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Aging and Maintaining Intentions Over Delays: Do It or Lose It

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When execution of retrieved intentions must be briefly delayed, older adults display deficits in performing those intentions (G. O. Einstein, M. A. McDaniel, M. Manzi, B. Cochran, & M. Baker, 2000). This initial finding was extended by showing age-related deficits with 5-s unfilled delays, with instructions to rehearse during the delay, and with divided attention during initial retrieval of the intention. Performance increased with a break at the end of the delay period, such that when combined with full attention (during retrieval), older adults' performance approached that of younger adults. These results suggest that age compromises maintenance of information in awareness. Consequently, when forced to delay execution of retrieved intentions, older adults may rely more on plan reformulation and subsequent retrieval of the intention from long-term memory at the end of the delay.

Remembering to perform an intended action at some appropriate instance in the future is an important everyday memory activity for both younger and older adults. In keeping with the literature, we term this *prospective memory*. Arguably, prospective memory may have more critical implications for older than for younger adults, as many older adults must remember to take medications or keep appointments with health professionals. However, the degree to which aging will impact prospective memory is theoretically uncertain. Some researchers assume that prospective memory requires strategic or self-initiated processes that decline with age (e.g., see Craik, 1986; Maylor, 1996), whereas others assume that prospective memory is supported by spontaneous and relatively automatic processes that are spared with age (Einstein & McDaniel, 1990; McDaniel & Einstein, 2000). Accordingly, understanding age-related changes in prospective memory performance is important from both theoretical and applied perspectives (e.g., Craik, 1986; Einstein & McDaniel, 1990; Park & Kidder, 1996).

Much of the research directed at prospective memory and aging has thus far focused on a "standard" prospective memory situation in which participants are instructed to remember to perform an intended action when a particular target event appears during the course of the experiment (see Einstein & McDaniel, 1990; Maylor, 1996). Although the pattern of age-related effects is mixed, a significant number of studies show little or no age-related decrements in prospective memory performance on this event-based prospective memory task (Cherry & LeCompte, 1999; Cherry et al., 2001, Experiments 2 and 3; Einstein, Holland, McDaniel, & Guynn, 1992; Einstein & McDaniel, 1990; Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). As well, a more real-world event-based task of remembering to ask the experimenter to return a personal possession at the end of the experiment has not displayed age differences (Kliegel, McDaniel, & Einstein, 2000; see also Rendell & Craik, 2000, Experiment 2, for similar absence of age effects in a naturalistic context, but see Mäntylä & Nilsson, 1997, for age differences). This pattern possibly suggests that age-related decline on this type of prospective memory task is not overly or generally dramatic (see also Park, Hertzog, Kidder, Morrell, & Mayhorn, 1997; but see Maylor, 1995, for a different view).

Einstein, McDaniel, Manzi, Cochran, and Baker (2000) recently noted that this standard paradigm fails to capture a common element of many everyday prospective memory tasks. In some situations, a person may successfully retrieve the intention but have to briefly delay execution of the task. For instance, a person may remember that she needs to take her medication when in the bathroom but must walk to the kitchen to get the medication, thereby requiring a brief delay between retrieving the intention and being able to execute it. Or upon seeing a colleague in conversation, you may remember that you need to give that colleague a message but have to delay communication of the message until there is a break in the conversation. Einstein et al. developed a laboratory paradigm to investigate prospective memory in these *delayed-execute* prospective memory situations and examined performance for younger and older adults. (Einstein et al. used *retrieve delay* to label these situations; however, we now believe that *delayed-execute* is a more descriptive label.) Unexpectedly and in contrast to some of the literature focusing on the usual prospective memory paradigm, Einstein et al. found that older adults displayed robust deficits on the delayed-execute task relative to younger adults. This age deficit emerged even when the delays between retrieval and the opportunity to execute the intended action were as brief as 10 s. Since reporting this finding, colleagues (older ones especially) have shared examples with us of their prospective

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memory failures in situations that would be considered delayed-execute tasks. Thus, both preliminary laboratory evidence and individual everyday experiences converge on the possibility that the delayed-execute prospective memory task represents a surprisingly challenging prospective memory situation for older adults.

The major objectives of this study were to replicate the basic age-related deficit for the delayed-execute prospective memory task, to examine whether this deficit extends to even briefer delays, and to illuminate the factors that contribute to older adults' relatively poor performance.

Experiment 1

One plausible explanation for an age-related decline in delayed-execute prospective memory tasks is that older adults do not strategically rehearse the intention over the delay interval so as to maintain the intention in working memory (or focal attention). Younger adults do appear to spontaneously engage rehearsal activities to perform this task. Einstein, McDaniel, Williford, Pagan, and Dismukes (2003, Experiment 2) reported no differences in prospective memory performance for younger adult participants who were instructed to rehearse relative to those not instructed to use a rehearsal strategy. Further, the no-instruction group displayed decrements in performance on the ongoing task (relative to trial blocks for which there was no prospective memory task), decrements that were also found for the rehearsal instruction participants. These patterns imply that younger adults spontaneously implement rehearsal and that rehearsal is somewhat resource demanding. In this experiment, we applied a similar experimental strategy for investigating older adults' prospective memory performance. One group of older adults was strongly instructed and reminded to rehearse the intended action over the delay intervals, whereas another group was not given rehearsal instructions. A no-instruction younger group was also tested.

Older adults' deficits may be due to a disinclination to rehearse. For instance, older adults may not be attuned to the fleeting nature of the representation and the need to engage rehearsal to maintain the representation in awareness (i.e., a metamemory problem). If the deficit is solely a result of this disinclination to rehearse, then the older group instructed to rehearse should show general improvement over the older control group and perform as well as the younger control group.

Alternatively, perhaps older adults' limited resources (Craik, 1986; Craik & Byrd, 1982; Hasher & Zacks, 1988) do not enable them to effectively sustain rehearsal of the intention over the delay (owing to either basic capacity limitations, increased susceptibility to distraction, or both). If this is the case, then even when the older adults are instructed to rehearse, they will continue to perform significantly more poorly than the younger adults. Moreover, the rehearsal instructions should produce no benefits relative to the older control condition.

Still another possibility is that the deficits of the older adults reflect both a disinclination and an inability to rehearse. According to this view, rehearsal instructions should overcome the disinclination to rehearse, but the resource limitations of older adults would attenuate effective rehearsal (in the rehearsal-instructed group) as the demands of the delay interval increase (i.e., longer and filled delays).

The other important feature of this experiment was that we investigated delays as brief as 5 s. In Einstein et al. (2000), the shortest delays examined were 10 s. If robust age-related deficits emerge when execution of a retrieved intention need be delayed by only 5 s, then this would signal that age compromises performance on a memory task that does not appear to be especially demanding and that is common in everyday settings.

Method

Participants and design. The design of this study was a 3 × 2 × 2 mixed factorial with instructional group (younger control, older control, or older rehearsal) varied between subjects and length of delay (5 s or 15 s) and activity during the delay (unfilled or filled) varied within subjects. Twenty participants were assigned to each of the three conditions. Younger adults, who ranged in age from 18 to 21 years ($M = 19.0$), were general psychology students at Furman University and received course credit for participating. The older adults, who ranged in age from 56 to 79 years ($M = 69.8$ for older control and $M = 69.5$ for older rehearsal), were community dwelling and were paid $10 for participating. The older adults ($M = 16.9$ for control and $M = 16.1$ for rehearsal) performed significantly better than the younger adults ($M = 14.8$) on the Mill Hill Vocabulary Test (Raven, 1965), $F(2, 57) = 7.33$, $MSE = 3.07$. Older adults ($M = 15.7$ for control and $M = 16.1$ for rehearsal) had significantly more years of education than the younger participants ($M = 13.4$), $F(2, 57) = 7.16$, $MSE = 5.85$. Rated health (on a 5-point Likert scale with 1 indicating *poor* and 5 indicating *excellent*) was high and not reliably different for older ($M = 4.0$ for control and $M = 4.2$ for rehearsal) and younger ($M = 3.9$) adults, $F(2, 57) = 1.23$, $MSE = 0.50$.

