Psychology and Aging
1994, Vol. 9, No. 1, 81-89

0882-7974/94/$3.00

Source Memory: Extending the Boundaries of Age-Related Deficits

Daniel L. Schacter, Dana Osowiecki, Alfred W. Kaszniak, John F. Kihlstrom, and Michael Valdiserri

Previous research has established that elderly adults can exhibit impaired memory for the source of newly acquired facts even when levels of fact recall in old and young do not differ. However, source memory impairments have been observed only under conditions of many-to-1 mapping: A large number of facts are related to either of 2 sources. It is thus possible that apparent source memory impairments reflect a more general age-related problem in handling many-to-1 mappings. Two experiments provide evidence against this possibility by demonstrating age-related source memory deficits with 1-to-1 mapping between facts and sources. The data also indicate that source memory deficits are observed across encoding tasks that manipulate the allocation of attention to the source or to the fact.

The term *source memory* refers to recollection of the person or place from which an item or fact was acquired. A growing body of research has indicated that source memory can be dissociated from item or fact memory. Studies of hypnotic amnesia (Evans, 1979; Evans & Thorn, 1966), organic amnesic syndromes (Schacter, Harbluk, & McLachlan, 1984; Shimamura & Squire, 1987), and patients with frontal lobe lesions (Janowsky, Shimamura, & Squire, 1989) have all provided evidence for selective loss of source memory, a condition sometimes referred to as *source amnesia* (cf. Evans & Thorn, 1966; Schacter et al., 1984).

Recent studies of aging memory have pointed toward a similar dissociation in elderly adults. For example, McIntyre and Craik (1987, Experiment 2) investigated source memory with a paradigm developed by Schacter et al. (1984) in which subjects are told a series of fictitious facts by either of two experimental sources. McIntyre and Craik found that the elderly showed marked impairments relative to the young in recollecting the source of retrieved facts and exhibited considerable source amnesia when tested at a 1-week delay; however, they also showed impaired fact memory. Several studies have provided evidence concerning source memory and aging by using reality monitoring paradigms in which subjects attempt to remember how they acquired a study list word (e.g., from reading, generating, or an external source). Cohen and Faulkner (1989), Hashtroudi, Johnson, and Chrosniak (1989), and Rabinowitz (1989) all reported age-related source memory deficits under certain experimental conditions, together with impairments of item recognition.

The experimental evidence to date, then, clearly indicates that old adults exhibit source memory deficits and raises the possibility that memory for source information may be especially or selectively disrupted by aging (see also, Dywan & Jacoby, 1990; Kausler & Puckett, 1981; for review, see Johnson, Hastroudi, & Lindsay, 1993; Schacter, Kihlstrom, Kaszniak, & Valdiserri, 1993). If source memory is indeed especially affected by aging, this observation might provide important clues concerning the mechanisms of age-related memory loss. However, the aforementioned studies also found that old adults are characterized by impaired retention of items or facts, thereby suggesting that poor source memory may be simply an expression of generalized episodic memory impairment.

Two recent studies have provided evidence that the elderly can exhibit source memory deficits that are disproportionate to their deficits in item or fact recall. Schacter, Kaszniak, Kihlstrom, and Valdiserri (1991) used a variant of the Schacter et al. (1984) fictitious facts paradigm in which presentation of facts was blocked so that each source presented a segment of the list. Under these encoding conditions, Schacter et al. (1991) reported impaired source memory in old subjects at each of two retention intervals in which their level of fact memory was indistinguishable from that of young subjects. Ferguson, Hashtroudi, and Johnson (1992) found that when multiple cues to source were made available to subjects (e.g., perceptual and spatial cues), old adults exhibited a source memory deficit under conditions in which their level of item recognition was equivalent to that of young subjects.

Importantly, however, both Schacter et al. (1991) and Ferguson et al. (1992) also uncovered conditions in which source memory was not disproportionately impaired in relation to fact recall or item recognition. In the Schacter et al. study, elderly adults failed to exhibit a disproportionate source memory deficit in an unblocked condition where fact presentation alternated randomly between sources, and Ferguson et al. did not observe age-related source memory deficits when only a single cue to source was available to subjects. Thus, a variable relation was observed between item and source memory across experimental conditions.

The foregoing studies have provided a beginning empirical foundation for evaluating the status of source memory in old adults. However, it seems equally clear that experimental

Daniel L. Schacter and Dana Osowiecki, Department of Psychology, Harvard University; Alfred W. Kaszniak, John F. Kihlstrom, and Michael Valdiserri, Department of Psychology, University of Arizona.

This research was supported by National Institute on Aging Grant 1 RO1 AG08441-01.

We thank Wilma Koutstaal for comments concerning an earlier draft of this article.

Correspondence concerning this article should be addressed to Daniel L. Schacter, Department of Psychology, William James Hall, Harvard University, 33 Kirkland Street, Cambridge, Massachusetts 02138.

knowledge of the phenomenon is limited, and theoretical understanding of it is rather modest. The purpose of the present study is to enhance our knowledge and understanding of source memory in the elderly by examining two unexplored, but potentially important, aspects of the relation between source and fact memory. The first concerns the nature of the *mapping* between facts and sources. All published studies of source memory and aging have used a *many-to-one* mapping between facts and sources: A large number of items or facts have been imparted by a small number of sources (usually two). Thus, each source is associated with numerous facts. It is possible that when disproportionate source memory deficits are found in the elderly, they can be attributed to a general problem in handling many-to-one mappings (of any kind) rather than to specific problems with remembering source information. That is, the elderly may be especially sensitive to interference effects that arise when a cue is "overloaded" (Watkins & Watkins, 1975) by associating it with a large number of target items. We refer to this idea as the *cue overload* hypothesis. To test this hypothesis, we examine fact and source memory under conditions in which there is a one-to-one mapping between fact and source.

