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Age Differences in Using Source-Relevant Cues

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Subjects heard words originating from 2 speakers and later decided which of the 2 speakers said the words. Older adults had difficulty with source monitoring when perceptual cues from 2 sources were similar (2 female speakers), but this difficulty was overcome when perceptual cues were distinctive (a male and a female speaker) and were the only salient cues to source. Older adults also benefited from distinctive spatial cues when these were the only salient cues to source. Older adults, however, experienced difficulties in using multiple cues (both perceptual and spatial) to source effectively, whereas younger adults were able to use multiple cues to enhance their source-monitoring performance. It is suggested that age differences in source monitoring result from differential cue utilization.

To remember an event, one has to recapture such aspects of the experience as time, place, what was said and by whom, and so forth. That is, one has to recapture the source of the memory. We have referred to the collection of processes involved in making attributions about the origins of memories as *source monitoring* (Hashtroudi, Johnson, & Chrosniak, 1989; Johnson, 1988; Johnson, Hashtroudi, & Lindsay, 1992). There has been a recent upsurge of interest in examining disruptions in source monitoring, including those associated with aging. Several recent studies (Cohen & Faulkner, 1989; Dywan & Jacoby, 1990; Hashtroudi et al., 1989; Hashtroudi, Johnson, & Chrosniak, 1990; McIntyre & Craik, 1987; Rabinowitz, 1989; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991) demonstrated age-related breakdowns in remembering source, suggesting that source-monitoring disruption is an integral part of the age-related differences in memory that deserves further investigation.

Thus far, studies of source monitoring in older adults have focused on the basic question of whether aging impairs source-monitoring performance. Although there are a few exceptions (Guttentag & Hunt, 1988; Kausler, Lichty, & Freund, 1985; Mitchell, Hunt, & Schmitt, 1986), overall these studies provide fairly strong evidence that age differences in source monitoring occur across a variety of situations (Cohen & Faulkner, 1989; Hashtroudi et al., 1989, 1990; McIntyre & Craik, 1987; Rabinowitz, 1989; Schacter et al., 1991). For example, McIntyre and Craik reported that relative to younger adults, older adults had difficulty remembering whether a fact was learned in an experiment or whether it came from another source and whether it was presented visually or auditorily (see also Lehman & Mellinger, 1984). Older adults also had trouble remembering whether an item was generated or read (Rabinowitz, 1989), which of two people said something, and whether they themselves said something aloud or only thought about it (Hashtroudi et al., 1989). In addition, older subjects were more likely than younger subjects to say that imagined actions had been watched and that watched actions had been performed, thereby showing evidence of source forgetting for everyday actions (Cohen & Faulkner, 1989). There is also some evidence that source-monitoring deficits may occur independently of differences in remembering content and, thus, do not simply reflect a general memory impairment for previously acquired events (Schacter et al., 1991).

Although the preceding studies clearly establish that there is an age-related decrement in remembering source, there are no studies to date that have examined the mechanisms of age differences in source monitoring. To understand and investigate the processes involved in remembering source, including those involved in age differences in memory for source, we have proposed a source-monitoring framework (Hashtroudi et al., 1990; Johnson, 1991; Johnson et al., 1992). According to this framework, source monitoring is based on characteristics of memories in combination with decision processes. Among the most important memory characteristics are records of perceptual information (e.g., color, sound), contextual (spatial, temporal) information, semantic detail, affective information (e.g., emotional reactions), and cognitive operations (e.g., imagining or elaborating) that took place when the memory was formed. Decisions regarding source involve evaluating the kind and amount of these characteristics. For example, compared with memories for internally generated events, memories for externally derived events typically include more perceptual, contextual, semantic, and affective information and include less infor-

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mation about cognitive operations. Thus a memory with a great deal of visual and spatial detail and very little information about cognitive operations should be judged to have been externally derived (Johnson & Raye, 1981). Source decisions may also be made on the basis of a match between the qualities of a memory and knowledge about particular sources. For example, if the auditory quality of a memory matches your idea of (or schema for) Mary's voice, you attribute a statement to Mary.

Many source-monitoring decisions are made in a rapid, nondeliberate fashion based on qualitative characteristics of memories that are activated. Sometimes, however, source decisions are slower and more deliberate and involve retrieval of supporting memories and initiation of reasoning (e.g., Does this seem plausible given other things I know?). Hence, one might correctly attribute the memory of a conversation with a person to imagination on the basis of the knowledge that one is not acquainted with that person. (These two types of judgments can be characterized in terms of the two types of reflective processes, R-1 and R-2 in Johnson's Multiple-Entry, Modular memory model [MEM], see Johnson, 1991; Johnson et al., 1992). According to the framework, there are at least two ways for source monitoring to break down. First, the various memory characteristics may not be available or may not be salient. For example, a subject may fail to encode salient perceptual information or may encode this information but not access it later. Second, a person may fail to engage in reasoning and retrieval of prior knowledge or may engage in faulty reasoning.

In an earlier experiment motivated by this framework (Hashtroudi et al., 1989), we examined the effects of aging on two types of source-monitoring situations: reality monitoring (discriminating between what one said and what one heard) and external source monitoring (discriminating words said by one person from words said by another person). We found no difference between performance of younger and older adults in reality monitoring, whereas performance of older adults was lower than that of younger adults in external source monitoring. We also found that younger and older subjects showed a similar bias on false positives in this experiment, suggesting that older subjects used some of the same decision rules as younger subjects.

