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The Relation Between Source Memory and Aging

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Previous research has shown that elderly adults have difficulty recalling the source of recently acquired facts but does not indicate whether source memory is more impaired than fact memory. This study examined old and young subjects' memory for novel facts that had been read to them by 1 of 2 experimental sources either in a random order or in a blocked order. When fact memory was equated in young and old at different levels of performance, the elderly exhibited disproportionate source memory deficits in the blocked condition but not in the random condition. Results suggest that the relation between fact and source memory in the elderly varies across experimental conditions.

An enduring question in the study of cognitive aging concerns the selectivity and specificity of age-related memory deficits: Are all aspects of memory impaired equally in elderly adults, or does aging impair some features of memory more than others? This fundamental issue has been raised and explored in a number of different contexts, including studies that have examined whether secondary memory is more impaired than primary memory (e.g., Craik, 1977), whether recall is more impaired than recognition (e.g., Craik & McDowd, 1987), and whether explicit memory is more impaired than implicit memory (e.g., Graf, 1990; Light & Singh, 1987). Although the issues are complex and many key questions remain unresolved, evidence exists to support the idea that not all aspects of memory are affected equally by aging (cf. Burke & Light, 1981; Craik, 1983; Light, 1991; Schacter, Kaszniak, & Kihlstrom, 1991; Schacter, Kihlstrom, Kaszniak, & Valdiserri, in press; Shimamura, 1989).

Issues concerning the selectivity of age-related memory deficits have recently arisen in relation to investigations of *source memory*—recollection of the episodic source from which a specific item or fact was acquired (e.g., from a person, a book, or television). Evidence from studies of hypnotic and organic amnesia indicates that source memory can be dissociated from item or fact memory. For example, Evans and Thorn (1966) found that hypnotized subjects could sometimes recall one or more of three obscure facts that had been read to them by an experimenter but did not remember that the experimenter was the source of the facts. Evans and Thorn termed this phenomenon *source amnesia*. Schacter, Harbluk, and McLachlan (1984) developed an experimental paradigm to study source amnesia systematically in brain-damaged patients with severe memory disorders. One of two experimenters told subjects fictitious facts about well-known and unknown people (e.g., "Bob Hope's father was a fireman"), and memory for facts and sources was tested after brief delays of several minutes. Amnesic patients showed significant source amnesia: After recalling a fact, patients frequently failed to remember that either of the experimenters had told them the fact. In addition to showing poorer source memory than control subjects, amnesic patients also recalled fewer facts. However, when levels of fact recall were equated in the two groups by testing control subjects after a 1-week retention interval, control subjects still showed significantly less source amnesia than did amnesic patients. This latter finding suggests that source memory is disproportionately impaired relative to fact memory in amnesic patients (see also Shimamura & Squire, 1987). The key issue addressed in this article is whether elderly adults are also characterized by disproportionate impairments of source memory.

Source Memory in the Elderly: Experimental Evidence

McIntyre and Craik (1987) reported two experiments that investigated memory for facts and sources in elderly adults. In the first experiment, subjects were initially provided with the answers to trivia questions about obscure facts that were presented either visually or auditorily and were later tested for fact memory and source memory (i.e., modality of presentation). Elderly subjects showed poorer source memory than did young subjects, but it was not clear whether source memory was disproportionately impaired relative to fact memory. In a second experiment that used the Schacter et al. (1984) materials and experimental procedure, McIntyre and Craik found both fact and source-memory deficits in the elderly. Janowsky, Shimamura, and Squire (1989) included groups of old and young control subjects in a study that focused primarily on source memory in patients with frontal lobe lesions. Using a paradigm similar to the one developed by Schacter et al. (1984) with a 1-week

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retention interval, Janowsky et al., in their first experiment, failed to show significant differences between old and young subjects in either fact or source recall, and a second experiment revealed an overall trend for lower fact memory and lower source memory in the old subjects relative to the young subjects. Kausler and Puckett (1981) reported that memory for a specific source attribute—sex of voice—was impaired in elderly adults but also observed that memory for previously studied sentences was even more impaired. However, this study does not allow a straightforward comparison between fact and source memory because Kausler and Puckett investigated memory for sex of voice with a recognition test and sentence memory with a recall test.

Pertinent data have also been provided by recent studies that have used experimental paradigms developed in the study of reality monitoring (e.g., Johnson & Raye, 1981). In an experiment by Hashtroudi, Johnson, and Chrosniak (1989), subjects studied a list of words that was acquired from an internal source (e.g., imaging a word), an external source, or both. They found that elderly adults were not impaired relative to young adults in the condition that included both internal and external sources but were impaired in other conditions. However, older adults' recognition of target items was impaired relative to young subjects, as indicated by significantly lower d' scores in old than in young. Rabinowitz (1989) reported similar reality-monitoring deficits in elderly adults on a task in which subjects were required to judge whether a test item had previously been read or generated. However, Rabinowitz also found substantial recall and recognition deficits in the older group. Cohen and Faulkner (1989) observed age-related deficits on some, but not all, reality-monitoring tasks and also found diminished recognition accuracy in the old.