We also examine the possibility that source memory deficits in the elderly are attributable to differences in the allocation of attention to facts and sources by old and young adults. In previous studies, subjects have either been instructed to attend to both facts and sources in preparation for a memory test (e.g., Schacter et al., 1991) or have been tested under conditions of incidental learning (e.g., Ferguson et al., 1992). However, there have not been any attempts to control or manipulate systematically whether subjects attend to the item or to the source. It is conceivable that old adults allocate less attention to the source than do young subjects. For example, if old adults have less attentional or working memory capacity available than do the young (e.g., Craik, 1991; Zacks & Hasher, 1988), then they may focus their limited attentional resources primarily on the target item, resulting in disproportionately poor source recall. We refer to this as the *differential attention* hypothesis. To test this hypothesis, we manipulate systematically whether subjects attend primarily to the fact or to the source at the time of study.

Experiment 1

To investigate the cue overload hypothesis, it is necessary to develop an experimental paradigm in which each to-be-remembered fact is uniquely associated with a single source; this task poses a number of methodological challenges. For example, in the typical two-source paradigm, subjects can indicate recollection of source with reference to a salient distinguishing property of the two sources (i.e., male or female, left or right side of the room, and so forth). If, however, subjects are presented with a typical list of 30 to 40 facts, each presented by a unique and unfamiliar source, then it is no longer obvious how subjects can indicate their recollections of source without ambiguity. One possibility would be to teach subjects the names of the sources before the experiment. A drawback with this approach, however, is that old adults would probably require more training trials than young adults to learn the names, thereby producing differential familiarity with the sources. In addition, even if impaired source memory were observed in the elderly, it would always be possible to attribute forgetting to a failure of name retrieval.

We developed an alternative approach to the problem. Specifically, we created a series of sources, each of whom could be identified uniquely by a particular combination of binary attributes: male or female, black or white, old or young, wearing glasses or not, and wearing a hat or not. The orthogonal combination of these attributes yielded a set of 32 unique sources that could be specified by subjects in terms of the appropriate pattern of the five attributes. Thus, for example, when asked which source imparted the fictitious fact that "Bob Hope's father was a fireman," subjects could respond by indicating that it was a young/black/female/wearing a hat/not wearing glasses.

To evaluate the differential attention hypothesis, we used two different orienting tasks to control the allocation of attention during the study task. To focus attention primarily on the fact, we required subjects to make *believability* judgments: They rated the extent to which each fictitious fact was a believable assertion about the target person. To focus attention primarily on the source, we required subjects to make *likability* judgments: They rated the likability of each face.

The experiment consisted of two parts. In the first part, old and young subjects were run under identical conditions, and fact and source memory were compared. On the basis of previous research, we expected that old adults would exhibit lower levels of fact recall than the young. To evaluate source memory under conditions in which levels of fact recall were equivalent in old and young, we included a second part of the experiment in which levels of fact recall were equated in old and young by giving an additional group of elderly subjects additional study list exposures. The critical question concerns the relative degree of source recall in old versus young when levels of fact recall in the two age groups are equated.

According to the cue overload account noted earlier, we should not observe evidence for disproportionate source memory problems in the elderly (given equivalent levels of fact recall), because the one-to-one mapping between facts and sources eliminates the cue overload problem. If, however, source memory problems in the elderly are not attributable to cue overload, then some evidence for disproportionate source memory impairment should be observed. According to the differential attention hypothesis, age-related source memory impairments are attributable to elderly adults' allocation of attention to target facts at the expense of the sources. Thus, the most straightforward prediction from this hypothesis is that source memory deficits in the elderly should be attenuated or even eliminated in the likability encoding condition, which focuses subjects' attention on source characteristics.

Method

Main Experiment

Subjects. Thirty-two elderly and 32 young subjects participated in the main experiment. Sixteen subjects in each age group were assigned randomly to the likability or believability encoding conditions. Subjects were paid $10 for their participation. Elderly subjects were recruited from advertisements placed in local newspapers, and young subjects were recruited through sign-up sheets posted at Harvard University.

All subjects were native speakers of English 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 interviewed individually to rule out those with a history of alcoholism or substance abuse, recent myocardial infarction, cerebrovascular accident, present or previous treatment for acute or chronic psychiatric illness, syphilis, brain damage sustained earlier from a known cause (e.g., hypoxia), metabolic or drug toxicity, and primary degenerative brain disorders (e.g., Alzheimer's disease, Parkinson's disease, or Huntington's disease).

Elderly subjects had a mean age of 68.3 years (SD = 5.13, range = 61–78), and they had an average of 15.39 years of education (SD = 2.80, range = 8–20). The mean age of young subjects was 19.8 years (SD = 1.51, range = 17–24), and they had an average of 14.16 years of education (SD = 1.23, range = 12–17). All subjects completed the Vocabulary and Information subtests of the Wechsler Adult Intelligence Scale—Revised (WAIS-R; Wechsler, 1981). Elderly adults achieved a mean score of 62.59 (SD = 8.15, range = 38–70) on the WAIS-R Vocabulary subtest and a mean score of 22.92 (SD = 4.01, range = 14–29) on the Information subtest. Young subjects performed similarly, averaging 65.13 (SD = 3.43, range = 58–70) on the Vocabulary subtest and 24.40 (SD = 2.33, range = 19–28) on the Information subtest.

