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Telling the Same Story Twice: Output Monitoring and Age

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When people have to remember to perform an act in the future, they must also keep a record of the act already performed so as not to repeat it. This neglected aspect of everyday memory was investigated by examining the alleged preponderance of action repetitions in old age (e.g., telling the same story over and over, taking a medicine too often, etc.). We propose that such action repetitions stem from a deficiency in the monitoring of actions performed. Although older subjects remembered fewer words from a study list than younger subjects, they were more likely to repeat them in free recall (Experiments 1 and 2). When later presented with the study words and asked to judge whether they had recalled them in a previous recall phase, older people classified more recalled words as unrecalled. In Experiment 3 subjects classified words according to (a) whether they had appeared in a study list (input monitoring) and (b) whether they had been previously classified by them on the test list (output monitoring). The older subjects were more deficient in output monitoring than in input monitoring. Their most frequent error was classifying old-output items as new-output items, the error assumed to underlie action repetition. Several interpretations of these results were proposed.

Recently there has been a growing interest in the investigation of real-life memory processes of the sort not readily explorable in the laboratory (see Harris & Morris, 1984; Neisser, 1978, 1982). This focus has brought to the fore a certain type of memory process termed prospective memory (Harris, 1984; Harris & Wilkins, 1982; Meacham & Leiman, 1975). Prospective memory refers to the process of remembering to carry out an action in the future, such as showing up for an appointment, taking medicine, or taking the cake out of the oven. This process has also come under the rubric of "remembering to remember" (Reed, 1979; Schonfield & Stones, 1979) or "remembering to recall" (Wilkins & Baddeley, 1978).

The present study focuses on a neglected aspect of prospective memory, the memory that a planned act has been executed. Consider a typical situation in which one needs to remember to perform a task. The sequence of events involved may be roughly divided into three stages. In the encoding stage, the person might undertake some mental or physical operation (e.g., tying a knot in one's handkerchief) that is designed to serve as a cue for retrieving the necessary information under the appropriate conditions. In the second, retrieval stage, memory is probed in response to the cue, and the act is performed. In the third stage, some measure must presumably be taken to ensure that the action is not repeated in the future. This may be achieved by destroying the mnemonic cue (e.g., untying the knot in the handkerchief), by erasing the underlying command from the mental schedule, or by checking it off as one that has already been completed. If this process fails, one may find oneself inappropriately repeating the same task.

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The purpose of the present study was to gain some insights into this last stage by focusing on the processes underlying the repetition of planned actions among older persons. Cursory observations suggest that older people have difficulty clearing from memory the intention to perform an act even after it has been completed. This is illustrated by the common observation that they tend to tell the same story twice, or to take a medicine more often than prescribed, apparently because they forget that they have already done so. In the present study we first sought experimental evidence for the alleged high incidence of action repetitions among elderly people. Then we examined the hypothesis that the tendency to repeat a planned action is associated with a particular impairment in memory monitoring.

Previous research has indicated some age differences in remembering to perform future actions, as well as in the memory for previously performed actions. In a study by Schonfield (see Welford, 1958) subjects were asked to solve a problem, but before giving their answers they had to press a key. The likelihood of forgetting to press the key increased systematically with age. Under real-life conditions, however, somewhat different results were obtained by Moscovitch (1982). He instructed subjects to telephone once a day for 2 weeks at a fixed time of their choosing. The younger subjects were more likely to forget to call and were late more often than the older subjects. Since these differences may have been due to the older people living more regular lives, a second study was run in which only three phone calls were required over a period of 2 weeks, at randomly determined times. The results again indicated better performance by the older group. One possible explanation for this finding is that older people mistrust their memories and tend to rely more extensively on external aids. Indeed, in subsequent experiments subjects were intructed to avoid using external aids, and among those who complied with the instruction there was no old-age advantage.

When memory for past actions was studied, older subjects were found to exhibit poorer memory for previously performed activities, particularly when these were not cognitively demanding (Kausler & Hakami, 1983). This suggested an age-related deficit in memory for activities that is strongest for activities yielding less distinctive memory traces. Older subjects also exhibited poorer recognition of activities performed earlier, though they were as proficient as younger people in reality monitoring, that is, in discriminating between planned and performed activities (Kausler, Lichty, & Freund, 1985). It is notable that memory for performed activities was not affected by the intention to learn for either old or young subjects. This was true for both recall (Kausler & Hakami, 1983) and recognition (Kausler et al., 1985), and suggests that memory for activities is a form of automatic or rehearsal-independent memory.

Memory for subject-performed tasks (SPT) was investigated by Cohen (1981) and Cohen and Stewart (1982). They instructed subjects to perform a series of acts (e.g., ring the bell, clap hands), and then tested their memory for these acts. No effects of level of processing and no primacy effects were found, suggesting that memory for performed tasks is nonstrategic. In contrast to the results of Kausler and his associates, Backman and Nilsson (1984) found no age differences in the SPT memory, and proposed that the multimodality and richness of aspects involved in the SPT helped the elderly to accomplish compensating strategies.

There has been little research on the tendency to repeat a task that has already been performed. The frequency of such repetitions in everyday life is not known, except perhaps in selected pathological groups of obsessive-compulsive individuals (see Reed, 1985). The results obtained by Wilkins and Baddeley (1978) suggest that among normal adults the frequency of action repetitions is much lower than that of forgetting to perform an action. They used an analog of a pill-taking task in which subjects were required to operate a portable print-out clock at prearranged times. Among their 31 subjects a total of 30 omissions were observed, but there was no instance in which a response was repeated before the next one was due. Apparently, if subjects forgot to operate the clock they were also unaware of the omission, whereas if they operated it they remembered that they had done so.

