cognitive impairment; m-TICS = Modified Telephone Interview of Cognitive Status; ROCF = Rey-Osterrieth Complex Figure Test; PA = Paired Associates; HADS = Hospital Anxiety and Depression Scale; MAC-S = Memory Assessment Clinics Subject-Rating Scale.
*Group difference significant at $p < .05$.

In the EF-EP condition, the experimenter displayed a word stem, read three words that could complete the stem, and for each, indicated that the completion was possible, but was not the word to be remembered. Finally, the target word was presented, followed by the two semantic cues. In the EF-SG condition, participants were shown a word stem and had a maximum of three guesses to identify the correct target word before the experimenter revealed the word to remember. Participants who generated the target word (e.g., “banana”) were told that they were incorrect, and the next completion (e.g., “band”) then became the new target word. The two semantic cues were then presented. The experimenter recorded all errors generated by the participant.

Following presentation of each list, participants counted backwards by threes from a specified number for 20 seconds to eliminate recency effects. They then completed a test of free recall. To prevent masking of findings due to potential floor effects, each list was presented again in the same manner, followed by a second free recall test and then a test of cued recall. For three of the conditions (EL-EP, EF-EP, and EF-SG), the cue in the cued recall test was the second (i.e., more specific) cue (e.g., “fruit” for “banana”). For the EL-SG condition, the cue was the one that had led to a correct response at encoding. In all recall tests, participants provided written responses and covered previously written words.

After a 20-min filled delay, participants were administered a word stem completion task presented via a booklet containing 48 stems that participants studied, 12 stems that were included for another purpose not reported here, and 60 new, nonstudied stems. Words assigned to nonstudied stems did not differ from studied stems in word frequency, word length, or word stem completion frequency, all *t*s < 1. Participants were told that they were helping in the development of materials for another study by completing the word stems with the first word that came to mind. They were provided up to 5 seconds to complete each stem, and were not permitted to go back to missed stems. The experimenter recorded all responses by hand.

A yes-no recognition test was then administered, which included 48 target words and 192 nontarget words, printed individually on card stock. Participants responded “yes” to target words and “no” to nontarget words, which comprised the three alternate nouns for each of the 12 word stems in each list, plus one additional noun for each stem. These additional nouns did not differ from the assigned nouns in word frequency, word length, or word stem completion frequency, all *t*s < 1. An additional 60 nontarget words were interspersed throughout the recognition test for another purpose not reported here. Finally, participants were asked a series of graded questions to determine whether they were aware that the word stems corresponded to studied items (e.g., Why do you think we presented you with word stems and had you generate the first word that came to mind? Did you notice anything about the words you completed?).

RESULTS

Overview of Statistical Analyses

Statistical analyses for both studies were performed using SPSS for Windows, Version 15.0. A series of mixed-design analyses of variance (ANOVAs) were conducted, and an alpha value of .05 was used throughout. The between-subject factor was group (healthy controls *vs.* aMCI), and the within-subject factors were error (errorless *vs.* errorful) and generation (self-generated *vs.* experimenter-provided). Because there were different numbers of items on the recall and recognition measures, to facilitate comparisons across tasks, proportional data served as the primary dependent measure for free recall, cued recall, and recognition. Initial encoding, intrusions, and false positive responses were also analyzed.

Generation Performance during Initial Encoding

In the EL-SG condition, cuing levels were coded as 1 (one cue required), 2 (two cues required), or 3 (multiple choice level required). There were no group differences in the level of cuing required (Controls: mean (M) = 1.89, standard error of measurement (SEM) = .07; aMCI: M = 1.94, SEM = .08) before correct generation of the target word on the first learning trial, $t(36) < 1$. However, on the second learning trial, participants with aMCI required more cueing (M=1.50, SEM=0.10) than did healthy controls (M=1.22, SEM=0.03), $t(36)$ = 2.64, p = .012, which underscores their reduced learning. Regardless, participants in both groups almost always generated the target word in the EL-SG condition, rarely requiring selection of the target word from a choice of nonwords (number of trials requiring this step: Controls: M = 0.63, SEM = .32; aMCI: M = 1.05, SEM = .33, $t(36) < 1$).

In the EF-SG learning condition, the groups generated an equivalent number of errors on the first learning trial (Controls: M = 2.58, SEM = .06; aMCI: M = 2.56, SEM = .09), $t(36) < 1$, but on the second learning trial, participants with aMCI generated more errors (M = 1.64, SEM = .09) relative to healthy controls (M = 1.32, SEM = .11), $t(36)$ = 2.25, p = .031, again demonstrating their reduced learning.

Free Recall

On the first free recall trial (Figure 1, top panel), performance was higher in the healthy control group (M=.28, SEM=.03) than in the aMCI group (M=.19, SEM=.03), $F(1, 36)$=5.63, p=.023, η^2=.14. Free recall was better following errorless learning (M=.27, SEM=.02) than errorful learning (M=.21, SEM=.03), $F(1,36)$=7.03, p=.01, η^2=.17. No other effects were significant, all Fs(1, 36) < 1.7. Similarly, on the second trial (Figure 1, bottom panel), healthy controls (M=.53, SEM=.03) outperformed individuals with aMCI (M=.39, SEM=.03), $F(1, 36)$=8.42, p=.006, η^2=.19, and recall was better following errorless (M=.50, SEM=.02) than errorful (M=.42, SEM=.03) learning, $F(1, 36)$=14.67, $p < .001$, η^2=.29, but no other significant effects were observed. Free recall of prior errors in the EF conditions was rare (Ms < .01) across groups and conditions.

