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Age-Related Differences in Cued Recall: Effects of Support at Encoding and Retrieval

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ABSTRACT

The literature is unclear about the relative contributions of environmental supporting conditions to younger and older adults' episodic memory performance. The work reported addresses the conditions under which different support patterns are obtained. In three experiments, younger and older adults learned picture-word pairs and were then tested with a cued-recall task. Supportive conditions included semantic relations between the pair members (all experiments), and first-letter cues for the target words at retrieval (Experiments 2 and 3). Results of the three experiments indicated different patterns of support for younger and older adults, depending on the number and location of the supporting conditions used. These different patterns are in line with the suggestion that whereas younger adults benefit substantially from support at encoding only, older adults require support at both encoding and retrieval. Alternative accounts of the results are also discussed.

There is general agreement that episodic memory performance declines from young to older adulthood (see Balota, Dolan, & Duchek, 2000; Craik & Jennings, 1992; Zacks, Hasher, & Li, 2000, for reviews). One way of accounting for such episodic memory deficits was suggested by Craik (1983, 1986). According to this view, cognitive processing reflects an interaction between processes that are driven by external stimulation and those that are initiated by the individual. These latter processes are dependent to a great degree on available processing resources, and may decline in effectiveness as the person ages. Such decreases in performance can be reduced by minimizing the demands on diminished resources and maximizing the contributions of external stimulation and environmental support. For example, a free recall task involves substantial self-initiated activity as relatively few cues are present in the environment. In contrast, recognition memory involves substantial environmental support because the target item is re-presented. Results in the literature support this argument by showing much larger age effects on recall than on recognition (Craik & McDowd, 1987). Pre-existing knowledge may also act to support the formation of richer encoded representations and to guide retrieval processes. Use of such knowledge in episodic memory tasks thus serves as "schematic support" (Craik & Bosman, 1992) in a manner analogous to environmental support, and may also act to reduce age-related memory decrements.

These ideas suggest that age-related declines in episodic memory should be reduced or even eliminated as the memory task involves greater degrees of environmental and schematic support. The empirical evidence relevant to these predictions is not clearcut, however. Although some studies show that more supportive conditions are indeed differentially better for older adults, other

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studies indicate equal support for both age groups, and still other studies indicate that younger participants benefit more under supportive conditions. One example of greater improvement to older adults was provided by West and Boatwright (1983). They presented words to younger and older participants in the context of either rhyme or semantic orienting questions, and later tested cued recall for the word using the original rhyme or semantic questions as cues. Performance of the young group rose from 41% to 82% correct using rhyme and semantic cues, respectively, whereas the cued recall performance of the older group improved from 18% to 73% in the corresponding conditions. Older participants thus showed a greater benefit associated with the more effective semantic encoding and retrieval cues. A second study, by Park, Smith, Morrell, Puglisi, and Dudley (1990), also demonstrated that older adults benefited more than young adults from the provision of context, provided the context was well integrated with the target to be remembered.

Other studies have shown greater improvements for younger adults, however. For example, Craik and Rabinowitz (1985) found that younger participants' free recall performance benefited more than that of older adults when presentation rate during study was increased from 1.5 to 6 s per word. Similarly, Rabinowitz (1989) showed that younger adults benefited more than their older counterparts from optimal study conditions in which participants could take notes and generate cues for themselves. Finally, yet other studies have shown equal effects of support on younger and older adults. For example, Rankin and Collins (1985) found older adults to benefit as much as their younger counterparts from the provision of precise elaborators for words in a sentence. Likewise, Park, Puglisi, and Smith (1986) showed that younger and older participants benefited to the same degree in a recognition test from the provision of more elaborate pictorial information.

In their review of the literature on human memory and aging Craik and Jennings (1992) discussed several possible reasons for these conflicting patterns of results. One is the various amounts of effort required in the more supportive conditions. For example, it may be that a change in the materials provides a better encoding in a relatively automatic fashion (e.g., pictures vs. words); in this case we might expect older adults to take greater advantage of these improved conditions. However, it could be that such enhanced encoding can be achieved only with the expenditure of extra effort, not available to the older participants (see Craik, 1983), in which case younger participants may show greater benefit. Another reason suggested by Craik and Jennings relates to the complex interactions between acquisition variables, test variables, materials employed, and subjects (see also Jenkins, 1979). Their suggestion was that as encoding or retrieval conditions improve gradually from extremely poor to excellent, younger participants can take earlier advantage of improved conditions and thus increase the age-related difference in performance. The younger adults' performance would eventually asymptote at a functional ceiling level depending on the materials, the participants' skill, and so forth. Older adults are less responsive initially, but then start to improve, and finally may achieve a level of performance close to that of the young. This notion thus suggests that a diverging pattern of age-related results may characterize situations in which conditions move from poor to moderate, a parallel pattern may be typical of middle ranges of support, and a converging pattern of "compensation" may be found as support moves from good to excellent.

