Psychology and Aging
1998, Vol. 13, No. 1, 21–28

0882-7974/98/$3.00

Age Differences in Context Integration in Memory

Anderson D. Smith
Georgia Institute of Technology

Denise C. Park
University of Michigan

Julie L. K. Earles
Furman University

Raymond J. Shaw
Merrimack College

Wythe L. Whiting, IV
Georgia Institute of Technology

This research examined the role of contextual integration in memories of younger and older adults. In 2 experiments, recall of a target picture to a context picture cue was better when sentences were generated that integrated the picture pair and when the picture pairs were already related to each other. Age differences were smallest when sentences were generated for semantically related pairs. Older adults generated the same type sentences as younger adults, although they generated fewer integrations for unrelated pairs. In a 3rd experiment, younger adults could not differentiate between younger- and older-generated sentences from Experiment 1, and the sentences did not differentially affect recall performance. The results are discussed in terms of age differences in self-initiated processing when using context.

Episodic memory performance is in part determined by the availability and utility of contextual cues at the time of recall. One earlier hypothesis suggested that older adults might use contextual information less than younger adults, and this would account for their poorer performance on episodic memory tasks (Burke & Light, 1981; Craik & Simon, 1980). Subsequent research findings on age differences in the effects of context on memory, however, failed to provide clear support for such an hypothesis. Some research has shown that the availability of contextual cues equally benefited the memory performance of younger and older adults (e.g., Cherry & Park, 1993; Earles, Smith, & Park, 1994; Park, Cherry, Smith, & Lafronza, 1990; Park, Puglisi, Smith, & Dudley, 1987; Zelinski & Light, 1988), and some studies even found that older adults actually benefit more from facilitative context than younger adults (i.e., context that supports recall of the to-be-remembered information; e.g., Cherry & Park, 1989; Park, Smith, Morrell, Puglisi, & Dudley, 1990; Sharps & Gollin, 1987).

In their review of the aging and memory literature, Craik and Jennings (1992) suggested that if the contextual information is integrated with the target information, older adults can use context similarly to younger adults. On the other hand, if contextual cues and targets are not well integrated by preexisting associations, then participants must generate the integrating relationships at encoding and have them available at the time of recall in order for the cues to be useful. Craik (1986) has suggested that such a requirement of self-initiated processing should magnify age differences on memory tasks. Integration of context to the to-be-remembered information is an associative process that promotes the recall of the target in the presence of the contextual cue.

One laboratory technique that can be used to examine memory in the presence of contextual cues is the paired-associate procedure. The degree of self-initiated processing required in integrating the contextual stimulus cue to the to-be-remembered response target can be manipulated by varying the preexisting relationship between stimulus cue and the response target. Using picture stimuli, Park, Smith, et al. (1990) found large age differences in recall when contextual cues were unrelated to the target items (e.g., *cherry*, *ant*; older performance = 36% of younger performance), but much smaller age differences when contextual cues were related to and thus integrated with the targets (e.g., *spider*, *ant*; older performance = 70% of younger performance). These results, therefore, support the hypothesis that age differences are smaller if integration of context and target is provided by the preexisting relationship between the items.

Our research is designed to examine more fully whether or not integration is important in determining the degree of context facilitation on memory performance in different aged adults. In the first two experiments reported here, participants are pre-

Anderson D. Smith and Wythe L. Whiting, IV, School of Psychology, Georgia Institute of Technology; Denise C. Park, Department of Psychology and Institute for Social Research, University of Michigan; Julie L. K. Earles, Department of Psychology, Furman University; Raymond J. Shaw, Department of Psychology, Merrimack College.

This research was supported by National Institutes of Health/National Institute on Aging Grant RO1 AG06265 and by National Institutes of Health Institutional Research Training/National Institute on Aging Grant T32 AG00175.

We are grateful to Michelle Vernon, John Roach, and Lisa Hill for their help in conducting this research.

Correspondence concerning this article should be addressed to Anderson D. Smith, School of Psychology, Georgia Institute of Technology, Atlanta, Georgia 30332-0170. Electronic mail may be sent via Internet to anderson.smith@psych.gatech.edu.

sented with pairs of simple pictures like the ones used by Park, Smith, et al. (1990), with one picture being designated as the to-be-remembered target. The degree of integration between context cues and memory targets is manipulated in two ways. First, as in the Park, Smith, et al. study, preexisting integration is manipulated by varying the relationship between the items themselves, in that half of the context–target pairs were conceptually related to each other and the other half were not. If the context and target are already associatively related, less active integration (i.e., self-initiated processing) is required. Instead, the integration is, in part, automatically activated by the semantic association between the items themselves. Jacoby and his associates (Jacoby, Jennings, & Hay, 1996; Jennings & Jacoby, 1993) have shown large age differences in memory performance when deliberate or self-initiated processing is measured, but small age differences when memory is determined by familiarity or automatic processing. Therefore, age differences should be smaller when the items are related and larger when they are unrelated to each other.

