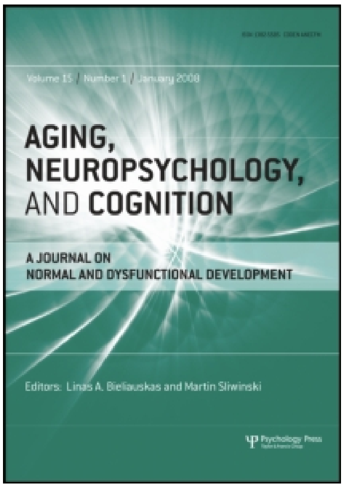

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Repetition Errors in Habitual Prospective Memory: Elimination of Age Differences via Complex Actions or Appropriate Resource Allocation

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Repetition Errors in Habitual Prospective Memory: Elimination of Age Differences via Complex Actions or Appropriate Resource Allocation

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ABSTRACT

A challenge in habitual prospective memory tasks (e.g., taking medication) is remembering whether or not one has already performed the action. Einstein, McDaniel, Smith, and Shaw (1998, *Psychological Science, 9*, 284) showed that older adults were more likely to incorrectly repeat an action on habitual prospective memory tasks. Extending this research, we (a) biased participants either toward repetition or omission errors, (b) investigated whether performing a more complicated motor action can reduce repetition errors for older adults, and (c) examined participants' resource allocation to the prospective memory task. Older adults committed more repetition errors than younger adults regardless of biasing instructions when ongoing task demands were challenging (Experiment 1). Performing the more complex motor action, however, reduced repetition errors for older adults. Further, when the ongoing task was less demanding, older adults' repetition errors declined to levels of younger adults (Experiment 2). Consistent with this finding, the resource allocation profiles suggested that older participants were monitoring their output (prospective memory execution) in each trial block.

Keywords: Prospective memory; Habitual prospective memory; Resource allocation; Output monitoring; Older adult intervention.

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INTRODUCTION

Prospective memory refers to remembering to perform an action at an appropriate time in the future (Brandimonte, Einstein, & McDaniel, 1996; Ellis & Kvavilashvili, 2000; Kliegel, McDaniel, & Einstein, 2008; McDaniel & Einstein, 2007). So far, most prospective memory research has focused on the retrieval, initiation and performance of an intended action that has to be performed either once or several times in response to a discrete single event (e.g., pressing a predetermined key whenever a certain target word on the computer screen appears; Einstein & McDaniel, 1990). These tasks can be summarized under the term single-event prospective memory tasks (Einstein et al., 1998).

Many everyday prospective memory tasks, however, including those that are of great importance to older adults such as taking medication, can be designated as habitual prospective memory tasks. Meacham and Leiman (1982) defined a prospective memory task as habitual when it was performed frequently and in a routine manner.[1] Moreover, in habitual tasks the necessity of responding at the present moment depends strongly on one's accurate memory for the previous outcome of an action. For example, one may remember to take vitamins in the morning, but then have problems before leaving the house determining if the vitamins were indeed taken that particular morning. Thus, output monitoring becomes a crucial element of habitual prospective memory tasks (Ellis, 1996; Park & Kidder, 1996). Output monitoring is potentially challenging in a habitual task, however. The action is repeatedly executed and perhaps thought about periodically, thus creating possible confusion over the source of memories of particular outcomes.

Important for present purposes, research suggests that older adults especially may experience source confusion when a similar action is performed and imagined repeatedly (McDaniel, Lyle, Butler, & Dornburg, 2008b; Thomas & Bulevich, 2006; see also Hashtroudi, Johnson, & Chrosniak, 1998). Additionally, Kausler, Lichty, and Davis (1985) reported age differences in identifying the time blocks in which certain tasks were performed. These age-related source memory difficulties might reduce older