The present experiments were intended to explore the suggestion made by Craik and Jennings (1992) that there may be different patterns of supports for young and old depending on the materials, the task, and the acquisition conditions. In the first experiment we explored the type of supportive encoding operations that may benefit older adults' memory more than that of the young. In one condition, participants had to use self-initiated processes in order to tie together two unrelated events, while in the other condition participants could rely on pre-existing knowledge to relate these events. Participants were shown pictures of everyday scenes and were asked to associate four presented words to each scene; two of the words referred to objects that were related to their associated scene, and two words referred to objects unrelated to the scene. After the presentation phase the pictures were re-presented as cues for the studied words. Our prediction was

that whereas all participants would show higher recall levels for the related words than for the unrelated words, this improvement would be greater for the older adults, since they could make use of existing knowledge in the related conditions. In the unrelated condition, in contrast, younger participants might nevertheless be able to generate some association between the object and the scene, whereas older participants would be less likely to do so.

To prefigure the pattern of findings, the results of Experiment 1 were directly contrary to our expectations, in that younger adults showed significantly greater benefits from the related condition. We then hypothesized that to show good performance levels, older adults may require substantial environmental support at both encoding and retrieval. Accordingly, in Experiment 2 we varied the degree of encoding support (words related or unrelated to the pictures) but also provided good retrieval support by giving the first letters of the words as cues. Under these conditions, older adults' cued recall performance benefited more than that of younger adults from the related conditions at encoding. Experiment 3 confirmed the overall pattern of results by replicating the findings from the first two experiments in one within-subject design. That is, enhanced encoding support with weak retrieval support is of greater benefit to younger adults, but if greater support is provided at both encoding and retrieval then older adults' performance improves more than that of younger adults, and the age-related memory decrement is reduced.

EXPERIMENT 1

METHOD

Participants

A total of 28 adults (14 in each of the two age groups) participated in the experiment. The younger participants (Mean age = 20.9, $SD = 1.25$) were Ben-Gurion University undergraduates, who received course credit for their participation; the older group (Mean age = 74.6, $SD = 5.9$) consisted of volunteers from the community. The younger group had a slightly greater number of years of formal education (Mean = 12.5 years, $SD = 0.7$) than the older group (Mean = 11.7, $SD = 2.72$), $t(26) < 1$, ns. All older participants reported being in good health and having good hearing and vision.

Design

Two independent variables were used in a mixed design: age (young vs. old) was a between-subject variable, and level of support (related vs. unrelated pairs) was a within-subject variable. The dependent variable was the percentage of correctly-recalled words in a cued-recall test.

Materials

A total of 21 unique pictures of everyday scenes (e.g., various foods and plates on a table; three people paddling a canoe on a river) were chosen along with 51 unique common words. Of the 21 pictures, 10 were the experimental ones, 6 were used as buffer items to absorb effects of primacy and recency, and 5 were used as practice. Each of the 10 experimental pictures was paired with 4 words (total of 40 words). Two of these words either referred to an aspect of the picture or were related to it semantically; the other two words were unrelated to the picture. The remaining 11 buffer and practice pictures were each paired with 1 of the remaining words, some of which were related and some unrelated. Each of these 51 pairs appeared on an index card on which the picture appeared in the middle and the word below. For the test phase the 10 experimental pictures appeared 1 on each index card with 4 lines for the participants to write their responses.

The words used were high frequency words of 1–3 syllables, taken from Hebrew norms (Balgur, 1968). Word frequency was matched between the related and unrelated lists. The pictures were scenes of indoor and outdoor settings, some with people in them and some not. These pictures were shown to a group of pilot subjects who were asked to generate three conceptually related word associations to each picture. About 12% of the words produced by the pilot group were designated "related" whereas none of the "unrelated" words were produced by the pilot group. There were no instances in which a word referred directly to an object shown in its associated picture. Finally, both the related and unrelated words for a given picture were unrelated to each other, and therefore could not serve as cues for one another. The related words were, of course, related to the theme of their associated picture, but referred to different aspects of their associated picture. Three typical examples are:

> A picture of a person standing in the water at the bottom of a small waterfall; the related words were "cold" and "shower," and the unrelated words were "bench" and "bag."
>
> A picture of a young woman sitting holding a telephone; the related words were "sadness" and "ring," and the unrelated words were "tail" and "song."