Repetition behavior, in general, may be examined within two somewhat different theoretical perspectives. The first is exemplified by some of the work on perseveration behavior (see Goldberg & Tucker, 1979; Sandson & Albert, 1984). This behavior involves the continuation or recurrence of an activity without the appropriate stimulus, and is most clearly seen in patients with frontal lobe lesions. Although there are different types of perseverative behaviors, some of these seem to involve a failure of control, as when the person is aware of the inappropriateness of his behavior, but nevertheless is unable to terminate the execution of a motor act or to shift completely from one action to another. A similar phenomenon is displayed in some of the repetition behaviors of obsessive compulsives: They tend to check that a task has been accomplished (e.g., that a door has been locked) even though they can remember having done so (see Reed, 1977). This discrepancy between cognition and action is similar to that observed in impulsive behavior (e.g., Nisan & Koriat, 1977), and seems to call for an explanation in terms of "motivation" or "self control." Kurt Lewin's (1935) analysis of the tendency to repeat interrupted tasks was also cast in motivational terms: The intention to perform a task was assumed to create a tension system (a "quasi need") that presses toward task completion. If the task is interrupted, the unreleased tension can have behavioral and cognitive consequences, such as a stronger tendency to resume the activity, and a better memory for the unfinished task (the Zeigarnik effect) (see Van Bergen, 1968). Perhaps in older people the accomplishment of a task fails to cause a complete discharge of the specific tension system, thus leading to a stronger tendency to repeat an act. According to this interpretation, action repetition in old age stems from a motivational drive (or an "executive deficit") (see Goldberg & Bilder, 1986) rather than from a failure of memory.

In the present paper we adopted a somewhat different theoretical perspective, one that is more cognitively oriented. We propose that repetition behavior of the sort evidenced in telling a story twice need not stem from impaired control, but can result from a deficient monitoring of one's own actions. Older people tend to repeat the same story over and over not so much because they are unable to overcome an impulse to do so, but because they are unaware that they have already done so. In a similar vein, Sher, Frost, and Otto (1983) argued that compulsive checking behavior stems from a memory failure. They found compulsive checkers to have a poorer memory for performed actions than noncheckers. We propose that older people are similarly deficient in monitoring their own actions.

In the present study we investigated output monitoring in the context of a memory task. In the first experiment we examined the hypothesis that older people are more likely to repeat words in free recall than younger people. The subsequent experiments were intended to tie response repetition in old age to a specific impairment in the monitoring of output occurrence.

EXPERIMENT 1

Experiment 1 examined age differences in the tendency to repeat words in free recall. In a typical free recall task subjects try to reproduce as many words as they can, and there is generally an implicit expectation that each word should be recalled once. Optimal performance may be assumed to involve the concurrent examination of two lists, an input list, presumably containing a record of the words learned, and an output list containing a record of the words that have already been recalled. An item is reported only if it is contained in the first list and not yet included in the second list (see Murdock, 1974). Poor memory for one's past responses may be expected to result in the tendency to repeat words in free recall.

A series of studies by Gardiner and his associates (Gardiner & Klee, 1976; Gardiner, Passmore, Herriot, & Klee, 1977) indicated that subjects generally remember which words they have emitted and which they have not in a previous free recall test. Impairing the feedback from one's free recall responses (e.g., by asking subjects to recall the words orally while they hear white noise through earphones) resulted in poorer monitoring of the recalled items and in a higher incidence of recall repetitions relative to an unimpaired condition. These results suggest that the free recall task may be effectively used to capture processes of output monitoring. Thus, Experiment 1 compared the tendency to repeat words in free recall among older and younger subjects. In order to maximize the occurrence of response repetitions, the study list was composed of words that were related to one another along various semantic dimensions, and recall was tested orally to prevent the inspection of previous responses.

Method

Subjects. Forty subjects participated in the study, 20 young people (9 women) aged 20–30 years, and 20 elderly people (12 women) aged 65–87. The young group included students who were paid for participation, and the older group included volunteers from the community.

Stimulus materials. The stimulus list was taken from Koriat and Melkman (1987; Experiment 1). It included 28 Hebrew words that could be grouped into 14 pairs of categorically related words (e.g., pants–boots), or alternatively into 14 pairs of associatively related words (e.g., pants–tailor). Each word was printed on a 12 × 6-cm white card using a 1-cm Letraset print.

Procedure. Subjects were tested individually, either in a laboratory or in their homes. They were told that they had to learn a list of words, each word appearing on a separate card. The words were presented by manually displaying the cards one at a time at a rate of one card every 5 s. When presentation was completed, the subjects were asked to recall as many words as they could from the list in any order they desired. Two minutes were allotted for recall, and the responses were tape recorded. No feedback was given, and when subjects asked a question (e.g., "have I said this word before?"), the experimenter replied with a neutral statement. The study and recall phases were repeated four more times, with presentation order determined randomly for each trial by manually shuffling the cards.

Results

Means of number of words correctly recalled by the young group for trials 1 to 5 were 14.70, 21.90, 23.95, 25.65, and 25.10, respectively. The respective means for the older group were 6.80, 11.00, 13.20, 16.00, and 19.05. A two-way analysis of variance (ANOVA) yielded $F(1,38) = 88.11, p < .01$ for group, $F(4,152) = 110.46, p < .01$ for trial, and $F(4,152) = 5.90, p < .01$ for the interaction. The inferior recall performance of the older subjects is consistent with previous findings (e.g., Perlmutter & Mitchell, 1982). The difference between the age groups is stronger for the earlier trials, apparently because the younger subjects attain asymptotic performance earlier.