Procedure and materials. The procedure for this study was modeled closely after the second experiment of Einstein et al. (2000). The Appendix provides a summary of the flow of the various tasks in the paradigm. Initially, participants were told that their primary task involved reading three-sentence paragraphs and then answering comprehension questions about them. These sentences were presented on a computer screen, one at a time for 10 s. After reading the third sentence for a particular paragraph, participants received either a synonym task or a break period, followed in turn by two trivia questions and two comprehension questions. The synonym task consisted of presenting either one synonym item (5 s) or three synonym items (15 s). The synonym items were presented for 5 s each, with the item listed at the top of the screen and four choices below it. The break periods lasted either 5 s or 15 s. Thus, the delays were always either 5 s or 15 s, and they were either unfilled (a break) or filled (a synonym task).

After the synonym task or break, two trivia questions were presented for 10 s each. Next, participants answered reading comprehension questions pertaining to the paragraph read earlier. Both the synonym and the comprehension items appeared in a multiple-choice format with four possible choices. Because this experiment included several different tasks, a heading (e.g., "Trivia Question") appeared at the top left of each screen to help participants determine the nature of their tasks in a particular phase.

To attempt to equate the demands of the various activities for younger and older adults (cf. Einstein et al., 2000), we asked older adults to call out their responses, and the experimenter circled their answers on the answer sheet. Younger participants responded by circling their selections on the answer sheet in front of them. Pilot work had shown that it was very difficult for older adults to monitor the screens on the computer while also locating the appropriate response areas within the time constraint imposed by the various tasks.

After receiving instructions for the paragraph-comprehension task, participants were told that the experimenter had an additional interest in their ability to remember to perform actions in the future. Specifically, all participants were told that if they ever encountered the words *technique* or *system* in the paragraphs, they should press the "1" key—but not until they reached the trivia phase of the experiment. A prospective memory target word (i.e., *technique* or *system*) appeared in 8 of the 20 paragraphs (each target word appeared in 4 paragraphs) and always in the last sentence of the paragraph. Importantly, target words were always presented in capital letters, whereas the rest of the words in the paragraph were in lowercase letters. Past research (Einstein et al., 2000) indicated that presenting the target word in capital letters makes it highly salient and easily noticed. Thus, with such a distinctive target event, we assumed that participants would notice and retrieve the prospective memory intention on virtually all trials; we provide direct support for this assumption in Experiment 2b.

Participants in the older-rehearsal condition were additionally warned about the difficulty of maintaining intentions over brief delays. They were told that retrieved intentions often appear to be vivid and indelible in memory as soon as they are retrieved. We warned them that these thoughts are quite fleeting, however, and that constant rehearsal is crucial to maintaining them. Thus, we instructed them to rehearse the association "trivia—press key" whenever they saw a target word. In addition, to support the use of this strategy, participants received a reminder to rehearse when a target word appeared. Specifically, the word *rehearse*, presented in capital letters, flashed on and off three times at the bottom of the screen during the last 4 s of the 10 s presentation of a target sentence. Participants in the younger and older control conditions were simply given the general prospective memory instructions; the need for rehearsal was not mentioned. To ensure that participants understood the prospective memory instructions, they were asked to repeat them to the experimenter, and all misunderstandings were explained. Participants in the rehearsal condition were additionally asked to indicate the rehearsal strategy that they had been instructed to use.

Next, participants were given a practice trial consisting of a paragraph, one synonym item, two trivia questions, and two comprehension questions. After going through this example, the experimenter gave the participants a chance to ask any final questions.

Before beginning the paragraph comprehension task, participants completed the Mill Hill Vocabulary Test. The 20 paragraphs and questions were presented next. Each participant received five 5-s unfilled, five 5-s filled, five 15-s unfilled, and five 15-s filled delayed periods. At least two and no more than three delay periods of each type occurred within the first set of 10 paragraphs and the last set of 10 paragraphs. Prospective memory targets (i.e., *technique* or *system*) appeared in Paragraphs 3, 5, 8, 10, 13, 15, 18, and 20. Each of the four types of delay period was represented in the first four prospective memory target paragraphs and also in the last four prospective memory target paragraphs. Paragraphs were always presented in the same order, and four counterbalanced orders were created such that across participants in a group, each target paragraph occurred with each type of delay an equal number of times.

Following the paragraph comprehension task, participants were asked to recall the two prospective memory target words. In the few cases in which participants did not recall both words, they were given a list of eight words and asked to recognize the two target items. Finally, participants were asked to rate on a 5-point Likert scale how often they thought about pressing the "1" key during the synonyms and during the breaks. On this scale, 1 was defined as *rarely*, 3 as *sometimes*, and 5 as *all of the time*.

Results

Prospective memory. A correct prospective memory response was evidenced by participants pressing the "1" key sometime during the presentation of the first trivia question (which stayed on the screen for 10 s). Participants sometimes did not press the "1" key until the second trivia question or the comprehension questions, but this was relatively infrequent (16% of the time), and counting these responses as correct did not change the pattern of results. Participants were carefully instructed that after seeing a target word, they should not press the key until they reached the trivia phase. Nonetheless, participants occasionally pressed the key early, with younger control, older control, and older rehearsal participants pressing early on 1.9%, 3.1%, and 6.9% of the trials, respectively. Figure 1 gives the proportion of correct prospective memory responses as a function of group (younger control, older control, or older rehearsal), length of the delay interval (5 s or 15 s), and activity during the interval (unfilled or filled). These data were submitted to a 3 × 2 × 2 mixed analysis of variance (ANOVA), with group as the between-subjects factor and delay length and interval type as within-subject factors. An alpha level of .05 was adopted for all statistical tests, with the magnitude of the

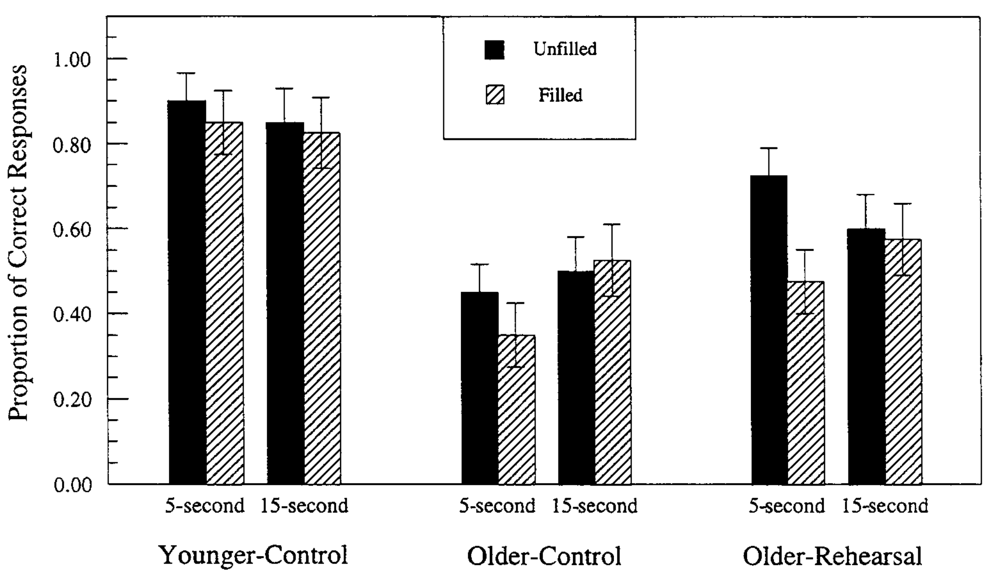

Figure 1. Mean proportion of correct prospective memory responses in Experiment 1. Error bars reflect the standard error of the mean.

significant and marginally significant prospective memory effects indicated by eta squared (η^2).