A scene of jockeys on galloping horses near the seashore; the related words were "speed" and "gambling," and the unrelated words were "forgiveness" and "jewellery."

Procedure

Participants who were tested individually were sequentially presented with a list of picture-word pairs. They were instructed to study the words in each pair in preparation for an upcoming word test, the nature of which was explained. They were told to pay attention to the picture, as it would be provided at the test phase as a cue for recalling the words.

The picture-word pairs were presented sequentially at a pace of one pair every 8 s. After presentation of the first five pairs which were used for practice, any questions the participants might have had were answered. In the next experimental phase, participants were presented with the remaining 46 pairs, one at a time without pauses. Of these pairs, the first and last three served as buffer items to absorb effects of primacy and recency. The remaining 40 experimental pairs included 10 pictures, each of which appeared 4 times, on two occasions with related words and on two occasions with unrelated words. Two randomized orders of the experimental pairs were prepared, each used with half of the participants of each age group. In each of these randomized orders, each two appearances of a given picture were separated by at least 4 other picture-word pairs.

At the end of the study phase, participants had to count backwards by threes for 90 s as an interpolated activity. Then the cued-recall memory test was presented in which participants were shown the 10 experimental pictures in random order, one at a time, and asked to write down the 4 words which appeared with each picture at study. Participants had as much time as they needed to complete the memory test. The order of the cues presented at test was randomized for each participant.

RESULTS

Table 1 shows the percentage of correctly-recalled words in the cued-recall task. The table demonstrates that overall, as expected, younger participants ($M = 51.1\%$) outperformed the old ($M = 26.5\%$). In addition, performance in the supportive (related) condition ($M = 60.8\%$) was better than in the unsupportive (unrelated) condition ($M = 16.8\%$). Finally, the table indicates that younger participants benefited more from the supportive condition than the older ones. These trends were confirmed in a 2-way analysis of variance (ANOVA) conducted with age as a between-subject variable, and support as a within-subject variable. The analysis yielded a significant effect of age, $F(1, 26) = 54.7$, $p < .01$ ($MSE = 2.0$); a significant effect of support, $F(1, 26) = 392.4$, $p < .01$ ($MSE = 0.8$); and a significant interaction $F(1, 26) = 16.98$, $p < .01$ ($MSE = 0.8$). This interaction, reflected the fact that younger participants improved more from the unrelated to the related condition (21.7–80.5%, a 58.8% improvement), than older participants (11.8–41.1%, a 29.3% improvement; note that the 11.8% performance was significantly better than the 0% chance level performance, $p < .05$). Post hoc comparisons using the Neuman–Keuls procedure indicated that the improvement in the related relative to the unrelated condition was significant both for younger and for older adults ($p < .05$ in both cases).[1]

DISCUSSION

The two main effects obtained are not surprising and conformed to our expectations. Older adults do not perform as well as younger adults in a cued-recall task. This result is similar to those reported in the literature (e.g., Craik & McDowd, 1987; Kausler & Puckett, 1980; Naveh-Benjamin, 2000). Similarly, related stimuli are better remembered than unrelated stimuli as shown in the literature (e.g., Jenkins & Russell, 1952). More interestingly, the results indicate an interaction between age and support. While it is no surprise that both age groups took advantage of the semantic relationships between the word and picture, the fact that younger adults were more supported by the semantic relationships than older adults is somewhat surprising, given that we had predicted a greater effect for the older group.

Given that related words were generated by the group of pilot subjects, it is possible that recall of the related words reflects guessing to some extent. This factor cannot explain the whole effect of relatedness, however, since the original genera-

[1]The results obtained in the three experiments are not due to the younger and older adults differing in their respective baseline performance (the no-support condition). The exact same results emerged in all the three experiments when relative scores were computed.

Table 1. Means and Standard Deviations (in Parentheses) of Percentage Correctly Recalled Words in the Different Conditions of the Three Experiments.