Cued Recall

Cued recall did not differ between the two groups, $F(1,36) < 1$ (see Figure 2), but was better following errorless (M=.82, SEM=.03) than errorful (M=.60, SEM=.05) learning, $F(1, 36)$=87.29, $p < .001$, η^2=.70, and following self-generated (M=.77, SEM=.04) than experimenter-provided (M=.66, SEM=.05) encoding, $F(1, 36)$=28.88, $p < .001$, η^2=.45. These main effects were qualified by a significant error by generation interaction, $F(1, 36)$=21.05, $p < .001$, η^2=.37. In the errorless conditions, cued recall was better when targets were self-generated (M=.91, SEM=.03) than when they were experimenter-provided (M=.73, SEM=.04), $t(37)$=5.92, $p < .001$, η^2=.49, but in the errorful conditions this was not the case, $t(37)$=1.34, p=.19. Cued recall of prior errors in the EF conditions was rare (Ms < .01) and did not differ across groups or conditions.

Recognition Memory

Figure 3 shows the proportion of hits minus the proportion of false alarms for each study condition. Recognition memory was higher in the control group (M=.74, SEM=.04) than in the aMCI group (M=.61, SEM=.05), $F(1, 36)$=4.23, p=.05, η^2=.10. Recognition was better following errorless (M=.73, SEM=.03) than errorful (M=.62, SEM=.04) learning, $F(1, 36)$=16.07, $p < .001$, η^2=.31. No other effects were significant, Fs(1, 36) < 1.93. Participants were more likely to falsely recognize a self-generated (M=.15, SEM=.03) than experimenter-provided (M=.07, SEM=.01) prior error, $F(1, 36)$=12.53, p=.001, η^2=.26, but this did not differ between, $F(1, 36)$=2.95, p=.095, or interact with, $F(1, 36) < 1$, groups.

Word Stem Completion

Priming of target words [the probability of completing a studied word stem with a target word minus the baseline probability of completing a nonstudied word stem with a predesignated word, the latter of which did not differ between groups, $t(36) < 1$], is displayed in Figure 4 (left panel). There was no difference in target priming between groups (Control M = .15, SEM=.03; aMCI M = .11, SEM = .03),

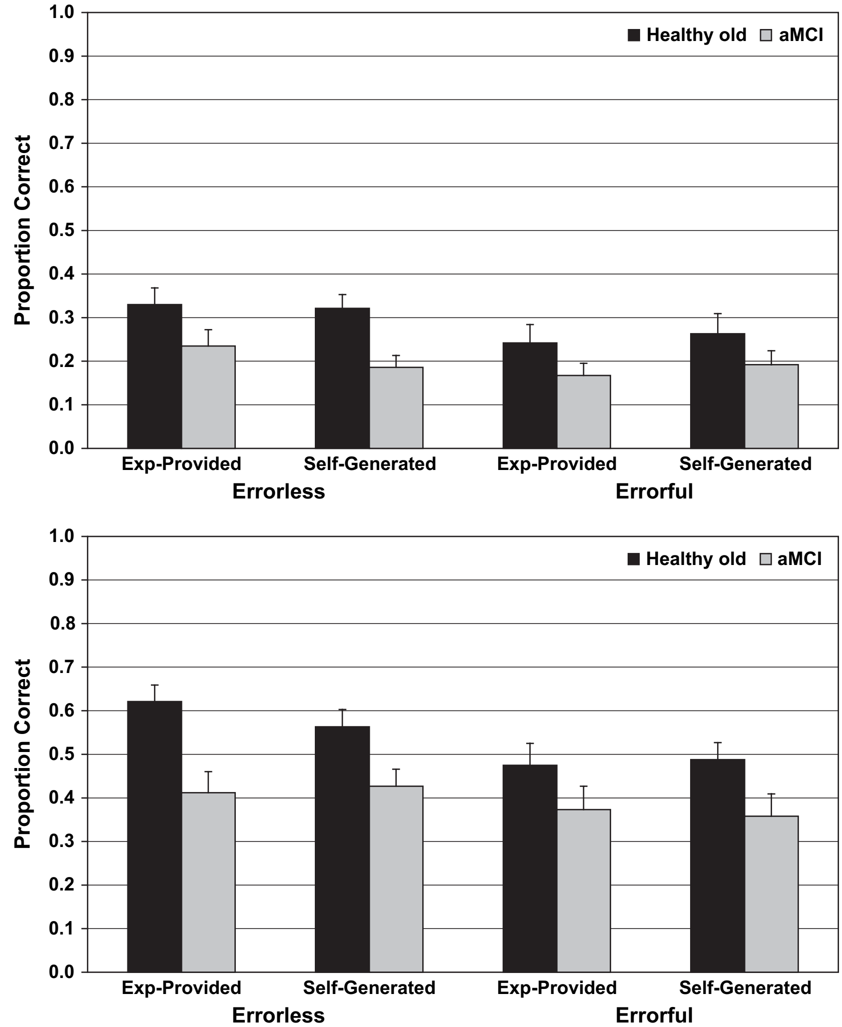

Fig. 1. Free recall performance after Trial 1 (top panel) and Trial 2 (bottom panel) in Study 1 (error bars = SEM).