In summary, existing experimental evidence indicates that retrieval of source information is impaired in elderly subjects on a variety of tasks. This impairment of source memory has been implicated as a contributing factor to other memory problems experienced by older adults, such as telling the same story twice (Koriat, Ben-Zur, & Sheffer, 1988) or falsely judging a nonfamous name to be famous on the basis of a prior presentation of the name (Dywan & Jacoby, 1990). However, source-memory deficits have consistently been observed in conjunction with substantial deficits of item or fact memory. Thus, it is not yet clear whether or to what extent source memory is disproportionately impaired relative to fact memory in elderly adults, although several kinds of experimental (Cohen & Faulkner, 1989; Dywan & Jacoby, 1990) and correlational (Craik, Morris, Morris, & Loewen, 1990) evidence are consistent with this possibility. To address the issue directly, data are required from experimental conditions in which elderly subjects' fact memory is equivalent to that of young subjects. The present experiments provide such data.

Comparing Source and Fact Memory: Logic of Experimental Inference

As indicated by the foregoing discussion, the simple demonstration that elderly adults perform more poorly than young subjects on a test of source memory does not alone provide evidence of a selective or disproportionate impairment; it is also necessary to demonstrate source-memory impairments above and beyond any deficits in fact memory. A useful strategy in this regard is to match the level of fact memory in old and young subjects through an appropriate experimental manipulation and determine whether source-memory deficits in the elderly can still be detected.

One possible problem with such a matching strategy is that performance is equated at only a single point, thereby raising questions about the generality of results based on the matching procedure. To obtain a broader picture of the relation between fact and source memory in the elderly, we think that it is important to match fact recall at multiple levels of performance. Such a procedure could yield one of three possible outcomes: (a) Source memory is no more impaired than fact memory at all matching points, (b) source memory is disproportionately impaired relative to fact memory at all matching points, or (c) source memory is disproportionately impaired at some matching points but not at others. The first and second outcomes are relatively unambiguous: The former would provide evidence against, and the latter evidence for, a selective impairment of source memory in the elderly. The third outcome is perhaps less clear cut, although no less interesting, inasmuch as it would suggest that the relation between fact and source memory in the elderly varies across experimental conditions. Nevertheless, we think that this outcome does provide evidence for a selective impairment, although the evidence is somewhat weaker than would be provided by the second outcome. The reasoning here is that if source memory is not selectively disrupted in the elderly, then source recall should be no more impaired than fact recall across a wide range of experimental conditions.

To investigate source memory, we used a variant of the procedure developed by Schacter et al. (1984): Subjects were read fictitious facts about well-known people by one of two sources and were later tested for both fact and source recall. To allow comparisons between young and old subjects at more than one matching point, we tested fact and source recall at two retention intervals: 2 min and 2 hr. The logic here is straightforward: If old subjects recall fewer facts than young subjects at these delays, then fact memory can be matched in old and young by testing additional elderly subjects under conditions in which their level of fact recall is equivalent to the level of fact recall observed in young subjects at both 2-min and 2-hr delays. We accomplished this by providing elderly subjects with a sufficient number of extra study list exposures to yield matched performance.

We also attempted to generate additional matching points by varying the conditions under which facts and sources were studied. Specifically, we manipulated the organization of the study list. For some subjects, the study list was unorganized: The two experimental sources read each fact in a randomly determined order, with frequent alternation between sources. For the other subjects, list presentation was organized: Blocks of facts were read by each source according to an ABAB scheme. It is well-known that organizing a study list into blocks of conceptually related items improves recall of studied words and other materials (e.g., Mandler, 1968; Tulving, 1962), but there is no information concerning effects of contextual organization on source or fact memory. For our purposes, the key feature of the organizational manipulation is that it allows us to determine whether

source memory in elderly subjects is disproportionately impaired in both the blocked and random conditions at 2-min and 2-hr delays. However, to provide a benchmark for assessing fact recall performance in the blocked and random conditions, we also ran additional groups of old and young subjects in a single-source condition, where all facts were presented by one source.

One further issue concerns the distinction made by Schacter et al. (1984) between source forgetting and source amnesia. *Source forgetting* refers to situations in which subjects remember that a fact was acquired from an experimental source but attribute the fact to the wrong source (an intraexperimental source error). *Source amnesia* refers to situations in which subjects fail to remember that a fact was acquired from either experimental source and attribute it to guessing or to a source outside the experiment (an *extraexperimental* source error). Whereas amnesic patients show source amnesia even at brief retention intervals of several minutes (Schacter et al., 1984), elderly adults tend to show appreciable amounts of source amnesia only after a long (i.e., 1 week) delay (McIntyre & Craik, 1987). Because we tested subjects at 2-min and 2-hr delays, we expected to observe relatively little evidence of source amnesia. Accordingly, we focus on the accuracy of source memory, with the expectation that most source errors will be of the intraexperimental type. Note, however, that although source amnesia and source forgetting can be distinguished operationally, there is no strong reason to believe that they differ qualitatively.

Method

Main Experiment

Subjects. Forty elderly and 40 young subjects participated in the main experiment, with 20 subjects in each group assigned randomly to the blocked and random conditions. All subjects were paid $10.00 for their participation. Elderly subjects were recruited through advertisements and sign-up sheets posted in local public libraries, four different senior centers, and retirement newsletters from the University of Arizona. Young subjects were recruited through sign-up sheets posted at the University of Arizona.