	Experiment 1		Experiment 2		Experiment 3			
	Unrelated pairs	Related pairs	Unrelated pairs	Related pairs	No first-letter cue		First-letter cue	
					Unrelated	Related	Unrelated	Related
Age								
Young	21.7 (9)	80.5 (10)	43.2 (18)	69.6 (12)	32.0 (20)	60.8 (22)	40.8 (20)	68.0 (18)
Old	11.8 (7)	41.1 (13)	14.3 (8)	56.4 (13)	12.7 (13)	20.0 (11)	16.7 (11)	56.0 (19)

tion rate by pilot subjects was 12% and the recall rates were 41% and 81% by the old and young participants, respectively. In any event, the interesting aspect of the results is not the effect of relatedness per se, but the differential effect of relatedness on the two groups.

As described earlier, Craik (1986) suggested that age-related decrements in memory performance can be reduced either by the use of richly detailed stimuli (e.g., pictures) which allow rich, meaningful, and distinctive encoding, or by utilizing the participant's existing knowledge to enrich the stimuli and relate them to each other. In the supportive condition (related pairs), old participants should have used their previous semantic knowledge to relate the two items, (one of which was a richly detailed picture), and as a result we expected them to take advantage of this support to at least the same degree as younger adults. As previously described, results showing equal support (e.g., Park et al., 1986) or greater support for the elderly (e.g., Canestrari, 1968) when pre-existing semantic relationships are employed, have been reported in the literature.

Why was the effect of support greater for the young than for the old in this experiment? Clearly the support provided by the related pairs was very effective – performance in the young group improved from 22% to 81% – so it can hardly be described as a minimal increase in support. One possibility is that older adults may require support at retrieval as well as at encoding before their performance improves relative to their younger counterparts, and the purpose of the second experiment was to check this hypothesis. In Experiment 2 we therefore varied the degree of encoding support (words related or unrelated to the pictures); good retrieval support (first-letter cues) was provided in all cases.

EXPERIMENT 2

METHOD

Participants

A total of 30 adults (15 in each of the two age groups) participated in the experiment. The younger participants (Mean age = 19.8, $SD = 1.35$) were University of Toronto undergraduates, who received course credit for their participation; the older group (Mean age = 72.6, $SD = 4.9$) consisted of volunteers from the community. The older group had a slightly greater number of years of formal education (Mean = 13.9 years, $SD = 2.7$) than the younger group (Mean = 13.4 years, $SD = 0.9$), $t(28) < 1$, ns. All older participants reported being in good health and having good hearing and vision.

Design

Two independent variables were used in a mixed design: age (young vs. old) was a between-subject variable, and level of encoding support (unrelated vs. related pairs) was a within-subject variable. The dependent variable was the percentage of correctly-recalled words in a cued-recall test.

Materials

Twenty three unique pictures of everyday scenes were chosen along with 78 unique common concrete nouns. Of the 23 pictures 10 were the experimental ones, 8 were used as buffer items to absorb effects of primacy and recency, and 5 were used as practice. Each of the 10 experimental pictures was paired with 6 words (total of 60 picture-word pairs). Three of these words either referred to some aspect of the picture or were related to it semantically as in Experiment 1. The other 3 words were unrelated to the picture. Each of the 6 words had a different initial letter. The 8 buffer pictures were each paired with 1 of the remaining words (half related and half unrelated), and the 5 practice pictures were each paired with 2 of the remaining words (one related and one unrelated). Each of these 78 picture-word pairs appeared on an index card in which the picture appeared in the middle and the word below. In the test phase the 10 experimental pictures were each presented on two occasions, but separated by several intervening pictures. On each occasion, the experimental picture was presented on an index card with three lines below the picture. The first letter of 3 of the words associated with that picture (either 2 related and 1 unrelated, or 2 unrelated and 1 related) were provided at the beginning of each line, and the participant's task was to recall the word and write it down.

As in Experiment 1, the related words were chosen from words provided by a group of pilot subjects who were asked to generate 3 words related to each picture. In this case, approximately 15% of the generated words were chosen as the related words, but they were also chosen so that they were not high associates of each other; all 3 words were related to the picture, but to different aspects of the picture. In a further attempt to minimize the possibility of words cueing each other in the recall phase, related and unrelated words were mixed on the test cards at retrieval (see examples below). The 30 unrelated words were concrete nouns,

unrelated to their paired pictures, and matched in word frequency to the related words. The median word frequencies for related and unrelated words were 21 and 20 per million, respectively (Kucera & Francis, 1967). Three typical sets of picture-word pairs, and their test-cue combinations are:

1. Kitchen scene: Bags of groceries sitting on counter. Woman with fridge door open.
   Related: grocery, appliance, cockroach. Unrelated: umbrella, puzzle, compass.
   Test 1: grocery, cockroach, compass. Test 2: umbrella, appliance, puzzle.
2. Rowers: 3 rowers on water; mist rising off water; sunrise and city background.
   Related: teammate, morning, muscle. Unrelated: office, window, basement.
   Test 1: morning, muscle, office. Test 2: window, basement, teammate.
3. Carriage: Two people dressed in black, driving black carriage through snow.
   Related: ancestor, winter, transportation. Unrelated: experiment, missile, cigar.
   Test 1: experiment, cigar, winter. Test 2: transportation, ancestor, missile.

Procedure

Participants, who were tested individually, were presented sequentially with a list of picture-word pairs. They were told to study the word in each pair in preparation for an upcoming word test, the nature of which was explained. They were also instructed to pay attention to the pictures, as they would be provided at the test phase as cues for recalling the words.

The pairs were presented sequentially at a rate of one pair every 5 s. After presentation of the first 10 pairs (5 pictures, each with 1 unrelated and 1 related word), which were used for practice, any questions the participants might have had were answered before the next experimental phase started. In this phase participants were presented with the remaining 68 pairs, one at a time without pause. Of these pairs, the first and the last 4 served as buffer items to absorb effects of primacy and recency. The remaining 60 experimental pairs included 10 pictures each of which appeared with 3 related and 3 unrelated words. Two randomized orders of the experimental pairs were prepared, each used with half of the participants of each age group. In each of these randomized orders, every appearance of a given picture was separated from its previous appearance by at least 4 other picture-word pairs.

At the end of the study phase, participants had to count backwards by threes for 90 s as an interpolated activity. Then the cued-recall memory test was presented in which participants were shown the 10 experimental pictures, each on two occasions, separated by several intervening pictures. On each occasion, the test picture was accompanied by 3 first-letter cues for the target words. The order of the first-letter cues was randomized for each participant, and participants had as much time as they needed to complete the memory test.

RESULTS

Table 1 shows the percentage of correctly-recalled words in the cued-recall task. The table demonstrates that overall, as expected, younger participants ($M = 54\%$) outperformed their older counterparts ($M = 35\%$). In addition, performance in the related condition ($M = 63\%$) was better than in the unrelated condition ($M = 29\%$). Finally, the table indicates that older adults benefited more from the related condition than the younger ones. These trends were confirmed in a 2-way ANOVA conducted with age as a between-subject variable, and support as a within-subject variable. The analysis yielded a significant effect of age, $F(1, 28) = 21.3$, $p < .01$ ($MSE = 3.3$); a significant effect of support, $F(1, 28) = 159.7$, $p < .01$ ($MSE = 1.1$); and a significant interaction, $F(1, 28) = 7.35$, $p < .05$ ($MSE = 1.1$). This interaction reflected the fact that the older participants improved more from the unrelated to the related condition (14–56%, a 42% improvement), than the younger participants (43–70%, a 27% improvement). Post hoc comparisons using the Neuman–Keuls procedure indicated that the improvement in the related over the unrelated condition was significant for both younger and older adults ($p < .05$ in both cases).

There was a small tendency for participants to guess in this experiment, as indexed by intrusion of words as responses that had not occurred in the experiment. This guessing rate was 0.03 for the young adults and 0.06 for old adults, $t(28) = 1.84$, $p > 0.05$.

DISCUSSION

The two main effects replicated the findings obtained in Experiment 1: Younger adults performed better than older adults in the cued-recall task. In addition, semantically-related pairs are better remembered than unrelated ones. More

interestingly, the results indicate an interaction between age and support. Although both age groups took advantage of the semantic relationships between the picture and the word in each pair, unlike Experiment 1 older adults were better supported by the semantic relationships than were the younger adults. The older adults improved their performance by 42% as a result of the support, whereas the young improved by only 27%. The smaller improvement of the younger adults cannot be attributed to ceiling effects; their performance in the supported condition does not quite reach 70%.

Why was the effect of support larger for the oldthan for the young in this experiment – just opposite to the result obtained in Experiment 1? Our hypothesis is that older adults require support at both encoding and retrieval, and when such support was provided in the present experiment their performance decrement, relative to the younger group, was greatly reduced. There were also several procedural differences between the experiments, however. First, rate of presentation at study was faster in the present experiment than in Experiment 1 (5 s per pair, compared with 8 s per pair). Second, there were 60 experimental pairs in this experiment, compared to 40 in Experiment 1. Third, the experiments used different materials and were run in different countries with different participants. Additionally, the older adults showed a slightly greater tendency to produce intrusions. None of these changes provide a convincing account of the difference in experimental outcome, however.