Second, half the participants in Experiment 1 and all the participants in Experiment 2 are asked to generate sentences that integrate the context cues with the to-be-remembered targets (self-initiated processing). It was predicted that recall would be higher when the integrating relationship is actively generated. Research on word recall has shown that when younger and older adults actively generate to-be-remembered words by filling in the words in a sentence frame or by completing word stems (e.g., bar-st—) rather than just passively reading the words (e.g., bar-stool), memory performance for recalling the target is improved in both groups (e.g., Mitchell, Hunt, & Schmitt, 1986; Rabinowitz, 1989). Our research differs from other studies of generation, however, because here no direction is provided to generate a particular response as when using word stems or sentence frames. In our studies, participants do not generate an experimenter-determined, particular response, but any response that they believe relates the context cue to the memory target. They have to self-generate sentences with no support or guidance other than the semantic meanings of the two pictures. It remains to be determined whether such a procedure provides integration relationships equally in both age groups. Furthermore, even when self-generated integrations are produced, our research should show whether the integrations are equally effective in improving target recall for younger and older adults.

Several results are possible. First, by actively generating integration sentences, the age differences seen without instructions to integrate may be reduced. In other words, older adults may not engage in self-initiated processing spontaneously, but may be able to adequately process the items when directed to do so by the experimenter. Such a result would be similar to that seen when specific organizational instructions are used in cued recall (Hultsch, 1974) or when imagery mediators are given in paired-associate learning (Hulicka & Grossman, 1967).

Second, if the deliberate processing necessary to generate sentences requires considerable extra effort on the part of the older adults, there may actually be larger age differences with the sentence-generating task. Craik and Jennings (1992) have suggested that if an encoding task is helpful and supportive, but only with the expenditure of considerable effort, younger adults take advantage of the task, whereas older adults may not.

It may also be the case that older adults can generate integrations as easily as younger adults, but that they are not as effective in promoting recall of the target as those generated by younger adults. In other words, younger and older adults may not differ in their ability to perform the integration task, or in providing self-generated integrations of contextual cue and target, but rather in the nature of the integrations themselves and how effective they are in promoting later recall. Early free-association research indicated that younger and older adults differed in the nature of associations they generated to words (Riegel, 1968). More recent work, however, has shown that younger and older adults are similar in the types of free associations they produce both to words (e.g., Burke & Peters, 1986; Lovelace & Cooley, 1982) and to pictures (Puglisi, Park, & Smith, 1987). Other research, however, has suggested that even though older adults can generate very specific types of associations to words representing objects as well as younger adults (i.e., controlled associations), older adults are not as effective as younger adults with some types of associations (e.g., characteristic feature of the objects; Nebes & Brady, 1988).

Nebes and Andrews-Kulis (1976) actually had younger and older adults generate sentences to pairs of words, a similar procedure to that used in the present experiment. They found no differences in the length of the sentences generated and no differences in the grammatical constructions of sentences generated by the different age groups. Grammatical construction, however, did not predict later recall.

In the present study, rather than just relying on quantitative, syntactic measures of the productions such as sentence length, the nature of each integration was coded to determine if there are semantic differences in the nature, or type, of the sentences generated by younger and older adults. A further objective was to determine if the different types of sentences lead to different levels of later recall performance. If older adults generate different types of sentences, and if the type of integrating sentence influences later recall of the targets, then the age-related recall differences may be due to the effectiveness of the integrations produced by the different age groups.

Experiment 1

Method

Participants. Forty younger adults (mean age = 20.1 years) and 36 older adults (mean age = 68.7 years) participated in the experiment. The younger adults were college students who participated to receive extra credit in undergraduate psychology courses. The older adults were healthy, active community-dwelling adults aged 60 years or older. They received $10 for volunteering to participate in the experiment. The younger group consisted of 64% men and the older group consisted of 56% men. The average ratings of health for both groups were between good and excellent, with mean ratings of 1.5 (SD = .06) for younger adults and 1.9 (SD = .07) for older adults. The older adults also had marginally higher vocabulary scores on the Gardner and Monge (1977) 30-point Word Familiarity Survey. Furthermore, all participants had at least 20/30 corrected binocular vision as measured by a Snellen eye chart.

Design. Age (younger or older adults) and instructions (association or integration) were between-subjects variables, and type of cue–target relationship (related or unrelated) was a within-subject variable.

Stimulus materials. Thirty-six pairs of pictures that were all line drawings of simple, concrete objects were selected from those used in earlier context studies in this laboratory and are described elsewhere (Park, Smith, et al., 1990). Each pair represented two items from a single conceptual category. One member of each pair was randomly selected to be the target, and the other item was presented as a related context cue for half the pairs presented in any list. The same target pictures were used for all participants, but whether the stimulus cue was related or unrelated to the target was counterbalanced across participants. The related contextual cue was the other member of the related pair, and the unrelated cue was a picture from another category with no obvious relationship to the target that was selected from the picture pool used by Park, Smith, et al. The target picture was drawn in heavier dark lines and was surrounded by tiny dots. The participants therefore could easily tell which picture was the target and which picture was the contextual cue. The target and context pictures were presented side by side to each other on a single slide with the target presented half of the time on the left of the slide and half the time on the right.