All subjects were native speakers of English, performed normally on a reading screening test in which they read aloud from printed passages in standard book type, and passed (at 80% or better accuracy) a speech discrimination test consisting of repeating words and phrases from the Boston Diagnostic Aphasia Examination Repetition subtest (Goodglass & Kaplan, 1983) that were spoken by the experimenter. In addition, all subjects were individually interviewed to rule out those with a history of alcoholism or substance abuse; recent myocardial infarction or chronic cardiovascular disease; cerebrovascular accident; present or previous treatment for acute or chronic psychiatric illness; syphilis; brain damage sustained earlier from a known cause (e.g., hypoxia); chronic renal, hepatic, pulmonary, or endocrine disease; uncontrolled chronic hypertension; primary systemic illness; metabolic or drug toxicity; primary degenerative brain disorders (e.g., Alzheimer's disease, Parkinson's disease, or Huntington's disease); and cancer. Finally, no subjects were admitted to the study who had a score of 11 or greater on the Geriatric Depression Scale (Scogin, 1987; Yesavage et al., 1983) or who had subscale scores that were two or more standard deviations above the mean for older adults on the Brief Symptom Inventory (Hale, Cochran, & Hedgepeth, 1984).

Mean age of elderly subjects was 69.0 years (SD = 5.49; range = 60–81), whereas mean age of young subjects was 19.3 years (SD = 2.55; range = 17–30). To assess possible differences among subjects on various background measures of cognitive function, we performed a series of 2 × 2 analyses of variance (ANOVAs) in which the two between-subjects factors were age (old vs. young) and encoding condition (blocked vs. random). There were no effects of encoding condition in any of the analyses (all Fs < 1), nor were there any significant Age × Encoding Condition interactions (all Fs < 2.38), so we report only effects of age in the individual analyses. Elderly subjects had significantly higher mean years of education than did the young (old, 14.95 years; young, 12.53 years); $F(1, 79) = 31.28$, $MS_e = 117.61$; older subjects achieved correspondingly higher raw scores than did the young on the Vocabulary subtest of the Wechsler Adult Intelligence Scale—Revised (WAIS–R; old, 60.58; young, 51.83), $F(1, 79) = 26.61$, MS_e = 1,531.25, and on the Information subtest of the WAIS–R (old, 24.13; young, 20.53), $F(1, 79) = 19.83$, $MS_e = 304.21$. However, the young subjects obtained significantly higher raw scores than the old on the Logical Memory subtest of the Wechsler Memory Scale—Revised (WMS–R; old, 42.85; young, 52.33), $F(1, 79) = 11.99$, $MS_e = 2{,}194.51$, and on the Visual Reproduction subtest of the WMS–R (old, 60.98; young, 75.45), $F(1, 79) = 36.32$, $MS_e = 4{,}336.56$.

Materials. The target materials were 40 fictitious facts about well-known people taken from Schacter et al. (1984; e.g., "Bob Hope's father was a fireman"; "Elizabeth Taylor grows peaches in her orchard"). All 40 items were presented in the study list, half read by one source and half read by the other. The 40 target items were preceded and followed by a total of 8 similar buffer items (4 at the beginning of the list and 4 at the end of the list) that were not tested subsequently. In addition, 8 well-known facts about well-known people (e.g., "John F. Kennedy was assassinated in Dallas") were randomly inserted into the study list and also served as nontested buffer items.

Four videotapes were constructed for presentation of these materials. For each tape, a male and a female source were seated next to one another behind a testing table, facing the video camera. In the random condition, facts were randomly assigned to sources with the constraint that neither source could read more than three facts consecutively. Two versions of the tape for the random condition were made (Tapes 1 and 2), such that items read by the male source on Tape 1 were read by the female source on Tape 2, and items read by the female source on Tape 1 were read by the male source on Tape 2. Two further tapes were prepared for the blocked condition using a similar counterbalancing scheme. In the blocked condition, however, the list was divided into four main subsections that each consisted of 12 items (10 targets plus 2 buffers); one of the two sources read all items from a given subsection. Sources alternated between subsections according to an ABAB scheme. In addition, the first 4 and last 4 buffer items were read by a different source than the one that read the immediately following or preceding subsection.

Fact recall was tested by providing subjects with response sheets containing questions that required one- or two-word answers (e.g., "What job did Bob Hope's father have?"; "What does Elizabeth Taylor grow in her orchard?"). For each subject, two test forms were constructed; one form was administered at the 2-min delay, and one form was administered at the 2-hr delay. Each form contained half of the target items that had been read by each source. In addition, each form contained eight output buffer questions that asked about items that had not been presented before. Four buffer questions were designed to elicit relatively easy answers that could be attributed to an extraexperimental source (e.g., "What country did Adolf Hitler lead?"); the other four buffer questions queried about trivial items that were similar to the fictitious critical targets (e.g., "What is Gerald Ford's favorite type of pet?"). The buffer items were used by Schacter et al. (1984) to make it plausible for subjects to make extraexperimental source attributions.