Prospective memory performance significantly differed across the groups, $F(2, 57) = 15.46$, $MSE = 0.21$, $\eta^2 = .35$, reflecting a decline for older adults relative to the young. The decline in proportion of correct responses was most dramatic for the older controls ($M = .46$), who showed a .40 difference in performance from the high prospective memory levels achieved by the young controls ($M = .86$), $F(1, 57) = 29.91$, $MSE = 0.21$, $\eta^2 = .34$. Even at a 5-s unfilled interval, older controls showed a substantial level of forgetting relative to the young (.45 vs. .90, respectively), $F(1, 57) = 29.96$, $MSE = 0.07$, $\eta^2 = .34$. The two-way interactions involving group and nature of the delay (short or long; filled or unfilled) and the three-way interaction were not significant (largest $F = 1.25$), thereby reinforcing the observation that the differences between the older adult groups and the young controls were observed in all of the delay conditions (see Figure 1). To confirm this conclusion, we computed individual comparisons between the rehearsal-instructed older adults ($M = .59$; the higher performing of the two older adult groups) and the young controls for each delay condition (computed with the three-way interaction error term). These comparisons verified that even rehearsal-instructed older adults performed significantly more poorly than younger adults for every type of delay: smallest $F(1, 57) = 4.53$, $MSE = 0.07$, $\eta^2 = .07$, for the comparison at the 5-s unfilled delay.

The ANOVA also revealed two marginally significant effects. In general, filled delays were associated with somewhat lower performance than unfilled delays, $F(1, 57) = 3.61$, $p < .07$, $MSE = 0.07$, $\eta^2 = .06$, with this difference emerging primarily at the 5-s delays, $F(1, 57) = 3.47$, $p < .07$, $MSE = 0.05$, $\eta^2 = .06$, for the two-way interaction. Comparisons for each group further revealed that the decline for filled relative to unfilled delays was significant only for older adults with rehearsal instructions, $F(1, 57) = 4.57$, $MSE = 0.08$, $\eta^2 = .07$ (Fs < 1 for the older control and the younger adult groups).

Finally, to further evaluate the theoretical views outlined in the introduction, we compared the rehearsal-instructed and control older groups (again using the appropriate error terms from the ANOVA). In general, instructions to rehearse tended to improve performance relative to no rehearsal instructions, $F(1, 57) = 3.56$, $MSE = 0.21$, $p < .07$, $\eta^2 = .06$. More fine grained comparisons revealed that the advantage in prospective memory performance for the older rehearsal group relative to the older control group was significant with short unfilled intervals, $F(1, 57) = 11.19$, $MSE = 0.07$, $\eta^2 = .16$, but not with short filled, $F(1, 57) = 2.31$, $\eta^2 = .04$; long unfilled, $F(1, 57) = 1.48$, $\eta^2 = .03$; and long filled ($F < 1$) intervals.

To determine whether the prospective memory failures were due to momentarily forgetting the intention or to forgetting the task demands (a retrospective memory failure), we asked participants at the end of the experiment to recall (or recognize) the target words for the prospective memory task. All participants were able either to recall or to correctly recognize both target items. As further indication that participants understood and remembered the task demands, all but 2 participants (both older adults) performed the prospective memory task correctly on at least one of the eight trials. Both of the participants who failed on all eight occasions had at least one late response.

Participants were also asked to indicate the extent to which they thought about the intended action during the delays (i.e., breaks and synonyms). This was done on a 5-point Likert scale in which 1 was labeled *rarely*, 3 *sometimes*, and 5 *always*. These scores were included in a 3 × 2 mixed ANOVA that included group (younger control, older control, or older rehearsal) and type of delay (break or synonym) as the independent variables. Although the mean rating was higher for breaks ($M = 3.00$) relative to synonym delays ($M = 2.78$), this difference was not reliable, $F(1, 57) = 1.42$, $MSE = 0.99$. There was a marginally significant effect of group, $F(2, 57) = 2.90$, $p = .06$, $MSE = 2.95$, $\eta^2 = .09$, indicating that the younger adults ($M = 3.43$) rated themselves as thinking about the task more often during the delays than the older control ($M = 2.63$) and older rehearsal ($M = 2.63$) groups. There was no interaction between these variables ($F < 1$).

Other measures. Because all materials were presented at the same pacing for participants and there is some slowing that occurs with age (Salthouse, 1991), we attempted to equate the demands of the ongoing activities for younger and older adults by having older adults call out their responses and younger adults circle their responses on an answer sheet. To get a sense of the difficulty of these activities, we compared younger and older adults on the number of synonyms, trivia questions, and comprehension questions answered correctly. We submitted the scores from each of these measures to a single-factor ANOVA with group (younger control, older control, or older rehearsal) as the independent variable. The analysis of the number of synonym items answered correctly (out of 20) revealed that older adults had nominally higher scores (Ms = 16.2, 17.2, and 18.1 for younger control, older control, and older rehearsal groups, respectively), but this effect was not reliable, $F(2, 57) = 2.75$, $MSE = 6.56$, $p = .07$. In terms of the number of trivia questions answered correctly (out of 40), scores were nominally higher for younger adults (Ms = 29.3, 28.4, and 26.6 for younger control, older control, and older rehearsal groups, respectively), but these differences were not reliable, $F(2, 57) = 2.75$, $MSE = 14.07$, $p = .07$. Younger adults performed nominally higher on the 40 comprehension questions (Ms = 29.7, 26.0, and 27.7 for younger control, older control, and older rehearsal groups, respectively), but these differences were not reliable, $F(2, 57) = 2.65$, $MSE = 26.55$, $p = .08$.

We also examined the percentage of trials on which participants were able to make a response within the allotted time. These percentages were high for all participants on the synonym (Ms = 98% and 94% for younger and older adults, respectively), trivia (Ms = 99% and 97% for younger and older adults, respectively), and comprehension (Ms = 98% and 94% for younger and older adults, respectively) tasks. All in all, these results suggest that the pacing of the ongoing activities was similarly demanding for younger and older adults.

Discussion

A number of important findings and theoretical implications emerged from this experiment. First, following Einstein et al. (2000), we found substantial age-related decrements in prospective memory performance when participants had to delay executing a cued intention for intervals that were 15 s or shorter. On average, over half of the time, older adults forgot to execute the intended action, whereas younger adults forgot less than 15% of the time.

Perhaps even more compelling are the two new findings: First, performance for the older adults remained poor (45% successful prospective memory) even when the delay was a brief 5 s and was unfilled with any distracter activity (by contrast, younger adults performed with 90% success). Second, performance of the rehearsal-instructed adults was significantly poorer than that of the younger adults at every type of delay.

These results help legislate between the disinclination and the inability views outlined in the introduction. If the age deficit in delayed-execute prospective memory found here and reported in Einstein et al. (2000) were solely due to a disinclination to rehearse (in uninstructed groups), then rehearsal instructions should have eliminated the differences between the older and younger adults. Clearly, the observed age differences remained at all delay conditions with rehearsal instructions. This pattern strongly suggests that older adults are unable to effectively maintain intentions over brief delay intervals. Both declining working-memory resources (Craik & Jennings, 1992) and problems in inhibiting task-irrelevant information (Hasher & Zacks, 1988) would limit the ability of older adults to effectively sustain rehearsal processes in the face of distracting activity and throughout a delay interval. Even for the 5-s unfilled interval, resource limitations would be pertinent because both younger and older adults may continue to review their understanding of the paragraph to prepare for the upcoming comprehension question. This would make it especially difficult for the older adults, who have greater resource limitations, to maintain active rehearsal strategy over the delay.