Procedure. The instructions emphasized that the participants were to remember the target that was printed in darker ink and surrounded by small dots. The participants in the integration condition were also told that they should generate a single sentence that integrated the target with the context picture. Participants in the free-association condition were told to name another word that went with each of the pictures (free association to each picture).

Each participant then was administered a three-pair practice list to insure that the instructions were followed. Following the recall of the three practice targets, the participants were administered one of four different 36-picture-pair lists. Each list had 18 related pairs and 18 unrelated pairs. Each target was paired with either an unrelated context picture in one list or a related context picture in another list. The other two lists were different random orders of the first two lists. Each pair was presented for 10 s. The sentences or free associations generated by the participants in the integration condition were tape-recorded and later transcribed. After the last pair was presented, each participant was told to count backwards by 7 from 500 for 2 min. Then, the participants were shown a random order of the context pictures, one at a time, and asked to recall the target that was paired with the context cue. Finally, demographic information, health status, and vocabulary were measured. All participants were then debriefed as to the nature of the experiment.

Results and Discussion

Recall performance in Experiment 1 is presented in Table 1. A three-factor analysis of variance (ANOVA) was conducted with age group (younger and older) and instruction (integration and free association) as between-subjects factors and cue–target relationship (related and unrelated) as a within-subject factor. All main effects were significant: Younger adults recalled more targets than older adults, $F(1, 68) = 48.17$, $p < .001$; more targets were recalled when integration sentences were generated, $F(1, 68) = 289.53$, $p < .001$; and more targets were recalled when the context was related to the target, $F(1, 68) = 442.51$, $p < .001$. Furthermore, all interactions between the variables were significant: age by instructions, $F(1, 68) = 5.22$, $p < .03$; age by relationship, $F(1, 68) = 4.82$, $p < .04$; instructions by relationship, $F(1, 68) = 29.31$, $p < .001$; and the triple interaction between age, instructions, and relationship, $F(1, 68) = 30.41$, $p < .001$.

Simple effects analysis of the triple interaction indicated that the interaction between age and instruction was significant with the unrelated items, $F(1, 34) = 20.24$, $p < .001$, but not with the related items, $F(1, 34) = 1.27$, $p = .26$. With related items, generating integration sentences improved recall and did so similarly in both age groups. When unrelated items were used, however, the integration sentences helped the younger adults significantly more than did the older adults.

Table 1
Mean Recall Performance as a Function of Age, Encoding Condition, and Context–Target Relationship in Experiments 1 and 2

	Context–target relationship			
	Unrelated		Related	
Instructions/age group	*M*	*SD*	*M*	*SD*
Free association (Experiment 1)				
Younger	1.31	1.10	10.56	2.65
Older	0.06	.24	7.25	2.25
Integration (Experiment 1)[a]				
Younger	14.17	3.04	16.63	1.22
Older	7.25	3.78	14.50	2.50
Integration (Experiment 2)				
Younger	26.8	5.81	29.9	3.00
Older	16.3	7.38	26.8	6.95

[a] Context–target relationship was manipulated within subjects in Experiment 1 and between subjects in Experiment 2.

The results of the experiment support the hypothesis that context is useful to support the memory of older adults if the context is integrated with the to-be-remembered targets (Craik & Jennings, 1992; Park, Smith, et al., 1990). The recall performance of both older and younger adults was improved when integration was provided either through preexisting conceptual relationships between the target and context (i.e., environmental support) or when the participants supplied integrations by generating sentences that related the target to the context (i.e., self-initiated processing). Furthermore, the effects seem additive given that the best level of recall for both groups occurred when integrating sentences were generated for semantically related target and context items.

The results also suggest that the older adults seem to rely more heavily on the passive environmental support provided by the related context–target pairs. Whereas the improvement in recall of having related context–target pairs was found for both age groups, this effect was apparently greater in the older adults. Unfortunately, this conclusion is tenuous given the high level of recall for the younger group when generating sentences for the semantically related items and the low level of recall in the free-association condition with the unrelated items. Clear ceiling effects for the younger adults in the integration condition prevent an unequivocal interpretation of the interaction between age and context–target relationship. For this reason the interaction in the integration condition between age and context–target relationship (unrelated vs. related) was replicated in Experiment 2. To reduce ceiling effects, the number of unrelated and related stimulus–target pairs for recall was increased to 36 from the 18 pairs used in each condition of Experiment 1 with the integration instructions. In Experiment 2, participants received either 36 unrelated pairs or 36 related pairs. The relationship between the target and the context, therefore, was manipulated between

subjects rather than within subjects as in Experiment 1. In addition, the recall task in Experiment 2 was delayed 10 min to reduce the overall level of performance.

A second objective of our research was to examine the nature of the sentences generated by the two age groups to see if they were somehow different. The results of the analysis on the nature of the sentences generated in Experiment 1, however, will be delayed until a replication of the interaction between age and relationship when sentences are generated can be demonstrated.