We proposed that the age difference in external source monitoring was most likely to result from a difference between younger and older adults in the way they encode or access various memory characteristics. Several studies have indicated that older adults have trouble remembering perceptual aspects (Kausler & Puckett, 1980, 1981a, 1981b), spatial and temporal attributes (Kausler, Lichty, & Davis, 1985; Light & Zelinski, 1983; Moore, Richards, & Hood, 1984; Park, Puglisi, & Lutz, 1982; Perlmutter, Metzger, Nezworski, & Miller, 1981; Pezdek, 1983), and semantic aspects of presented information (Craik & Simon, 1980; Hess, 1984; Rabinowitz & Ackerman, 1982; Rabinowitz, Craik, & Ackerman, 1982). To the extent that source monitoring relies on these memory characteristics, age differences in the availability of these characteristics may lead to difficulties in source monitoring.

Our earlier experiment (Hashtroudi et al., 1989) was not designed to determine the relative importance of various memory characteristics in age differences in remembering source. However, the fact that the age difference occurred in external source monitoring, where subjects have to remember specific perceptual information such as voice quality, and not in reality monitoring, where the presence or absence of one's own cognitive operations is a salient cue for source monitoring, suggested that perceptual information may be particularly important in conditions in which older adults had the most trouble. Therefore, in a second study (Hashtroudi et al., 1990), we examined whether some memory characteristics were affected more by aging than others. In this study, on the first day subjects participated in some everyday situations (e.g., packing a picnic basket, and having coffee and cookies) and imagined themselves participating in other situations. The next day subjects recalled all they could about each situation. Recollections were evaluated for mention of information such as colors, objects, and spatial references. Older adults had particular difficulty in remembering perceptual and spatial information. In addition, in a source-monitoring test given 3 weeks later, older adults had lower performance than younger adults. Given these findings and the theoretical idea that perceptual and spatial information are salient cues to source (Johnson & Raye, 1981; see also Johnson, Foley, Suengas, & Raye, 1988), we hypothesized that source-monitoring problems may be related to older adults' difficulty in remembering perceptual and spatial information.

In the three experiments reported here, we directly assessed the role of perceptual and spatial information as cues to source in younger and older adults. The question addressed was whether older adults use different information as cues to source than younger adults and whether it is this differential cue use that leads to problems in source monitoring. One way to examine the role of various memory characteristics in source monitoring is to vary systematically the availability of these characteristics and to determine the effect of this manipulation on source-monitoring decisions. We refer to this procedure as the *cue salience technique.*

All three studies used the same basic external source-monitoring situation used earlier (Hashtroudi et al., 1989). Subjects first heard a list of words originating from two experimenters. This was followed by a surprise memory test in which studied items were presented along with new items, and subjects were asked to indicate for each item whether it was said by Experimenter 1, said by Experimenter 2, or whether it was a new item. In Experiment 1 we investigated the role of perceptual information by varying the physical similarity of the two experimenters (female–female vs. male–female), and in Experiment 2 we examined whether, under conditions in which perceptual cues are equally distinctive for younger and older adults, adding distinctive spatial cues differentially improves source-monitoring performance of younger and older subjects. Finally, in Experiment 3 we examined the effectiveness of spatial cues for younger and older adults when they are the only salient cues to source.

Experiment 1

This experiment used the cue salience technique to investigate the role of perceptual cues in external source monitoring for younger and older adults. There were two acquisition conditions. In one condition, subjects heard a list of words spoken by two female experimenters, and in the second condition, subjects heard a list of words spoken by a male experimenter and a female experimenter. A comparison of performance in these two conditions would indicate whether, relative to younger adults, older adults' source-monitoring performance improves differentially when the two external sources are perceptually distinctive (i.e., male vs. female).

In our earlier study (Hashtroudi et al., 1989) discussed above, we suggested that the age difference we found in source monitoring in the female–female condition may arise from the differences between younger and older adults in using perceptual information. However, in that study, the two experimenters occupied a consistent location throughout the experiment, and it is possible that the location of the experimenters served as an additional cue to source. Thus, the age difference may have been related to the use of both perceptual and spatial cues. In the present experiment, we had the two experimenters switch seats halfway through the presentation of the acquisition list. Under these conditions, subjects could not rely on speaker location as a cue to source and would have to rely primarily on perceptual information.

On the basis of the earlier study (Hashtroudi et al., 1989), we expected an age difference in external source monitoring when both speakers were women. There were, however, no clear predictions regarding the potential differences between the female–female and male–female conditions because the importance of perceptual information in source monitoring for older adults is yet to be established. Earlier experiments have shown age differences in remembering whether the speaker was a man or a woman (Kausler & Puckett, 1981a, 1981b), but the differential effects of deciding between two female sources versus a male and a female source have not been examined. Nevertheless, on the basis of Kausler and Puckett's studies, one might expect that older adults may benefit less from provision of salient perceptual cues, indicating that they have difficulty in using these cues. On the other hand, it is possible that older adults have problems in source monitoring when perceptual cues are similar, but they may benefit as much as or more than younger adults when the cues are perceptually distinctive.

Method

Participants. Forty younger and 40 older adults participated in this experiment. The younger subjects were undergraduate students at George Washington University who received course credit or payment for their participation. The older subjects were community-dwelling adults from the Washington, DC, area who were paid for their participation. Both groups of subjects reported themselves to be in good health and were free from sensory difficulties or had corrected vision or hearing. The mean age of the younger adults was 20.0 years (range = 18–23), and the mean age of the older adults was 70.1 years (range = 65–75).

The mean number of years of education was 14.1 (SD = 1.0) for the younger adults and 16.0 (SD = 1.8) for the older adults. A 2 × 2 analysis of variance (ANOVA) on years of education showed that there was a main effect of age, $F(1, 76) = 35.77$, $MS_e = 2.18$, but no main effect of condition and no significant interaction between age and condition (both $Fs < 1$). Older adults were more educated than younger adults, but years of education did not differ across experimental conditions.