[1]Because some single-event laboratory tasks include elements that are typically more related to habitual prospective memory tasks (e.g., Marsh, Hicks, Hancock, & Munsayac, 2002, who combined an event-based prospective memory task with an output monitoring element), distinguishing between these two types of prospective memory in laboratory tasks can arguably get somewhat murky. In lieu of a definitive set of criteria, in an attempt to derive a distinction for laboratory tasks, we note that in prototypical single event-based prospective memory tasks, repeated task executions are in response to repetition of an identical target word(s) presented in the identical ongoing activity, with the repetition of the target word(s) not structured in any way, and the frequency of repetition unbeknownst to subjects. In contrast, in the present paradigm, to allow the formation of a routine, subjects are informed that execution of the task needs to be repeated throughout the experiment in a manner that fits with an anticipated structure of events.

adults' output monitoring accuracy in a habitual prospective memory task (in which the same action is performed repeatedly and perhaps thought about repeatedly). Indeed, even in prospective memory tasks that are not habitual, initial studies that have focused on output monitoring per se, have reported that older adults show output-monitoring deficiencies (Marsh, Hicks, Cook, & Mayhorn, 2007; Skladzien, 2007). Age-related deficiencies in output monitoring could in turn lead to older adults incorrectly performing the habitual prospective memory task more than once within a particular time frame (Einstein et al., 1998). In sum, age-related decrements in the performance of habitual prospective memory tasks might be expected, and more specifically, older adults' source or output monitoring failures (or both) may manifest in age-related increases in repetition errors.

Alternatively, it is not certain that older adults will necessarily suffer output monitoring difficulties and consequently display repetition (or omission) errors in habitual prospective memory. In support of this possibility, for simple actions ('flip the coin') older adults are comparable to younger adults in correctly judging that performed actions were in fact performed (rather than imagined or imagined and performed), and in judging how frequently a given action was performed (McDaniel et al., 2008b). More directly, Skladzien (2007, Experiment 4) recently reported that when the demands of the prospective memory task were eased (in a non-habitual prospective memory task), output monitoring errors for older adults diminished significantly.

Despite the theoretical and practical relevance of the above issues, the possible consequences of age-related decline in output monitoring for habitual prospective memory tasks and resultant output (e.g., repetition) errors have received little attention in the experimental literature. In one of the few experimental studies examining habitual prospective memory and aging, Einstein et al. (1998) asked participants to perform a prospective memory task at regular time periods while they were busily engaged in a variety of ongoing activities. The main results supported both positions discussed above. Older and younger adults displayed few prospective memory errors (either repetitions or omissions) when engaged in one primary ongoing activity. By contrast, when participants were given an additional activity (digit monitoring) beyond the primary ongoing activity, older adults committed a higher number of repetition errors than younger adults. Under these conditions, older adults were also significantly more likely than the younger adults to omit a response but reported that they had performed it. Both kinds of errors implied an age-related decline in output monitoring.

We conducted Experiment 1 to attempt to replicate and extend Einstein et al.'s (1998) initial finding of age-related deficits in habitual prospective memory, and to explore a technique to assist older adults with output monitoring and thereby reduce (or eliminate) their habitual prospective memory errors. In Experiment 2 we introduce a novel paradigm to reveal the resource allocation policies within and across the prospective memory blocks for younger and older adults. A primary purpose in this experiment was to chart younger and older adults' approaches to the habitual prospective memory task, and to gain insight into possible age-related differences in the processes supporting habitual prospective memory.

EXPERIMENT 1

Because Einstein et al.'s (1998) study is the only laboratory study that has investigated age-related effects in habitual prospective memory, we thought it important to replicate their findings, particularly with regard to the age-related increases in repetition errors. Accordingly, we implemented only the challenging attentional situation in which participants were busily engaged in several concurrent ongoing activities.

Second, we were interested in a more extensive examination of repetition and omission errors in habitual prospective memory tasks, especially with regard to age-related effects. The older participants in Einstein et al.'s (1998) study committed more repetition than omission errors. Einstein et al.'s instructions, however, encouraged participants to repeat the prospective memory task whenever they were unsure about having performed the task. To determine if the prominence of repetition errors was dependent on Einstein et al.'s instructional bias, we manipulated the bias of the instructions toward either repetition or omission errors. Of particular interest was whether repetition errors would persist even under instructions biasing toward omission errors or whether such instructions might result in a higher number of omission errors for older adults.