Experiment 2

Method

Participants. Twenty-four additional younger adults (mean age = 20.5 years) and 24 older adults (mean age = 69.4 years) participated in Experiment 2. The participants were screened in the same manner as in Experiment 1. The younger adults were college students who participated to receive extra credit in undergraduate psychology courses. The older adults were community-dwelling adults aged 60 years or older who received $10 for volunteering to participate in the experiment. As in Experiment 1, the ratings of health for both groups were between good and excellent (younger, 1.4, SD = .10; older, 1.8, SD = .14). The vocabulary measures also showed the groups to be equivalent to the participants used in Experiment 1.

Materials. The same 36 targets used in Experiment 1 were used in Experiment 2, except that in any list all the pairings were either related or unrelated. Four different 36-pair lists were used. All participants were presented the same target items, but for half the participants, the target was paired with a related item, and for the other half of the participants, the target was paired with an unrelated item. Two different list orders were used with half the participants getting each of the two orders.

Procedure. The procedures used in this experiment were identical to those used for the integration condition in Experiment 1 with the exception that all participants generated sentences to each context–target pair and that a 10-min delay was added between presentation and recall. During the delay participants filled out the demographic and health questionnaires. The vocabulary test was administered after recall of the pictures.

Results

The results of Experiment 2 are also presented in Table 1. A 2 × 2 factorial ANOVA was conducted for the two between-subjects variables: age and context–target relationship. The effects found in Experiment 1 were replicated. Again, the younger adults recalled more target items than did the older adults, $F(1, 22) = 17.20$, $p < .01$, and more items were recalled when the target was semantically related to the context cue, $F(1, 22) = 18.51$, $p < .01$, and the interaction between age and context–target relationship was replicated, $F(1, 22) = 7.44$, $p < .01$. Whereas the older adults always recalled fewer targets than the younger adults, the age difference after generating integrating sentences in the related condition was not statistically significant ($p > .05$). Again, older adults did not recall as many unrelated targets as did younger adults, replicating the finding from Experiment 1.

Discussion

Age differences were larger when the context and target were unrelated to each other. Furthermore, the best level of performance in the younger group was only 80%, and it is unlikely that the interaction could be attributed to ceiling effects with the related pairs as in Experiment 1.

Now that the replication of the interaction in the integration condition has been demonstrated by the results of Experiment 2, we return to an analysis of possible age differences in the nature of the generated sentences from Experiment 1.

First, several quantitative measures were examined. Separate analyses showed that there were no age differences in either the length of the generated sentences (average number of words in a sentence), the number of elaborative phrases included in the sentences, the repetitive use of identical sentence frames, or the number of sentences based on the verb, *to be*. The failure to find structural differences in the sentences as a function of age replicates the earlier study by Nebes and Andrews-Kulis (1976). In the present study, the only detected quantitative difference was in the number of complete sentences generated to the entire set of picture pairs by the different age groups (younger = 35.25, SD = 3.9; older = 30.25, SD = 4.5), $F(1, 38) = 11.78$, $p < .05$.

The sentences were also coded qualitatively, according to the nature of the relationship generated for the context and target pictures. The sentences were coded solely on the basis of the relationship between the two items, ignoring extra elaboration if present in the sentence. The coding categories are listed in Table 2. All sentences were coded through this scheme with an interjudge reliability of over 90%.

The proportion of sentences generated for each integration type in the two age groups is presented in Figure 1. ANOVAs indicated that the older adults generated fewer action sentences

Table 2
Types of Integration Sentences Generated for Context–Target Pairs and Examples

Integration types
Comparison
Object comparison: The target and cue are placed into a collective category. ("The spider and ant are both bugs.")
Feature comparison: The target and cue are compared on some feature such as size or color. ("The spider is bigger than the ant.")
Action
Single action: The target and cue are involved in a single action combining the items. ("The ant ate the cherry.")
Double action: Two actions are described for the two objects, but they occur in the same context. ("The spider climbed the tree while the ant watched.")
Other
Spatial relation: A spatial relation is used to relate the context to the target. ("The ant is next to the cherry.")
Transformation: Some transformation is made to the meaning of the object, such as a homophone, metaphor, etc. ("My 'ant' Mary makes the best cherry pie.")
Distinct phrases: Two distinct actions are described, one for each object and independent of each other. ("You can pick cherries and ants live underground.")
Incomplete
Incomplete: Either no sentence is given or an incomplete or incomprehensible response is made. ("Ants . . . uhm . . . I can't think of anything.")