Consideration of the complete pattern of results suggests, however, that older adults are also less inclined to spontaneously rehearse intended actions over delay intervals. Older adults who were instructed to rehearse the intention tended to perform better on the delayed-execute task than older adults who were not given such instructions. Critically, the advantage of rehearsal instructions for older participants was robust enough to achieve significance when the delay interval was 5 s and unfilled (an increase of .28 correct responses relative to the uninstructed older adults). Taken in concert, these results converge on two problems for older adults in maintaining intentions over brief delays. First, the older adults seemed disinclined to spontaneously attempt to maintain the intention. Second, older adults are less able to sustain a strategic rehearsal process, especially with longer and filled delays.

It is unclear why older adults seem less inclined to spontaneously rehearse over a brief delay. One possibility is that older adults may not realize the fleeting nature of information held in focal awareness. A metamemory failure of this type is understandable by considering that information in awareness is readily accessible and can seem indelible. As a related phenomenon, judgments of learning are relatively inaccurate when the judgments are made immediately after study, presumably because the to-be-learned item can be so easily and accurately accessed (Dunlosky & Nelson, 1997). A second possibility is that older adults (in the uninstructed condition) were disinclined to implement rehearsal because they realized that they were unable to effectively sustain rehearsal throughout the delay. Because they were unable to anticipate the kind of delay present on any given trial (i.e., they could not necessarily anticipate a relatively easy short, unfilled delay), they did not rely on rehearsal as a strategy.

Finally, one might note that the rehearsal manipulation, in addition to strongly prompting rehearsal, instructed participants to rehearse the phrase "trivia—press key." This represents a possible reformulation of the prospective memory intention at the time of initial retrieval, and such a reformulation could have produced the benefit of the rehearsal instruction (relative to the uninstructed older control). That is, the benefits of the rehearsal manipulations may arise not from getting participants to actively rehearse the intention over the delay but rather from getting them to update or reformulate their intention to press the key in the context of the trivia task. The prospective memory instructions at the start of the experiment may be generally represented as "technique—press key, but only after a delay." Reformulation of the intention after encountering the *technique* or *system* would establish an important link between the cue and the intended action. Thus, for participants thinking "trivia—press key," the intention to press the key may be more likely to be retrieved from long-term memory when the trivia items are encountered. The current pattern, however, is more consistent with the idea that the functional process stimulated by the rehearsal instructions was active maintenance of the intention. Specifically, the benefit of rehearsal instruction was robust only at the 5-s unfilled delay, the delay condition that was the most favorable to active maintenance.

Experiment 2a

The results of the first experiment along with our prior results (Einstein et al., 2000) strongly suggest that remembering intentions over brief delays is a fundamental problem for older adults. As just discussed, older adults seem unable and disinclined to actively rehearse intentions over delays. If older adults have difficulty maintaining the activation of intentions over delays, then their performance should be more dependent on favorable conditions present at encoding (i.e., when the intention is initially retrieved) and retrieval.

Our thinking here is that there are multiple ways to perform on a delayed-execute task. As assumed throughout this article thus far, one way is to rely on working memory resources to actively maintain the intention (press key) over the brief delay. In lieu of using this strategy, however, participants may rely on retrieval from long-term memory at the end of the delay. Thus, another way to do well on this task is by reformulating one's plan after retrieving an intention (i.e., after seeing the target word *technique* or *system*, mentally noting that the new demand is to press the key when reaching the trivia phase). Following the research of Guynn, McDaniel, and Einstein (1998), this kind of reformulation should serve to associate the target and action and should aid retrieval when the target period (i.e., trivia task) is encountered. To the extent that participants rely on this strategy, they should be sensitive to the availability of resources for performing the reformulation (Einstein, Smith, McDaniel, & Shaw, 1997) and also for later retrieving that reformulated intention from long-term memory (Marsh & Hicks, 1998). In the present experiment we varied the resources available to younger and older participants at encoding and retrieval, and our expectation was that reducing attentional resources at either encoding or retrieval would be more detrimental for older adults.

The foregoing idea implies that if resources are "soaked up" with a secondary task during the time that the initial intention is retrieved (during the presentation of the prospective memory targets *technique* and *system*), then reformulation of the plan will be compromised. If reformulation of the plan is an important process in the delayed-execute task, then performance should accordingly suffer. Further, to the degree that older adults have difficulty maintaining the activation of intentions over delays and are thereby more reliant on plan reformulation and subsequent retrieval from long-term memory, dividing attention during the period in which reformulation is likely to occur should have more pronounced effects for older adults (relative to younger adults).

To test this prediction, in the present experiment we implemented a secondary digit-detection task during the presentation of the target word. Two critical points regarding this manipulation warrant mention. First, Einstein et al. (2000) showed that when the prospective memory task does not require delayed execution (i.e., the prospective memory response can be executed immediately upon presentation of the prospective memory target), performance for younger and older adults remained very high (over 90%) under the present divided-attention manipulation. This finding establishes that *retrieval* of the intention is not compromised when attention is divided (by the digit-monitoring task) during the presentation of the target. Second, in this experiment attention was divided only during presentation of the target word and not during the delay interval. Thus, processes other than plan reformulation that occur during the delay (e.g., rehearsal) would not be affected by the present manipulation. If these processes are the primary component in supporting delayed-execute prospective memory, then the present divided-attention manipulation should have little effect on delayed-execute prospective memory.

A second potentially important feature of our delayed-execute paradigm with regard to aging decrements is that the start of a new task always provides the signal for executing the intended action. We explicitly included this feature because we reasoned that it is characteristic of typical everyday delayed-execute tasks. For example, after remembering that you need to take medication when you are in the bathroom, you might walk to the kitchen (where the medication is kept). When you arrive in the kitchen, however, other tasks likely confront you and attract attention (such as dirty dishes, a blinking message indicator on the phone, a book on the counter). The attentional demands of new tasks (either presented in the experiment or occurring naturally in the real-world environment) should create difficulties for retrieving the reformulated intention from long-term memory (e.g., “Take medication when I get to the kitchen”). On the other hand, when the intention is being actively maintained throughout the delay (“I need to take medication”), no additional resources are needed to bring the intended action to mind so that it can be executed upon encountering the new task. Thus, the attentional demands of the new task should interfere only minimally with executing the intended action.

These assumptions, along with our working hypothesis that younger adults maintain the intention over the delay whereas older adults rely more on retrieval of the intention from long-term memory upon encountering the target task, suggest that the demands at retrieval should interact with age. Again, on the basis of findings from Experiment 1, older adults might have to rely more on long-term memory retrieval of the intention after the delay because older adults have difficulty maintaining the intention in working memory during the delay. In the present experiment we compared a condition in which the execution of the prospective memory intention was signaled by a break in the ongoing activity with one in which the execution was signaled by the onset of the trivia task (as in Experiment 1). If older adults rely to a greater extent on retrieval from long-term memory, then they should show greater improvement when the execution cue is a break (freeing up attentional resources at retrieval) rather than a new task compared with younger adults, who should be minimally affected by the nature of the execution cue.

Method

Participants and design. The design of this experiment was a $2 \times 2 \times 2$ mixed factorial that included the between-subjects variable of age (younger or older) and the within-subject variables of resources at encoding (full or divided) and demands at retrieval (break or trivia task). The 40 younger participants ($M = 20.13$ years) ranged in age from 19 to 22. They were students at Furman University and were either paid \$5 for participating or given course credit. The 40 older participants ($M = 68.08$ years) ranged in age from 60 to 80. As in the first experiment, they were community dwelling, drove to campus to be tested, and were paid \$10 for participating. Older participants ($M = 16.05$) scored marginally higher ($p < .10$) than younger participants ($M = 15.32$) on the Mill Hill Vocabulary Test, $F(1, 78) = 3.41$, $MSE = 3.09$. Older adults ($M = 16.08$) had significantly more years of education than the younger adults ($M = 14.62$), $F(1, 78) = 10.71$, $MSE = 3.93$. Generally, rated health was high as indicated by average health ratings of over 4.0 on a 5-point scale for both younger and older adults (with 1 representing *poor* and 5 representing *excellent*). Still, the rated health of the younger adults ($M = 4.43$) was significantly higher than that of the older adults ($M = 4.13$), $F(1, 78) = 3.88$, $MSE = 0.46$, $p = .05$.