A third major goal was to investigate the effectiveness of a technique for helping older adults reduce repetition and/or omission errors in habitual prospective memory tasks. Because the nature of habitual prospective memory tasks may lead to low output monitoring activity, a technique was designed to guide older participants' attention toward performance of the intended activity to improve output monitoring. We asked one group of older participants to perform the prospective memory action with a more complex set of motor movements than would typically be used to perform the action. We reasoned that performing the relatively complex motor action would require more conscious engagement during the performance of the habitual task, thereby increasing memory for the execution of the prospective-memory response and the context in which it was executed (i.e., the particular interval/ongoing task). Such increases in source memory and output monitoring would presumably help older adults avoid repetition (or omission) errors. Because Einstein et al. (1998) showed that the younger adults performed the habitual prospective memory task well, we did not include a condition in which younger adults performed the complex motor action.

The anticipated benefit of the complex motor response is not a foregone conclusion, however. In a surprising finding, Marsh et al. (2007) reported that requiring a more elaborate and complex motor response for an event-based prospective memory action tended to exaggerate output monitoring errors for older (but not younger) adults. That is, the more complex motor response 'confused older adults about their past performance'. If similar dynamics were present in the current prospective memory paradigm, then the complex motor action could either provide no benefit or might even produce unintended negative consequences (see also Butler, McDaniel, McCabe, & Dornburg, in press, for negative effects of elaborative encoding in exaggerating older adults' false recall).

Method

Participants and Design

The design was a 2 × 3 between-subjects factorial, in which the variables of instructional bias (repetition, omission) and condition (younger standard, older standard, older with motor action) were manipulated. A total of 31 young and 57 older adults were included in the analysis (see Table 1 for the distribution of participants across conditions). Preceding the data analysis, 2 younger and 5 older participants were excluded because they performed the prospective memory task either too early (within the first 30 s, see below) or not at all. The younger participants were psychology students at the University of New Mexico who participated to fulfill a course requirement. They were between 18 and 47 years old, with a mean age of 22.48[2] (*SD* = 6.60). The mean age across the two

TABLE 1. Experiment 1: Mean Proportion and Standard Deviation of Repetition Errors, Omission Errors and Prospective Memory Failures as a Function of Age, Instructional Bias and Trial Set

	Younger Standard Instruction Bias		Older Standard Instruction Bias		Older Motor Action Instruction Bias	
Trial Set	Repeat (N = 17)	Omit (N = 14)	Repeat (N = 14)	Omit (N = 14)	Repeat (N = 14)	Omit (N = 15)
Repetition errors						
Early	0.00 (0.00)	0.02 (0.07)	0.02 (0.07)	0.07 (0.15)	0.08 (0.15)	0.00 (0.00)
Late	0.00 (0.00)	0.04 (0.12)	0.16 (0.20)	0.17 (0.25)	0.09 (0.17)	0.03 (0.07)
Omission errors						
Early	0.07 (0.12)	0.09 (0.12)	0.05 (0.15)	0.04 (0.09)	0.03 (0.09)	0.07 (0.15)
Late	0.01 (0.05)	0.03 (0.07)	0.01 (0.05)	0.06 (0.12)	0.04 (0.11)	0.06 (0.09)
Prospective memory failures						
Early	0.00 (0.00)	0.00 (0.00)	0.11 (0.23)	0.09 (0.19)	0.00 (0.00)	0.02 (0.07)
Late	0.04 (0.11)	0.00 (0.00)	0.04 (0.16)	0.07 (0.15)	0.04 (0.08)	0.01 (0.00)