We assessed performance on each of the WAIS-R subtests with 2 × 2 analyses of variance (ANOVAs) in which age (old vs. young) and experimental condition (believability vs. likability encoding task) were the between-subjects variables. No significant effects were observed for either measure. For years of education, however, there were significant effects of age, $F(1, 60) = 5.63$, $MS_e = 4.22$, $p < .05$, and experimental condition, $F(1, 60) = 8.89$, $MS_e = 4.22$, $p < .01$. These analyses indicate that the old subjects had on average 2 more years of education than did young subjects and that subjects in the likability condition had on average 2 more years of education than subjects in the believability condition. Because these small differences are not related in any obvious way to the between-group differences that we observed in the experiment, we do not discuss them further.

Materials. The target materials were 32 fictitious facts about well-known people taken from Schacter et al. (1984, 1991), such as "John Wayne was a minister before becoming an actor" and "Elizabeth Taylor grows peaches in her orchard." All of the target facts were spoken and recorded by each of the 32 sources who participated in the experiment, using a MacRecorder with SoundEdit software. We then randomly selected one fact for each source to be used in the experiment.

Each of the 32 sources was uniquely identified by a specific combination of five features: They were either male or female, black or white, young (18–27 years) or old (60–80 years), wearing a hat or not wearing a hat, and wearing glasses or not wearing glasses. Color photographs were taken of each source sitting in front of a flat, white background. Focal length was held constant at approximately 4 ft (1.2 m) so that the source's face filled the entire picture frame. The photographs were scanned into the computer with a Microtek flatbed color/gray scanner using Adobe Photoshop 3.0 software. Any extraneous border area surrounding the photo was cropped so that each photo would fill as much of the screen as possible. Adjustments were also made in the hue, saturation, and brightness so that all the photographs were as standard as possible. The sources were presented on the computer screen as digitized 7 × 5-in. (17.8 × 12.7-cm) color photographs. The resolution of the photographs as they appeared on the monitor was 72 pixels per inch (about 28 pixels per centimeter).

Stimuli were presented on a Macintosh IIfx and a Macintosh Quadra 700, each equipped with a 13-in. (33-cm) color monitor with an Apple 8-24 GC color accelerator video card set to 24-bit color mode. The application used to present stimuli was Aldus Supercard 1.6.

Design and procedure. The main design consisted of a 2 (young vs. old) × 2 (likability vs. believability) factorial, in which age and encoding task were between-subjects variables.

In the likability condition, young and old subjects were told that they would be viewing photographs of people on the computer screen and rating how likable they appeared on a 1–4 scale (1 = *very unlikable*, 2 = *somewhat unlikable*, 3 = *somewhat likable*, and 4 = *very likable*). Subjects were told that performing the rating task would make it easier for them to remember the individuals later. Subjects were also asked to repeat what each source said immediately after each fact was presented (during the first study exposure) to ensure that they correctly heard each trivial fact. In the believability condition, young and old subjects were told that they would be viewing photographs of people who were stating trivial facts and that they should rate the believability of the facts on a 1–4 scale (1 = *very unbelievable*, 2 = *somewhat unbelievable*, 3 = *somewhat believable*, and 4 = *very believable*). Subjects were told that performing the rating would help them to remember the facts later, and they were asked to repeat each fact during the first viewing.

The 32 target items were presented in random order during the study phase. Subjects were exposed to the targets twice, with the second list exposure immediately following the first; they sat approximately 2 ft (0.6 m) from the computer screen. Photographs were presented for 5 s, during which a recording of the source stating the appropriate fictitious fact was played at a normal conversational level. Immediately following each source presentation, subjects viewed on the monitor either a likability rating scale or a believability rating scale. Subjects were asked to make their rating by pressing a number from 1 to 4 on the computer keyboard.

The study phase was followed by a 10-min delay, after which the experimenter tested subjects on fact recall by asking questions that required one or two word answers (e.g., "What did John Wayne do before becoming an actor?" "What does Elizabeth Taylor grow in her orchard?"; Schacter et al., 1984). In addition, each subject was asked to identify the source for each item by specifying each of the five criteria for each source (i.e., What was each source's age, sex, race, and were they wearing a hat or no hat, or glasses or no glasses?).

The experiment lasted approximately 50 min. After completing the recall task, subjects were debriefed concerning the nature and purpose of the experiment.

Matching Condition

We had expected that old adults would remember fewer facts than the young subjects, but this outcome was observed only in the likability encoding condition; old and young subjects recalled approximately equal numbers of facts in the believability condition (see the *Results* section). Accordingly, to achieve matched levels of fact recall it was necessary to test additional elderly subjects only in the likability encoding condition. In an attempt to bring their fact recall to a level similar to that obtained by the young, we gave elderly subjects in the matching group three study list presentations.

Sixteen old adults who had not previously participated in the experiment were assigned to the matching group. Their mean age was 68 years (SD = 4.88, range = 62–76), they had an average of 16.18 years of education (SD = 2.21, range = 12–20), and their mean scores on the WAIS-R Vocabulary and Information subtests were 65.41 (SD = 6.70, range = 47–70) and 23.66 (SD = 3.44, range = 16–28), respectively. The Vocabulary and Information scores of these subjects did not differ significantly from those of young subjects in the likability condition, but the elderly did have on average 2 more years of education than the young, $t(14) = 2.81$, $p < .05$. All aspects of the materials and testing procedure were the same as described previously for the likability condition, except that the subjects in the matching group were exposed to all facts and sources three times instead of only twice.

Results

A preliminary analysis was carried out that compared the mean likability and believability ratings of young and old subjects during the encoding tasks, and no significant differences were observed. We also examined consistency of rating across the two study exposures for the likability and believability tasks. Ratings were highly correlated across exposures on both tasks, and the pattern of correlations was virtually identical in young and old subjects (all $rs > .74$).