Of more interest are the data on commission errors. Across all trials the mean number of words recalled by the younger and older subjects was 22.26 and 13.21, respectively. However, the total number of words emitted averaged 25.38 and 17.21 for the two groups, respectively. The additional words were distributed as follows for the young and old subjects, respectively: second occurrences of a correct word (2.69 and 2.81), third (or more) occurrences of a correct word (0.12 and 0.17), extralist intrusions (0.30 and 0.83), and second occurrences (or more) of these intrusions (0.01 and 0.19).

It may be seen that despite the marked age difference in numbers of words recalled, the older subjects produced about the same number of repetitions as the younger group. Counting only first repetitions (i.e., second occurrences of a correct word) the likelihood of repeating a word for the young group was .12, .12, .12, .13, and .11 for trials 1 to 5, respectively. The respective means for the old group were .22, .20, .23, .22, and .21. A Group × Trial ANOVA yielded a significant effect for group ($F(1,38) = 5.77$, $p < .05$), and no other effects. Thus, the proportion of first repetitions remains constant across trials, but for each trial it is nearly twice as high for the older than for the younger group. A similar trend was observed when all repetitions (not only first) were included. The likelihood of such repetitions across trials was .13 for the younger subjects and .23 for the older subjects ($F(1,38) = 5.40$, $p < .05$).

Older subjects also committed a larger number of extralist intrusions. Counting only first occurrences of an intrusion, a two-way ANOVA on number of intrusions emitted yielded $F(1,38) = 11.05$, $p < .01$ for group, $F(4,152) = 2.94$, $p < .05$ for trial, and $F(4,152) = 1.33$, *ns* for the interaction. Number of intrusions decreased with trial but for each trial the older subjects produced a larger number of intrusions than the younger subjects. The likelihood of repeating an extralist intrusion was also higher for the elderly (.16) than for the young subjects (.07), though the difference was not significant.

Discussion

The results on recall performance are consistent with previous findings of poorer recall among older subjects. However, despite the smaller number of words recalled by the older group, the likelihood of repeating a word for a second or a third time was higher than that exhibited by the younger group. This is in line with the postulated old age deficiency in output monitoring. If older persons are deficient in monitoring their past actions, they should be more likely to repeat an act that has already been accomplished.

Older persons also exhibited a relatively large number of extralist intrusions. Examination of these intrusions indicated that some were semantic associates of the words in the original list. This may suggest that older people are also deficient in monitoring items for input occurrence during free recall. The observation that number of intrusions decreased with trials is consistent with the proposition that extralist intrusions may stem from inefficient input monitoring.

EXPERIMENT 2

Experiment 2 included two tasks. The first, a recall task, was similar to that used in Experiment 1, and was intended to extend the results of Experiment 1 to a study list composed of unrelated words. The second, an output recognition task, was intended to examine more directly the hypothesized old age deficiency in output monitoring. Subjects were presented with a second list of words for one study–recall trial, and were then tested for the memory of which words they had remembered.

The output recognition task allows examination of age differences in the type of output monitoring error assumed to underlie response repetition, namely, a belief that a performed action has not been performed. The higher proportion of response repetitions found for the older subjects in Experiment 1 was attributed to this type of monitoring deficiency. However, it could also result from other sources. Thus, it can simply derive from the older subjects adopting a laxer criterion for emitting items that come to mind. Also the older subjects may deliberately repeat words as a device to aid concentration on the task, or to help in retrieving additional words. These problems of interpretation are inherent in the recall repetition paradigm, which relies on aspects of spontaneous behavior.

In the output recognition task we measured recognition memory for previously recalled words. It was predicted that older subjects would evidence a stronger propensity to misclassify recalled words as unrecalled. Also by correlating memory indices derived from the recall and output recognition tasks it was hoped to obtain further evidence relating response repetitions in old age to a failure to remember performed actions.

Method

Subjects. Sixty subjects participated in the study, 30 young people (21 women) with average age 22.7 years (range 18–28 years), and 30 elderly people (15 women) with average age of 70.1 years (range 60–87 years). The young group consisted mostly of first year students, while the elderly group included volunteers from the community. The average years of formal education was 12.46 (range 12–15) for the younger subjects and 12.20 (range 8–16) for the older subjects.

Stimulus materials. Two lists of 24 Hebrew nouns each were used, matched for word concreteness and word frequency. One (List 1) was used for the recall task and the other (List 2) was used for the output recognition task. Each word was printed on a 6.5 × 10-cm white card in Hebrew block letters of a 0.6-cm height.

Procedure. Subjects were tested individually. The experiment included two tasks, a recall task followed by an output recognition task. The procedure for the recall task was similar to that of Experiment 1 except that presentation rate was one card every 4 s, and that subjects read the words aloud as they were displayed. One and a half minutes were allotted for recall. The study and recall phases were repeated for two more trials.

Following the third recall of List 1 the subjects were asked to learn a second list. List 2 was then presented using the same procedure as before, and the subjects were allowed 1.5 min for recall. Then a timed filler task requiring number–form matching was administered for 1.5 min. Finally, the subjects were given the 24 cards of List 2 and were asked to sort them into words that they had recalled and those they had not.

Results

We shall first examine the results for the recall task. The number of words recalled by the young group averaged 11.63, 16.50, and 18.87 for trials 1, 2, and 3, respectively. The respective means for the older group were 6.83, 9.77, and 12.20. A two-way ANOVA yielded $F(1,58) = 83.80$, $p < .01$ for group, and $F(2,116) = 205.75$, $p < .01$ for trial. The interaction was also significant ($F(2,116) = 6.13$, $p < .01$), apparently due to the greater improvement from the first to the second trial for the young group.