Procedure and materials. The procedure of the second experiment was very similar to that of the first. Again, participants were told that the primary task was to read three-sentence paragraphs and then answer questions about them. In this experiment, however, the sequence for each of the 20 paragraph trials was to present the three sentences and then two synonym items (presented for 5 s each). On half of the trials (i.e., 10 paragraphs), the synonym items were followed by two 10-s trivia items, and on the other half the items were followed by two 10-s breaks. After the trivia questions or breaks, participants answered two reading comprehension questions presented for 10 s each. The materials were identical to those in the first experiment, and as in the first experiment, older adults called out their responses whereas younger adults circled their answers on a sheet.

After receiving a general overview of these tasks, participants were told that occasionally they would hear digits presented at the rate of one every 2 s and that they should press a counter held in their nonpreferred hand whenever they heard two consecutive odd-numbered digits. They were given 30 s of practice with this task, and any questions about the digit-detection task were answered at this point.

Next, participants were told that we had a secondary interest in their ability to remember to perform actions in the future. Specifically, they were told that whenever they saw the target words *technique* or *system*, they should press the “1” key—but not until after the synonym items. A prospective memory target word (*technique* or *system*) appeared in 8 of the 20 paragraphs and always in the last sentence of the paragraph. As in the first experiment, target words were always presented in capital letters. On four of these trials, the trigger for performing the action was a break period; on the other four, the trigger was the trivia task.

Following the procedure of the first experiment, all participants were asked to repeat the instructions to the experimenter, and any questions or misunderstandings were resolved. Participants were then given a practice trial consisting of a paragraph, two synonym items, two trivia questions, and two comprehension questions. Following the example, participants were given another opportunity to ask questions. We used the same counterbalancing conditions as those used in the first experiment. Specifically, prospective memory targets appeared in Paragraphs 3, 5, 8, 10, 13, 15, 18, and 20, and each of the four target conditions (full attention, trivia; divided attention, trivia; full attention, break; divided attention, break) was represented once in the first four prospective memory target paragraphs and also once in the second four prospective memory target paragraphs. Paragraphs were always presented in the same order, and across the four counterbalancing orders, each target paragraph occurred with each condition an equal number of times.

After the instructions, and before the paragraph comprehension task, participants were given the Mill Hill Vocabulary Test. Following the paragraph comprehension tasks, participants were asked to recall the two target words. When they could not recall these words, they were asked to recognize them from a set of eight items. Next, participants were asked to indicate whether they "constantly rehearsed" the intention during the delay or let the thought "pop into mind" at the appropriate time.

Results

Prospective memory. Prospective memory responses were scored as in Experiment 1. As in the first experiment, younger and older participants occasionally pressed the key early (younger adults did so on 0.9% of the trials, and older adults on 3.1% of the trials). The mean proportions of correct prospective memory responses are shown in Figure 2. These data were submitted to a three-factor mixed ANOVA, with age group (young or old) as the between-subjects factor and attentional demands during target presentation (full or divided) and trigger type at end of the delay (break or trivia task) as the within-subject factors. All of these variables significantly impacted prospective memory performance. Consistent with Experiment 1, older adults (M = .56) performed less well on the prospective memory task than did younger adults (M = .83), $F(1, 78) = 31.44$, $MSE = 0.18$, $\eta^2 = .29$. Full attention during the presentation of the target word (M = .77) led to better performance than divided attention (M = .62), $F(1, 78) = 27.68$, $MSE = 0.07$, $\eta^2 = .26$. Presenting a break (M = .76) to signal when the intended action should be performed produced better prospective memory performance than presenting another task—the trivia task (M = .63), $F(1, 78) = 12.38$, $MSE = 0.11$, $\eta^2 = .14$. The latter two variables also interacted such that the advantage in prospective memory that existed when the break (compared with the trivia task) signaled performance of the intended action was more prominent when the prospective memory target was earlier presented under the full attention condition, $F(1, 78) = 4.93$, $MSE = 0.08$, $\eta^2 = .06$.

Importantly, the effects of divided attention during presentation of the target word were more exaggerated for older than for younger adults, $F(1, 78) = 3.89$, $p = .052$, $MSE = 0.07$, $\eta^2 = .05$. Divided attention produced a decline of .09 in prospective memory relative to full attention for younger adults—a significant decline, $F(1, 78) = 5.44$, $\eta^2 = .07$—whereas the decline was over twice that for older adults (a significant difference of .21 between divided and full attention conditions), $F(1, 78) = 26.37$, $\eta^2 = .25$. Further, there was a marginally significant interaction between age and demands at retrieval (break or trivia task), $F(1, 78) = 2.81$, $p < .10$, $\eta^2 = .04$. To help interpret this interaction and inform the theoretical issues introduced earlier, we examined the effects of the type of activity at retrieval separately for each age group (using the interaction error term). For younger adults, there was only a small and nonsignificant advantage in remembering to execute the intended action when a break appeared relative to when the trivia task appeared (mean difference = .07), $F(1, 78) = 1.72$. In contrast, older adults executed the intended action significantly more often when a break appeared than when the trivia task appeared (mean difference = .19), $F(1, 78) = 13.15$, $MSE = 0.11$, $\eta^2 = .14$.

When asked to recall the target words at the end, all participants were able to recall or correctly recognize both items. This, as well

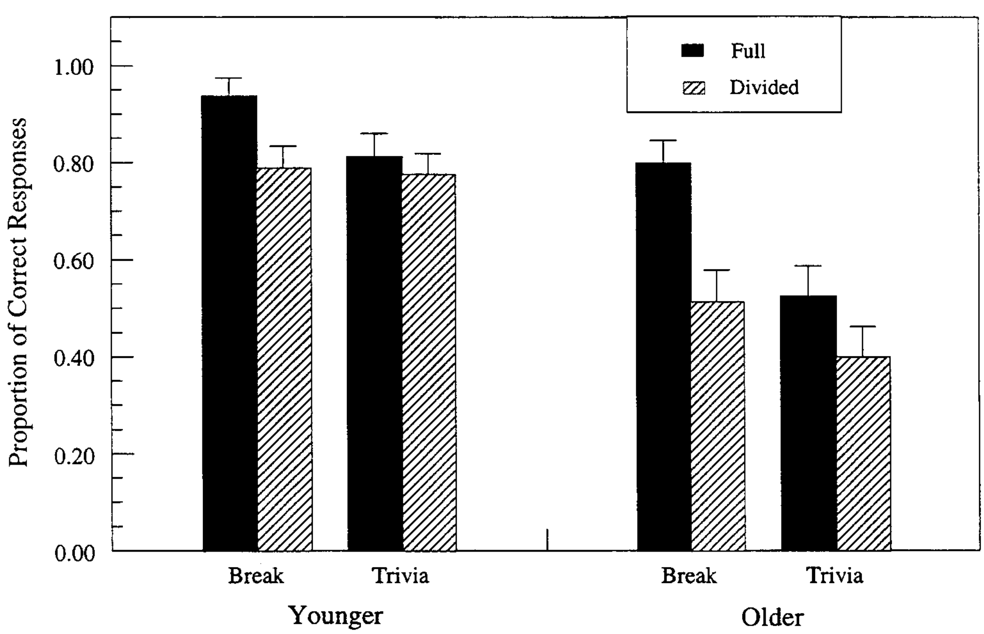

Figure 2. Mean proportion of correct prospective memory responses in Experiment 2a. Error bars reflect the standard error of the mean.

as the result that 100% of the participants remembered to perform the prospective memory task on at least one of the eight trials, indicates that memory failures were not due to problems in understanding or remembering the task demands.