instructional-bias groups of the younger adults was comparable ($F < 1$). The older participants were recruited from the New Mexico Aging Process Study of nutrition and health (NMAPS; Garry, Hunt, Koehler, VanderJagt, & Vellas, 1992). They were all healthy, community-dwelling adults who drove to campus to be tested; prior to their entry into NMAPS they were screened for a variety of clinical conditions that precluded their inclusion in the pool (including dementia, depression, or neurological disorder; see Driscoll, McDaniel, & Guynn, 2005, for additional details). They were between 66 and 88 years old, with a mean age of 72.79 ($SD = 5.15$). The mean ages of the four groups of older adults were also comparable, $F(3, 53) = 1.69$, $p = .18$, $MSE = 25.58$. One of the ongoing experimental activities (see below) consisted of the first 20 items of the Mill Hill Vocabulary Scale. The vocabulary questions were performed under time limitations (a 3-min interval was given to answer 10 questions and each question had to be answered within 18 s). Even with these time limitations, older adults scored significantly higher than the younger adults ($M = 14.54$ and 11.35, respectively), $F(1, 86) = 28.73$, $p < .001$, $MSE = 7.11$.

Procedure

Other than adding the motor action and varying the instructional bias, the procedure closely followed that of Einstein et al. (1998). The entire experiment was computer-based and lasted approximately 1 h. The participants were first introduced to 6 tasks which were spaced out over 12 trials. Each task was designed to measure a different cognitive ability or construct. Their order was randomly determined for each participant and included a test for vocabulary (2 trials), source monitoring for performed actions (2 trials), word recognition and implicit memory (3 trials), perceptual speed (1 trial), a questionnaire asking for subjects' motivation in problem solving (2 trials) and action control (2 trials). Each trial lasted 3 min and began with a green 'go'-screen and ended with a yellow 'stop'-screen. Both the nature of the different tasks and the required responses were described on an introduction screen before the green screen came up.

The participants were then introduced to the prospective memory task. They were told that we wanted to examine how well they could remember to perform a particular task while doing other things. Specifically, the participants were asked to press a designated key (F1) on the

[2]This age profile is characteristic of the undergraduate population at the University of New Mexico, as a number of students in the state postpone or interrupt their college education for various reasons (e.g., economic, personal). We did not exclude the undergraduate participants who were older than typical college students because Einstein et al. (1995, Experiment 3) reported that middle-aged adults displayed prospective memory performances that were at least as good as that displayed by typical college-aged adults.

keyboard once and only once during each 3-min interval. Further, they were instructed not to press the key immediately after the task started but to wait for at least 30 s to elapse. The prospective memory task was implemented in a time-based manner (Ellis, 1996) in order to possibly further facilitate the commission of source monitoring errors by thinking about the task but not being able to perform it. In order to practice the timing of the prospective memory response, the participants performed some practice trials (as described below). To ensure that they did not use a watch for timing their prospective memory response, we removed watches at the start of the experiment.

In the instructional condition biased toward repetition, participants were told that if they were not sure whether they had already hit the key during the current interval, it would be better to hit the key more than once in an interval than to omit it completely. In the instructional condition biased toward omission, participants were told that if they were not sure whether they had already hit the key during the current interval, it would be better to omit the key press in an interval than to hit it twice.

The older participants in the motor action condition were additionally informed that in order to help them remember the key-press they should press the F1-key in a special way. Specifically, they were told to put one hand on their head while pressing the key with the other hand (for ease of exposition, we will label this the *motor* condition). The younger and older participants in the standard condition read some general information in the meantime.

The instructions were followed by five practice trials, which were designed to make sure that the participants understood the instructions, to familiarize them with the prospective memory task in general as well as with the additional motor action in particular, and to practice the timing of the prospective memory response. For each of these 1-min practice trials, a series of letters appeared in random order in the middle of the computer screen. The task was to press the letter on the keyboard that followed the presented letter in the alphabet. For example, if the letter on the screen was G, the participants should press the letter H on the keyboard. As soon as the participants responded, the next letter appeared on the screen and so on. The experimenter timed the prospective memory response during each practice trial and gave feedback. In general, participants were told not to worry about the exact timing of their response but to wait 30 s or so after the presentation of the green ‘go’-screen before they made their prospective memory response. Participants who pressed the key early (within the first 30 s) were asked to delay their response appropriately. After finishing all five practice trials the participants seemed to have developed a feeling for how long to wait for 30 s to elapse and performed the prospective memory task as instructed.