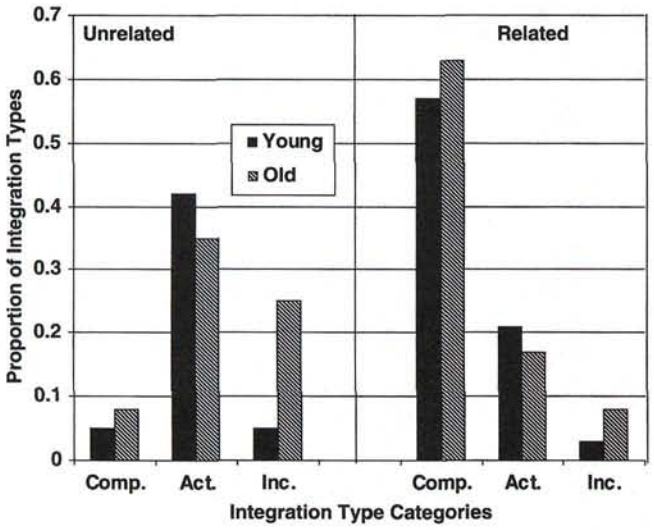

Figure 1. Proportion of sentence types generated as a function of adult age and coded context–target relationship. Comp. = comparison; Act. = action; Inc. = incomplete.

for both the unrelated, $F(1, 38) = 10.03$, $p < .01$, and related, $F(1, 38) = 8.30$, $p < .01$, context–target pairs. The only other significant difference was found for incomplete responses with the unrelated sentences; the older adults had significantly more incomplete responses, $F(1, 38) = 25.96$, $p < .01$. Because no age differences were found for the three different codes listed in the Other condition (spatial relations, transformations, and distinct phrases), they were not included in Figure 1.

With the exception of incomplete sentences, the age groups differed little in the pattern of sentence types produced for the related and unrelated items. As seen in Figure 1, both age groups produced a greater number of comparison sentences for the related items and a greater number of action sentences for the unrelated items.

When generating sentences for the related items, the two age groups performed similarly. The self-generated integrations were effective in facilitating recall in both age groups, and in both age groups equally. Also, the types of sentences generated to the related pairs were similar in pattern in both age groups. Thus, as shown earlier by Park, Smith, et al. (1990), older adults can use contextual information if it can be integrated with the target information.

When the context cue was unrelated to the target, however, the older adults did not benefit as much as the younger adults in the integration conditions. The largest age difference in recall was found in both experiments when sentences were generated for the unrelated items. This result supports Craik and Jennings's (1992) conclusion that when a change in encoding condition involves an expenditure of extra effort, such as would be the case when trying to generate sentences involving unrelated items, the younger adults benefit from this change more than the older adults. This conclusion is further supported by the analysis of the generated sentences for the unrelated pairs. When older adults generated complete, meaningful sentences, the pattern of sentence types was very similar to the ones generated by the younger adults. Their sentences were also similar in structure to the sentences generated by younger adults as evidenced by the various quantitative measures included in the analyses. The only age difference found in the sentences was that older adults failed to generate as many meaningful, complete sentences for the unrelated pairs. They had more incomplete sentences with these pairs. Even though the increased failure to generate sentences resulted in a reduction in the number of action sentences for the older adults, the action sentences still predominated as the primary sentence type for unrelated pairs in both age groups. In other words, the pattern of sentence types did not differ between the age groups for the unrelated pairs, except in the incomplete category.

Because the production of integrating sentences enhanced recall, the greater failure to generate sentences for unrelated pairs in the older group reduced their recall performance. In fact, the probability of the older adults recalling an unrelated item given an incomplete sentence (72 instances) was only .18, whereas the probability of recalling an unrelated target after generating an action sentence (149 instances) was .59.

In summary, the results of the first two experiments show a quantitative age difference in the ability to self-produce integration sentences for unrelated items. Older adults experienced a greater number of integration failures when the target and context were unrelated to each other. When integrations were produced, however, or when integration was provided through existing semantic relationships between the context and target, older adults and younger adults both benefited by the provision of context cues at the time of recall. There is little evidence to support qualitative differences in the nature of the integrations produced by younger and older adults. Both younger and older adults tend to use action sentences for unrelated context–target pairs and comparison sentences for related pairs.

One obvious problem with the qualitative analysis, however, is that the coding scheme was experimenter developed. Although it served to satisfactorily code the different types of relationships contained in the sentences, it may not have captured some subtle difference between the different age groups' sentences that could affect recall performance. Marshall et al., (1978) had younger and older adults generate natural-language mediators to nonsense syllable pairs (nonword letter trigrams, e.g., *LAJ*). Although there were no detectable differences in the types of mediators generated by the two age groups that could be determined by the experimenter (e.g., type of words, complexity of words, etc.), another group of younger adults was able to pick out the mediators generated by older adults at a level better than chance. They also could learn a paired-associate task better if it contained younger-generated mediators rather than older-generated mediators.

To see if either prediction of recall or recall performance itself could be influenced by the sentences generated by the different aged adults in Experiment 1, a third experiment was conducted, providing a performance-based test similar to that of Marshall et al. (1978). If there were age-related differences between sentences that were not captured by the coding scheme developed in our research, these differences may differentially control performance in a separate group of participants.

Experiment 3

Method

Participants. One hundred thirty-seven undergraduate students participated in this study for extra credit in their introductory psychology classes. The average age of the group was 19.6 years. Half of the participants were presented younger-generated sentences, and the other half were presented older-generated sentences. The participants assigned to these two groups did not differ in average age, gender, rated health, or vocabulary.