$F(1, 36) < 1$, but there was a significant group by error by generation interaction, $F(1, 36) = 6.53$, $p = .02$, $\eta^2 = .16$. For healthy controls, target priming was higher after errorless learning ($M = .20$, $SEM = .04$) than errorful learning ($M = .11$, $SEM = .03$), $F(1, 18) = 5.34$, $p = .03$, $\eta^2 = .23$, but no other effects were significant. However, in the aMCI group the error by generation interaction was significant, $F(1, 36) = 5.54$, $p = .03$, $\eta^2 = .24$. In this group, the combination of errorless learning and self-generation led to greater priming of target words compared to each of the other three conditions, $t\text{s}(18) > 2.20$, $p\text{s} < .05$, which themselves did not differ, $t\text{s}(18) < 1.14$, *ns*

Priming for errors (the probability of completing a studied word stem with 1 of the 36 errors presented during the EF-EP condition or 1 of up to 36 errors generated in the EF-SG condition, minus the probability of completing a nonstudied word stem with a predesignated word) is shown in Figure 4 (right panel). There was no main effect of group, $F(1, 36) = 1.64$, $p = .21$, but there was a significant group by condition interaction, $F(1, 36) = 5.55$, $p = .02$, $\eta^2 = .13$. Based on 95% confidence intervals, the healthy older adults showed no priming for prior errors in either condition. Participants with aMCI showed reliable priming of self-generated, but not experimenter-provided, errors.

Two participants in each group reported awareness of the relation between the word stems and study items. The patterns of priming were unchanged when those participants were excluded.

DISCUSSION

Errorless learning led to better free recall, cued recall, and delayed recognition compared to errorful learning. Most notably, combining errorless learning with self-generation produced an added benefit to memory performance for both groups, suggesting that elaborative encoding enhances the errorless learning advantage, but this occurred only when memory was tested by cued recall. The multifactor view (Hirshman & Bjork, 1988; McDaniel et al., 1990) proposes that generation advantages are observed when the memory test is compatible with the type of processing strengthened by generation (c.f. encoding specificity, Tulving & Thomson, 1973, and transfer-appropriate processing, Morris, Bransford, & Franks, 1977). The current results extend this view by

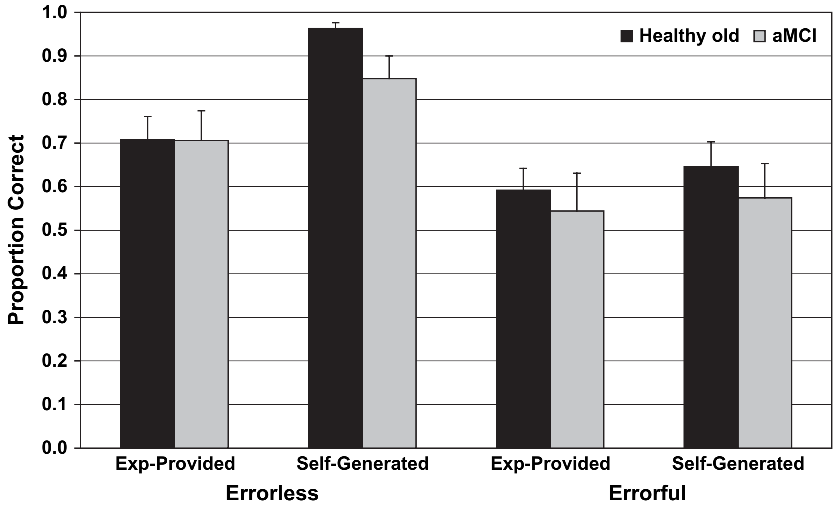

Fig. 2. Cued recall performance in Study 1 (error bars = SEM).

demonstrating that transfer of the generation advantage occurs under errorless, but not errorful, conditions.

The current results are also consistent with the notion that implicit memory contributes to the errorless learning advantage. Errorless learning led to greater priming of target words than did errorful learning, and in the case of self-generated learning, this was particularly the case for individuals with aMCI. Moreover, participants with aMCI showed greater priming relative to controls for prior errors that they had emitted, providing further evidence that the current results reflect an implicit mechanism.

STUDY 2

We sought to explore whether the super-additive effects of errorless, self-generated learning in cued recall would replicate when different materials (sentences) were used. We also incorporated a *cued* recognition test to further test the hypothesis that errorless learning enhances the generation advantage when the type of processing, guided by the encoding condition, is required for retrieval.

METHOD

Participants

Twenty-three independently living individuals meeting criteria for aMCI and 23 healthy older adults participated in Study 2. Six healthy older adults and 10 participants with aMCI had participated in Study 1. Additional participants were recruited and screened using the same exclusionary criteria as in Study 1. Four potential participants were excluded following phone screening because of medical conditions.

Subsequent neuropsychological testing was conducted at Baycrest or in the participants' homes to determine group assignment. Additional neuropsychological measures were added to the Study 1 battery to further increase diagnostic reliability: Hopkins Verbal Learning Test–Revised (Brandt & Benedict, 2001), the Vocabulary subtest of the Shipley Institute of Living Scale (Zachary, 1985), and Lawton Independent Activities of Daily Living Inventory (Lawton & Brody, 1969). The same criteria as in Study 1 were used to

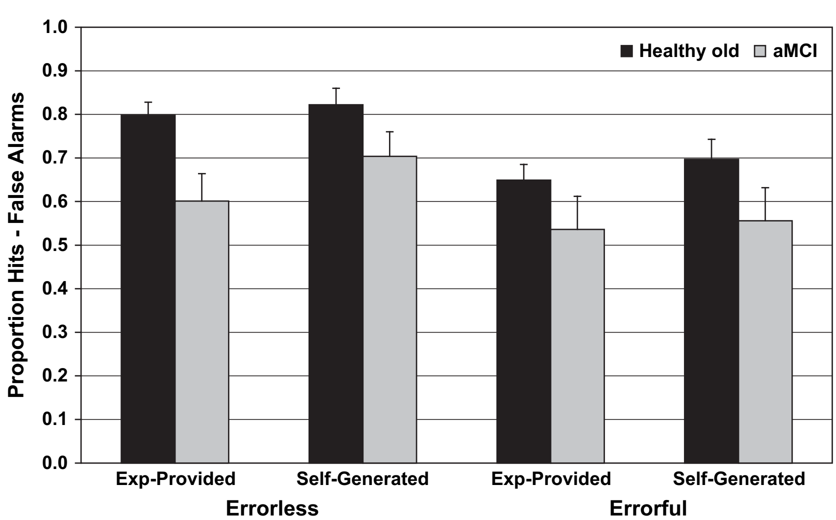

Fig. 3. Recognition performance in Study 1 (error bars = SEM).