The yellow ‘stop’-screen at the end of each trial included a short post-trial questionnaire. The participants were queried whether they remembered pressing the F1-key (the prospective memory response) during the last interval.[3] Specifically, we asked them to indicate whether they were sure they pressed the F1 key, thought they pressed the F1 key, thought they did not press the F1 key, or were sure they did not press the F1 key during the past interval. For example, if participants omitted a response but later indicated that they had made a response, this would be suggestive of an omission error (a memory failure due to a source memory problem) and not a prospective memory failure (a failure in remembering to think about initiating the action during the trial). The confidence-ratings were not further analyzed as the primary objective was to gain information concerning the likelihood of omission and repetition errors in a habitual prospective memory paradigm.

All participants were then introduced to a digit detection task. The task was justified to participants with the purpose of investigating how well people can perform several different tasks at the same time. A series of digits was read aloud at the rate of one every 2 s on a tape. The participants were asked to press the lever of a handheld counter whenever they heard two consecutive odd numbers. Altogether, there were 219 pairs to detect. The participants were given a 30-s practice trial where they only listened to the tape and pressed the lever. Participants then began the 12 experimental trials. After the completion of all 12 trials and a short demographic questionnaire, participants were debriefed. During the experimental trials, younger and older adults performed equally well on the digit detection task ($M = 175.81$ and 166.53 pairs detected, respectively; $t(86) = 1.47$, $p = .15$).

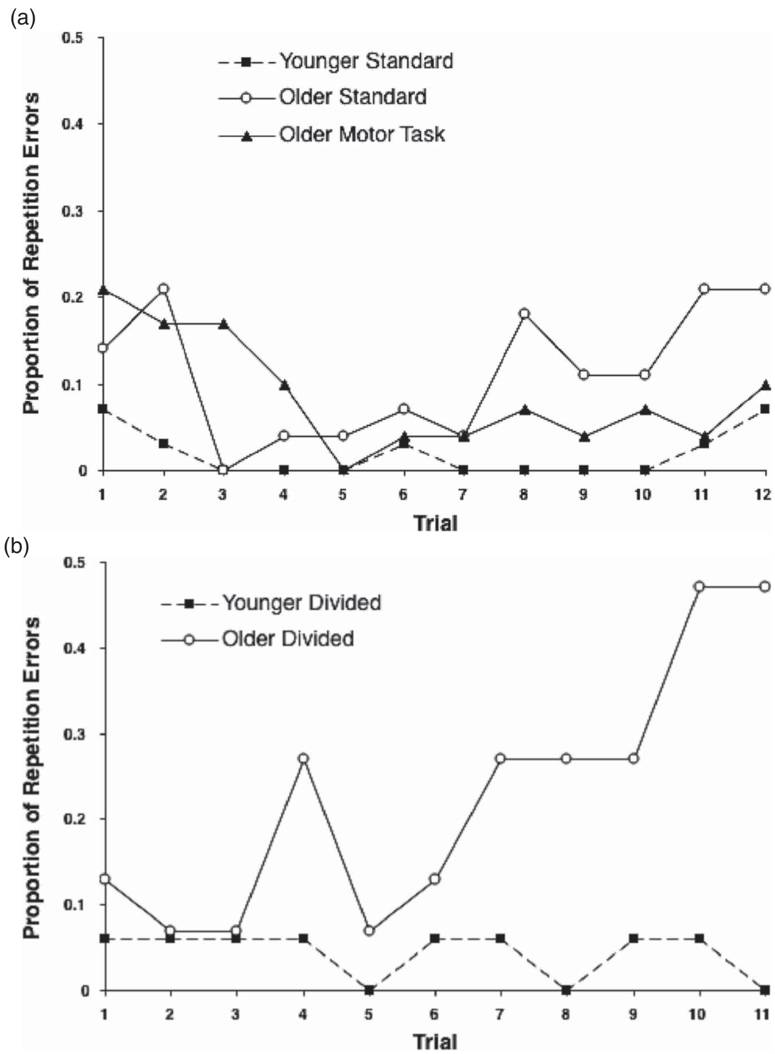
Although all participants seemed to understand the instructions and performed the prospective memory task correctly after the five practice trials, 5 older adults in the condition with the motor action and 4 older adults in the standard condition attempted to press the F1 key in 30-s intervals instead of only once after 30 s during the first experimental trials. After having recognized this error, the experimenter interrupted these participants (after the third experimental trial at the latest) and clarified the prospective memory task instructions once again. Because of this instructional confusion, we expected an artifactually high number of repetition errors on the first three trials.