Design and procedure. The main design consisted of a 2 (young vs. old) × 2 (blocked vs. random) × 2 (2-min vs. 2-hr delay) mixed factorial

in which age and study list organization were between-subjects variables and retention interval was a within-subjects variable. The experiment was completely counterbalanced such that each of the two sets of target materials were read equally often by each of the two experimental sources, studied equally often by the two subject groups, and appeared equally often in both study list conditions and at both retention intervals.

All subjects were told that they would be shown a videotape in which a man and a woman would read a series of facts about some famous people and that they should pay careful attention both to the facts and to the sources because they would be asked questions about them later. The appropriate videotape was then started, with about 4 s allowed for each source to read each fact. Subjects sat approximately 3 to 4 ft (0.9144 m to 1.2192 m) from the monitor. The entire videotape was shown twice to all subjects. After the conclusion of the second viewing of the videotape, subjects performed unrelated tasks for 2 min. They were then given a test sheet containing questions concerning half of the previously presented facts intermixed with the output buffers. Subjects were told to do their best to answer each question and were instructed to guess if they were not sure. They were also told to indicate the source of their answer for each question and were informed that for some questions the appropriate source was one of the two experimenters who had appeared on the videotape, whereas for other questions the appropriate source was outside of the experiment, such as television, school, or newspapers. Subjects were further instructed that if they could not recall a specific source for a particular fact, they should indicate a guess. The test typically required 10–15 min to complete.

After finishing the first test, subjects performed unrelated tasks until approximately 2 hr had elapsed since the conclusion of the study list. They were then tested with the other half of the study list facts and output buffers under the same conditions as during the 2-min test. At the conclusion of the 2-hr test, all subjects were debriefed concerning the nature of the experiment.

Single-Source Condition

To provide a benchmark for assessing fact recall performance in the blocked and random conditions, we ran an additional 20 elderly and 20 young subjects in a single-source condition. All aspects of the study and test procedures described for the main experiment were used, with the exception that only a single videotaped source read all of the study list materials. For half the subjects in the old and young groups, the female source from the main experiment presented all study list items, whereas for the other half, the male source from the main experiment presented all the items. To keep the test procedure as similar as possible to the procedure used in the blocked and random conditions, subjects were tested for both fact and source recall, although only the fact recall data are reported. Instructions were modified so that subjects were instructed to indicate whether they had acquired a recalled fact from the experimenter or from an extraexperimental source.

Mean age of old subjects in this condition was 71.9 (SD = 6.56, range = 60–82), whereas mean age of the young subjects was 20.3 (SD = 2.05, range = 18–25). Old and young did not differ significantly with respect to years of education (old, 14.9; young, 14.1), WAIS–R vocabulary (old, 56.4; young, 56.1), or information (old, 23.0; young, 21.9; all $ts < 1$), whereas young subjects scored significantly higher on WMS–R logical memory (old, 36.6; young, 57.4) and visual reproduction (old, 60.5; young, 75.4; $ts > 5.43$, $p < .001$).

Matching Conditions

We had expected that elderly adults would recall fewer facts than young subjects in both the blocked and random conditions and hence planned to run additional groups of elderly subjects in both conditions to obtain matched levels of fact recall. However, as discussed in the next section, level of fact recall in the blocked condition did not differ in old and young. Therefore, it was only necessary to run additional elderly subjects in the random condition. Pilot work indicated that with four study list exposures in the random condition, level of fact recall in the elderly was approximately equal to the levels observed in the young in the main experiment. Accordingly, an additional 20 elderly subjects were run in the random condition with four study list presentations.

The mean age of elderly subjects in the matching condition was 72.5 years (SD = 6.16; range = 61–83). These subjects were similar to the elderly subjects who participated in other aspects of the experiment with respect to years of education (14.8 years), raw scores on WAIS–R vocabulary (61.00) and information (23.55) and WMS–R logical memory (47.20) and visual reproduction (60.65). All aspects of materials, design, and procedure were the same as described for random condition subjects in the main experiment except that study list presentation was repeated four times.

Results

Main Experiment

Fact recall. Table 1 displays the proportion of facts recalled by old and young subjects tested under identical conditions. Not surprisingly, in the random condition young subjects recalled more facts than elderly subjects at both retention intervals. By contrast, in the blocked condition there was no evidence of a fact recall deficit in the old subjects; indeed, elderly adults recalled a slightly higher proportion of facts than did young subjects at both delays. An ANOVA revealed main effects of age, $F(1, 76) = 4.05$, $MS_e = .022$, $p < .05$; study condition, $F(1, 76) = 6.03$, $MS_e = .022$, $p < .02$; and retention interval, $F(1, 76) = 42.25$, $MS_e = .003$, $p < .001$. Most important, there was also an Age × Study Condition interaction, $F(1, 76) = 10.94$, $MS_e = .022$, $p < .002$, indicating that young subjects' level of fact recall was unaffected by the blocked–random manipulation, whereas elderly adults recalled fewer facts in the random than in the blocked condition. No other effects were significant. Separate ANOVAs were performed on the data from the random and blocked conditions. They showed that in the random condition, elderly adults recalled significantly fewer facts than the young, as indicated by a main effect of age, $F(1, 38) = 10.80$, $MS_e = .056$, $p < .01$, whereas in the blocked condition the main effect of age did not approach significance, $F(1, 38) = 1.21$, $MS_e = .029$.