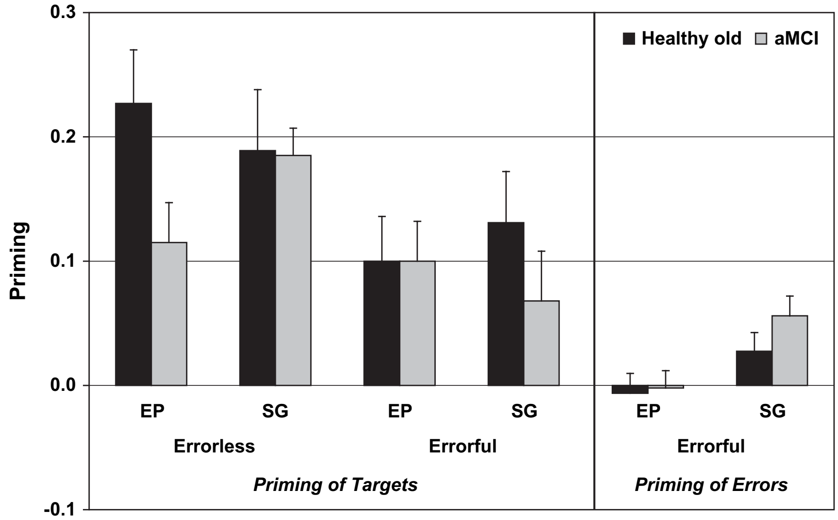

Fig. 4. Priming of target words (left panel) and learning errors (right panel) in Study 1 (error bars = SEM).

classify individuals as healthy or as having aMCI. All participants gave informed consent and were paid $30.

The healthy controls and aMCI groups did not differ in age or education, *t*s(44) < 1, or in sex distribution, $\chi^2(1, N = 46) = 1.43$, $p = .23$ (see Table 2). The aMCI group performed worse than healthy controls on measures of memory, *t*s(44) > 2.5, $p < .001$, but not on nonmemory measures, although naming approached significance, *t*s(44) < 1.89. The aMCI group reported worse memory relative to other people their age (MAC-S Global), $t(44) = 3.07$, $p < .004$. All participants reported they were fully independent in their activities of daily living.

Materials

Sixteen medium-close sentence frames (5–10 words, range in probability .20 to .60) drawn from Bloom and Fischler's (1980) sentence norms were created for each of the four conditions, for a total of 64 sentence frames. Four different final words selected from pilot data were assigned to each sentence, creating 256 unique sentences. As in Study 1, the order of the noun completions was counterbalanced so that target word frequency, word length, and completion frequency were equivalent across lists and across words within lists, *F*s < 1. Finally, the order of the lists, order of the conditions, and the "word number" identifying which of the four nouns was the target was counterbalanced across all participants.

Procedure

The procedure was very similar to Study 1, with the following exceptions. Sentences were presented on a laptop computer, Windows Version 2000, controlled by E-Prime (version 1.1, Service Pack 3; Psychological Software Tools, Inc.). This program randomly ordered the 16 sentence frames within a given list. The experimenter read each sentence frame out loud (e.g., "Hank reached into his pocket to get the ______."), pausing at the blank space. Participants were required to either read or generate the final words depending on the particular encoding condition. The examiner controlled presentation of the final target word. In the EL-SG condition, the first letter of the target word was shown and the first semantic cue (e.g., "glass") was read to the participant to generate the target word (e.g., "marbles"); the second semantic cue was provided if needed (e.g., "balls"). In the other three conditions, the first letter was shown immediately before the target word, and the two cues were both presented after the target word. Finally, participants studied each list only once.

After each study list, participants counted backwards by threes for 20 seconds to eliminate recency effects, then completed a free recall test of the target words. Next, participants were shown the 16 sentence frames on the computer screen, one at a time in a random order, and were asked to write the target words (cued recall). After a 20-min filled delay following the cued recall test for the fourth study list, participants were administered a cued recognition memory test consisting of the 256 unique sentences printed in a booklet. Participants were given unlimited time to determine whether the final word of each sentence had been a target word, a word that was said aloud but was not to be remembered (i.e., a prior error), or a word that was never encountered during the session. We call this task a cued recognition memory task, because recognition memory for the targets was tested not in isolation, but in the context of the sentence frame cues.

RESULTS

Generation Performance during Initial Encoding

There were no group differences in the number of cues required to generate the target word during encoding in the EL-SG condition (Controls: $M = 1.65$, $SEM = .04$; aMCI: $M = 1.75$, $SEM = .04$) or in the number of errors generated