Stimulus materials. The same set of 36 picture pairs used in Experiment 1 were used in this experiment. As in the other two experiments, one picture of the pair was clearly identified as the target picture and the other the context. Each picture pair was assigned two younger-generated sentences and two older-generated sentences from Experiment 1. One sentence for each target was randomly selected from the sentences generated by younger and older participants in Experiment 1. A second sentence from each age group's pool of sentences was selected from only those sentences that led to correct recall in Experiment 1.

Thus, two groups were used. One group received sentences that led to correct recall in Experiment 1 by the individual generating the sentence ($N = 89$). A second group received sentences that were randomly selected from the younger- and older-generated sentences from Experiment 1 ($N = 48$). The following rules were used to select and assign the sentences. For the 89 participants in the first group, all selected sentences were associated with correct recall of the target for the individual generating that sentence in Experiment 1. The younger-generated and older-generated sentences for each pair were matched for sentence type. For each pair of pictures, the sentence type most frequently used by both younger and older adults was selected for that pair. For the 18 related items, 17 of the sentence types were comparisons, and the other was an action type. For the unrelated items, the lists contained either 16 or 17 action sentences and one or two spatial relations depending on which word was paired with an unrelated cue. For the 48 participants in the second group, the sentences were randomly selected from the pool of generated sentences but matched for the sentence type used for the other group. In other words, the second group saw sentences without regard to whether they led to correct recall in Experiment 1, but they saw the same type sentences as did the other group whose sentences had led to correct recall.

Procedure. The experiment was conducted in a group setting, with eight groups consisting of from 12 to 25 persons. Two of the eight groups saw one of four different lists (younger-generated, random; younger-generated, correct recall; older-generated, random; older-generated, correct recall). All participants were instructed that they would see a series of picture pairs for which other people had generated sentences to help them remember the items. Participants were told that they were to rate each sentence on a 10-point scale, indicating how likely it was that the person whose sentence they were reading recalled the target word to the cue target. This memorability rating procedure has been used previously by Shaw and Craik (1989). A score of 10 would indicate that they were sure the target had been recalled (100% sure), and a score of 0 would mean that they were 100% sure the target had not been recalled. They were not told that there would be a later memory test. Then the picture pairs were projected one at a time at a 10-s rate on a screen in front of the room. While each picture pair was being projected, participants read a sentence generated for the picture pair from the earlier study that was printed on a numbered sheet of paper in front of them. A cover sheet was used to cover the sentences not read. They marked their ratings of memorability on a line to the left of the sentence as the experimenter called out the number of the pair. Half of the participants read sentences generated by younger adults and the other half read sentences generated by older adults. After all 36 picture pairs had been presented and each sentence had been rated, the participants engaged in a 2-min subtraction task (continuously subtracting 7s, starting with 500, and writing down answers). Then the context picture was presented from each pair, and the participants wrote down the name of the target picture that went with each context cue. The experimenter called out the number of the cue as it was presented. The cues were presented at an 8-s rate.

Results

As can be seen in Table 3, the participants in Experiment 3 did not make differential predictions about the memorability of the pictures with the younger-generated and older-generated sentences that led to correct recall in Experiment 1 ($F < 1$). The participants did, however, predict that the related pairs would be more memorable than the unrelated pairs, $F(1, 87) = 28.64$, $p < .001$.

Furthermore, their predictions were correct. Recall of targets after seeing either the younger-generated or the older-generated sentences was at the same level, and this was true for both the unrelated and related context–target pairs ($Fs < 1$). As the participants predicted, and as found in Experiments 1 and 2, the related pairs were recalled better than the unrelated pairs, $F(1, 87) = 116.33$, $p < .01$.

Identical results were found for the participants who received a random selection of the younger-generated and older-generated sentences, regardless of whether the sentence led to correct recall or not in the first experiment. Again, the only significant differences were that memorability ratings, $F(1, 46) = 15.48$, $p < .01$, and actual recall performance, $F(1, 46) = 11.22$, $p < .01$, were better for the related than the unrelated context–target pairs. Again, there were no differences between the younger-generated and older-generated sentences.

A final analysis looked at the memorability ratings for the sentences conditioned on whether the target was later recalled during the memory test. There were no differences in the ratings of the younger-generated and older-generated sentences for any of the categories (related–recalled; related–not recalled; unrelated–recalled; or unrelated–not recalled), $Fs < 1$.

Table 3
Prediction of Recall Facilitation and Mean Recall Performance for Young-Generated and Old-Generated Sentences in Experiment 3

	Mean prediction[a]				Mean recall			
	Younger generated		Older generated		Younger generated		Older generated	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Sentences producing correct recall								
Related	6.11	1.27	6.01	1.07	14.24	2.71	13.91	2.94
Unrelated	5.40	1.36	5.06	1.26	10.91	3.68	11.00	4.47
Random sentences								
Related	5.91	1.48	5.73	1.62	13.76	2.89	13.27	3.63
Unrelated	4.97	1.77	4.67	1.26	9.88	4.34	9.27	5.23

[a] Predictions made on a 10-point scale, with 10 meaning 100% certain that the target would be recalled with the sentence.