Fact Recall

Consider first the fact recall data, presented in Table 1. For both old and young subjects, fact recall was much higher in the believability condition than in the likability condition. The young exhibited considerably higher levels of fact recall than did the old in the likability condition but showed only slightly higher fact recall in the believability condition. A 2 × 2 mixed model ANOVA revealed main effects of encoding condition, $F(1, 60) = 91.96$, $MS_e = 0.026$, $p < .001$, and age, $F(1, 60) = 7.45$, $MS_e = 0.026$, $p < .001$, together with a marginally significant Encoding Condition × Age interaction, $F(1, 60) = 3.82$, $MS_e = 0.026$, $p = .055$. A significant age difference in the likability condition was revealed through t tests, $t(30) = 2.55$, $p < .05$, together with a nonsignificant age difference in the believability condition, $t(30) = 0.98$. Thus, even though we achieved (somewhat unexpectedly) matched levels of fact recall between young and old in the believability condition, the apparent matching may be attributable to ceiling effects (see the *Discussion* section).

Source Recall

The data concerning source recall are depicted in Table 2. To analyze these data, we used two different scoring criteria. According to the strict criterion, source recall was scored as correct only when subjects remembered all five source attributes accurately (chance level of performance = .031). However, because levels of source memory were quite low when the strict criterion was used, we also used a lenient criterion. According to the lenient criterion, source recall was scored as correct when subjects remembered correctly the three main source attributes of gender, race, and age, irrespective of whether they remembered the two more peripheral attributes (i.e., glasses/no glasses and hat/no hat; chance level of performance = .125).

Table 1
Proportions of Facts Recalled by Old and Young Subjects in Experiment 1

Subject group	Encoding condition: Believability	Encoding condition: Likability
Old		
M	.899	.432
SD	.096	.219
Young		
M	.930	.621
SD	.085	.200
Old matched		
M		.635
SD		.205

Table 2
Proportions of Sources Recalled by Old and Young Subjects as a Function of Encoding Condition and Scoring Criteria in Experiment 1

Subject group	Believability: Strict	Believability: Lenient	Likability: Strict	Likability: Lenient
Old				
M	.045	.151	.053	.191
SD	.065	.117	.047	.126
Conditionalized *M*[a]	.048	.155	.049	.224
SD	.067	.115	.058	.175
Young				
M	.170	.473	.186	.391
SD	.120	.194	.154	.202
Conditionalized *M*	.175	.472	.209	.472
SD	.124	.196	.175	.208
Old matched				
M			.072	.235
SD			.077	.152
Conditionalized *M*			.084	.265
SD			.083	.174

[a] Conditionalized on correct fact recall.

As the data in Table 2 indicate, old adults exhibited lower levels of source recall than did the young in both encoding conditions and according to both scoring criteria. Consider first overall source memory performance. For the strict scoring criterion, an ANOVA revealed a highly significant main effect of age, $F(1, 60) = 23.90$, $MS_e = 0.011$, $p < .001$, together with a nonsignificant effect of encoding condition and a negligible interaction between the two variables (both $Fs < 1$). For the lenient scoring criterion, the same pattern was observed: There was a highly significant effect of age, $F(1, 60) = 40.44$, $MS_e = 0.027$, $p < .001$, together with a nonsignificant effect of encoding condition and a nonsignificant interaction between the two (both $Fs < 1$). Two-tailed t tests revealed that old adults' level of source recall did not differ significantly from chance in either the likability or believability conditions, $t(15) = 1.24$ and $t(15) = 0.86$, respectively, whereas young subjects' source memory was well above chance in both conditions, $t(15) = 4.03$ and $t(15) = 4.63$, respectively, $p < .01$.

Table 2 also presents source recall conditionalized on correct fact recall. The pattern of results was the same as in the nonconditionalized data: Older adults exhibited markedly lower levels of source recall than did the young. There were main effects of age for both the strict criterion, $F(1, 60) = 24.30$, $MS_e = 0.013$, $p < .001$, and the lenient criterion, $F(1, 60) = 40.52$, $MS_e = 0.031$, $p < .001$, with no other effects approaching significance (all $Fs < 1$). Although source recall in young subjects was much higher than the chance level of .125, source recall in the elderly did not differ significantly from chance in the believability condition, $t(15) = 0.88$, although it showed borderline levels of significance in the likability condition, $t(15) = 2.10$, $p < .10$ (two-

tailed). Thus, the elderly were much less likely to remember the source of correctly recalled facts than were the young and were almost entirely unable to remember accurately any sources of correctly recalled facts.

Matched Fact Recall

As noted earlier, levels of fact recall in the believability condition did not differ in old and young, so we did not run additional matching subjects in this condition. For the likability condition, the mean level of fact recall in the elderly matching group was .635 (Table 1). This value is nonsignificantly higher than the level of fact recall (.621) observed in young subjects, $t(30) < 1$. Nevertheless, the matched elderly subjects still showed lower levels of source recall than did young subjects, according to both the strict criterion (.072 vs. .186) and the lenient criterion (.235 vs. .391; Table 2). Both differences were significant, $t(30) = 2.63$ and $t(30) = 2.48$, respectively, $p < .01$. The elderly did, however, achieve above-chance levels of source recall with both the strict criterion, $t(15) = 2.13$, $p = .05$, and the lenient criterion, $t(15) = 2.89$, $p < .05$. When source recall was conditionalized on correct fact recall, young subjects still showed significantly higher levels of performance than the old with both strict and lenient criteria, $t(30) = 2.59$ and $t(30) = 3.04$, $p < .01$, respectively. The conditionalized data revealed above-chance levels of source recall for the elderly according to both the strict and the lenient criteria, $t(15) = 4.04$ and $t(15) = 3.22$, $p < .01$, respectively.