Of more interest are the data on recall repetitions. Counting only first repetitions, the likelihood of repeating a correctly recalled word on trials 1, 2, and 3, respectively, was .11, .15, and .13 for the young group, and .16, .20, and .23 for the elderly group. An ANOVA on these data yielded $F(1,58) = 5.67$, $p < .05$ for group, $F(2,116) = 1.85$, *ns* for trial, and $F(2,116) = 0.99$, *ns* for the interaction. Essentially the same results were found when all repetitions (not only first) were included. Across all trials, the likelihood of such repetitions was .13

for the young group and .21 for the elderly group ($F(1,58) = 4.80$, $p < .05$), with no significant effects for either the trial ($F(2,116) = 1.46$) or the interaction ($F(2,116) = 0.94$).

As in Experiment 1, older subjects also produced more extralist intrusions (mean 0.59) than younger subjects (mean 0.39), but the difference was not significant ($F(1,58) = 1.73$). For both groups, the number of extralist intrusions decreased with trial ($F(2,116) = 8.97$, $p < .01$). The likelihood of repeating an extralist intrusion was higher among the older (.12) than among the younger subjects (.03).

We shall turn next to the data from the output recognition task. In this task subjects decided for each word whether they had recalled it in the preceding recall phase or not. Signal detection indices were utilized in analyzing these data. A hit rate was defined as the proportion of words judged as "recalled" out of those actually recalled. False alarm rate was defined as the proportion of words incorrectly classified as "recalled" out of all unrecalled words. We also calculated corrected scores, based on subtracting false alarm rate from hit rate (Swets, 1986). The corrected hit rate means averaged .87 for the young group and .58 for the elderly group ($t(58) = 4.43$, $p < .01$), indicating that the older subjects were poorer at recognizing the words they had recalled. This difference was mostly due to the hit rate component: The older group exhibited a significantly lower mean hit rate (.65) than the younger group (.92; $t(58) = 4.60$, $p < .01$). In contrast, the respective means for false alarm rate were .07 and .05, and did not differ significantly ($t(58) = 1.16$). Thus, older subjects evidenced a greater tendency to treat recalled words as though they were not recalled, while they were not more liable to misclassify unrecalled words as ones that have been recalled.

To examine the relationship between memory monitoring and response repetition we calculated the correlation between the likelihood of response repetition in the recall task and the scores derived from the output recognition task. For the older group the proportion of repetitions, averaged over the three trials, correlated $-.40$ ($p < .05$) with hit rate and $-.45$ ($p < .01$) with the corrected hit rate measure. The respective correlations for the younger subjects were much lower, amounting to $-.17$ and $-.12$, respectively.

Although the older and younger groups were equated on the average number of years of formal education, the older group was more heterogeneous in this respect. The above analyses were therefore repeated, including in the older group only subjects with at least 12 years of schooling ($N = 21$). The differences between the younger and the older subjects in proportion of repetitions and output recognition were very similar to those reported above for the entire sample.

Discussion

Experiment 2 replicated the main finding of Experiment 1 with a list of unrelated words: Older subjects exhibited a greater tendency for output repetition than younger subjects. The results from the output recognition task point to a possible source of this age effect. Older subjects were found to have greater difficulty in recognizing which words they had recalled. About a third (.35) of the words they had recalled were classified by them as unrecalled, compared to only .08 for the young group. In contrast, older subjects were not particularly apt to classify unrecalled words as recalled. Furthermore, among the older group, the tendency to repeat a response in the free recall task was negatively correlated with hit rate in the output recognition task. That is, subjects who evidenced more repetitions in free recall were more likely to classify recalled words as unrecalled. These results are consistent with the proposition that response repetition in old age stems from a deficient monitoring of the actions performed.

EXPERIMENT 3

The view of the free recall task adopted in the present paper assumes the operation of a selection mechanism during recall, which serves to inhibit the overt production of inappropriate word candidates. These are words, judged not to have been included in the study list, or words believed to have been previously recalled. This view implies that word candidates that come to mind during free recall are normally monitored for both input and output occurrence prior to overt production. Indeed, when subjects are given "uninhibited" recall instructions, they produce significantly more extralist intrusions and more intratrial repetitions in comparison to the standard recall instructions (Bousfield & Rosner, 1970).

The results of Experiment 1 indicated significant age differences in both response repetitions and extralist intrusions, suggesting that older people are deficient in output monitoring, and possibly in input monitoring as well. Experiment 2 replicated the age differences in response repetition, and suggested that they derive from the failure of older people to recognize that a word candidate has already been produced. In Experiment 3 we wished to obtain more information on the input and output monitoring assumed to underlie the selection of responses in free recall. A recognition memory paradigm was employed to simulate the on-line screening of word candidates in free recall. The rationale was as follows: During recall the subject must judge each word candidate in terms of two criteria: first, whether it has appeared in the study list (input monitoring), and second, whether it has been already recalled (output monitoring). These two binary decisions essentially sort the word pool (the candidate pool) into four sets. One of the sets defines the words to be overtly produced (the recall set). This set consists of the words judged to be included in the input list and not yet contained in the output list. This double-classification process was simulated in Experiment 3 as follows: Subjects first learned a list of words. Then they were presented with a series of test words (equivalent to the candidate pool) which included the study words and new words, each appearing twice. Subjects were asked to sort the words into four piles in terms of both input and output occurrence. Thus, the words in one pile (equivalent to the recall set) ideally duplicated the study list, including one and only one exemplar of each of the study words. The subject was to put a word into this pile if (a) it was a study word, *and* (b) it was not already represented in that pile. Placing more than one exemplar of the word in this pile represents the type of output monitoring error assumed to underlie response repetitions. Classifying a distractor as a study word represents the kind of input monitoring error likely to lead to extralist intrusions.