All subjects completed the Vocabulary subscale of the Wechsler Adult Intelligence Scale—Revised (WAIS–R; Wechsler, 1981). The mean scores were 52.3 (SD = 6.5) for the younger adults and 60.4 (SD = 5.8) for the older adults. A 2 × 3 ANOVA with age and source-monitoring conditions as variables showed that older adults had higher WAIS–R scores, $F(1, 76) = 33.39$, $MS_e = 38.57$, although these scores did not differ across experimental conditions (both $Fs < 1$, for the main effect of condition and the interaction of age and condition).

Design and materials. The design was a 2 × 2 factorial with age (younger and older adults) and source-monitoring condition (female–female, or FF, and male–female, or MF) as variables. Twenty subjects were tested in each condition.

The materials consisted of 52 nouns with frequency of 30 to 40 occurrences per million, selected from the Thorndike-Lorge (1944) word count. Half of the words were randomly designated as the target list, and the remaining half served as the new list (distractor list) for a later source-monitoring test. The lists were counterbalanced such that each list appeared equally often as the target and the distractor list across subjects. Within the target list, 13 words were assigned to each of the two types of words. For example, in the male–female condition, 13 items were designated as those that the male assistant would say, and 13 items were designated as those that the female assistant would say. Across subjects, each target item appeared equally often in each of the two categories.

At study, the target words were presented randomly with the restriction that no more than two items of each type were presented successively. At test, the order of presentation of the items was determined by randomly assigning the items to the 52 positions with the following restrictions: (a) The words from the beginning and the end of the study list were not placed first or last on the test list, and (b) no two words that were adjacent on the study list were presented successively on the test list.

Procedure. We tested each subject individually. All subjects first completed a personal information questionnaire about present occupation, education, and general health. Subjects then heard an acquisition list, followed by an identification of source test and the WAIS–R Vocabulary test.

At acquisition, there were two assistants (either two women or a man and a woman) present in addition to the primary experimenter (a woman). Female assistants were chosen to be similar in physical characteristics. Both spoke with a similar voice and accent, and their style and color of dress were comparable. The male and female assistants were chosen to have different physical appearances as well as different voice tones. These differences were emphasized by having them wear different-colored clothing.

The acquisition list was presented at the rate of 5 s per item. All words were spoken loudly and clearly to ensure that older subjects would not have difficulty hearing them. Each word was heard twice. That is, the primary experimenter read each word and then asked one of the assistants to say it aloud (e.g., "Ann, say 'sunlight' "). We informed subjects that sometimes one assistant would repeat aloud the word said by the primary experimenter and that at other times the second assistant would repeat the word aloud. We asked them to listen carefully to the two assistants. It should be noted that the source monitoring procedure used in these experiments may be somewhat more difficult than in everyday situations because each word was spoken by the primary experimenter as well as by one of the assistants. Nevertheless, we have used this procedure in previous studies (e.g., Foley, Johnson, & Raye, 1983; Hashtroudi et al., 1989) in which we examined age differences in source monitoring.

As in most studies of source monitoring (e.g., Hashtroudi et al., 1989), we did not inform subjects about the memory test. They were told that the purpose of the experiment was to provide control data from adults to compare with a study designed for children. Four practice trials preceded the acquisition phase.

The subject was seated near the middle of a rectangular table, and the primary experimenter (a woman) was seated to the right of the subject at one end of the table. The two assistants were seated next to each other, opposite the subject and facing the subject. The assistants were sitting against a plain background, and halfway through the acquisition list they switched seats. In both the FF and MF conditions, the initial position of the first female assistant or the male assistant, whether on the left-hand or right-hand side, was counterbalanced across subjects.

Immediately following the acquisition phase, we administered a surprise source identification test. We gave subjects in all conditions a booklet that contained 52 words (26 old words and 26 new words). They were asked to circle the name of the assistant that they remembered saying the word or to circle *new.* The source identification test was self-paced. Very few younger or older subjects expected this test. Following the test phase, we administered the WAIS–R Vocabulary test to each subject.

Results and Discussion

Source-monitoring scores. The source-monitoring scores are shown in Table 1. To obtain these scores, for each subject the total number of words attributed to the correct source was divided by the total number of words correctly identified as old. For example, in the MF condition, the source-monitoring scores refer to the number of words correctly identified as words that the male assistant said, plus the number of words correctly identified as words that the female assistant said, divided by the total number of words correctly identified as old. The possible source-monitoring scores ranged from 0 to 1. The significance level was set at .05 for all of the statistical analyses reported in this article, unless otherwise specified.

To examine whether there were any differences between Acquisition Lists 1 and 2, a 2 (age) × 2 (source-monitoring condition) × 2 (list) ANOVA was first conducted. There was no main effect of list and no interaction of list with other variables in this experiment (all Fs < 1) or in any of the other experiments reported in this article. Therefore, the results were collapsed across the two lists throughout the article.

A 2 × 2 ANOVA, with age and source-monitoring condition (FF and MF) as variables, showed a significant main effect of age, $F(1, 76) = 7.86$, $MS_e = 0.019$; a significant main effect of condition, $F(1, 76) = 4.11$; and a significant interaction of these variables, $F(1, 76) = 4.96$. Simple effects analyses showed that the performance of the younger adults was the same in the MF and FF conditions ($F < 1$), whereas older adults had reliably higher scores when discriminating between the male and the female sources, $F(1, 76) = 9.05$, $MS_e = 0.019$. Furthermore, a comparison of source-monitoring scores for younger and older adults showed that the age difference was significant in the FF condition, $F(1, 76) = 12.65$, $MS_e = 0.019$, but not in the MF condition ($F < 1$).