Table 2. Demographic and neuropsychological data for subject groups in Study 2

	Healthy Controls ($n=23$)		aMCI ($n=23$)	
	Mean	*SD*	Mean	*SD*
Age	73.00	4.37	75.30	7.41
Education	14.65	3.05	13.74	3.11
Sex				
Male	7		11	
Female	16		12	
m-TICS* (raw scores)	38.43	3.82	35.52	3.44
Dementia Rating Scale (SSs)				
Attention	12.22	1.24	11.48	1.47
Initiation	11.29	1.31	10.43	1.83
Construction	10.00	0.00	9.87	0.63
Conceptualization	12.13	1.42	11.57	1.65
Memory*	11.48	1.93	9.43	3.16
HVLT (SSs)				
Learning Total*	12.39	3.12	7.70	2.25
Delay*	11.43	2.13	6.91	2.81
% Retention*	10.87	2.40	7.52	3.40
Recognition*	11.22	1.31	9.65	2.69
Logical Memory I* (SS)	12.04	2.40	8.13	3.33
Logical Memory II* (SS)	11.52	1.73	8.04	3.46
ROCF Test (SS)				
Copy	10.35	2.29	9.65	3.17
Immediate*	11.74	3.49	7.57	3.50
Delay*	11.29	3.23	7.87	3.35
Block Design (SS)	12.74	3.19	11.26	2.94
PA I (SS)*	11.83	3.03	9.13	2.22
PA II (SS)*	12.65	1.53	10.91	2.17
Boston Naming Test (SS)	12.74	3.28	11.22	2.04
Shipley Vocabulary (SS)	14.30	1.58	13.61	1.62
HADS (raw scores)				
Anxiety	4.39	1.75	4.74	2.03
Depression	3.13	2.18	2.13	1.49
MAC-S (raw scores)				
Ability	61.86	7.27	58.64	10.23
Frequency	73.05	12.09	68.41	8.60
Global Rating*	3.32	0.65	2.73	0.63

Note. See Table 1 note for abbreviations, except HVLT = Hopkins Verbal Learning Test.
*Group difference significant at $p < .05$.

during encoding in the EF-SG condition (Controls: $M=2.97$, $SEM=.02$; aMCI: $M=2.88$, $SEM=.03$), $ts(44) < 1.6$, *ns*.

Free Recall

Healthy controls demonstrated better free recall performance ($M=.27$, $SEM=.02$) than did participants with aMCI ($M=.19$, $SEM=.02$), $F(1, 44)=8.17$, $p=.006$, $\eta^2=.16$ (see Figure 5). However, no other significant effects were observed, $Fs(1, 44) < 1$. Free recall of prior errors in the EF conditions was rare ($Ms < .01$) for both groups.

Cued Recall

Healthy controls had higher cued recall performance ($M=.78$, $SEM=.02$) than did participants with aMCI ($M=.64$, $SEM=.02$), $F(1, 44)=18.69$, $p < .001$, $\eta^2=.30$ (see Figure 6). Cued recall was better following errorless ($M=.78$, $SEM=.02$) than errorful ($M=.64$, $SEM=.02$) learning, $F(1, 44)=96.65$, $p < .001$, $\eta^2=.69$, and following self-generated ($M=.75$, $SEM=.02$) rather than experimenter-provided ($M=.62$, $SEM=.02$) learning, $F(1, 44)=22.82$, $p < .001$, $\eta^2=.34$. There was also an error by generation interaction, $F(1, 44)=23.06$, $p < .001$, $\eta^2=.34$. In the errorless conditions, participants correctly recalled a greater number of self-generated ($M=.85$, $SEM=.02$) than experimenter-provided ($M=.71$, $SEM=.02$) words, $t(45)=7.09$, $p < .001$, $\eta^2=.53$. However, in the errorful conditions, self-generated and experimenter-provided errors led to comparable performance, $t(45) < 1$. Cued recall of prior errors was rare (Ms = .01–.03), and did not differ between groups or conditions.

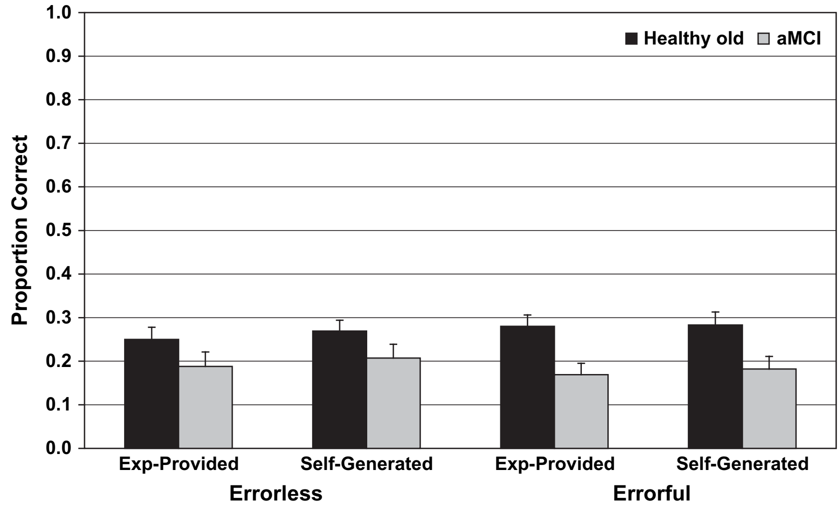

Fig. 5. Free recall performance in Study 2 (error bars = SEM).

Cued Recognition Memory

Figure 7 shows the proportion of hits minus the proportion of false alarms for each study condition. To amend a methodological oversight resulting in no recognition lures in the EF-EP condition (only the four noun completions for each sentence were presented), the average false alarm rate across the other three conditions was subtracted from the EF-EP hit rates.[d] Recognition memory was better in healthy controls ($M = .79$, $SEM = .03$) than in participants with aMCI ($M = .59$, $SEM = .03$), $F(1, 44) = 30.79$, $p < .001$, $\eta^2 = .41$, following errorless ($M = .73$, $SEM = .02$) rather than errorful ($M = .65$, $SEM = .02$) learning, $F(1, 44) = 27.77$, $p < .001$, $\eta^2 = .37$, and following self-generated ($M = .75$, $SEM = .02$) rather than experimenter-provided ($M = .64$, $SEM = .02$) encoding, $F(1, 44) = 38.98$, $p < .001$, $\eta^2 = .47$. There was also a group by error interaction, $F(1, 44) = 12.14$, $p = .001$, $\eta^2 = .22$. For participants with aMCI, errorless learning ($M = .66$, $SEM = .03$) led to better recognition memory than did errorful learning ($M = .52$, $SEM = .03$), $F(1, 22) = 26.06$, $p < .001$, $\eta^2 = .54$, but this was not the case for healthy controls, $F(1, 22) = 2.67$, $p = .18$.