Discussion

The most important outcome of Experiment 1 is that old adults exhibited disproportionately impaired source recall relative to young subjects when there was a one-to-one mapping between facts and sources, thus providing evidence against the cue overload hypothesis. In addition, the disproportionate deficit was observed in both the believability and likability conditions. This outcome is inconsistent with the differential attention hypothesis because it shows that age-related impairments of source memory can be observed even when an encoding task (likability judgment) focuses attention on source characteristics.

One potential objection to the latter point emerges from the failure to find significantly higher levels of source memory in the likability condition than in the believability condition; all analyses of the source recall data revealed nonsignificant main effects of encoding task and nonsignificant Encoding Task × Age interactions. If the likability condition had indeed successfully focused study processing on source characteristics, one might have expected this to be reflected by higher levels of source recall in the likability than in the believability condition. Note, however, that overall levels of fact recall in the believability condition were much higher than in the likability condition. It is possible that this generally higher level of memory performance in the believability condition worked against finding a source memory advantage in the likability condition. Consistent with this suggestion, the elderly were able to achieve above-chance levels of source memory in the likability condition, whereas their source recall consistently remained at chance levels in the believability condition, even when they achieved near perfect (i.e., 90%) levels of fact recall. These considerations suggest that the likability rating task did indeed focus old adults' attention on source characteristics.

To address this point more directly, we attempted to provide a manipulation check by running additional elderly adults in the likability and believability conditions and then testing them with a yes–no recognition task. On a yes–no recognition test, memory for the sources can be assessed without the confounding influence of the differing levels of fact recall observed in the believability and likability tasks. Thus, if the likability task does indeed focus old adults' attention on the source to a greater extent than the believability task, they should exhibit more accurate recognition memory after likability judgments than after believability judgments. Twelve elderly adults were randomly assigned to each encoding condition; their mean age (67.33 years), years of education (14.67 years), and WAIS–R subtest scores (Information = 23.00 and Vocabulary = 56.42) were comparable to those of subjects in Experiment 1, and the two groups did not differ significantly on any measure. The set of 32 sources was divided into two sets of 16, Set A and Set B. Half of the subjects in each encoding condition studied Set A and half studied Set B; the nonstudied sets for each group were used as distractor items on the recognition test. The likability and believability encoding tasks were administered exactly as in Experiment 1, except that there was only one study list exposure. Following a delay of about 75 min (to avoid possible ceiling effects), subjects were shown all 32 sources and were instructed to respond "yes" when they remembered a source from the study list and "no" when they did not.

Results revealed higher levels of recognition accuracy in the likability condition (hit rate = .755, false-alarm rate = .161) than in the believability condition (hit rate = .609, false-alarm rate = .244). A t test that was performed on corrected recognition scores (i.e., hits minus false alarms) revealed that the between-groups difference was significant, $t(22) = 2.48$, $p < .05$. These results indicate that the likability task did indeed focus old adults' attention on the source. Thus, it seems safe to conclude that age-related source memory deficits can be observed even when the elderly focus on the source during the encoding task and that previous demonstrations of source memory deficits are not attributable to the elderly's failure to attend to the source during the study task.

Experiment 2

Although the overall pattern of results in Experiment 1 was relatively clear, the strength of the evidence for disproportionate source memory deficits in the believability condition can be questioned. On the one hand, the elderly did exhibit significantly impaired source recall when their level of fact recall was statistically indistinguishable from that of young subjects. On the other hand, the apparent matching of fact recall in old and young may have been an artifact of ceiling effects: Fact recall performance was approximately 90% correct in both groups, so potentially significant between-group differences may have been obscured. Thus, although it seems safe to conclude that these data indicate that old adults exhibit poor source recall even when their fact recall is nearly perfect, the presence of ceiling

effects calls into question whether old and young were indeed matched in the believability condition.

To investigate this issue and to provide more information about the relation between source and fact recall in the believability condition, we performed an additional experiment in which we addressed the issue of ceiling effects by testing subjects under conditions that should yield below-ceiling levels of fact recall. Specifically, we reduced the number of study list exposures from two to one and increased the retention interval from 10 min to 2 hr. We expected (and found) lower levels of fact recall in old than in young subjects under these conditions. Accordingly, we ran an additional group of old subjects at a shorter retention interval to match the level of fact recall attained by the young.

Method

Main Experiment

Sixteen young and 16 elderly subjects participated in the main experiment. The mean age of the elderly subjects was 72 years (SD = 5.09, range = 64–78), and they had an average of 13.5 years of education (SD = 2.95, range = 10–18). The mean age of the young subjects was 18.81 years (SD = 2.53, range = 16–26), and they had an average of 13 years of education (SD = 2.13, range = 11–16). The elderly obtained mean scores of 57.75 (SD = 7.33, range = 49–68) and 22.0 (SD = 4.30, range = 15–26) on the Vocabulary and Information subtests of the WAIS–R, respectively; the corresponding mean scores for young subjects were 61.31 (SD = 4.97, range = 51–70) and 25.9 (SD = 2.18, range = 18–27). No significant age differences were observed for Information and Vocabulary subtests or for years of education.

All aspects of the materials, design, and procedure were the same as in the believability condition of Experiment 1, except that subjects only viewed the study materials once and were tested after a 2-hr delay rather than a 10-min delay.