[3]The imposed waiting time of 30 s as well as the post-trial questionnaire introduced aspects to the task that are not necessarily reflective of a prototypical habitual prospective memory task. They were included, however, in part to simulate and evaluate the aspects of habitual prospective memory of most interest here. With regard to the questionnaire we wanted to minimize the trials before there would be minimal forgetting (that the prospective memory action needed to be performed). This allowed more opportunity for source monitoring problems to be manifested, which was our main focus of interest. Also, the questionnaire allowed some leverage on distinguishing errors of omission from response failures based on forgetting to perform the intended action; again, the omission errors were of interest here.

Results

To evaluate the consequences of the just-mentioned instructional confusion for some subjects, we compared the pattern of repetition errors in the present study with that of Einstein et al.'s (1998) study (see Figure 1a,b for a comparison of the two studies). We observed a similar increase in repetition errors over trials for the older adults in the standard condition, as

FIGURE 1. (a) Mean proportion of repetition errors per trial as a function of condition in Experiment 1 (collapsed over the instructional bias variable). (b) Mean proportion of repetition errors per trial for the younger and older adults in the Einstein et al. (1998) conditions comparable to the younger and older standard groups in the current study.



Einstein et al. did for their older adults in the parallel condition. However, the relatively large proportions of repetition errors on the first three trials for the older adults in the standard and the motor action condition in the present study diverged from that reported in Einstein et al.'s study. As mentioned above, this was due to some older participants inappropriately pressing the F1 key every 30 s on the first three trials and thus artificially inflating repetition errors on these trials. Because we considered the later trials of the habitual prospective memory task as most important for current concerns, and because of pragmatic obstacles in securing replacements for these participants, we decided to exclude the first three trials in analyzing the repetition errors. Also, in order to ensure consistency across analyses, the first three trials were excluded from the omission-error analysis and from the analysis of prospective memory failures.

In line with Einstein et al.'s (1998) procedure (see also Elvevåg, Maylor, & Gilbert, 2003), the remaining trials were divided in two sets to create a within-subjects variable of trial set (early trials: 4–7; late trials: 8–12). A $2 \times 3 \times 2$ mixed analysis of variance (ANOVA) was computed with the between-subjects variables of instructional bias (repetition, omission) and condition (younger standard, older standard, older with motor action) and the within-subjects variable of trial set (early, late). The rejection level for inferring statistical significance was set at .05.

Repetition Errors

Pressing the F1 key more than once during a 3-min trial was scored as a repetition error. Table 1 displays the mean proportion of repetition errors as a function of the independent variables. The ANOVA revealed a significant interaction of trial set by condition, $F(2, 82) = 3.77$, $p = .027$, $MSE = 0.01$. To help interpret this interaction, *post-hoc* multiple comparisons were conducted (Scheffe for the between-group and Bonferonni-corrected *t*-tests for the within-group comparisons). The number of repetition errors committed by the younger adults and the older adults in the motor condition did not significantly differ across trial sets (see top part of Table 1). By contrast, the repetition errors for the older adults in the standard group increased significantly across trial sets. Furthermore, on the late trial set, the standard group of older adults evidenced significantly more repetition errors than either the younger adults ($p = .001$) or the motor-condition older adults ($p = .03$).[4] The younger adults and the motor-condition older adults did not differ significantly

[4]Because vocabulary scores differed across young and old, a reviewer was concerned that a possible relation between vocabulary scores and repetition errors could underlie the age effects in repetition errors. Accordingly, we computed correlations between vocabulary scores and repetition errors for each condition (young, older standard, older with motor action) collapsed across instructional bias. No significant correlations emerged (largest $r = .25$, $p = .20$, for the older standard condition).