We argue instead that the provision of first-letter cues at retrieval in Experiment 2 was the crucial change underlying the different pattern of results. Nonetheless, given the other changes in materials and procedure, it seemed wise to corroborate this explanation by attempting to replicate the two patterns in one experiment. Experiment 3 thus varied both the type of semantic support at encoding (related or unrelated picture-word pairs) and the support available at retrieval (presence or absence of first-letter cues). We thereby hoped to replicate both previously obtained patterns of findings and thus to provide an unequivocal interpretation of the results.

EXPERIMENT 3

METHOD

Participants

A total of 40 adults (25 younger adults and 15 older adults) participated in the experiment. The younger participants (Mean age = 22.7, $SD = 1.28$) were Ben-Gurion University undergraduates, who received course credit for their participation; the older group (Mean age = 73.5, $SD = 3.9$) consisted of volunteers from the community. The older group had a slightly smaller number of years of formal education (Mean = 13.2 years, $SD = 2.9$) than the younger group (Mean = 13.4 years, $SD = 0.8$), $t(38) < 1$, ns. All older participants reported being in good health and having good hearing and vision.

Design

Three independent variables were used in a mixed design: age (young vs. old) was a between-subject variable, and semantic support (related-unrelated) and first-letter support (present-absent) were within-subject variables. The dependent variable was the percentage of correctly-recalled words in a cued-recall test.

Materials

Twenty one unique pictures of everyday scenes were chosen along with 51 unique common words. These materials were substantially the same as the picture-word pairs used in Experiment 1. Of the 21 pictures 10 were the experimental ones, 6 were used as buffer items to absorb effects of primacy and recency, and 5 were used as practice. Each of the 10 experimental pictures was paired with 4 words (total of 40 words). Similar to the previous experiments, 2 of these words either described some aspect of the picture or were related to it semantically, but, as noted in Experiments 1 and 2, the 2 related words were not associates of each other. The other 2 words were unrelated to the picture. Each of these 4 words had a different initial letter. The 5 practice pictures and the 6 buffer items were each paired with 1 of the remaining words, approximately half of which were related and half unrelated to the picture. Each of these 51 pairs appeared on an index card where the picture appeared in the middle and the word below. In the test phase, the 10 experimental pictures appeared 1 at a time on an index card with 4 lines on it; on 2 of the lines the first letter of the target word appeared (1 for a related and 1 for an unrelated target), while on the other 2 lines (again, 1 designated for the related and 1 for the unrelated target) no letter cues appeared. Participants were expected to write their responses on these lines.

Procedure

Participants who were tested in groups of 3–5 saw a list of picture-word pairs presented sequentially. They were told to study the words in each pair in preparation for an upcoming word test, the nature of which was explained. They were told to pay attention to the picture as it would be provided at the test phase as a cue for recalling the words.

The pairs were presented sequentially at a rate of one pair every 5 s. After presentation of the first five practice pairs, any questions the participants may have had were answered before the next experimental phase started. In this phase participants were presented with the remaining 46 pairs, 1 at a time without pause. Of these pairs, the first and the last 3 served as buffer items to absorb effects of primacy and recency. The remaining 40 experimental pairs included 10 pictures each of which appeared 4 times with 2 related and 2 unrelated words. Two randomized orders of the experimental pairs were prepared; each was used with half of the participants of each age group. In each of these randomized orders, every two appearances of a given picture were separated by at least 4 other picture-word pairs.

At the end of the study phase, participants had to count backwards by threes for 60 s as an interpolated activity. Then the cued-recall memory test was presented in which participants received the 10 experimental pictures in random order and were asked to write down the 4 words which appeared with each one during the study phase. For 2 of these words (1 related and 1 unrelated) they received the first letter as a cue. The order of the cues presented at test was randomized. Participants had as much time as they needed to complete the memory test.