The double-classification task of Experiment 3 is similar to the continuous recognition task. We believe that the latter task also captures certain rudimentary aspects of output monitoring by virtue of the fact that the encoding of an item takes place in the context of the processes that occur while being tested on it. Although in the continuous recognition task the feedback from one's own responses is more limited than in free recall, there is evidence that the responses in this task (e.g., frequency judgments) tend to be consistent not only with input occurrence but also with the previous response to the same item, suggesting that subjects utilize both item and response information in subsequent judgments (see Begg & Rowe, 1972; Hockley, 1984; Ratcliff & Hockley, 1980). The double-classification task of Experiment 3 differs from the continuous recognition task in that subjects are explicitly instructed to make their responses to a word contingent upon their response to that word on a previous encounter. This requires that subjects retain a record of the processes that take place during the memory test itself.

The double-classification recognition test allows a conjoint assessment of input and output monitoring, and may help reconcile our interpretation of age differences in response repetition with previous findings on the memory for frequency information. According to our interpretation, response repetitions in older people derive from their failure to discriminate between first and second occurrences of an item in an output list. However, previous results indicated that memory for frequency information is among the skills that display the least deterioration with age, consistent with the proposal that frequency of occurrence is automatically encoded (Hasher & Zacks, 1979, 1984). On the basis of these results one would expect little age differences in repetition behavior of the sort illustrated by taking the same medicine twice. Apparently, such repetitions can be prevented on the basis of a simple frequency count. Our findings that older persons do exhibit more response repetitions and impaired output recognition suggest that it might be important to distinguish between recognition memory for input events and recognition memory for output events. In Experiment 3 we examined the hypothesis that it is the estimation of output occurrence which is specifically impaired in old age.

Experiment 3 also allows a comparison of the kind of memory errors committed by the younger and older subjects in monitoring input and output occurrence. In several studies older subjects were found to evidence a higher false-alarm rate than younger subjects, that is, a stronger tendency to misclassify "new" items as "old" items (Ferris, Crook, Clark, McCarthy, & Rae, 1980; Harkins, Chapman, & Eisdorfer, 1979; Light, Singh, & Capps, 1986). This is exactly the reverse of the output monitoring error assumed to underlie telling a story twice, namely classifying "old" items as "new." It is this latter type of error that was found to characterize the older subjects' performance in the output recognition task of Experiment 2. In Experiment 3 we examined the hypothesis that although older subjects may yield a higher false alarm rate for input monitoring (the type of error likely to lead to extralist intrusions), they should exhibit a higher rate of misses for output monitoring (the type of error assumed to lead to response repetition).

Method

Subjects. Eighty subjects participated in the study, 40 young people (26 women) with an average age of 24.5 years (range 21–31 years), and 40 elderly people (12 women) with an average age of 71.2 years (range 61–85 years). The young group included mostly first year students who participated in the experiment for course credit. The elderly group included volunteers from the community, most of whom were recruited through senior citizens clubs. All elderly subjects (except one) managed their own households and led independent lives.

Stimulus materials. The word stimuli were the same as those of Experiment 2, with the 24 words of List 1 used for the study phase, and the 24 words of List 2 included as the new items in the test phase.

The stimuli were printed on cards exactly as in Experiment 2. For the study phase, one deck of 24 cards was prepared. For the test phase, each of the old and new words was printed on 2 cards. Thus, the test deck included 96 words, 24 old and 24 new words, each appearing twice. The two occurrences of each word were separated by either 7, 15, 23, or 31 words, with an equal number of old and new words in each lag. The lags were distributed randomly throughout the list, with the constraint that they were equally represented in the first and second halves of the list.

Two versions of the test deck were prepared, one for each of the two trials of the experiment. They conformed each to the above specifications and differed only in the order of the words within the list.

Procedure. Subjects were tested individually. They were told that they had to learn a series of words, reading each aloud as it was shown. The words were presented at a rate of one card every 4 s.

When presentation was completed, the experimenter placed four boxes on the table. Two boxes, labeled A1 and B1, were close to the subject, A1 on the right and B1 on the left. The other two boxes, labeled A2 and B2, were placed behind the first two, so that their labels were also visible to the subject. Subjects were handed the 96 cards and were told that they included words from the study list as well as new words. They were instructed to sort the words into those that were seen during study (box A1), and those that were not (box B1). In addition, they were told that each word would appear twice, and that their goal was to ensure that box A1 contained all the words from the study list, each appearing only once. Thus, if they saw a word that they had placed in box A1 they were to place it now in box A2. Similarly, if they saw a word they had already placed in box B1, they were to place it now in box B2. Subjects were to say each word aloud and to put the card in the appropriate box face down.

When sorting was completed, the entire procedure of one study phase and one test phase was repeated using the same list and the same exact procedure. For the study phase the cards were presented in a random order that remained the same for all subjects and for both trials. For the test phase a different version of the test deck was used for each trial, with the order of administration of the two versions counterbalanced across subjects for each age group.

Results

As a preliminary analysis, we examined the distribution of the four response types for each of the four stimulus categories: first occurrence of an old (i.e., study) item, second occurrence of an old item, first occurrence of a new item, and second occurrence of a new item. For each subject the proportion of each response type was calculated for each of the four stimulus categories for each of the two trials. The means of these proportions are presented in Table 1 for the young and the elderly groups.