The interaction between error and generation was also significant, $F(1, 44) = 12.14$, $p < .001$, $\eta^2 = .22$. Generation had a larger effect in the errorless conditions (EL-SG, $M = .82$, $SEM = .02$; EL-EP, $M = .65$, $SEM = .03$), $t(45) = 6.73$, $p < .001$, $\eta^2 = .52$, than in the errorful conditions, (EF-SG, $M = .67$, $SEM = .03$; EF-EP, $M = .62$, $SEM = .03$), $t(45) = 2.23$, $p = .03$, $\eta^2 = .10$. The three-way interaction was not significant, but the power to detect this interaction was low (.10). Nevertheless, when the data from the two groups were analyzed separately, the error by generation interaction was more reliable for the aMCI group, $F(1, 22) = 8.61$, $p = .008$, $\eta^2 = .28$, than for the healthy control group, $F(1, 22) = 3.95$, $p = .06$, $\eta^2 = .15$.

False recognition of prior errors in the EF conditions were more common in the aMCI than in the healthy control group, $F(1, 44) = 8.68$, $p = .005$, $\eta^2 = .17$, and were more common when self-generated than when experimenter-provided, $F(1, 44) = 22.17$, $p < .001$, $\eta^2 = .34$, particularly for individuals with aMCI (*M*s = .21 *vs.* .05) relative to the controls (*M*s = .06 *vs.* .05), $F(1, 44) = 12.41$, $p = .001$, $\eta^2 = .22$.

Discussion

Combining errorless learning with self-generation of final sentence words produced an added benefit to cued recall and recognition performance for both groups. These results replicate those of Study 1 and further extend them by demonstrating the errorless, self-generated advantage in cued recognition memory, where the encoding conditions were recapitulated.

GENERAL DISCUSSION

The combination of errorless learning and elaborative self-generation provide synergistic mnemonic benefits for both healthy older adults and older adults with aMCI. In addition to supporting previous reports of the errorless learning advantage being increased by elaborative encoding (e.g., Evans et al., 2000; Tailby & Haslam, 2003), our findings also demonstrate the importance of the multifactor view and delineate the role of explicit and implicit memory in the errorless learning effect.

The current results extend the multifactor view of generation (Hirshman & Bjork, 1988; McDaniel et al., 1990). There was no relation among target items within list in either study, which prohibited processing of relations among targets that would produce a generation advantage in free recall; moreover, generation focused encoding away from processing features specific to individual targets, thereby eliminating a generation advantage in recognition. By contrast, generation emphasized the semantic association between the cue and target, thereby facilitating a generation advantage in cued recall and cued recognition (c.f. DeWinstanley, Bjork, & Bjork, 1996). However, this was evident only in the errorless learning conditions, which

[d] False alarm rates in the EF-EP condition did not differ from the other three conditions in Study 1, suggesting that an average false-alarm rate of the other three conditions is a reasonable estimate in this case.

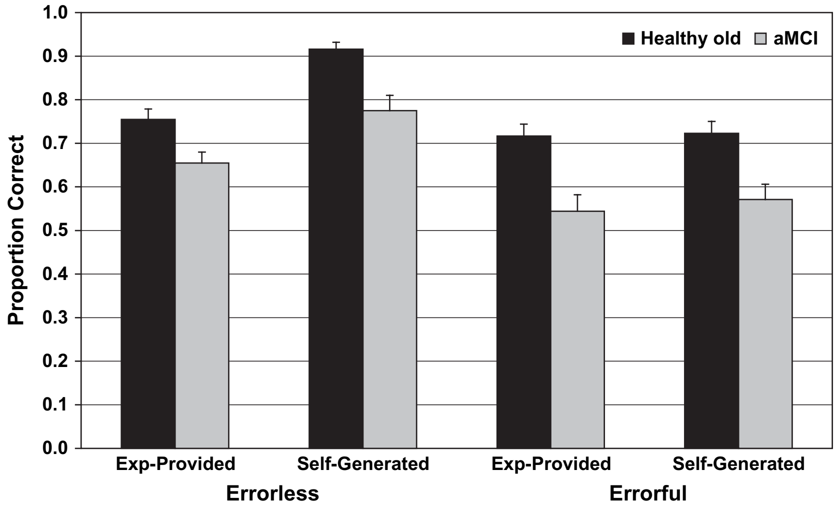

Fig. 6. Cued recall performance in Study 2 (error bars = SEM).

suggests that errors may interfere with the advantage afforded by having encoding processes recapitulated at retrieval.

The current results are also consistent with the idea that the errorless learning advantage is mediated by implicit memory (Anderson & Craik, 2006; Baddeley & Wilson, 1994; Hunkin, Squires, Parkin, & Tidy, 1998). Exposure to or experience with correct or incorrect information heightens its activation in implicit memory, and explicit memory is required to eliminate incorrect information. Because of reductions in explicit memory associated with atrophy in medial temporal lobe structures (e.g., Stoub, Rogalski, Leurgans, Bennett, & Detoledo-Morrell, 2008), coinciding with intact implicit memory (c.f. Anderson et al., 2008), individuals with aMCI are less able to remember whether a word was previously correct or not and are more reliant on implicit memory, in which both correct information *and* prior errors are strengthened by their prior occurrence. This leads to both greater false recognition and greater priming of prior errors in individuals with aMCI than their healthy counterparts. For both groups, errorless learning conditions eliminated the demand on explicit memory to keep track of which memoranda are correct, as well as the implicit influence of prior errors, resulting in better explicit memory performance in free recall (Study 1), cued recall (Studies 1 and 2), and recognition (Studies 1 and 2).