RESULTS

Table 1 shows the percentage of correctly-recalled words in the cued-recall task. The table demonstrates that overall, as expected, younger participants ($M = 50\%$) outperformed the old ($M = 26\%$). In addition, performance in the related condition ($M = 51\%$) was better than in the unrelated condition ($M = 25\%$). Finally, the table shows that performance was better when a first-letter cue was provided at retrieval ($M = 45\%$) than when no first-letter cue was provided ($M = 31\%$). These trends were confirmed in a 3-way ANOVA conducted with age as a between-subject variable, and semantic support (related-unrelated), and first-letter cue support (present-absent) as within-subject variables. The analysis yielded a significant main effect of age, $F(1, 38) = 29.2$, $p < .01$ ($MSE = 7.4$); a significant effect of semantic support, $F(1, 38) = 169.7$, $p < .01$ ($MSE = 1.5$); and a significant effect of first-letter cue support, $F(1, 38) = 25.9$, $p < .01$ ($MSE = 2.8$).

The interaction of age with first-letter cue was also significant, $F(1, 38) = 4.75$, $p < .05$ ($MSE = 2.8$), indicating that older adults ($M = 16\%$ and 36%) benefited more from the first-letter cue than younger adults ($M = 46\%$ and 54%). The interaction of age with semantic support was not significant, $F(1, 38) = 1.4$, $p > .05$ ($MSE = 1.5$). The interaction of semantic support and first-letter cue support was significant, $F(1, 38) = 13.40$, $p < .01$ ($MSE = 1.6$), indicating that improvement from the unrelated to the related condition was larger when the first-letter cue was provided (27% vs. 63%) than when it was not (21% vs. 39%). Finally, and most interesting, the triple interaction was significant, $F(1, 38) = 16.4$, $p < .01$ ($MSE = 1.6$). Follow-up analyses examining the interaction of age and semantic support for each of the two first-letter cue conditions separately indicated that both two-way interactions were significant, $F(1, 38) = 11.4$, $p < .01$ ($MSE = 1.9$), and, $F(1, 38) = 5.8$, $p < .05$ ($MSE = 1.2$), for no first-letter cue and first-letter cue, respectively. Note however that the direction of the interaction was different in the two cases. Whereas in the no first-letter cue condition younger participants benefited more than the older adults from the introduction of semantically related pairs, in the first-letter cue condition older adults benefited more from the semantically related pairs. As in Experiment 2, intrusion rates were quite low in the first-letter condition – 5% for the young group and 3% for the older adults, $t(38) = 0.77$, $p > .05$. Note that the age difference in intrusions was in the opposite direction to that found in Experiment 2.

DISCUSSION

The results of this experiment showed main effects of age, semantic relatedness at encoding, and the provision of first-letter cues at retrieval. All of these effects were expected on the basis

of previous research and from the results of Experiments 1 and 2. The interactions were more interesting. First, there was a significant interaction between age and first-letter cue support; older participants profited more than the younger participants when retrieval support was provided. In turn, this result suggests that good retrieval support may be crucial for good memory performance in older adults, and that the absence of good retrieval support may underlie many age-related memory decrements (Craik, 1983, 1986). Second, there was a strong interaction between relatedness at encoding and first-letter support at retrieval, and this effect may be construed as showing that good retrieval conditions may be necessary to reveal the benefits of improved encoding conditions. It is worth noting that in this case the encoding and retrieval manipulations are quite dissimilar; the interaction is not an example of encoding specificity or transfer-appropriate processing.

The final result of interest is the 3-way interaction among age, relatedness, and first-letter cues. Subsequent analyses showed that this result confirmed the findings from Experiments 1 and 2; when no first-letter cues were present young adults benefited more from the provision of relatedness, but older participants profited more when first-letter cues were present. Older adults required support at both encoding and retrieval to achieve high levels of memory performance and to reduce the discrepancy between their performance and the performance of younger adults.

GENERAL DISCUSSION

The results reported in this paper do not provide a simple answer to the question regarding the conditions under which older adults will benefit more, less, or to the same degree as younger adults. Those conditions of support can be either internal, in the form of use of well-learned schematic information, or external support, such as external cues provided at retrieval. As we saw, the use of semantically-related pairs as a way of facilitating the learning of episodic picture-word pairing yielded contrasting results in Experiments 1 and 2; whereas Experiment 1 indicated more support for the young, Experiment 2 showed that older adults benefited more from such support. One factor that emerged as a possible modulator of the semantic-relatedness effect at encoding was whether or not retrieval conditions were also supportive; in Experiment 1 only the pictures were re-presented as cues whereas in Experiment 2 first-letter cues were also presented. Experiment 3 confirmed that relatedness at encoding was of greater benefit to younger adults in the absence of first-letter cues at retrieval, but of greater benefit to older adults when such retrieval cues were provided.