Table 1
Source-Monitoring Scores[a] *of Younger and Older Adults in Experiment 1*

Source monitoring condition	Younger adults		Older adults	
	Score	*SD*	Score	*SD*
Female–female	.72	.15	.56	.10
Male–female	.71	.14	.69	.16

[a] Total number of words attributed to the correct source divided by the total number of words correctly identified as old.

Table 2
Recognition Performance of Younger and Older Adults in Experiment 1

Source monitoring condition	Younger adults		Older adults	
	Score	*SD*	Score	*SD*
Female–female				
Hits	0.75	0.14	0.73	0.21
False positives	0.16	0.16	0.15	0.16
Corrected[a]	0.59	0.15	0.58	0.22
d′	1.99	0.65	2.02	0.84
Male–female				
Hits	0.83	0.12	0.78	0.16
False positives	0.19	0.15	0.17	0.20
Corrected[a]	0.64	0.18	0.61	0.25
d′	2.17	0.88	2.26	1.05

[a] Difference between the proportion of hits and false positives.

Clearly, older adults had trouble discriminating between two external sources when the two sources were similar, yet when distinctive cues were available, their performance improved substantially. In fact, providing additional perceptual information eliminated the age difference in source monitoring. For younger adults, the addition of distinctive perceptual cues had no effect on their source-monitoring performance.

It should be noted that the absence of an age difference in source memory when the speakers were a man and a woman is not consistent with the earlier findings that older adults have difficulty in remembering the voice of a speaker (Kausler & Puckett, 1981a, 1981b). However, in those studies, the materials were presented by using an audiotape. Thus, it is quite likely that the live presentation of materials in the present experiment provided more embellished perceptual information.

Old–new recognition. Recognition scores refer to the recognition of old items without regard for correct identification of source. Table 2 shows the proportion of hits, false positives, corrected recognition scores (hits minus false positives), and d' scores for the two source-monitoring conditions. A 2 × 2 ANOVA on hits revealed that there was no significant main effect of age, $F(1, 76) = 1.02$, $MS_e = 0.025$, or condition, $F(1, 76) = 3.40$, and no interaction of these variables, $F < 1$. The same pattern of results was found in all the other recognition measures. There was no difference in performance between the two age groups as measured by d' scores or corrected recognition scores (both Fs < 1), nor was there any reliable difference in false positives ($F < 1$). Recognition performance for younger and older adults was equivalent.

It is interesting to note that although older adults had lower source-monitoring performance than younger adults when discriminating between two female experimenters, they did not have lower recognition performance in this condition. Hence, the age difference in source-monitoring performance found here cannot be characterized as reflecting a more general memory impairment.

Overall, the results of this experiment using the cue salience technique suggest that older adults can use perceptual information as cues to source because making these cues distinctive, that is, by varying the sex of the assistants, improved their performance significantly. Older adults had difficulty in processing perceptual information when this information was minimal, as in the FF condition, but when perceptual information was distinctive, the age difference was eliminated. For younger adults, however, the addition of more salient perceptual information did not affect their source monitoring performance.

Experiment 2

The purpose of this experiment was twofold. The first goal was to replicate the surprising finding from Experiment 1 that when distinctive perceptual cues were present and there were no salient spatial cues to source, the age difference in source monitoring was eliminated. The second purpose was to examine whether the presence of spatial information provides an additional cue to source. We used the MF condition from Experiment 1, in which the perceptual cues were equally distinctive for younger and older adults, and we examined whether under these circumstances adding spatial information differentially improves the performance of the two age groups.

There were two different external source-monitoring conditions in which younger and older adults heard a list of words spoken by a male and a female assistant. In the MF nonspatial condition (same as the MF condition of Experiment 1), the two assistants were sitting close together against the same background, and they switched seats halfway through the presentation of the acquisition list. In the spatial location condition (MF spatial), the two assistants were seated on opposite sides of the room, facing the subject, each against a different background (a print on the wall or a plant against the wall). They remained in the same seats throughout the acquisition phase. A comparison of these two conditions would indicate whether adding spatial cues to perceptual cues increases source-monitoring performance in younger and older adults and whether this increase is the same for the two age groups.

The importance of location cues for source monitoring has been explored in some studies that examined source identification in a young population (Geiselman & Crawley, 1983; Rothkopf, Fisher, & Billington, 1982). When location cues are consistently associated with a source during acquisition, as when speakers occupy a distinct location throughout an exchange, they can provide an additional cue to source. If subjects are unable to remember who made a particular statement, memory for the location from where that statement came may provide sufficient information to specify the source. For example, Rothkopf et al. (1982) demonstrated that when three speakers were each consistently shown on different television monitors, source identification was greatly facilitated compared with a condition in which the speakers' location was switched among the three television monitors. Similarly, in a study by Geiselman and Crawley, one group of young subjects heard sentences presented by a male and a female experimenter, with all sentences broadcast from the left and right speakers simultaneously; another group heard sentences in which a given voice emanated consistently either from the left speaker or from the right speaker. Geiselman and Crawley found that a consistent source location improved speaker identification significantly.

There are no studies to date that have examined the importance of location cues in source identification in an elderly population. Nevertheless, there is evidence that older adults do not remember spatial location as well as younger adults do (e.g., Light & Zelinski, 1983; Park et al., 1982; Perlmutter et al., 1981). On the basis of these findings and our earlier study demonstrating that older adults report less spatial information in remembering complex events (Hashtroudi et al., 1990), one might expect that older adults' source-monitoring performance may improve less than that of younger adults when spatial cues are salient and can be used consistently as a cue to source. On the other hand, there is also evidence that older adults' memory for spatial information is improved when location is made salient (Park, Cherry, Smith, & Lafronza, 1990; Sharps & Gollin, 1987; Zelinski & Light, 1988). Thus, it is also possible that older adults benefit as much as or more than younger adults when spatial cues are salient.