We also scored participants' response to the questionnaire item of whether they "constantly rehearsed" (scored as 1) or let the thought "pop into mind" (scored as 2) during the delays. Several participants indicated that they did both, and we scored these responses as a 1.5. An ANOVA revealed no reliable difference between younger ($M = 1.63$) and older ($M = 1.78$) adults, $F(1, 78) = 2.44$, $MSE = 0.18$. Unlike in Experiment 1, younger adults did not report greater rehearsal of the intention over delays; however, as opposed to Experiment 1 the response scale was dichotomous. To the extent that one can rely on retrospective and subjective assessments of rehearsal, these data suggest that both younger and older participants tended not to rehearse constantly over the delays.

Other measures. To get a sense of the difficulty of the ongoing activities, we compared younger and older adults on the number of synonyms, trivia questions, and comprehension questions answered correctly. We submitted the scores from each of the synonym and trivia measures to a single-factor ANOVA with age group as the independent variable. Older adults ($M = 32.67$) correctly answered slightly over one more synonym item (out of 40 possible) than younger adults ($M = 31.45$), but this difference was not reliable, $F(1, 78) = 1.24$, $MSE = 24.27$. In terms of the number of trivia questions answered correctly (out of 40), younger adults ($M = 15.55$) answered more correctly than older adults ($M = 14.02$), $F(1, 78) = 10.22$, $MSE = 4.55$. The number of correct answers on the comprehension questions was submitted to a 2×2 mixed ANOVA that included the variables of age and division of attention at encoding (full or divided). This analysis revealed that dividing attention ($M = 16.5$) reduced performance relative to full attention ($M = 18.6$), $F(1, 78) = 61.99$, $MSE = 2.85$, and that younger adults ($M = 18.3$) had better comprehension than older adults ($M = 16.7$), $F(1, 78) = 25.74$, $MSE = 2.85$. The significant interaction between these variables, $F(1, 78) = 17.79$, $MSE = 2.85$, indicated that the effects of dividing attention during the presentation of the sentences disrupted comprehension more for older ($M = 15.1$ for divided attention vs. $M = 18.3$ for full attention) than for younger adults ($M = 17.9$ vs. $M = 18.8$).

We also examined the percentage of trials on which participants were able to make a response within the allotted time. These percentages were high for all participants on the synonym (Ms = 94.0% and 95.1% for younger and older adults, respectively), trivia (Ms = 99.0% and 96.3% for younger and older adults, respectively), and comprehension (Ms = 99.7% and 97.1% for younger and older adults, respectively) tasks. These results suggest that the pacing of the ongoing activities was not overly demanding for older adults.

Discussion

This experiment produced several novel findings. First, dividing attention during the presentation of the cue for initial retrieval of the intention (*technique* or *system*) significantly reduced execution of that intention after a brief delay. Einstein et al. (2000, Experiment 1) also reported disruption of delayed-execute prospective memory with divided attention; however, their divided attention task extended throughout the delay period. Thus, their result left unclear whether the disruption related to processes at the time of initial retrieval, processes during the delay, or both. In the present experiment, because attention was divided only during the presentation of the target for initial retrieval and not during the delay, the decline in performance could not be attributed to interference with processes operative during the delay (processes that would presumably help maintain the intention in mind). The disruption due to divided attention reveals that processes occurring at the time when the intended action is retrieved play an important role in the delayed execution of that action.

One possibility is that dividing attention during the appearance of the target word precluded the retrieval of the intended action. This is unlikely in light of Einstein et al.'s (2000, Experiment 1) finding for both younger and older adults that performance was high and not attenuated by divided attention when the intention could be executed immediately. Given that the present procedure was patterned after that of Einstein et al., there is little reason to expect that retrieval was compromised by divided attention in this experiment. Nonetheless, because there were some minor procedural differences between this experiment and that of Einstein et al. (2000), we thought it prudent to replicate the Einstein et al. finding using procedures identical to those in Experiment 2a. We report this next experiment following the present discussion.

The remaining possibility is that dividing attention interfered with further encoding of the retrieved intention. Such encoding might involve reformulation of the task (e.g., "Press the key after the synonym task"; Einstein et al., 2000) or perhaps more focused processing of the intended action, thereby creating a more highly activated representation (e.g., Mäntylä, 1996). Either of these processes would presumably make it more likely that the intention could be retrieved (or activated) upon conclusion of the brief delay period. The key point is that the divided attention pattern provides the first direct evidence for the involvement of processes related to online encoding of the initially retrieved intention in successful delayed execution. This evidence urges refinement of our initial expectation that when faced with executing an intended action after brief delays, participants would rely extensively or even exclusively on maintenance of the intention in awareness during the delay. If such were the case, then divided attention only during the presentation of the target word should have been irrelevant to eventual prospective memory performance.

Moreover, the negative effects of divided attention in the delayed-execute task were significantly more extreme for older adults than for younger adults (as well, the effect size of divided attention was notably greater for older than for younger adults). This second novel finding indicates that older adults' delayed-execute performance may be especially dependent on their activities during initial retrieval of the intended action. The interpretation just suggested gains currency in the presence of the Experiment 1 findings showing that older adults are relatively ineffective at maintaining the intention in awareness during the delay. More specifically, the idea is that in lieu of support from a putative working memory system, performance would need to be supported by long-term memory processes. Such processes would presumably be facilitated by full attention during initial retrieval, allowing effective encoding activities to be engaged (e.g., reformulation of the intention). These encoding activities would in turn facilitate retrieval of the intended action after the delay (cf. Guynn et al., 1998; McDaniel & Einstein, 2000).

A third important finding was that the type of activity at the end of the delay period affected the likelihood of executing the prospective memory task. When the activity was a break rather than another task (the trivia task), prospective memory performance significantly improved for older adults but not for younger adults. Indeed, for the older adults given a break at the end of the delay and full attention for the target word, prospective memory performance ($M = .80$) was nearly as high as that for younger adults averaged over all conditions ($M = .83$) and higher than that of older adults in any other conditions, despite having the delay filled with activity. This pattern suggests that the type of activity at the end of the delay is a powerful factor for age-related decline in delayed-execute tasks. The practical implications are clear cut. Older adults will not show dramatic deficits in delayed-execute tasks if new activity after the brief delay in execution can be avoided.

It seems plausible that older adults' performance was lower when the intended action needed to be executed during the trivia task rather than during a break because the trivia task required resources, thereby challenging the already limited resources of the older participants. In particular, retrieval of the intended action, either self-initiated (Craik, 1986) or more spontaneously prompted (Einstein & McDaniel, 1996), could require resources that were otherwise allocated to starting the trivia task. This idea is consistent with the finding that the break was especially effective when full attention could be devoted to the target cue prior to the delay. With full attention during initial retrieval, participants could reformulate their intention to execute the action when the synonym task is completed. With such reformulation and the resources allowed during the break, retrieval from long-term memory of the intended action should be more successful.[1]

Experiment 2b

Throughout this study, we have assumed that the observed age decrements in prospective memory performance are associated with the brief delays interposed between the presence of the prospective memory target word and the opportunity to execute the intended action, rather than some other aspect of the prospective memory paradigm. This assumption is based on Einstein et al.'s (2000) Experiment 1, showing that with paragraphs identical to those used in the present ongoing task, as well as identical prospective memory target words embedded in the paragraphs, older adults performed as well as younger adults (with performance being nearly perfect) when the prospective memory response could be executed immediately upon presentation of the target word. Yet there were several minor differences between Einstein et al.'s procedure and that used herein. One is that different fonts were used for the materials in the current and previous research, and perhaps the capitalized target items were perceptually more distinctive in the previous research. Another potentially important difference is that in the Einstein et al. (Experiment 1) procedure, every different phase of a paragraph comprehension trial was signaled with different colored screens (on which the material in that phase was presented). In the present study (and Einstein et al.'s Experiment 2), all phases were presented on the same white background. Finally, in the present research, we asked participants to complete the Mill Hill Vocabulary Test after the prospective memory instructions and before the paragraph comprehension task.