Source recall. Table 1 also displays the overall proportion of sources recalled correctly. These results are characterized by a different pattern than the fact recall data: Elderly adults performed more poorly than young subjects in both the blocked and random conditions, and there were no differences in performance as a function of study condition. An ANOVA showed significant main effects of age, $F(1, 76) = 11.23$, $MS_e = .019$, $p < .001$, and retention interval, $F(1, 76) = 41.79$, $MS_e = .004$, $p < .001$. No other main effects or interactions were significant. The critical result here is that in the blocked condition, elderly adults showed poorer source memory than did young subjects at both retention intervals, even though the two groups showed equivalent levels of fact recall at each delay.

A separate ANOVA performed on the data from the blocked

Table 1
Proportions of Facts and Sources Recalled by Old and Young Subjects as a Function of Encoding Condition and Retention Interval

	Encoding condition/retention interval					
	Blocked			Random		
Item type	2 min	2 hr	*M*	2 min	2 hr	*M*
			Old			
Fact						
M	.843	.750	.796	.648	.528	.588
SD	.121	.178	.157	.219	.218	.224
Source						
M	.650	.570	.610	.655	.515	.585
SD	.139	.163	.155	.185	.218	.071
			Young			
Fact						
M	.798	.700	.748	.820	.740	.780
SD	.104	.196	.163	.174	.183	.180
Source						
M	.748	.653	.700	.748	.693	.721
SD	.119	.184	.162	.154	.165	.160

condition revealed main effects of age, $F(1, 38) = 4.21$, $MS_e = .035$, $p < .05$, and retention interval, $F(1, 38) = 14.64$, $MS_e = .011$, $p < .001$, together with a nonsignificant Age × Retention Interval interaction, $F(1, 38) < 1$. These results indicate that elderly adults' source memory was impaired at the 2-min and 2-hr delays in the blocked condition, even though fact recall in old and young did not differ at either delay.

Table 2 shows source recall data conditionalized on successful fact recall, with incorrect source responses separated into intraexperimental and extraexperimental errors. As in the unconditionalized analysis, old subjects recalled fewer correct sources than the young in both blocked and random conditions and at both the 2-min and 2-hr delays. An ANOVA on the proportion of sources recalled correctly revealed main effects of age, $F(1, 76) = 21.06$, $MS_e = .040$, $p < .001$, and retention interval, $F(1, 76) = 21.09$, $MS_e = .009$, $p < .001$. There was also an unexpected Age × Retention Interval interaction, $F(1, 76) = 6.31$, $MS_e = .009$, $p < .02$. The interaction reflects that in young subjects source recall conditionalized on fact recall was relatively unaffected by the retention interval, whereas old subjects showed forgetting across the delay, just as in the unconditionalized analysis. No other effects were significant.

Consideration of the distribution of errors indicates that, as expected, virtually all incorrect source responses were intraexperimental errors; there were few instances in which young or old subjects made extraexperimental errors for correctly recalled facts. The only condition in which extraexperimental errors exceeded 2% was the random condition for old subjects, but even here the overall proportion of extraexperimental source errors is too low to infer a meaningful trend. Thus, elderly adults' low level of source memory for recalled facts is almost entirely attributable to source forgetting; there was little evidence of source amnesia under the present experimental conditions. Elderly adults and young subjects did, however, make numerous extraexperimental errors for incorrectly recalled facts (approximately 20%–30% across conditions).

Single-Source Condition

The fact recall data from the single-source condition are presented in Table 3. Young subjects showed higher levels of fact recall than did the old at both delays, as indicated by significant main effects of age, $F(1, 38) = 16.06$, $MS_e = .046$, $p < .001$, and retention interval, $F(1, 38) = 21.78$, $MS_e = .009$, $p < .001$. The Age × Retention Interval interaction was not significant, $F(1, 38) = 3.22$, $MS_e = .009$.

The main purpose of the single-source condition was to provide points of comparison for evaluating fact recall in the blocked and random conditions of the main experiment. To accomplish this objective, we performed separate ANOVAs that compared fact recall in these two conditions to the single-source condition. For young subjects, fact recall in the single-source condition and in the random condition were similar, as indicated by a nonsignificant main effect of study condition, $F(1, 38) = 1.95$, $MS_e = .043$; however, recall in the single-source condition exceeded recall in the blocked condition, $F(1, 38) = 5.69$, $MS_e = .033$, $p < .05$. By contrast, for elderly subjects fact recall in the single-source condition was substantially lower than in the blocked condition, reflected by a main effect of study condition, $F(1, 38) = 8.29$, $MS_e = .049$, $p < .01$. There was a trend for the random condition to yield lower levels of fact recall than the single-source condition, but the main effect of study condition did not approach significance, $F(1, 38) = 1.14$, $MS_e = .074$. Thus, it looks as though elderly adults' superior fact recall in the blocked condition relative to in the random condition is attributable to the beneficial effects of blocked source presentation rather than to the interfering effects of random source presentation.