It should be noted that in this experiment we varied both the distinctiveness (plant and picture) and consistency of location cues. Our goal was to examine the effectiveness of salient spatial information (consistent and distinctive) as a cue to source rather than to determine the effectiveness of location consistency or location distinctiveness per se. Varying both consistency and distinctiveness of location was intended to provide a powerful manipulation of spatial cues.

Method

Participants. Thirty-two younger and 32 older adults participated in this experiment. The younger and older subjects were selected from the same subject pool as in Experiment 1, but none of the subjects had participated in that experiment. The mean age of the younger adults was 20.0 years (range = 18–30), and the mean age of the older adults was 69.8 years (range = 65–75).

The mean number of years of education was 14.0 (SD = 1.1) for the younger adults and 16.7 (SD = 2.1) for the older adults. For the WAIS–R Vocabulary subscale, the mean scores were 51.3 (SD = 6.1) for the younger adults and 61.0 (SD = 4.9) for the older adults. Two separate 2 × 2 ANOVAs with age and source-monitoring condition as variables were conducted on the WAIS–R scores and years of education. These data showed that the older subjects were more educated, $F(1, 60) = 39.28$, $MS_e = 2.87$, and had higher WAIS–R scores, $F(1, 60) = 48.85$, $MS_e = 31.33$, than younger subjects. However, there was no main effect of condition and no interaction between age and condition for either the WAIS–R scores or years of education (all Fs < 1).

Design and materials. The design was a 2 × 2 factorial with age (younger and older adults) and source-monitoring condition (MF nonspatial vs. MF spatial) as between-subjects variables. Sixteen subjects were tested in each condition.

The study and test materials were the same as in Experiment 1.

Procedure. As in Experiment 1, we tested each subject individually. All subjects completed a personal information questionnaire. Then they received an acquisition list, followed by an identification of source test and the WAIS–R test.

At acquisition, the subject was seated near the middle of a rectangular table, and the primary experimenter (a woman) was seated to the right of the subject, at one end of the table. In the MF nonspatial condition, the two assistants were seated next to each other, against the same background, opposite the subject and facing the subject. Halfway through the acquisition list the assistants switched seats. In the MF spatial condition, the two assistants were seated in opposite corners of the room, facing the subject. One of the assistants was seated in front of a large potted plant, and the other assistant was seated in front of a colorful print. For half of the subjects in each condition the initial position of the male assistant was on the left-hand side of the female assistant, and for the other half of the subjects he was seated on the right-hand side of the female assistant.

All other aspects of the procedure were the same as in Experiment 1.

Results and Discussion

Source-monitoring scores. The source-monitoring scores were obtained in the same way as in Experiment 1 and are shown in Table 3. A 2 × 2 ANOVA with age and source-monitoring condition as variables showed a significant main effect of age, $F(1, 60) = 10.83$, $MS_e = 0.012$; a significant main effect of condition, $F(1, 60) = 6.88$; and a significant interaction of these variables, $F(1, 60) = 4.37$. Analyses of the simple effects of the interaction revealed that as in Experiment 1, performance of younger and older subjects was not different when distinctive perceptual cues were the only cues to source (MF nonspatial condition, $F < 1$), whereas older subjects' performance was lower than that of younger subjects when spatial cues were added to perceptual cues (MF spatial), $F(1, 60) = 14.48$, $MS_e = 0.012$. This finding suggests that younger adults' performance improves significantly when spatial cues are added to distinctive perceptual cues, whereas older adults' performance does not.

Old–new recognition. The results of the old–new recognition are shown in Table 4. A 2 × 2 ANOVA on hits showed no main effect of age, $F(1, 60) = 3.75$, $MS_e = 0.017$; no main effect of condition, $F(1, 60) = 1.44$; and no interaction between these two variables, $F(1, 60) = 2.02$. Similarly with false positives, there was no main effect of age, $F(1, 60) = 1.49$, $MS_e = 0.016$, and no interaction between age and condition, $F(1, 60) = 1.88$, although the proportion of false positives was greater in the MF nonspatial condition than in the MF spatial condition, $F(1, 60) = 5.80$. The latter finding indicates that recognition was more difficult in the MF nonspatial condition.

The results of the corrected recognition scores and d' scores were very similar to each other. There was no main effect of age for either of these two measures (both $Fs < 1$). However, there was a significant interaction of age and condition for both corrected recognition scores, $F(1, 60) = 5.68$, $MS_e = 0.023$, and the d' scores, $F(1, 60) = 4.31$, $MS_e = 0.552$. Further analyses revealed that younger adults had higher corrected recognition scores, $F(1, 60) = 5.89$, $MS_e = 0.023$, and higher d' scores, $F(1, 60) = 5.14$, $MS_e = 0.552$, in the MF spatial condition than in the MF nonspatial condition, whereas there was no significant difference in performance of older adults in the two conditions ($F < 1$).

Taken together, two points are clear from these data. First, as in Experiment 1, there was no difference in overall recognition performance between younger and older adults. Second, it appears that presenting the information in a salient location not only improved memory for source but also improved memory for items for younger adults. However, for older adults, the salience of location did not affect either recognition memory or source-monitoring performance.