Matching Condition

Because levels of fact recall in old and young did differ significantly in this experiment (see the *Results* section), we tested an additional group of 16 elderly subjects in an attempt to achieve matched levels of fact recall. To accomplish this objective, we changed the retention interval from 2 hr to 2 min. All other aspects of the materials and testing procedure were the same as in the main experiment. The mean age of the elderly subjects in the matching condition was 68.66 years (SD = 5.30, range = 62–79), they had an average of 15.25 years of education (SD = 2.55, range = 12–20), and their mean scores on the Vocabulary and Information WAIS–R subtests were 62.83 (SD = 3.62, range = 55–69) and 23.83 (SD = 2.51, range = 20–27), respectively. The Information and Vocabulary subtests of these subjects did not differ significantly from young subjects, but they did have on average 2 more years of education, $t(14) = 2.6$, $p < .05$.

Results and Discussion

A preliminary analysis was carried out that compared the believability ratings of young and old subjects during the encoding tasks, and no significant differences were observed.

Fact Recall

Reducing the number of study list presentations and increasing the retention interval had the intended effect of bringing fact recall performance off the ceiling for both young (.787) and old (.571). Under these conditions, young subjects achieved a significantly higher level of fact recall than did the old, $t(30) = 3.60$, $p < .01$.

Source Recall

Overall levels of source recall were quite low for both young and old, with elderly subjects showing little evidence of source memory (Table 3). Indeed, with the strict scoring criterion, both young and old failed to achieve above-chance levels of performance, $t(15) = 1.68$ and $t(15) = -0.17$, respectively, so these data are of limited interest. When the lenient criterion was used, performance of young subjects improved to an above-chance level, $t(15) = 2.33$, $p < .05$, whereas performance of the elderly remained slightly below chance; the difference between the two groups was significant, $t(30) = 2.77$, $p < .01$. Similarly, when source recall was conditionalized on correct fact recall, performance of young subjects under the strict criterion did not significantly exceed chance, $t(15) = 1.91$, $.05 < p < .10$, and the old again performed slightly below chance. When the lenient criterion was used, the young attained an above-chance level of performance, $t(15) = 2.55$, but the old remained (nonsignificantly) below chance; the between-group difference was significant, $t(30) = 3.48$, $p < .01$.

Matched Fact Recall

Shortening the retention interval had the intended effect of producing comparable levels of fact recall in young (.787) and old (.756; $t < 1$). Despite this increase in the old subjects' fact recall performance, their source recall remained at chance levels with both strict and lenient criteria and both when source recall was and was not conditionalized on successful fact recall (Table 3), all $t(15)$s < 0.38. Considering the data from the lenient scoring criterion, old subjects in the matching group exhibited lower overall levels of source recall than did the young, $t(30) = 1.78$, $p < .05$, and exhibited lower performance when

Table 3
Proportions of Sources Recalled by Old and Young Subjects in Experiment 2

Subject group	Strict	Lenient
Old		
M	.017	.098
SD	.025	.068
Conditionalized *M*[a]	.014	.080
SD	.028	.070
Young		
M	.047	.188
SD	.038	.110
Conditionalized *M*	.053	.204
SD	.046	.124
Old matched		
M	.033	.131
SD	.024	.064
Conditionalized *M*	.030	.119
SD	.031	.081

[a] Conditionalized on correct fact recall.

source recall was conditionalized on correct fact recall, $t(30) = 2.29$, $p < .01$. Thus, despite the presence of floor effects in source recall when the strict scoring criterion was used, old adults still exhibited disproportionately poor source memory relative to the young when the lenient criterion was used.

General Discussion

The present experiments have added to our knowledge of the relation between fact and source memory in old adults and have provided a basis for assessing two hypotheses concerning the nature of age-related source memory impairments. Experiment 1 revealed that old adults showed lower levels of source recall than did the young in both the believability and likability encoding conditions even when levels of fact recall did not differ in the two groups. Experiment 2 indicated that age-related source memory deficits in the believability condition of Experiment 1 could not be attributed to an artifactual matching of fact recall in young and old because of ceiling effects.

The consistent finding of disproportionate source memory deficits in the elderly under conditions in which there was a one-to-one mapping between facts and sources provides evidence against the cue overload hypothesis discussed earlier. If previous findings of age-related source memory deficits were attributable to the many-to-one fact–source mappings used in these studies (e.g., Ferguson et al., 1992; McIntyre & Craik, 1987; Schacter et al., 1991), then we should not have observed disproportionate deficits in our experiments. However, the evidence indicates unambiguously that we did. Thus, our results help to extend the range of conditions in which the elderly exhibit disproportionate impairments of source memory and demonstrate that one feature common to previous studies of source memory and aging, a many-to-one mapping between facts and sources, is not a necessary condition for observing disproportionate deficits.

The differential attention hypothesis also failed to receive empirical support from our research. If elderly adults exhibit source memory deficits because they attend to the target facts at the expense of the source, then their source memory deficit should have been attenuated or eliminated in the likability condition, where subjects were induced to focus on source characteristics. However, Experiment 1 indicated that the elderly showed significant source memory deficits under conditions of matched fact recall in the likability encoding condition. Moreover, the absolute magnitude of the source memory deficit was virtually identical in the likability and believability conditions when levels of fact recall were matched (Table 1). These considerations provide empirical grounds for rejecting the differential attention hypothesis.

One potential qualification to the foregoing conclusions is that the source memory task that we used was quite difficult for elderly adults, as indicated by their chance levels of performance in several experimental conditions. The target sources were in many respects quite similar to one another; they were all human faces consisting of different combinations of binary attributes. Thus, associating each fact with a single source may have created problems of interference for the elderly that are not unlike those that operated when many-to-one mappings were used in previous source memory experiments. Thus, it is conceivable that age-related source memory deficits might be reduced or eliminated by using some sort of intermediate mapping between facts and sources that falls between the extreme mappings used in the present experiments on the one hand and in standard source memory paradigms on the other. This possibility cannot be rejected conclusively and bears examining in future research. Nevertheless, it is worth noting that elderly adults exhibited disproportionate source memory impairments in our paradigm even when their overall levels of source recall significantly exceeded the chance level. This observation suggests that the phenomenon is not a simple consequence of using a task that is too difficult for the elderly to exhibit any evidence of memory.