Table 2
Proportions of Source Responses Conditionalized on Correct Fact Recall in Old and Young Subjects as a Function of Encoding Condition and Retention Interval

	Encoding condition/retention interval					
	Blocked			Random		
Response type	2 min	2 hr	*M*	2 min	2 hr	*M*
			Old			
Correct source						
M	.674	.610	.644	.753	.649	.706
SD	.150	.202	.184	.182	.185	.195
Intraexperimental error						
M	.323	.387	.353	.220	.327	.268
SD	.132	.147	.138	.121	.130	.124
Extraexperimental error						
M	.003	.003	.003	.027	.024	.026
SD	.011	.011	.011	.034	.028	.030
			Young			
Correct source						
M	.803	.763	.784	.826	.811	.819
SD	.123	.198	.171	.177	.167	.174
Intraexperimental error						
M	.182	.229	.204	.162	.182	.171
SD	.115	.122	.117	.121	.102	.110
Extraexperimental error						
M	.016	.007	.012	.012	.007	.010
SD	.032	.015	.025	.021	.015	.018

Matching Condition

Because level of fact recall in old and young was matched naturally in the blocked condition of the main experiment, it was only necessary to run an additional group of elderly subjects in the random condition. The data presented in Table 4 indicate that with four study list presentations, elderly adults' level of fact recall performance was quite similar to that of young subjects with two study list presentations: Performance of the two groups was virtually identical at the 2-min delay (.833 for old and .820 for young), and elderly adults recalled a slightly higher proportion of facts (.780) than the young (.740) at the 2-hr delay. An ANOVA that compared performance in these two conditions showed no effect of age, $F(1, 38) < 1$; a main effect of retention interval, $F(1, 38) = 11.42$, $MS_e = .008$, $p < .002$; and a nonsignificant Age × Retention Interval interaction, $F(1, 38) < 1$.

The foregoing analyses indicate that our matching procedure was successful. However, in contrast to the results from the blocked condition, there was no evidence of a source memory deficit in the elderly at matched levels of fact recall in the random condition. Comparison of young subjects' data in Table 1 and old subjects' data in Table 4 indicates that there was a modest trend for higher source recall in elderly adults at matched levels of fact recall, both at the 2-min delay (.820 for old and .748 for young) and the 2-hr delay (.725 for old and .693 for young). An ANOVA comparing these results showed a main

Table 3
Proportions of Facts Recalled by Old and Young Subjects in the Single-Source Condition

	Retention interval		
Subject group	2 min	2 hr	*M*
Old			
M	.720	.585	.653
SD	.190	.197	.203
Young			
M	.875	.815	.845
SD	.105	.156	.134

Table 4
Proportions of Facts and Sources Recalled by Old Subjects After Four Exposures to the Random List as a Function of Retention Interval

	Retention interval		
Item type	2 min	2 hr	*M*
Fact			
M	.833	.780	.806
SD	.128	.211	.174
Source			
M	.820	.725	.773
SD	.097	.153	.135

Table 5
Proportions of Source Responses Conditionalized on Correct Fact Recall in Old Subjects After Four Exposures to the Random List

Response type	Retention interval		
	2 min	2 hr	*M*
Correct source			
M	.832	.769	.802
SD	.144	.186	.171
Intraexperimental error			
M	.168	.231	.197
SD	.094	.114	.104
Extraexperimental error			
M	.000	.000	.000
SD	.000	.000	.000

effect of retention interval, $F(1, 38) = 16.64$, $MS_e = .007$, $p < .001$; a nonsignificant effect of age, $F(1, 38) = 1.58$, $MS_e = .035$; and a nonsignificant Age × Retention Interval interaction, $F(1, 38) = 1.18$, $MS_e = .007$.

Table 5 shows source recall conditionalized on successful fact recall for old subjects following four study list presentations. As with the unconditionalized data, there is no evidence for a source-memory deficit in comparison with the corresponding conditionalized source recall results for young subjects (Table 2): The conditional probability of source recall given fact recall was .832 for the elderly and .826 for the young at the 2-min delay and .769 for the elderly and .811 for the young at the 2-hr delay. An ANOVA showed a nonsignificant effect of age, $F(1, 38) < 1$; a marginally significant effect of retention interval, $F(1, 38) = 4.26$, $MS_e = .006$, $p = .046$; and a nonsignificant Age × Retention Interval interaction, $F(1, 38) = 1.74$, $MS_e = .006$. The elderly made no extraexperimental errors for correctly recalled facts in this condition.

Discussion

Previous research has demonstrated that elderly adults show poor source memory relative to young subjects, but existing evidence does not provide a basis for determining whether source memory is disproportionately impaired or is just one symptom of a generalized episodic memory deficit. Our data indicate clearly that conditions exist in which source memory is disproportionately impaired relative to fact memory. In the blocked study list condition, elderly adults' level of fact recall did not differ from that of young subjects at 2-min or 2-hr delays. However, their overall level of source recall, as well as their level of source recall conditionalized on fact recall, were significantly lower than the corresponding proportions for young subjects at both delays, thereby demonstrating selective source memory deficits at multiple levels of matched fact recall.

Our results also indicate, however, that source memory is not disproportionately impaired in all experimental conditions: When levels of fact recall were matched between young and old in the random condition by providing a group of elderly subjects with four study list presentations, levels of overall and conditionalized source recall in young and old did not differ at either the 2-min or 2-hr delay. This overall pattern of results raises a number of significant issues, and we discuss each of them in turn.