In summary, the results of this experiment replicate the finding from Experiment 1 that when there were no salient spatial cues available and perceptual cues were distinctive, the age difference in source monitoring was eliminated. In fact, in the MF nonspatial condition, the performance of both younger and older subjects was very similar in this experiment (.71 and .67) and in Experiment 1 (.71 and .69). More important, these results demonstrate that when salient spatial cues were added to distinctive perceptual cues, younger subjects' performance improved but older subjects' performance did not.

There are two possible interpretations for the latter finding. The first interpretation is that younger subjects are able to benefit from salient spatial information, whereas older subjects fail to benefit from this information. The second possibility is that older adults have a more general problem of managing multiple cues to source simultaneously. Older adults may have no difficulty in using salient spatial cues when these are the only cues to source, but they may have trouble with source monitoring when there are multiple cues. When given more than one cue (both perceptual and spatial), younger subjects may be able to use the most effective cue or to combine the cues in a way that improves their performance, whereas older adults may have difficulty in coordinating or combining different cues to source. The next experiment was designed to distinguish between these two interpretations.

Table 3
Source-Monitoring Scores[a] of Younger and Older Adults in Experiment 2

	Younger adults		Older adults	
Source-monitoring condition	Score	*SD*	Score	*SD*
Male–female nonspatial	.71	.12	.67	.13
Male–female spatial	.83	.10	.69	.09

[a] Total number of words attributed to the correct source divided by the total number of words correctly identified as old.

Table 4
Recognition Performance of Younger and Older Adults in Experiment 2

	Younger adults		Older adults	
Source-monitoring condition	Score	*SD*	Score	*SD*
Male–female nonspatial				
Hits	0.85	0.11	0.83	0.14
False positives	0.20	0.18	0.12	0.14
Corrected[a]	0.65	0.16	0.71	0.15
d'	2.20	0.69	2.60	0.68
Male–female spatial				
Hits	0.86	0.11	0.75	0.15
False positives	0.08	0.08	0.08	0.10
Corrected[a]	0.78	0.12	0.67	0.17
d'	2.80	0.67	2.42	0.90

[a] Difference between the proportion of hits and false positives.

Experiment 3

The purpose of this experiment was to examine the effectiveness of spatial cues in improving the source-monitoring performance of younger and older adults when these were the only salient cues to source. If older adults fail to benefit from these cues, this would indicate that they have difficulty in taking advantage of salient spatial information as a cue to source. On the other hand, if older subjects benefit as much as younger adults from spatial cues, this would indicate that the age difference in Experiment 2 may not be attributed to older subjects' failure to use spatial cues per se. Rather, the age difference may have occurred because older subjects use multiple cues to source less effectively than do younger adults.

There were two acquisition conditions in which the assistants were both women. In the FF nonspatial condition (the same as the FF condition of Experiment 1), the assistants were seated against the same background and switched seats halfway through the acquisition list. In the spatial condition (FF spatial), the two assistants occupied a distinctive and consistent location throughout acquisition as in Experiment 2.

Method

Participants. The participants were 32 younger and 32 older adults. The subjects were selected from the same subject pool as in Experiments 1 and 2, but none of them had participated in those experiments. The mean age of the younger adults was 18.9 years (range = 17–22), and the mean age of the older adults was 70.2 years (range = 65–75).

The mean number of years of education was 13.8 ($SD = 1.1$) for the younger adults and 16.3 ($SD = 2.4$) for the older adults. For the WAIS–R Vocabulary subscale, the mean scores were 55.7 ($SD = 4.3$) for the younger adults and 61.8 ($SD = 4.6$) for the older adults. Two separate 2 × 2 ANOVAs with age and source-monitoring condition as variables were conducted on the WAIS–R scores and years of education. These data showed that the older subjects were more educated, $F(1, 60) = 28.07$, $MS_e = 3.47$, and had higher WAIS–R scores than the younger subjects, $F(1, 60) = 29.77$, $MS_e = 20.37$. There was no main effect of condition and no interaction of age and condition for either years of education or WAIS–R scores (all $Fs < 1$).

Design and materials. The design was a 2 × 2 factorial with age (younger and older adults) and source-monitoring condition (FF nonspatial vs. FF spatial) as between-subjects variables. Sixteen subjects were tested in each condition.

The study and test materials were the same as in Experiments 1 and 2. The seating arrangement of the experimenters was the same as in Experiment 2. Both assistants were women, and, as in the first two experiments, the primary experimenter was also a woman. All other aspects of the procedure were the same as in Experiments 1 and 2.

Table 5
Source-Monitoring Scores[a] of Younger and Older Adults in Experiment 3

Source-monitoring condition	Younger adults Score	Younger adults *SD*	Older adults Score	Older adults *SD*
Female–female nonspatial	.69	.16	.60	.17
Female–female spatial	.83	.12	.69	.17

[a] Total number of words attributed to the correct source divided by the total number of words correctly identified as old.

Table 6
Recognition Performance of Younger and Older Adults in Experiment 3

Source-monitoring condition	Younger adults Score	Younger adults *SD*	Older adults Score	Older adults *SD*
Female–female nonspatial				
Hits	0.82	0.13	0.72	0.14
False positives	0.05	0.06	0.08	0.12
Corrected[a]	0.77	0.13	0.64	0.16
d'	2.89	0.67	2.29	0.73
Female–female spatial				
Hits	0.88	0.10	0.77	0.11
False positives	0.14	0.14	0.18	0.16
Corrected[a]	0.74	0.12	0.59	0.19
d'	2.65	0.68	1.90	0.78

[a] Difference between the proportion of hits and false positives.