If age-related source memory deficits cannot be attributed to cue overload or differential attention, what kinds of processes might be responsible for the impairment? One straightforward inference from our results is that source memory impairments in the elderly may reflect difficulties in the recollection of perceptual aspects of episodes. That is, elderly adults may have been less able than the young to reconstruct the perceptual features of target faces that were necessary for source identification. Age-related deficits in recall or recognition of various kinds of perceptual information have been documented, including unfamiliar faces (Bartlett, Strater, & Fulton, 1991), novel objects (Schacter, Cooper, & Valdiserri, 1992), nonsemantic attributes of words (Kausler & Puckett, 1981), and sensory modality of presentation (Light, LaVoie, Valencia-Laver, Albertson Owens, & Mead, 1992). Moreover, recent work by Ferguson et al. (1992) has implicated poor perceptual memory as a contributing factor to impaired source memory in the elderly. They found that old adults exhibited disproportionate source memory deficits when two experimental sources were perceptually similar (i.e., two female sources) but exhibited relatively normal source memory when two sources were perceptually distinct (i.e., a male and a female source). This suggestion may also bear on a puzzling finding from an experiment by Schacter et al. (1991) that used two experimental sources and a many-to-one fact–source mapping: Older adults exhibited disproportionate source memory deficits when each source presented a series of facts in a blocked manner but did not exhibit disproportionate deficits when fact presentation alternated randomly between sources. Perhaps the latter mode of presentation increased the perceptual distinctiveness of the two sources and thus produced levels of source memory in old adults that were commensurate with their level of fact memory performance.

Although the perceptual recollection hypothesis is attractive, at least two important qualifications must be added to it. First, because disproportionate deficits in the elderly have been observed in experiments in which the same two sources repeatedly present all facts (Ferguson et al., 1992; Schacter et al., 1991), a failure of perceptual reconstruction alone may not account for the aging effects. That is, it seems plausible to suggest that when only two sources are used in an experiment, elderly adults should be able to remember their salient perceptual features reasonably well. If in these circumstances the elderly are indeed able to remember perceptual features as well as the young, then their difficulty may lie in associating perceptual information with item or fact information. It would be desirable to tease apart these two related but rather different accounts, that is, that source memory impairments are produced by difficulties

in reconstructing perceptual information on the one hand versus difficulties in associating perceptual and item–fact information on the other. We are presently conducting experiments that address the issue.

A second qualification emerges from comparing the data reported by Ferguson et al. (1992) and Schacter et al. (1991). Although Ferguson et al. found normal levels of source memory in old adults when perceptually distinctive sources were used (i.e., male and female), the experiment in which Schacter et al. observed disproportionate deficits also made use of a male and a female source. There was, however, an important difference between the two studies. In the Schacter et al. experiment, it was possible for subjects to use spatial location as a cue to source identification, because the male and female sources occupied consistent spatial positions relative to the subject (i.e., one sat on the left and one sat on the right). In contrast, Ferguson et al. attempted to eliminate spatial position as a cue by having the sources switch spatial locations halfway through list presentation. In a second experiment, however, male and female sources occupied consistent spatial locations, and under these conditions, elderly adults showed disproportionate impairments of source memory. On the basis of results from other experiments that they conducted, Ferguson et al. argued that old adults' source memory deficits could be attributed, in part, to their failure to make use of multiple cues to source.

In the present experiments, access to perceptual information alone was sufficient for source identification. Thus, old adults exhibited source memory deficits even under conditions in which multiple cues to source (i.e., perceptual and spatial) were not available and hence could not be differentially exploited by young subjects. Although a failure to use multiple cues may contribute to age-related source memory impairments, our results indicate that such impairments can occur even when perceptual information is the sole cue to source identification. This observation is not inconsistent with the ideas of Ferguson et al. (1992), who acknowledged that perceptual memory failures constitute one basis for source memory impairment in the elderly.

If we tentatively assume that failures to recollect perceptual information contribute in some way to source recall deficits in the elderly, a natural question concerns the locus of the effect. Although it is possible that age-related impairments of perceptual encoding (e.g., Cerella, 1985) play a role, two observations suggest that problems in early stage perceptual processing are probably not a major factor in source memory impairments. First, previous studies have suggested a link between source memory and frontal lobe function, both in elderly adults (Craik, Morris, Morris, & Loewen, 1990; Schacter et al., 1991) and brain-damaged patients (Janowsky et al., 1989; Schacter et al., 1984). Frontal damage is not typically associated with perceptual-processing deficits, so the observed link between source memory and frontal function is not consistent with an early stage perceptual impairment hypothesis. Second, elderly adults exhibit normal or near-normal priming effects on a variety of implicit memory tasks that are thought to rely heavily on access to perceptual information (e.g., Light & Singh, 1987; Mitchell, Brown, & Murphy, 1990; Schacter et al., 1992). On the one hand, because priming on these tasks appears to depend on early stage perceptual representation systems (e.g., Schacter, 1990; Tulving & Schacter, 1990) or data-driven processes (e.g., Roediger, 1990), it seems unlikely that source memory deficits could be attributed to impairments of early perceptual processing. On the other hand, in view of the role that frontal regions appear to play in effortful retrieval and integrative processing (cf. Milner, Petrides, & Smith, 1985; Moscovitch, 1989; Schacter, 1987), it seems plausible to suggest that difficulties in reconstructing perceptual information, or reconstructing the link between perceptual features of the source and the target item, may be critically implicated in age-related source memory impairments. Future studies that examine this issue analytically should enhance our understanding of the relation between source memory and aging.