Consider first the unexpected finding that levels of fact recall in old and young did not differ in the blocked condition. Our initial expectation was that the blocking manipulation might improve source memory, but this result was not observed in either young or old. Moreover, young subjects' level of fact recall was unaffected by the blocked versus random manipulation. The question, then, concerns why blocking the list by source selectively improved fact recall in elderly subjects.

One possibility is that the result is attributable to spurious group differences between elderly subjects in the blocked and in the random conditions. Even though subjects were assigned randomly to conditions, it is conceivable that elderly subjects in the blocked condition differed from elderly subjects in the random condition with respect to some characteristic that is related to memory performance. This possibility seems unlikely because source memory did not differ between the two groups. Moreover, analyses reported earlier (see Method section) indicated that elderly subjects in the blocked and random groups did not differ with respect to age, years of education, WAIS–R vocabulary and information, and WMS–R logical memory and visual reproduction. Clearly, then, the blocked–random effect cannot be attributed to any simple difference between the two groups of elderly subjects.

The results from the single-source condition shed some light on the nature of the blocked–random effect. It is possible that elderly adults showed poorer fact recall in the random than in the blocked condition because frequent switching among sources in the random condition is especially disruptive to elderly subjects. The single-source data cast doubt on this possibility, however, because elderly adults' fact recall in this condition did not differ significantly from fact recall in the random condition. The finding that elderly subjects recalled significantly more facts in the blocked condition than in the single-source condition (and in the random condition) suggests that some aspect of the blocking manipulation is especially beneficial to fact recall (but not to source recall) in elderly adults (but not in young adults).

Alternatively, instead of trying to explain why elderly adults' fact recall was facilitated by the blocking manipulation, we could ask why young subjects' fact recall was not impaired by this manipulation. Note, however, that there is no good reason to expect that blocking by source will facilitate fact memory; our initial hypothesis was that blocking might improve source memory. Accordingly, the surprising outcome of our research is that blocking selectively improved fact recall in the elderly. We cannot yet say very much about precisely what properties of the blocking manipulation would produce such a pattern of results, and a detailed investigation of this issue lies beyond the scope of the present article. Further research is needed to replicate, extend, and explore the effects that we have observed. Along the same lines, it is not entirely clear why the blocking manipulation failed to influence source recall. One possibility is that the source recall of elderly adults was at the chance level and that this floor effect precluded the possibility of observing any effect of the blocking manipulation. Unfortunately, it is diffi-

cult to determine chance performance in our paradigm because subjects were allowed to make a variety of source responses (i.e., Experimenter A, Experimenter B, and various extraexperimental alternatives). Although subjects did not make many extraexperimental errors for correctly recalled facts, both young and old did make many extraexperimental errors for incorrectly recalled facts and used a variety of source responses. Note, however, that young subjects' source recall performance was also unaffected by the blocking manipulation, even though it was significantly higher than that of the old, thereby ruling out any possibility of a floor effect. It remains to be determined whether other types of contextual organization manipulations affect source memory in either young or old.

For our purposes, the crucial point is that the blocking manipulation produced equivalent levels of fact recall in the old and the young at two delays and at the same time revealed impaired source memory in the old at both matching points. Further documentation of elderly subjects' source-memory impairment was provided by the analysis of source recall conditionalized on successful fact recall: As in the unconditionalized analysis, source recall was impaired at both delays in the elderly subjects. In view of these results, it appears that elderly adults' poor source memory, as documented in previous studies (Cohen & Faulkner, 1989; Craik et al., 1990; Dywan & Jacoby, 1990; Hashtroudi et al., 1989; McIntyre & Craik, 1987; Rabinowitz, 1989) and in the present experiment, is not a simple consequence of a generally weak or degraded episodic memory.

In the context of this evidence for a disproportionate source-memory deficit in the elderly, the data from the random condition indicating no source deficit with matched fact recall are both important and puzzling. On the one hand, these results underscore the point made earlier about the need to use multiple matching points to avoid premature acceptance of the null hypothesis: Had we included only the random condition, we would have been tempted to conclude that source memory is no more impaired in elderly subjects than fact memory. On the other hand, while the data from the blocked condition establish that conditions exist in which source memory is disproportionately impaired in the elderly, they also raise the question of why the disproportionate deficit is revealed in one encoding condition and not in another. Stated slightly differently, the data from elderly subjects in the blocked condition suggest a degree of independence between source and fact memory, whereas the data from the other experimental conditions indicate positive correlation between the two.

The present results do not allow us to resolve these issues, nor do we know of any models of cognitive aging that would predict or readily explain the critical pattern of results. Thus, we think that our data constitute an empirical puzzle that should stimulate ideas and hypotheses about the nature of aging and memory. Nevertheless, there are several points about this puzzle, and possible approaches to understanding it, that we wish to note.