We had predicted that self-generated errors would be more disruptive than experimenter-provided errors to memory performance, based on findings that multiple-choice testing increases false memory for incorrect previously selected alternatives (Roediger & Marsh, 2005). However, in all cases, self-generated and experimenter-provided errors comparably reduced explicit memory performance, and participants rarely intruded these prior errors on explicit recall tests. This indicates that errors, regardless of their source, do not supersede target memoranda, but create interference that hinders older adults' recall of target information. Because individuals with aMCI kept self-generated prior errors activated, as

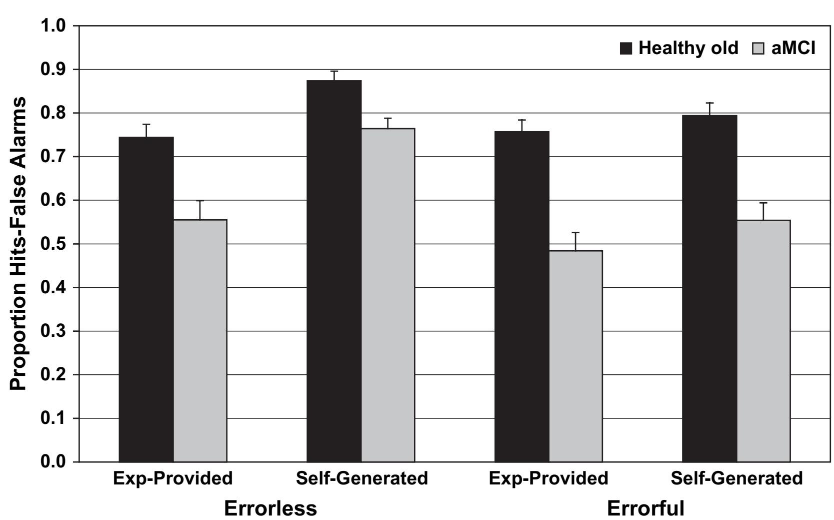

Fig. 7. Recognition performance in Study 2 (error bars = SEM).

evidenced by their reliable false recognition and priming of these errors, we would anticipate that conditions in which implicit memory is more influential, such as speeded recognition, may reveal that self-generated errors are more disruptive than experimenter-provided errors.

A limitation of the current studies is that target memoranda were not self-generated in the errorful, self-generated condition; instead, consistent with the previous literature (e.g., Baddeley & Wilson, 1994; Tailby & Haslam, 2003), participants generated errors, and then the target words were provided by the experimenter. It is possible that performance after an errorful, self-generated condition in which the targets, as well as the errors, are self-generated, would be comparable to that after errorless, self-generated learning. We are addressing this in ongoing studies.

Many traditional memory interventions employ a trial-and-error approach that allows clients to make errors while learning. For maximal benefit to learning, however, encoding should encourage the type of processing required at retrieval, and should encourage elaborative processing while constraining learning to avoid errors. Indeed, this advice is heeded by proponents of face-name learning strategies, wherein a name (e.g., 'Rose') is linked to a specific feature of a face (e.g., rosy cheeks). The facial feature in this case serves as a cue both to generate the name in the first place and to retrieve it at a later occasion. Additional research is needed to confirm whether retrieval of related information (e.g., the members of a bridge club) benefits most from errorless learning conditions that focus on interitem processing, and whether information that is usually recognized rather than recalled (e.g., the brand of butter preferred by one's spouse) is best enhanced by errorless, item-specific processing.

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REFERENCES

Anderson, N.D., & Craik, F.I.M. (2006). The mnemonic mechanisms of errorless learning. *Neuropsychologia*, *44*, 2806–2813.

Anderson, N.D., Ebert, P.L., Jennings, J.M., Grady, C.L., Cabeza, M., & Graham, S. (2008). Recollection- and familiarity-based memory in healthy aging and amnestic mild cognitive impairment. *Neuropsychology*, *22*, 177–187.

Baddeley, A., & Wilson, B.A. (1994). When implicit learning fails: Amnesia and the problem of error elimination. *Neuropsychologia*, *32*, 53–68.

Bloom, P.A., & Fischler, I. (1980). Completion norms for 329 sentence contexts. *Memory and Cognition*, *8*, 631–642.

Brandt, J., & Benedict, R.H.B. (2001). *Hopkins Verbal Learning Test - Revised (HVLT-R)* [Manual]. Lutz, FL: Psychological Assessment Resources.

Clare, L., & Wilson, B.A. (2004). Memory rehabilitation techniques for people with early-stage dementia. *Zeitschrift fur Gerontopsychologie & Psychiatrie*, *17*, 109–117.

Clare, L., Wilson, B.A., Carter, G., Roth, I., & Hodges, J.R. (2002). Relearning face-name associations in early Alzheimer's disease. *Neuropsychology*, *16*, 538–547.

Craik, F.I.M., & Tulving, E. (1975). Depth of processing and the retention of words in episodic memory. *Journal of Experimental Psychology: General*, *104*, 268–294.

Crook, T.H.III, & Larrabee, G.J. (1990). A subject-rating scale for evaluating memory in everyday life. *Psychology and Aging*, *5*, 48–57.

deWinstanley, P.A., Bjork, E.L., & Bjork, R.A. (1996). Generation effects and the lack thereof: The role of transfer-appropriate processing. *Memory*, *4*, 31–48.