References

Bartlett, J. C., Strater, L., & Fulton, A. (1991). False recency and false fame of faces in young adulthood and old age. *Memory & Cognition, 19,* 177–188.

Cerella, J. (1985). Information-processing rates in the elderly. *Psychological Bulletin, 98,* 67–83.

Cohen, G., & Faulkner, D. (1989). Age differences in source forgetting: Effects on reality monitoring and eyewitness testimony. *Psychology and Aging, 4,* 10–17.

Craik, F. I. M. (1991). Memory functions in normal aging. In T. Yanigihara & R. C. Peterson (Eds.), *Memory disorders: Research and clinical practice* (pp. 347–367). New York: Marcel Dekker.

Craik, F. I. M., Morris, L. W., Morris, R. G., & Loewen, E. R. (1990). Relations between source amnesia and frontal lobe functioning in older adults. *Psychology and Aging, 5,* 148–151.

Dywan, J., & Jacoby, L. (1990). Effects of aging on source monitoring: Differences in susceptibility to false fame. *Psychology and Aging, 5,* 379–387.

Evans, F. J. (1979). Posthypnotic source amnesia. *Journal of Abnormal Psychology, 88,* 556–563.

Evans, F. J., & Thorn, W. A. F. (1966). Two types of posthypnotic amnesia: Recall amnesia and source amnesia. *International Journal of Clinical and Experimental Hypnosis, 14,* 162–179.

Ferguson, S. A., Hashtroudi, S., & Johnson, M. K. (1992). Age differences in using source-relevant cues. *Psychology and Aging, 7,* 443–452.

Goodglass, H., & Kaplan, E. (1983). *Assessment of aphasia and related disorders.* Philadelphia: Lea & Febiger.

Hashtroudi, S., Johnson, M. K., & Chrosniak, L. D. (1989). Aging and source monitoring. *Psychology and Aging, 4,* 106–112.

Janowsky, J. S., Shimamura, A. P., & Squire, L. R. (1989). Memory and metamemory: Comparisons between patients with frontal lobe lesions and amnesic patients. *Psychobiology, 17,* 3–11.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114,* 3–28.

Kausler, D., & Puckett, J. M. (1981). Adult age differences in memory for sex of voice. *Journal of Gerontology, 36,* 44–50.

Light, L. L., LaVoie, D., Valencia-Laver, D., Albertson Owens, S. A., & Mead, G. (1992). Direct and indirect measures of memory for modality in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1284–1297.

Light, L. L., & Singh, A. (1987). Implicit and explicit memory in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 531–541.

McIntyre, J. S., & Craik, F. I. M. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology, 41,* 175–192.

Milner, B., Petrides, M., & Smith, M. L. (1985). Frontal lobes and the

temporal organization of memory. *Human Neurobiology, 4,* 137–142.

Mitchell, D. B., Brown, A. S., & Murphy, D. R. (1990). Dissociations between procedural and episodic memory: Effects of time and aging. *Psychology and Aging, 5,* 264–276.

Moscovitch, M. (1989). Confabulation and the frontal systems: Strategic versus associative retrieval in neuropsychological theories of memory. In H. L. Roediger III & F. I. M. Craik (Eds.), *Varieties of memory and consciousness* (pp. 133–160). Hillsdale, NJ: Erlbaum.

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

Roediger, H. L. III. (1990). Implicit memory: Retention without remembering. *American Psychologist, 45,* 1043–1056.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 501–518.

Schacter, D. L. (1990). Perceptual representation systems and implicit memory: Toward a resolution of the multiple memory systems debate. *Annals of the New York Academy of Sciences, 608,* 543–571.

Schacter, D. L., Cooper, L. A., & Valdiserri, M. (1992). Implicit and explicit memory for novel objects in older and younger adults. *Psychology and Aging, 7,* 299–308.

Schacter, D. L., Harbluk, J. L., & McLachlan, D. R. (1984). Retrieval without recollection: An experimental analysis of source amnesia. *Journal of Verbal Learning and Verbal Behavior, 23,* 593–611.

Schacter, D. L., Kaszniak, A. K., Kihlstrom, J. F., & Valdiserri, M. (1991). The relation between source memory and aging. *Psychology and Aging, 6,* 559–568.

Schacter, D. L., Kihlstrom, J. F., Kaszniak, A. K., & Valdiserri, M. (1993). Preserved and impaired memory functions in elderly adults. In J. Cerella, W. Hoyer, J. Rybash, & M. Commons (Eds.), *Adult information processing: Limits on loss* (pp. 327–350). San Diego, CA: Academic Press.

Shimamura, A. P., & Squire, L. R. (1987). A neuropsychological study of fact memory and source amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition,* 13, 464–473.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science, 247,* 301–306.

Watkins, O. C., & Watkins, M. J. (1975). Build up of proactive inhibition as a cue overload effect. *Journal of Experimental Psychology: Human Learning and Memory, 1,* 442–452.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale—Revised.* New York: Psychological Corporation.

Zacks, R. T., & Hasher, L. (1988). Capacity theory and the processing of inferences. In L. L. Light & D. M. Burke (Eds.), *Language, memory, and aging* (pp. 154–170). Cambridge, England: Cambridge University Press.

Received January 11, 1993
Revision received May 18, 1993
Accepted June 1, 1993 ■