Results and Discussion

Source-monitoring scores. The source-monitoring scores are shown in Table 5. A 2 × 2 ANOVA with age and source-monitoring condition as variables showed a significant main effect of age, $F(1, 60) = 8.99$, $MS_e = 0.024$, and a significant main effect of condition, $F(1, 60) = 8.52$. The interaction of age and condition was not significant ($F < 1$). These results indicate that making the spatial cues salient improves source-monitoring performance of younger and older adults to the same extent, although the age difference in source monitoring still remains. Older adults have difficulty in source monitoring when perceptual cues from two sources are similar (two women), even though they benefit to the same extent as younger adults from spatial cues.

It is important to note that the results of the FF nonspatial condition in this experiment replicate the findings from the same condition in Experiment 1. In Experiment 1, source-monitoring scores for younger and older subjects were .72 and .56, respectively, and the corresponding scores in the present experiment were .69 and .60, respectively.

Old–new recognition. The results of the old–new recognition are shown in Table 6. A 2 × 2 ANOVA on hits showed that there was a main effect of age, $F(1, 60) = 12.68$, $MS_e = 0.014$, but no main effect of condition, $F(1, 60) = 3.36$, and no interaction of age and condition ($F < 1$). With false positives, only the effect of condition was significant, $F(1, 60) = 9.12$, $MS_e = 0.015$; subjects had more false positives in the FF spatial condition than in the FF nonspatial condition.

The most important finding was that, relative to younger subjects, older subjects had lower recognition performance as measured by d' scores, $F(1, 60) = 14.33$, $MS_e = 0.512$, and corrected recognition scores, $F(1, 60) = 14.53$, $MS_e = 0.022$. In contrast to Experiments 1 and 2, in this experiment there was an age difference in recognition memory. There was no main effect of condition either for d' scores, $F(1, 60) = 3.12$, or for corrected recognition scores, $F(1, 60) = 1.00$. In addition, there was no interaction of age and condition for either of these measures (both $Fs < 1$).

Overall, the results of this experiment using the cue salience technique show that both younger and older adults benefited from spatial cues when these were the only salient cues to source. Thus, the age difference in source monitoring in Experiment 2 cannot be attributed to older subjects' failure to benefit from spatial cues per se. The age difference in that experiment may have resulted from less effective use of multiple cues by older adults. We return to this issue in the General Discussion section.

Correlations Between Source Monitoring and Recognition Memory

The results of the three experiments showed a variable relation between source monitoring and recognition memory. Sometimes recognition and source monitoring were both affected by aging (Experiment 3), and sometimes source monitoring was affected but recognition was not (Experiments 1 and 2). To examine further the relation between recognition memory and source-monitoring performance, we conducted correlations between d' scores and source monitoring scores. These correlations were significant in three cases for younger subjects: the MF condition of Experiment 1 ($r = .55$), the MF spatial condition of Experiment 2 ($r = .53$), and the FF spatial condition of Experiment 3 ($r = .51$). For older subjects, the correlation between d' and source monitoring scores was significant only in the case of the MF condition of Experiment 1 ($r = .66$). Therefore, the fact that recognition and source monitoring show a variable relation by this correlational analysis is consistent with the variable impact of manipulating cue saliency on recognition and source-monitoring performance.

General Discussion

The results of Experiment 1 showed that older subjects' source-monitoring performance was lower than younger subjects' when the two sources were perceptually similar, but the age difference was eliminated when the two sources were perceptually distinctive. Experiment 2 demonstrated that when the two sources were equally distinctive for younger and older subjects, adding a spatial cue improved performance of younger adults but not that of older adults. The results of Experiment 3, however, suggested that when spatial cues were the only salient cues to source, both younger and elderly adults benefited from these cues.[1] Together, these findings indicate that the age difference in Experiment 2 may have resulted from the older subjects' less effective use of multiple cues to source rather than their inability to use spatial cues per se. We propose that the age differences in source monitoring in these experiments arose from two factors. First, older adults have difficulty in source monitoring when two sources are perceptually similar, and second, older adults experience difficulties in using multiple cues to source.

The results of the FF and MF conditions indicate that perceptual cues play a critical role in source monitoring in older adults. There was an age difference in source monitoring when perceptual cues to source were similar (FF nonspatial condition), and this difference remained even when subjects were given additional spatial cues (FF spatial condition of Experiment 3). This finding suggests that younger adults were more sensitive to the small differences in perceptual cues in the FF conditions used in these experiments. That is, in the FF conditions, one major cue to source is perceptual differences in the voice and appearance of the two speakers. Younger subjects in these conditions evidently use such information more effectively than do older subjects. This may explain why increasing the distinctiveness of perceptual cues further, that is, by changing the gender of the two experimenters, had no effect on younger subjects' performance.

The disadvantage of older subjects when perceptual cues are similar may be related to problems they have in perceptual processing. Several studies have shown age differences in perceptual processing (Axelrod & Cohen, 1961; Basowitz & Korchin, 1957; Cerella, 1985; Danziger & Salthouse, 1978; Eisner, 1972; Kline, Culler, & Sucec, 1977) and in remembering perceptual information (Hashtroudi et al., 1990). Thus, it is not surprising that when perceptual information is minimal, there is an age difference in source monitoring. It is important to note, however, that older adults' difficulty in using perceptual cues may be overcome when distinctive perceptual information is provided and when this information is the only salient cue to source, as in the MF nonspatial condition. This finding is consistent with other experiments that showed that older adults' performance improves when given additional perceptual information (Hashtroudi, Chrosniak, & Schwartz, 1991).