One way of interpreting these results is that the memory performance of older adults can be optimized by the provision of good cognitive support at both encoding and retrieval. The significant interaction between relatedness at encoding and the provision of first-letter cues at retrieval in Experiment 3 suggests at first that this is a general effect, that good retrieval conditions optimize beneficial encoding operations. However, Table 1 shows that the interaction is driven entirely by the older participants; the beneficial effect of relatedness at encoding is approximately the same with and without first-letter cues for younger adults in Experiment 3 (27% and 29%, respectively), whereas the corresponding figures for older adults are 39% and 7% respectively. Older adults thus benefited disproportionately, and their performance levels approached those of younger adults, when support was provided at both encoding and retrieval. Two points are worth noting with respect to this result. First, the finding does not reflect ceiling effects in the younger group; the scores for young adults in the related/cues-present condition were 70% in Experiment 2 and 68% in Experiment 3. Second, the present experiments show that conditions can be found that optimize recall performance (as opposed to recognition) in older adults.

Whereas the provision of support at both encoding and retrieval provides the best description of the present results, other accounts are possible. One is that younger adults can take "earlier" advantage of improved conditions of encoding on retrieval, but older adults catch up when further supports are added at either encoding or retrieval (Craik & Jennings, 1992). This

account is supported by some results in the literature. For example, Treat and Reese (1976) used paired associates and manipulated both the instructions on how to encode the word pairs (imagery vs. standard learning) and also the time available for encoding and retrieval. Their results indicated that younger but not older adults benefited from the increased time under standard learning instructions, but that the older group benefited more than the younger group from the increased time under the more beneficial imagery instructions. That is, with two sources of 'support' the older adults' performance matched the level achieved by the younger group. Similarly, Backman (1986) presented short sentences for immediate free recall at either a fast or a slow rate. Additionally, the sentences were presented visually, auditorily, or in both modalities simultaneously. He found that age differences were smallest when the lists were presented at a slow pace and in both modalities; apparently, older adults had an advantage when several support conditions were combined. As a third example, Smith, Park, Earles, Shaw and Whiting (1998) presented picture pairs that were either related or unrelated semantically. In addition, in some conditions participants were asked to integrate the pairs by generating sentences relating the 2 pictures in each pair. Although the researchers were interested in the effects of context integration, their results can be interpreted in terms of our current discussion: when one source of extra support was provided (either by the semantic-relatedness of the pairs, or by generating the relating sentence), younger adults improved more than the old in their cued-recall performance (Experiment 1). When further support was added (both semantically related pairs and generation of sentences) older adults took more advantage of it and improved their cued-recall performance more than the young (Experiments 1 and 2).

The idea that younger adults can profit more than their older counterparts from one additional source of support, but that older adults profit relatively more from a second source thus describes the data, although it yields few insights into why this pattern occurs. With regard to the present results, we suggested earlier that older adults show relatively greater increases in recall performance when processing is supported at both encoding and retrieval. This description is also valid for the Treat and Reese (1976) results, but less so for the findings of Backman (1986) and Smith et al. (1998) which show the beneficial effects of two supportive encoding manipulations. A second possibility is that older people benefit disproportionately when the "search set" for recall is narrowed by experimental manupulations. In the present data, it can be argued that semantic relatedness both enriches encoding and also restricts the range of retrieval alternatives; provision of a first-letter cue clearly has that function. This version of retrieval support gives a good account of some results in the literature (e.g., Craik, 1968, 1983) although it is less appropriate for other results (e.g., Backman, 1986).

The present findings, along with some other published reports, suggest that the original environmental support concept (Craik, 1983; 1986) requires some modification. A task which provides more environmental support than one that does not, will not necessarily be more favorable to older people. Apparently, several background conditions are important in modulating the effects of environmental support, including acquisition variables, test variables and material variables (Jenkins, 1979). Without information about these variables it is difficult to predict a priori which conditions will differentially improve older adults' memory performance. The specific support variables employed in the present study are clearly not the only ones to elicit the patterns obtained, and future research should seek to map the combination of factors resulting in these differential supporting patterns. Nevertheless, the present results in conjunction with others reported in the literature suggest two useful empirical generalizations. First, even in the absence of ceiling effects, the greater the number of supportive manipulations, the more older adults' memory will improve relative to the levels achieved by their younger counterparts. Second, these beneficial effects to older people may be particularly effective when supportive conditions are provided at both encoding and retrieval.

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