Discussion

The participants in this experiment were unable to differentiate between the younger-generated and the older-generated subset of sentences from Experiment 1 regardless of whether the sentences were randomly selected or whether they were associated with correct recall in Experiment 1. Their predictions about later recall and recall performance itself were the same regardless of which age group had generated the sentence. The participants, however, were able to discriminate memorability of related and unrelated context–target pairs, and these ratings corresponded to later recall performance.

In an earlier study, Marshall et al. (1978) found that younger adults could differentiate between natural language mediators generated by younger and older adults for nonsense-syllable pairs. In the present experiment, however, sentences generated by younger and older adults did not produce performance differences in a separate group of younger adults.

General Discussion

The present results support the hypothesis suggested by Park, Smith, et al. (1990), and reiterated by Craik and Jennings (1992) and Smith (1996) in their reviews of the aging and memory literature, that older adults can use contextual information to help memory performance if that information is integrated with the to-be-remembered items. The results also suggest that older adults do well when the integration is automatically activated by existing semantic context–target relationships as with the related picture pairs in these experiments. This replicates earlier studies of Park, Smith, et al. (1990) and Earles et al. (1994) that found better recall and smaller age differences in recall when cues were semantically related to the information being remembered.

When deliberate processing is required, however, to relate or integrate the context cue to the memory target, such as when the integration sentences had to be generated for the unrelated context–target pairs in the first two experiments, the older adults did not show the same level of facilitation as did the younger adults even though both groups did show overall facilitation. The younger adults benefited from integration whether it was passively activated or effortfully produced. Unfortunately, floor and ceiling effects in Experiment 1 prevented a clear interpretation of the interactions. In Experiment 2, however, without ceiling effects, the interaction was replicated for the integration condition. Younger adults showed similar levels of performance for both the unrelated and related picture pairs after generating integrating sentences. The older adults, however, did much better with the related pairs. For the unrelated pairs, older adults have greater problems in self-generating integrating relationships themselves. When the relationship is automatically provided by the semantic overlap of context cue and target as with the related items, age differences are small as both age groups can take advantage of the integration provided by the semantic relationship. When the integrating relationship has to be self-generated, as with the unrelated pairs, larger age differences are found with much lower levels of recall in the older group. These findings are in agreement with the process dissociation research of Jacoby and his colleagues (Jacoby et al., 1996; Jennings & Jacoby, 1993), who found age differences when a memory task depends on deliberate processing but not when memory performance is dependent on familiarity or automatic processing.

The results also demonstrated that the older adults' failure to generate as many integrating sentences for unrelated items was more important than differences in the type of sentences when they were generated. When the integration sentences were classified as to type of relationship connecting the context cue to the target, little evidence was found for differences in the nature of the sentences generated by younger and older adults. The primary difference was that older adults failed to produce as many integration sentences for the unrelated items, corresponding to the larger age differences in recall for this category of items.

In Experiment 3, further evidence was provided that the sentences generated by younger and older adults were equivalent and not qualitatively different. Separate groups of younger adults indicated that the younger and older sentences would be equally effective for later recall, and when recall performance was actually compared, this was the case.

In summary, when context is integrated with to-be-remembered information because of the semantic meaning of the items, older adults are able to benefit from the relationship between context cue and target just like younger adults. When the integration must be self-generated by the participant, however, older adults do not seem to be able to take advantage of the context as well as younger adults. Many cognitive aging researchers have concluded that older adults are especially disadvantaged on tasks that require a great deal of effortful processing. Supporting the hypothesis by Craik and Jennings (1992), for example, the older adults in our studies had problems when the deliberate processing required to integrate context was effortful as when generating relationships for unrelated items. When the integration is less effortful, however, as when the items were already semantically related, older adults did benefit almost to the extent of younger adults by the presence of the integration between context and target. The analysis of sentence types (Figure 1) demonstrated that both younger and older adults can take advantage of the preexisting relationships. This is shown by the large proportion of comparison sentences generated for the related items by both age groups. The comparison sentences either explicitly acknowledge the preexisting relationship (object comparison) or comment on some existing semantic feature relating the two items together (feature comparison). On the other hand, few comparison sentences were generated for the unrelated items, but rather new and often novel interaction relationships had to be generated. This is evidenced by the large proportion of action sentences integrating the unrelated items on the basis of some created interaction between them. Younger adults seemed to be able to generate these action sentences for the unrelated pairs, but older adults had greater problems doing so as evidenced by the significantly fewer action sentences and the significantly higher number of incomplete integration sentences for the unrelated items.

It is often difficult to determine whether the failure of older adults to use context is due to a failure to encode the context and its relationship to the target or whether the relationship was encoded but not reconstructed at retrieval when recall is attempted. By reporting their integrations at encoding in the present research, at least some indication about age differences

in the ability to define integrating relationships could be assessed. The results showed that older adults often have problems in producing integrating relationships between context and target for unrelated items, even when instructed to do so. Because of this, recall performance was lower than the recall performance of younger adults.

References

Burke, D. M., & Light, L. L. (1981). Memory and aging: The role of retrieval processes. *Psychological Bulletin, 90,* 513–546.