The age difference in the MF spatial condition in Experiment 2 indicates that older subjects do not benefit from multiple cues. Although older subjects benefited from a single perceptual cue (MF condition vs. FF condition, Experiment 1) or a single spatial cue (FF nonspatial vs. FF spatial, Experiment 3), they did not show any additional benefit when both sets of cues were provided; performance in the joint cue condition (MF spatial) was the same as performance in either one of the single cue conditions (MF nonspatial and FF spatial). It could be argued that a comparison of the performance of the younger adults in the FF spatial condition of Experiment 3 and MF spatial condition of Experiment 2 suggests that these subjects do not benefit from multiple cues either. However, as stated earlier, in the FF spatial condition younger subjects may have been using both perceptual and spatial cues effectively, and hence may not have benefited from the additional information provided by the change in the gender of the speakers in the MF spatial condition.

[1] Using Batchelder and Riefer's (1990) suggested analysis for source-monitoring data applying Model 4, source-monitoring findings were consistent with those obtained with the ANOVAs. Source-monitoring scores of younger subjects were not different in the FF and MF conditions of Experiment 1 and were higher in the spatial than nonspatial conditions in Experiments 2 and 3. For older subjects, the source-monitoring scores were higher in the MF than in the FF condition in Experiment 1, were not affected by the availability of spatial information in Experiment 2 when one speaker was a man and one a woman, and were higher in the spatial than in the nonspatial condition in Experiment 3 when both speakers were women.

The less effective use of multiple cues may be one major reason for the frequently observed age differences in source monitoring. Most source-monitoring situations do not involve a single cue to source but include several different potential cues. Younger subjects may be able to coordinate the multiple cues to source to improve their performance. At acquisition or test, they may attend to or select the most effective cue or combine the different cues more efficiently. They may also be more flexible in their use of cues, such that different cues are used in different situations or for different items.

Older subjects, in contrast, may have difficulty in engaging in some or all of these activities. For example, the various aspects (semantic content, perceptual detail, spatial location, etc.) of complex memories become bound together as a consequence of processes that occur at acquisition (Johnson, 1992). These processes may range from the relatively automatic (e.g., association by contiguity) to the more deliberate or attention demanding (e.g., noting relations between current and previous events). Without such initial binding among memory attributes, memory would not be specific enough to yield recollection of source. Assuming that, for the most part, binding context to content is not automatic, gains in one type of contextual information (e.g., perceptual detail) would be at the expense of another type of contextual information (e.g., spatial location). Age-related differences in attention (e.g., Craik & McDowd, 1987; Hasher & Zacks, 1979) or in processing resources (e.g., Craik & Simon, 1980) should exaggerate this trade-off, producing memories in older individuals that are less rich in potential source-specifying information. Equally important, at the time of recollection, subjects not only must have source-specifying information available, they must also consult this information for it to affect source-monitoring performance. Even if older subjects did establish initial memories equivalent in detail to those established by younger subjects, older subjects might focus on a more restricted range of this information at test.

The results of these experiments also provide some information about the effectiveness of distinctive spatial location as a cue to source in older adults. Although several studies have demonstrated that older adults do not remember spatial information as well as younger adults (Light & Zelinski, 1983; Moore et al., 1984; Park et al., 1982; Perlmutter et al., 1981; Pezdek, 1983), there is also evidence that providing distinctive spatial cues benefits memory for spatial locations in older adults. For example, memory for the location of objects in a three-dimensional room was better than memory for the location of objects on a map (Park et al., 1990; Sharps & Gollin, 1987). Similarly, providing maps with a greater degree of background detail facilitated memory for the spatial location of objects in younger and older adults (Zelinski & Light, 1988). The fact that older subjects benefited from distinctive spatial cues in Experiment 3 is consistent with the latter studies.

Turning to the recognition results, the effect of aging on memory for content as measured by old–new recognition did not always parallel the effects of aging on memory for source. In Experiments 1 and 2, there was no overall difference between younger and older subjects in d' scores and corrected recognition scores, although source-monitoring performance of older adults was lower in some conditions. In Experiment 3, however, there was an age difference in both source monitoring and recognition performance as measured by d' scores and corrected recognition scores.

The finding that source memory may be impaired when recognition memory is intact supports the general idea that memory for source and content may sometimes be independent of each other (Johnson & Raye, 1981). More important, in the context of aging research, this finding addresses the issue of whether the age difference in remembering source is separate from the age difference in remembering content and whether source memory is affected more by aging than content memory (McIntyre & Craik, 1987; Schacter et al., 1991). Our results demonstrate unequivocally that source memory can be disproportionately impaired, relative to content memory, in older subjects. However, it should be emphasized that source monitoring is not always disproportionately impaired in aging. As Experiment 3 demonstrated, sometimes memory for source and content are both affected in aging (see also Hashtroudi et al., 1989; Schacter et al., 1991). The relation between content and source is variable because it reflects the extent to which subjects use similar information in particular content and source tasks. This will vary from situation to situation (see Johnson et al., 1992). Thus, age differences in source monitoring are interesting even when they are not disproportionate to age differences in remembering content because they may help identify circumstances under which similar information is important in both types of tasks.

In summary, three major conclusions emerge from our experiments using the cue salience technique. First, consistent with the source-monitoring framework, it is clear that source decisions are made on the basis of memory characteristics because changing these characteristics affects the level of source-monitoring performance for younger and older adults. Second, age differences in source monitoring can occur without age differences in recognition memory, indicating that sometimes these tasks may draw on different types of information or engage different processes. Thus, studying the effects of aging on source monitoring and comparing source memory with content memory can provide information beyond what can be learned by studying memory for content alone. Finally, and most important, younger and older adults may use the potential cues to source differentially. Relative to younger subjects, older subjects have problems in source monitoring when the two sources are perceptually similar; in addition, they seem to experience some difficulty in using multiple cues. A major task for the future is to examine further the interactions among various cues and to characterize the complex pattern of cue utilization in source monitoring in younger and older adults.

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