Though not likely, there is the possibility that with a different font, without a unique screen color to signal the appearance of a paragraph, and with an intervening task between the prospective memory instructions and the paragraph comprehension task, older participants would not be as sensitive to the appearance of the prospective memory cue word in the paragraph. If so, then older adults could potentially display significant decrements relative to younger adults even with immediate prospective memory responding (cf. Cherry & LeCompte, 1999; Maylor, 1995, 1996; Park et al., 1997) and capitalized target words (West & Craik, 1999). It is important to rule out this possibility, because the theoretical interpretation and empirical significance of the present findings rest on the assumption that older adults would fare as well as younger adults if allowed to respond immediately.

In the present experiment, participants were given the identical ongoing activities as in Experiment 2a, including the administration of the digit-monitoring task on some trials to divide attention during half of the prospective memory trials. Unlike in Experiment 2a, however, all participants were instructed that they should perform the intended action as soon as they could after encountering the prospective memory target word. Given that the target cues were quite salient (capitalized words in a paragraph) and that responding did not have to be delayed, we expected that both young and older participants would remember to perform the prospective memory task on nearly all trials. We further expected that there would be no significant decrement of dividing attention.

Method

Participants and design. The 2 × 2 mixed factorial design included the between-subjects variable of age (younger or older) and the within-subject variable of resources during the presentation of the prospective memory target word (full or divided). The 12 younger participants ranged in age from 19 to 42 years ($M = 31.33$). They were students enrolled in summer psychology courses at the University of New Mexico and were participating for extra credit. The 12 older participants ranged in age from 66 to 84 years ($M = 73.33$) and were New Mexico residents. As in the previous experiments, they were community dwelling, drove to campus to be tested,

[1] Another possible explanation for the greater age-related decrements in prospective remembering with greater demands at retrieval (i.e., trivia task relative to break trials) is that the presence of the trivia task created a scheduling and executing problem. The idea here is that upon seeing a trivia item, participants may start to process the new demand (answering the trivia item) and may briefly put completion of the prospective memory action on hold. Older adults may have difficulty maintaining the prospective memory intention over this new delay, and this may cause them increased forgetting when there is a task at retrieval. Arguing against this interpretation, however, is the finding that full attention at encoding amplified the benefits of reduced demands at retrieval for older adults. From the scheduling-problem interpretation, it would be expected that regardless of the conditions at encoding, the presence of new demands at retrieval should cause problems in scheduling and executing the intended action. Instead, our results showing high prospective memory for older adults with reduced demands at both reformulation and retrieval support the view that older adults do well under these conditions because they have more resources to reformulate their plan at initial retrieval and retrieve it later at the target tasks.

and were paid $10 for participating. Older participants (M = 16.2) scored significantly higher than younger adults (M = 13.8) on the Mill Hill Vocabulary Test, $F(1, 22) = 5.64$, $MSE = 5.79$. Older adults reported a mean of 15.8 years of education, comparable to that reported by older adults in the previous experiments. Some of the younger adults had been part-time college students for a number of years and apparently estimated their years of education in terms of the number of years they had been taking courses. Thus, the estimate for the younger adults was inflated (in terms of full years of education, M = 18.5). Generally, rated health was high, as both younger and older adults rated their health to be over 4.0 on a 5-point scale (with 1 representing *poor* and 5 representing *excellent*). The rated health of the younger adults (M = 4.7) was nominally higher than that of the older adults (M = 4.2), but the difference was not quite reliable, $F(1, 22) = 3.31$, $MSE = 0.31$, $p = .08$.

Procedure. The procedure was identical to that of Experiment 2a, except that participants were instructed to execute the intended action as soon as possible upon encountering the target item. Because of an oversight when implementing the experiment on different laboratory computers, for one target paragraph the prospective memory target word (*system*) was inadvertently omitted (however, the paragraph remained comprehensible). We were not alerted to this oversight until most of the participants had been tested. Consequently, in this experiment there were seven prospective memory trials instead of eight, with the trials evenly distributed between the full and divided attention conditions across participants.

Results and Discussion

One older participant consistently pressed the "2" key in response to the prospective memory target (instead of the "1" key). Following Einstein et al.'s (1992) distinction between the prospective memory and retrospective memory components of a prospective memory task, this response indicates successful completion of the prospective memory component and an error on the retrospective component (but note that the present error does not even necessarily reflect a memory error). Because our interest here was in the prospective memory component, we accepted these as correct responses. Table 1 shows the proportion of prospective memory responses as a function of age and attentional condition. As can be seen, the proportion of prospective memory responses was very high and similar for younger (M = .92) and older adults (M = .90). A 2 (age) × 2 (full vs. divided attention) mixed ANOVA confirmed that there was no main effect of age ($F < 1$). Prospective memory performance was somewhat lower with divided than with full attention but not significantly so, $F(1, 22) = 2.43$, $MSE = 0.03$, and the interaction between age and divided attention did not approach significance ($F < 1$).

Overall, the data confirmed our expectation that for the salient prospective memory target item used in Experiments 1 and 2a, removing the delay between the target item and the prospective memory response would lead to very high and equivalent performance for older and younger adults. Under these conditions, divided attention also did not significantly affect prospective remembering, and more important, young and older adults performed identically in the divided attention condition.

Table 1
Mean Proportion of Correct Prospective Memory Responses With Immediate Execution (Experiment 2b)

Attention condition	Younger	Older
Full	.97	.93
Divided	.87	.87
M	.92	.90

General Discussion

Einstein et al. (2000) reported an age-related decrement when execution of an intended action had to be delayed for brief intervals. The present results reinforce that finding and demonstrate its robustness over a variety of conditions. Older adults performed more poorly than younger adults for very short delays as well as longer delays, for delays that were filled or unfilled, for conditions that were more or less resource demanding during retrieval of the intention, for conditions in which a new task or no task had to be performed at the end of the delay interval, and with or without strategy instructions. Only under the full attention condition (at the point of encoding or plan reformulation) combined with a break at the end of the delay did older adults' performance levels approach those of the younger adults. (See also Einstein et al., 2000, Experiment 3, for instances in which older adults' performance does not decline for a delayed-execute task and West & Craik, 2001, Experiment 1, for conditions in which there is a similar decline for delayed-execute relative to immediate-execute performance for young and older adults.)

These patterns reveal the robust nature of the age-related decrement for delayed-execute prospective memory tasks. We implemented manipulations designed to relax the demands or difficulty of the delayed-execute task along dimensions that might reasonably be expected to favor older adults, yet the significant age-related declines persisted. Even when the delay interval was as brief as 5 s and was unfilled, older adults remembered to perform the task less than 50% of the time, a dramatic difference from the 90% performance levels exhibited by younger adults and the 93% exhibited by older adults for immediate execution (Experiment 2b in the comparable full attention condition). Moreover, when older adults were instructed to implement a rehearsal strategy and were continuously reminded to do so, their performance was significantly impaired relative to the younger participants who were not given the benefit of such instructions. Older adults showed general decrements relative to younger adults in remembering to perform the intention when participants were not required to begin another task at the end of the delay (the break condition in Experiment 2a).

To help understand and interpret this configuration of age-associated effects, we adopt the assumption that there are multiple ways to accomplish a delayed-execute prospective memory task. Two prominent possibilities are (a) that the participant can keep the intended action active in working memory (or focal awareness) and (b) that the participant can rely on retrieving the intention from long-term memory at the conclusion of the delay. This latter process might be combined with attempts to reformulate the intention when it is first retrieved (cf. Einstein et al., 2000). For instance, the intention might be originally coded as "Press a key after *technique* or *system* appears." Once that intention is retrieved in the presence of the target, the participant might then reformulate the intention to something like "Press a key once the trivia task appears" (or "when the synonym task is completed"; Experiment 2a).