The proportions of correct responses were generally high for the young group, and of comparable magnitude across the four stimulus classes. These proportions were lower for the elderly group, and relatively more so for the second than for the first occurrence of a word. The largest proportion of the elderly group's errors consisted of falsely classifying a second occurrence of a word as its first occurrence (Table 1). This pattern is consistent with the hypothesized old age deficiency in output monitoring.

We shall proceed to a detailed analysis of these data, first focusing on the hypothesis that older people are more deficient in output than in input monitoring. For both types of monitoring we calculated hit rate and false alarm rate scores. For input monitoring, a hit was defined as the correct recognition of a word as one that has been studied (i.e., old item), and a false alarm was defined as the incorrect classification of a new word as one that has appeared in the study list. Both of these indices were calculated disregarding the classification of the item as first or second occurrence. For output monitoring, a hit was defined as the correct judgment that a word was previously classified, and a false alarm was defined as the incorrect judgment that it was, irrespective of the classification of the item with regard to appearance in the study list.

The results, in general, indicated an old age deficiency in both types of monitoring, but the extent of this deficiency was stronger for output than for input monitoring. To evaluate this interaction, we calculated corrected hit rate scores (hit rate

TABLE 1
AVERAGE PROPORTIONS OF RESPONSES FOR FIRST AND SECOND OCCURRENCES OF OLD AND NEW WORDS

		Group:	Young				Elderly			
		Word type:	Old		New		Old		New	
		Occurrence:	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Trial 1 response	Old	1st	.70	.06	.09	.06	.61	.26	.08	.16
		2nd	.06	.66	.01	.11	.05	.41	.01	.09
	New	1st	.21	.04	.86	.13	.30	.16	.89	.43
		2nd	.04	.24	.05	.70	.04	.17	.03	.32
Trial 2 response	Old	1st	.75	.12	.09	.04	.62	.26	.12	.15
		2nd	.14	.77	.03	.12	.11	.47	.04	.12
	New	1st	.07	.02	.78	.10	.25	.13	.80	.36
		2nd	.04	.10	.10	.74	.03	.14	.05	.37

minus false alarm rate) for input and output monitoring. The older subjects evidenced inferior performance in output than in input monitoring, with corrected hit rates of .44 and .51, respectively, while the younger subjects exhibited the opposite trend, the respective means being .74 and .68. A three-way ANOVA, Group × Trial × Monitoring Type (input vs output) yielded a significant Group × Monitoring Type interaction ($F(1,78) = 15.50, p < .01$). This pattern was obtained mainly for the first trial, as indicated by a significant Group × Monitoring Type × Trial interaction ($F(1,78) = 24.68, p < .01$).

Older subjects yielded significantly lower corrected hit rate scores on output monitoring ($F(1,78) = 68.40, p < .01$). However, they also evidenced significantly lower corrected hit rate scores on input monitoring ($F(1,78) = 18.98, p < .01$). Two additional analyses were therefore performed, evaluating age differences in output monitoring with differences in input monitoring controlled. In the first, each subject's output monitoring scores were based only on items that were correctly classified by him/her as old or new with respect to input. In the second analysis, 15 young and 15 elderly subjects were identified whose corrected hit rate scores for input monitoring on the first trial were exactly matched. Both analyses yielded a significant old age deficiency in output monitoring of about the same magnitude as reported above.[1]

We shall turn next to the hypothesis that the age-related pattern of errors differs for input and output monitoring. Figure 1 presents the proportions of two types of errors, misses and false alarms. Miss rate is defined as the likelihood of classifying old items as new, or second occurrences as first occurrences, and is equivalent to the complementary of hit rate. False alarm rate represents the likelihood of classifying new items as old or first occurrences as second occurrences. As can be seen (Figure 1), the

[1] In response to the reviewers' comments regarding the possibility that education effects may be confounded with age effects, we made an effort to collect information concerning the subjects' formal education level. We have been able to secure the number of years of schooling for all young subjects and for 24 of the elderly subjects. These averaged 12.65 (range 12–17) for the young group, and 11.29 (range 6–16) for the 24 elderly subjects. The elderly group was divided into three subgroups: 13 subjects with 12 or more years of schooling (mean = 13.23), 11 subjects with less than 12 years of schooling (mean = 9.00), and 16 subjects with unknown level of formal education. ANOVAs comparing the three groups on input and output indices revealed no significant differences among the three subgroups. Moreover, a comparison of the young group to the elderly subgroup with the highest level of education revealed very similar differences in input and output indices to those reported above for the entire sample.

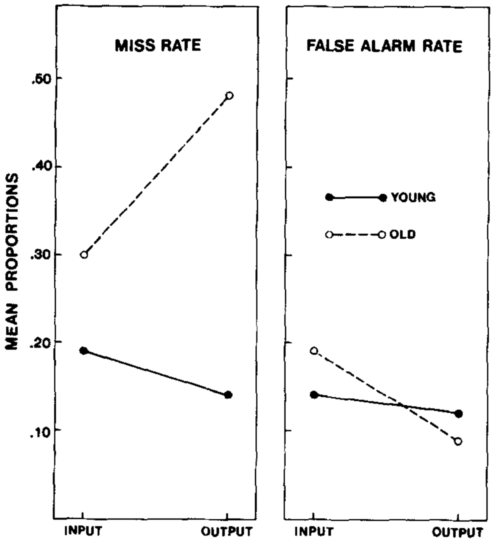

FIG. 1. Mean miss rate and false alarm rate as a function of monitoring typing and age group.

two types of errors seem to evidence a different pattern of Group × Monitoring Type interaction. Consider first the proportion of misses. The elderly subjects evidenced a higher miss rate overall than the younger subjects, but the difference was clearly more pronounced for output than for input monitoring. Thus, whereas the younger subjects evidenced more misses in input than in output monitoring, the elderly subjects had more misses in output than in input monitoring. Consider, on the other hand, the proportion of false alarm errors. Here the old age deficiency is stronger for input than for output monitoring. For input monitoring, elderly subjects yielded a higher false alarm rate than the younger subjects, whereas for output monitoring the reverse pattern was found. A four-way ANOVA, Group × Trial × Monitoring Type (input vs output) × Error Type (false alarms vs misses) yielded a significant effect for the Group × Monitoring Type × Error Type interaction ($F(1,78) = 46.60$, $p < .01$), and a nonsignificant four-way interaction.