Burke, D. M., & Peters, L. (1986). Word associations in old age: Evidence for constancy in semantic encoding during adulthood. *Psychology and Aging, 1,* 283–292.

Cherry, K. E., & Park, D. C. (1989). Age-related differences in three-dimensional spatial memory. *Journals of Gerontology: Psychological Sciences, 44,* P16–P22.

Craik, F. I. M. (1986). A functional account of age differences in memory. In F. Klix & H. Hagendorf (Eds.), *Human memory and cognitive capabilities* (pp. 409–422). Amsterdam: North-Holland.

Craik, F. I. M., & Jennings, J. M. (1992). Human memory. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 51–110). Hillsdale, NJ: Erlbaum.

Craik, F. I. M., & Simon, E. (1980). Age differences in memory: The roles of attention and depth of processing. In L. W. Poon, J. L. Fozard, L. S. Cermak, D. Arenberg, & L. W. Thompson (Eds.), *New directions in memory and aging: Proceedings of the George Talland Memorial Conference* (pp. 95–112). Hillsdale, NJ: Erlbaum.

Earles, J. K. L., Smith, A. D., & Park, D. C. (1994). Age differences in the effects of facilitating and distracting context on recall. *Aging and Cognition, 1,* 141–151.

Gardner, E., & Monge, R. (1977). Adult age differences in cognitive abilities and educational background. *Experimental Aging Research, 3,* 337–383.

Hulicka, I. M., & Grossman, J. L. (1967). Age group comparisons for the use of mediators in paired-associate learning. *Journal of Gerontology, 22,* 46–51.

Hultsch, D. M. (1974). Learning to learn in adulthood. *Journal of Gerontology, 29,* 302–308.

Jacoby, L. L., Jennings, J. M., & Hay, J. F. (1996). Dissociating automatic and consciously controlled processes: Implications for diagnosis and rehabilitation of memory deficits. In D. J. Herrmann, M. K. Johnson, C. L. McEvoy, C. Hertzog, & P. Hertel (Eds.), *Basic and applied memory research: Theory in context* (pp. 161–194). Mahwah, NJ: Erlbaum.

Jennings, J. M., & Jacoby, L. L. (1993). Automatic versus intentional uses of memory: Aging, attention, and control. *Psychology and Aging, 8,* 283–293.

Lovelace, E. A., & Cooley, S. (1982). Free association of older adults to single words and conceptually related word triads. *Journal of Gerontology, 37,* 432–437.

Marshall, P. H., Elias, J. W., Webber, S. M., Gist, B. A., Winn, F. J., King, P., & Moore, S. A. (1978). Age differences in verbal mediation: A structural and functional analysis. *Experimental Aging Research, 4,* 175–193.

Mitchell, D. B., Hunt, R. R., & Schmitt, F. A. (1986). The generation effect and reality monitoring: Evidence from dementia and normal aging. *Journal of Gerontology, 41,* 79–84.

Nebes, R. D., & Andrews-Kulis, M. E. (1976). The effect of age on the speed of sentence formation and incidental learning. *Experimental Aging Research, 2,* 315–332.

Nebes, R. D., & Brady, C. B. (1988). Integrity of semantic fields in Alzheimer's disease. *Cortex, 24,* 291–299.

Park, D. C., Cherry, K. E., Smith, A. D., & Lafronza, V. N. (1990). Effects of distinctive context on memory for objects and their locations in young and old adults. *Psychology and Aging, 5,* 250–255.

Park, D. C., Puglisi, J. T., Smith, A. D., & Dudley, W. N. (1987). Cue utilization and encoding specificity in picture recognition by older adults. *Journal of Gerontology, 42,* 423–425.

Park, D. C., Smith, A. D., Morell, R. W., Puglisi, J. T., & Dudley, W. N. (1990). Effects of contextual integration on recall of pictures by older adults. *Journal of Gerontology: Psychological Sciences, 45,* P52–P57.

Puglisi, J. T., Park, D. C., & Smith, A. D. (1987). Picture association among old and young adults. *Experimental Aging Research, 13,* 115–116.

Rabinowitz, J. C. (1989). Judgments of origin and generation effects: Comparisons between young and elderly subjects. *Psychology and Aging, 4,* 259–268.

Riegel, K. F. (1968). Changes in psycholinguistic performance with age. In G. A. Talland (Ed.), *Human aging and behavior* (pp. 239–279). New York: Academic Press.

Sharps, M. J., & Gollin, E. S. (1987). Memory for object locations in young and elderly adults. *Journal of Gerontology, 42,* 336–341.

Shaw, R. J., & Craik, F. I. M. (1989). Age differences in predictions and performance on a cued recall task. *Psychology and Aging, 4,* 131–135.

Smith, A. D. (1996). Memory. In J. E. Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (4th ed.; pp. 236–250). San Diego, CA: Academic Press.

Zelinski, E. M., & Light, L. L. (1988). Young and older adults' use of context in spatial memory. *Psychology and Aging, 3,* 99–101.

Received July 22, 1996
Revision received March 27, 1997
Accepted March 27, 1997 ■