Our results imply that older adults have special difficulty maintaining an intention or goal in an activated state. On the basis of the general view that older adults have fewer cognitive resources (e.g., Craik & Byrd, 1982), it might be expected that when delays are filled with ongoing activity, older adults show decline relative to younger adults in remembering to perform the intended activity. That older adults show just as dramatic a decline in prospective memory when there are no new activities during the interval and when the interval is as short as 5 s underscores that older adults have a fundamental problem with keeping goals activated even when resource demands are not present. This result could be explained by any of several current theoretical perspectives regarding elemental cognitive processes and their decline with age. Hasher and Zacks (1988) have proposed age-related decrements in inhibition, with such decrements causing interference with ongoing thoughts and processing of information for older adults. Other views suggest that working memory deficits, which are generally found in older adults, reflect the inability to concentrate attention appropriately in the presence of distraction (e.g., Kane, Bleckley, Conway, & Engle, 2001). This is also captured in Kimberg and Farah's (1993) view that working memory deficits compromise the ability to maintain an integrated representation of the current task concerns. More specifically, Braver et al. (2001) suggested that maintenance of contextual information necessary to bias attentional selection and response selection in accord with previous goals declines with age. Similarly, in explaining their prospective memory results, West and Craik (1999) proposed that older adults have difficulty maintaining a readily accessible representation of the task demands. More recently, Johnson, Reeder, Raye, and Mitchell (2002) found that aging compromises the core ability to refresh just-activated representations. Any or all of these processes appear to be potentially related to the age-related decrement reported herein in terms of being either facets of a similar underlying decrement or mechanisms at least partly responsible for the present decrement. Importantly, the current study demonstrates an everyday memory activity for which age-related decrements in maintaining thoughts in a sufficiently activated state greatly impair performance.

Further, in Experiment 1 instructions for older adults to implement a rehearsal strategy to maintain the intention in awareness did not eliminate the significant age-related performance decrements in the delayed-execute task. The instructions marginally improved performance, however, relative to the uninstructed older adults. These patterns together imply a twofold decrement for older adults. One is that older adults apparently do not spontaneously rehearse the intention, a strategy that would be useful in light of the possible age-related problems in nonstrategic maintenance of the intention in a highly accessible state (as discussed above). The other is that strategic rehearsal is difficult for older adults to effectively implement in the delayed-execute task. Successful rehearsal presumably would produce high levels of performance (e.g., Reitman, 1971) in this task; however, rehearsal instructions did not improve older adults' levels of prospective memory performance to that enjoyed by the younger adults. The difficulty of implementing rehearsal for older adults is further revealed by the minimal improvements produced by rehearsal instructions for older adults as the components of the delay interval became more demanding in terms of length and ongoing activities. Thus, delayed-execute prospective memory may be especially problematic for older adults because maintenance of information in awareness appears to be compromised by age. That is, for delayed-execute prospective memory, working memory processes and functioning in older adults may be relatively ineffective.

Accordingly, we suggest that older adults' performance in delayed-execute prospective memory may be more dependent or additionally dependent on reformulation of the initial intention and retrieval of the reformulated intention from long-term memory at the conclusion of the delay. This notion is consistent with the Experiment 2a findings that older adults were especially influenced by variables that would be expected to affect processes both prior and subsequent to the brief interval over which the intention might be maintained. These effects are salient in light of the absence of effects in Experiment 1 for older adults (in the no-strategy condition) of variables impacting the nature of the delay itself (length; filled vs. unfilled). As discussed in Experiment 2a, the negative effects of reducing resources available during encoding (i.e., initial retrieval of the intention) and during retrieval (but not during the delay) for older adults converge on the importance of long-term memory processes, rather than active maintenance, in supporting execution of the intended action even over brief delays. The idea is that dividing attention interfered with older participants' ability to appropriately reformulate their plans once the target event (the cue word) stimulated retrieval of the intention (Experiment 2b confirmed the successful initial retrieval under divided attention), with reformulation supporting better subsequent retrieval upon encountering another event at the end of the delay. There is evidence in naturalistic settings that people do engage in plan reformulation if the conditions for execution change (Marsh, Hicks, & Landau 1998). Similarly, having a break at retrieval rather than a task to perform frees up resources, and several studies have shown that freeing up resources at retrieval benefits prospective memory performance (Marsh & Hicks, 1998; McDaniel, Robinson-Riegler, & Einstein, 1998).

There is another interpretation of our results, however. Specifically, it is possible that older adults are not generally more reliant on retrieval from long-term memory than younger adults and that the greater effects of reducing resources at encoding and retrieval may simply reflect the greater susceptibility of older adults to the negative effects of dual tasks (see Glass et al., 2000). The idea here is that both younger and older adults rely to a similar extent on plan reformulation and retrieval from long-term memory on delayed-execute tasks and that reducing resources at encoding and retrieval (with the digit-detection and trivia tasks, respectively) creates a functionally greater reduction in resources for older adults.

Although this interpretation is possible, partially countering it is a previous finding that reducing resources during online encoding of a prospective intention negatively affected young adults and older adults to the same degree (Einstein et al., 1997, Experiment 2). The implication for the present findings is that if younger and older adults did rely on reformulation of the intention to the same degree, then they might have been expected to show a similar negative impact of divided attention. Older adults were significantly more impacted by divided attention at encoding (plan reformulation) than younger adults, however. Indeed, in the trivia task condition younger adults' performance was only slightly and nonsignificantly reduced by divided attention, whereas older adults' performance was significantly reduced.[2]

Thus, our preferred interpretation of these results is that older adults are more susceptible to the effects of resource limitations at encoding and retrieval because they rely on long-term memory processes to complete the delayed-execute task. This construal is based on the entire pattern of results showing greater age-related decrements when adding resource demands at encoding and retrieval but, if anything, smaller age-related decrements when increasing the demands during the delay phase. In the present Experiment 1, extending the delay period (from 5 s to 15 s) had nominally negative effects on younger adults but nominally positive effects on uninstructed older adults (see Figure 1). Further, adding a task (relative to having a break) during the delay period did not penalize uninstructed older adults more than younger adults; indeed, the decline was just slightly less for older adults. In Experiment 2 of Einstein et al. (2000), the decreased prospective remembering that occurred as a result of adding a task to the delay had a reliably smaller effect on older than on younger adults. Thus, taken together, older adults' performance on a delayed-execute task is *not* generally more sensitive than younger adults' performance to the availability of resources at all phases; instead, older adults are more highly affected by the availability of resources at encoding and retrieval but not more negatively affected by demands of the delays (i.e., the older control group in Experiment 1).

In summary, this study has illuminated a number of features of delayed-execute tasks that contribute to the dramatic age-related deficits on this kind of prospective memory task. Although existing prospective memory research has focused on determining the extent of age-related decrements in the initial retrieval of prospective memories, the present research suggests that older adults are especially susceptible to problems in maintaining retrieved intentions over brief intervals. Given the prevalence of delays and distractions in the real world, it seems important to warn older adults of this difficulty. To paraphrase a familiar adage, older adults should be cautioned to "do it or lose it."

[2] $F(1, 78) = 4.07$, $MSE = 0.08$, $\eta^2 = .05$, for the divided attention effect with older adults in the trivia-task condition. This comparison was conducted using the three-way interaction error term from the ANOVA in Experiment 2a.

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Appendix

Structure of the Delayed-Execute Prospective Memory Paradigm (Experiment 1)

1. Paragraph-comprehension task instructions
2. Prospective memory instructions: If *technique* or *system* in paragraph, then press “1” key but not until trivia phase
3. One practice trial of all tasks (in Item 5 below), excluding prospective memory
4. Mill Hill Vocabulary Test
5. Paragraph comprehension subsequence
   a. Three-sentence paragraph presented
   b. Synonym or break period lasting either 5 s or 15 s (one synonym item for 5-s period; three synonym items for 15-s period)
   c. Two trivia questions for 10 s each
   d. Paragraph comprehension questions
6. Repeat the paragraph comprehension subsequence for 20 paragraphs

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