In sum, older subjects exhibited poorer output monitoring, with a pronounced tendency to misclassify items that had already occurred in the output list as if they appeared for the first time. This is the error assumed to underlie response repetition. Input monitoring, in contrast, indicated a higher old age tendency to classify new items as old.

The stronger old age deficiency in output monitoring may derive, in part, from a failure to distinguish between input occurrence and output occurrence. Thus, it may be hypothesized that older people are more likely to lose origin information (see Anderson, 1984), which can lead to a greater difficulty in attributing a memory trace specifically to input or to output events. If this is correct, then older subjects should be particularly deficient in the input monitoring of second occurrence items and in the output monitoring of old (study) items. The results for input monitoring are generally consistent with this hypothesis. Older subjects did tend to make more false alarms on second occurrence (.26) than on first occurrence words (.12), while younger subjects exhibited comparable performance (.16 and .11, respectively). Group × Occurrence ANOVAs indicated a significant interaction for false alarm rate ($F(1,78) = 20.83$, $p < .01$), while the interaction effect for miss rate was not significant ($F(1,78) = 3.62$). Thus, older people tend to misclassify second occurrences of new words as old-input words, suggesting that they may have some difficulty in differentiating between the input and the output lists.

The results on output monitoring, however, did not conform to the hypothesis. If older people are more prone to lose origin information, they should exhibit a stronger impairment in output monitoring for old (study) words than for new (test) words. However, the older subjects' miss rate was in fact lower for old words than for new words (.41 and .55, respectively), while the younger subjects evidenced comparable scores (.12 and .17, respectively). Group × Word Type ANOVAs indicated a significant interaction for miss rate ($F(1,78) = 15.00$, $p < .01$), and a nonsignificant interaction for false alarm rate ($F < 1$).

Discussion

The results of Experiment 3 lend further support to the hypothesis that older subjects are relatively poor in output monitoring, and that the type of memory errors they make should result in the repetition of performed actions.

The comparison of age differences in input and output monitoring also helps to reconcile our explanation of response repetitions in old age with previous findings on age differences in memory. At first glance, our account appears inconsistent with two such findings. First, estimation of frequency is among the memory skills that evidence the least deterioration with age. Therefore, older people should not necessarily be deficient in determining whether a story has already been told. Second, older people evidence a tendency to classify new items as old, which is the reverse of the kind of error assumed to underlie response repetition. Both of these observations were obtained with tasks involving input monitoring. The results of Experiment 3, however, indicate different age effects for input and output monitoring. First, the old age impairment was more severe for output than for input monitoring. Second, although older subjects tended to evidence a higher false alarm rate for input monitoring, they exhibited a higher miss rate for output monitoring.

General Discussion

The present study focused on the ability to remember that a planned act has been performed. This type of memory seems to be crucial in everyday life, and its failure is expected to result in the repetition of a task that has already been accomplished. We sought to gain insight into this type of memory by analyzing repetition behaviors and their alleged preponderance among elderly people.

In Experiments 1 and 2 the tendency to repeat words in free recall was found to be stronger among older than among younger subjects. The results of the output recognition task of Experiment 2 pointed to a possible source of these age differences: Older subjects failed to recognize a larger proportion of the words they had previously recalled, compared to younger subjects. The tendency to repeat a word in free recall and the tendency to judge recalled words as unrecalled were positively correlated in the elderly subjects, again supporting the hypothesized relationship between repetition behavior and impaired output monitoring. Experiment 3, using a continuous recognition paradigm, indicated an old age impairment in output monitoring, which was more pronounced than that found for input monitoring. Furthermore, although older persons were more likely to classify new-input occurrences as old-input occurrences, they tended to classify old-output occurrences as new-output occurrences. This latter type of error is the one assumed to underlie action repetition. Altogether, the results of the present study suggest that older people have a stronger tendency to repeat an act that has been performed, and that this tendency stems from a deficiency in monitoring the actions performed by them.

The different patterns of age-related effects observed for input and output monitoring raise the general question of how the memory for output occurrence differs from that for input occurrence. How does the memory that I have already recalled a word differ from the memory that I have learned it? How does the memory that I have told a joke differ from the memory that I have heard it? Perhaps the critical difference is that memory for output occurrence concerns one's own actions. In several studies memory for activity was investigated by having subjects perform a series of activities and then testing their memory for those activities. The findings suggested that this type of memory is indifferent to the effects of level of processing or the instructions to learn. The results were in disagreement, however, with regard to the question of whether memory for activity declines with age (Backman & Nilsson, 1984; Cohen, 1981; Cohen & Stewart, 1982; Kausler & Hakami, 1983; Kausler et al., 1985).

Clearly, the experimenter-elicited tasks utilized in these studies differ from the subject-initiated tasks performed in real life, such as taking a medicine or locking the door. These latter acts are normally embedded within a cognitive plan that begins with the intention to perform the act, and ends with its execution (see Miller, Galanter, & Pribram, 1960). Therefore, the processes involved in planning the act, retrieving it, and performing it are probably critical in determining future recall that the act had been performed. This characteristic of subject-initiated acts must be taken into account in explaining the greater age impairment in output than in input monitoring. Three possible explanations are delineated below, based on what we know about memory in the elderly (see Kausler, 1982).