First, as discussed in the introduction, the existence of a disproportionate deficit in one set of encoding conditions and not in another suggests that the relation between fact and source memory in the elderly varies across experimental conditions. Of course, this type of relation necessarily implicates some degree of disproportionate deficit—that is, if source memory is not selectively impaired in old subjects, then we should fail to observe disproportionate impairments across a range of experimental conditions; our data indicate otherwise. Nevertheless, the present evidence for selective impairment is not as strong as would have been the case had the elderly shown selective source-memory impairments at all matching points. More generally, however, our results indicate that the relation between fact and source memory in the elderly is rather more complex than was previously thought and also highlight the need to include multiple matching points in experiments that investigate the issue. This general point may also apply to the broader literature on memory for contextual information in the elderly, where there is little evidence for a disproportionate contextual deficit (e.g., Denney, Miller, Dew, & Levav, in press); it is possible that such a deficit may be observed under specific experimental conditions that remain to be elucidated.

A second point concerns problems that our data raise for any attempt to interpret the disproportionate deficit that we did observe in terms of task or item difficulty (cf. Chapman & Chapman, 1973; McDowd & Craik, 1988). If we were to consider only the data from the blocked condition, it might be possible to argue that (a) the task of source recall is in some sense more difficult than the task of item recall, (b) elderly subjects are generally more impaired than young subjects, and (c) even though levels of fact recall do not differ between old and young in the blocked condition, the more impaired group (i.e., the elderly) still performs more poorly than the less impaired group (i.e., the young) on the difficult source recall test. The data from the random condition, however, provide a basis for rejecting such a task difficulty interpretation: If source recall is in some sense a more difficult task than fact recall and hence necessarily impairs the old more than the young, then elderly subjects' source recall should have been impaired in the random condition when their level of fact recall was matched to that of young subjects, but it was not. This observation indicates that elderly subjects' disproportionate source-memory deficit in the blocked condition should not be attributed to some sort of generalized task difficulty factor and highlights again the specific nature of this age-related impairment.

One possible account of such a deficit would involve an appeal to deficits in frontal lobe functioning that have been observed in the elderly (Craik et al., 1990). Evidence exists that frontal lobes play an important role in memory for certain kinds of contextual information (e.g., Janowsky et al., 1989; Schacter, 1987; Shimamura, 1989). Schacter et al. (1984) reported that in amnesic patients, performance on tasks sensitive to frontal lobe pathology correlated significantly with extent of source amnesia (i.e., proportion of extraexperimental source errors conditionalized on correct fact recall). Craik et al. observed a similar pattern of correlation between source amnesia and performance on frontal-sensitive tasks in elderly subjects. It is thus conceivable that the source-memory deficits that we observed are in some way related to specific deficits in frontal lobe functioning.

We collected data concerning elderly adults' performance on two tasks that are sensitive to frontal lobe dysfunction, which were both used by Schacter et al. (1984) and Craik et al. (1990): the modified Wisconsin Card Sorting Test (WCS; Hart, Kwentus, Wade, & Taylor, 1988) and a verbal fluency test (Benton & Hamsher, 1978). Because we observed virtually no extraexperi-

mental errors for correctly recalled facts in the present experiment, it was not possible to meaningfully investigate correlations between source amnesia and frontal task performance. However, we did examine correlations between source recall (conditionalized on correct fact recall) and performance on each of the frontal-sensitive tasks in the blocked and random conditions of the main experiment, where elderly adults exhibited source-memory impairment. Overall, there were nonsignificant correlations between the probability of source recall conditionalized on fact recall and the number of correct responses on the verbal fluency task ($r = -.09$) or the number of correct responses on the WCS task ($r = +.04$). There was, however, a significant negative correlation between conditionalized source recall and proportion of perseverative errors on the WCS, $r = -.29$, $t(38) = 1.95$, $p < .05$. Thus, poor source memory in the elderly was associated, albeit rather weakly, with an enhanced tendency to commit perseverative errors on the WCS (a perseverative error occurs when a subject sorts incorrectly on the basis of a sorting rule that was correct on previous trials). The tendency to commit perseverative errors on the WCS is a more sensitive indicator of the presence of frontal damage than is the total correct response score (Milner, 1963) and is a hallmark of patients with damage to frontal cortex (for review, see Stuss & Benson, 1986). There was a nonsignificant correlation between fact recall and perseverative errors on the WCS, $r = -.15$, $t(38) = .90$, which suggests that the observed negative correlation between source recall and perseverative errors is specific to source memory. However, the difference between the source-recall/perseverative error correlation and the fact recall/perseverative error correlation, as assessed with a test that takes into account the correlation between fact and source memory (Bruning & Kintz, 1977), was not significant, $t(77) = 1.03$.

The foregoing analyses are only partially consistent with the hypothesis that frontal lobe dysfunction plays a role in source-memory deficits exhibited by the elderly. Moreover, the notion of frontal lobe dysfunction is rather broad, subsuming a number of related processes and functions that appear to depend on different parts of frontal cortex (cf. Damasio, 1979; Schacter, 1987; Stuss & Benson, 1986); it is questionable whether the verbal fluency and WCS tests tap the same components of frontal function that may underly source memory. And even to the limited extent that our data suggest some role for frontal dysfunction, it is not clear how such dysfunction could produce a disproportionate source-memory deficit in one experimental condition and not in another. Further understanding of both cognitive and neuropsychological aspects of source-memory deficits in elderly adults will require experimental studies that examine fact and source recall at multiple levels of performance, across a range of experimental conditions, and in relation to a variety of neuropsychological measures.

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