Dunn, J., & Clare, L. (2007). Learning face-name associations in early-stage dementia: Comparing the effects of errorless learning and effortful processing. *Neuropsychological Rehabilitation*, *17*, 735–754.

Evans, J.J., Wilson, B.A., Schuri, U., Andrade, J., Baddeley, A., Bruna, O., et al. (2000). A comparison of "errorless" and "trial-and-error" learning methods for teaching individuals with acquired memory deficits. *Neuropsychological Rehabilitation*, *10*, 67–101.

Fastenau, P.S., Denburg, N.L., & Hufford, B.J. (1999). Adult norms for the Rey-Osterrieth Complex Figure Test and for supplemental recognition and matching trials from the extended Complex Figure Test. *The Clinical Neuropsychologist*, *13*, 30–47.

Hirshman, E., & Bjork, R.A. (1988). The generation effect: Support for a two-factor theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *14*, 484–494.

Hunkin, H.M., Squires, E.J., Parkin, A.J., & Tidy, J.A. (1998). Are the benefits of errorless learning dependent on implicit memory? *Neuropsychologia*, *36*, 25–36.

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

Ivnik, R.J., Malec, J.F., Smith, G.E., Tangalos, E.G., & Petersen, R.C. (1996). Neuropsychological tests' norms above age 55: COWAT, BNT, MAE Token, WRAT-R Reading, AMNART, STROOP, TMT, and JLO. *The Clinical Neuropsychologist*, *10*, 262–278.

Ivnik, R.J., Malec, J.F., Smith, G.E., Tangalos, E.G., Petersen, R.C., Kokmen, E., & Kurland, L.T. (1992a). Mayo's older Americans normative studies: WMS-R norms for ages 56 to 94. *The Clinical Neuropsychologist*, *6*(Supp 1), 49–82.

Ivnik, R.J., Malec, J.F., Smith, G.E., Tangalos, E.G., Petersen, R.C., Kokmen, E., & Kurland, L.T. (1992b). Mayo's older Americans normative studies: WAIS-R norms for ages 56 to 97. *The Clinical Neuropsychologist*, *6*(Supp 1), 1–30.

Kaplan, E., Goodglass, H., & Weintraub, S. (1983). *Boston Naming Test*. Philadelphia: Lea & Febiger.

Kim, S., Hasher, L., & Zacks, R.T. (2007). Aging and a benefit of distractibility. *Psychonomic Bulletin & Review*, *14*, 301–305.

Lawton, M.P., & Brody, E.M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Geronotologist*, *9*, 179–186.

Lezak, M.D., Howieson, D.B., & Loring, D.W. (2004). *Neuropsychological assessment* (4th ed.). New York: Oxford University Press.

Lucas, J.A., Ivnik, R.J., Smith, G.E., Bohac, D.L., Tangalos, E.G., Kokmen., E., et al. (1998). Normative data for the Mattis Dementia Rating Scale. *Journal of Clinical and Experimental Neuropsychology*, *20*, 536–547.

Mattis, S. (2001). *Dementia Rating Scale-2* [Manual]. Odessa, FL: Psychological Assessment Resources.

McDaniel, M.A., Rigler, G.L., & Waddill, P.J. (1990). Generation effects in free recall: Further support for a three-factor theory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *16*, 789–798.

Morris, C.D., Bransford, J.D., & Franks, J.J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior*, *16*, 519–533.

Parkin, A.J., Hunkin, N.M., & Squires, E.J. (1998). Unlearning John Major: The use of errorless learning in the reacquisition of proper names following herpes simplex encephalitis. *Cognitive Neuropsychology*, *15*, 361–375.

Petersen, R.C. (2004). Mild cognitive impairment as a diagnostic entity. *Journal of Internal Medicine*, *256*, 183–194.

Roediger, H.L.III, & Marsh, E.J. (2005). The positive and negative consequences of multiple-choice testing. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 1155–1159.

Rowe, G., Valderrama, S., Hasher, L., & Lenartowicz, A. (2006). Attentional disregulation: A benefit for implicit memory. *Psychology and Aging*, *21*, 826–830.

Shaw, R.J. (1997). Unprimed stem completion is only moderately predicted by word frequency and length. *Behavior Research Methods, Instruments, & Computers*, *29*, 401–424.

Slamecka, N.J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 592–604.

Stoub, T.R., Rogalski, E.J., Leurgans, S., Bennett, D.A., & Detoledo-Morrell, L. (2008). Rate of entorhinal and hippocampal atrophy in incipient and mild AD: Relation to memory function. *Neurobiology of Aging*. [Epub ahead of print]

Tailby, R., & Haslam, C. (2003). An investigation of errorless learning in memory-impaired patients: Improving the technique and clarifying theory. *Neuropsychologia*, *41*, 1230–1240.

Tulving, E., & Thomson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*, 352–373.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale – Revised* [Manual]. New York: The Psychological Corporation.

Wechsler, D. (1987). *Wechsler Memory Scale – Revised* [Manual]. New York: The Psychological Corporation.

Welsh, K.A., Breitner, J.C.S., & Hagruder, H.K. (1993). Detection of dementia in the elderly using telephone screening for cognitive status. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology*, *6*, 103–110.

Winblad, B., Palmer, K., Kivipelto, M., Jelic, V., Fratiglioni, L., Wahlund, L.-O., et al. (2004). Mild cognitive impairment – beyond controversies, towards a consensus: Report of the International Working Group on Mild Cognitive Impairment. *Journal of Internal Medicine*, *256*, 240–246.

Zachary, R.A. (1985). *Shipley Institute of Living Scale: Revised Manual*. Los Angeles: Western Psychological Services.

Zigmond, A.S., & Snaith, R.P. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica*, *67*, 361–370.