The first account, to be referred to as the list differentiation account, may be illustrated with the aid of an analogy. Assume that there is a meeting in a certain hall, and that a guard is assigned the job of keeping track of who enters the hall and who leaves. Every once in a while the guard may be asked to report whether a certain person has entered the hall, or whether he/she has already left. This situation has the important characteristic that since everyone who leaves the hall must have entered it at some time, the output list (the list of all those who left) must constitute a sublist of the input list (the list of those who entered). Under these circumstances, the judgment of familiarity is sufficient to allow classifying the person as one who *entered* the hall, but is not sufficient to allow the decision that he/she *left* the hall (see Mandler, 1980). This latter decision requires the additional information that the person was encountered in one particular context (going out) rather than in another (going in).

Thus, according to the list differentiation hypothesis, the primary difference between input monitoring and output monitoring is that the latter has often to rest on contextual cues that may not be necessary for the former. Since the stories I tell represent a subset of the stories I have come to store in my memory, familiarity with a story as such does not ensure that I have told it. This latter decision depends on the ability to retrieve the appropriate output context. An old age deficit in the encoding and/or retrieval of contextual information may thus explain the greater old age impairment in output than in input monitoring.

There is some evidence that older persons have greater difficulty in the encoding and/or maintaining of distinctive memory traces that retain contextual specificity (see Craik & Byrd, 1982; Schonfield & Stones, 1979). Kausler, Klein, and Overcast (1975) presented subjects with word pairs, one member of each pair denoted as correct. Older subjects had no greater difficulty than younger subjects in deciding whether a word appeared in the list or not, but were significantly worse in identifying the correct word. McCormack (1984) also found older subjects to have more difficulty in determining whether a specified item appeared in the context of one list or another.

If elderly subjects have greater difficulty in the encoding of contextual information, this may explain the stronger old age impairment in output than in input monitoring, and also some of the interactions observed in Experiment 3. Thus, for example, older people were more likely than the young subjects to classify new-input words as old-input words on their second occurrence than on their first occurrence. Other results, however, are difficult to reconcile with the list differentiation hypothesis, notably the observation that among older subjects output monitoring performance was better for old-input than for new-input items. Furthermore, this hypothesis does not allow specific predictions regarding the type of errors that may result from impaired list differentiation. Additional assumptions must be made to explain why insufficient differentiation between input and output occurrence in old age should specifically result in the tendency to classify old-output items as new-output items.

The second account focuses on attentional processes. According to Craik and Byrd (1982), old age impairment in memory is due to a decreased availability of attentional resources. It may be proposed that this attentional deficit should be more detrimental to output than to input monitoring. The encoding of output occurrence should be generally more demanding than the encoding of input occurrence, because it occurs in the context of the processes that underlie task performance. Since these latter processes normally demand attention, we may expect that there should be fewer spare resources in older people that may be allocated to the encoding of output occurrence. For example, in all of the experiments reported in the present paper, encoding input occurrence during the study phase may be assumed to be less cognitively demanding than keeping track of one's own responses during the test phase. This explanation, it should be noted, assumes that frequency information may not be automatically encoded under all conditions. Also, it appears inconsistent with the proposition that memory for activity is automatic (e.g., Kausler et al., 1985), though, as noted above, memory for subject-initiated activities may not be the same as memory for experimenter-elicited activities.

The third explanation is also related to the presumed old age deficit in attentional resources, but focuses on the nature of retrieval processes in old age. Recent views of the process of remembering (see Tulving, 1985) make a distinction between two types of retrieval processes. The first is a controlled, conscious process designed to reproduce a sought-for memory item. This process is tapped, for example, by a free recall test. The second process is more automatic and operates without the intention to access the specific memory entry. It is entailed, for example, in memory measures that rest on fragment completion (e.g., Tulving, 1985), word association (e.g., Koriat & Feuerstein, 1976), etc. Amnesic patients have been said to exhibit a deficiency in the former but not in the latter type of memory (e.g., Warrington & Weiskrantz, 1970). Recently, there has been some evidence indicating that elderly people also exhibit a similar pattern to that obtained with amnesics (e.g., Light et al., 1986).

The results suggest the interesting hypothesis that the unaided retrieval of information by older people relies more heavily on the automatic type than on the controlled type of memory processes. As people grow older retrieval processes become more automatic and less controlled. If this hypothesis is correct, it may explain the old age deficiency in output monitoring. We propose that the more automatic and "incidental" a retrieval act is, the less likely it is to acquire a contextual tag allowing future judgment of its output occurrence. Checking behavior (e.g., checking that we have locked the door) (see Reed, 1985), for example, seems to be particularly frequent with regard to routine acts that are normally carried out without attention. It is thus possible that both checking behavior among normal adults and repetition behavior among older persons have a common source, insufficient distinctive tagging of one's performed actions.

The three accounts outlined above are not mutually exclusive. Thus, for example, the presumed old age deficiency in list differentiation may itself derive from a deficit in attentional resources that hinders contextual tagging. We are presently investigating the list differentiation hypothesis by comparing age differences in two tasks, one testing the ability to differentiate between different input lists, and the other testing the ability to differentiate between different output lists. If the differences between input and output monitoring derive simply from the fact that output lists (e.g., stories told) generally constitute a subset of input lists (stories registered), then similar age differences should be obtained in the two tasks. If, on the other hand, there exist inherent differences between output and input monitoring processes, then perhaps older subjects should evidence greater impairment in distinguishing between output lists than in distinguishing between input lists.

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