on the late trial set. These results were general across instructional bias, as revealed by the absence of any significant effects involving the instruction bias manipulation ($F(2, 82) = 2.90$, $p = .06$ for the interaction of condition by instructional bias, all other Fs < 1).[5]

Omission Errors and Prospective Memory Failures

Not pressing the F1 key during a 3-min trial and indicating incorrectly on the post-trial questionnaire that the task had been performed was considered an omission error. The middle panel of Table 1 contains the mean proportion of omission errors as a function of the independent variables. As can be seen in Table 1, the proportion of this kind of error was roughly similar across conditions. The ANOVA on these data revealed no significant effects (largest $F(1, 82) = 2.21$, $p = .14$ for the main effect of trial set).

Forgetting to perform the intended prospective memory task during a trial and indicating correctly on the post-trial questionnaire not having performed the task was considered a prospective memory failure (see bottom panel of Table 1). The ANOVA on these data revealed a significant main effect of condition, $F(2, 82) = 4.80$, $p = .01$ $MSE = 0.02$.[6] *Post-hoc* comparisons showed that the older adults in the standard condition had significantly more prospective memory failures ($M = 0.08$) than the younger adults ($M = 0.01$; $p = .02$) and the older adults in the motor condition ($M = 0.02$; $p = .04$).

Discussion

Our results reinforce Einstein et al.'s (1998) initial report. We found significantly more repetition errors for a standard group of older adults (without a mnemonic aid) relative to a standard group of younger adults on the later trials of a habitual prospective memory task. As in Einstein et al.'s study, the age-related increase in repetition errors occurred when participants performed the prospective memory task under divided attention. Extending Einstein et al., the present study manipulated the bias of the instruction toward either repetition or omission errors. The results showed that for the group of older adults who performed the standard prospective memory response, regardless of the instructional bias, repetition errors but

[5]We also conducted parallel nonparametric analyses to reinforce the parametric analyses. The Wilcoxon–Signed–Ranks test was used to evaluate the repeated measures effects and the Mann–Whitney U-test and Kruskal–Wallis tests were used to evaluate the between-subjects effects. For repetition errors, the nonparametric results mirrored those found with ANOVA. Repetition errors across early versus late trial sets significantly increased for the standard older adults ($T = 1.99$, $p < .05$) but not for the younger adults or for the older adults in the motor condition ($T = 0.54$, $p = 0.59$; $T = 0.99$, $p = .32$, respectively). On the late trials, the standard older adults showed more repetition errors than the younger adults ($U = 259$; $p = .001$) and the motor-condition older adults ($U = 302$; $p < .05$).

[6]The nonparametric analyses indicated only a slight trend toward an effect of condition for prospective memory failures ($\chi^2(2, 88) = 4.43$, $p = .11$).

not omission errors (which were infrequent) increased over trials. The implication may be that when older adults forget whether they previously performed an action, they are biased toward ensuring that the action is executed (by performing the action again). The present results therefore provide further evidence that, as prospective memory tasks become habitual under demanding conditions, older adults will tend to commit repetition errors more so than younger adults.

Importantly, the results indicated that the older participants who performed a more complex motor action to implement the prospective memory activity showed a significant reduction in repetition errors relative to the older participants not instructed to perform the complex motor action. Thus, older adults benefit from the implementation of a more complex motor action in habitual prospective memory tasks. One idea is that performing the prospective memory task with the more complex motor action forced the older participants to pay full attention to the habitual task while performing it. Thus, this motor action would facilitate older adults' output monitoring activity (Ellis, 1996). In Experiment 2 we more directly examine older and younger adults' attentional allocation to the prospective memory task to gain insight into the output monitoring activity of older (and younger) adults.

Another, not necessarily incompatible idea is that performing a more complex motor action provides additional sensory information (Gathercole & Conway, 1988). This should help produce a more distinctive memory record about the performed action and thereby contribute to an accurate memory of whether a habitual task had been performed or merely thought about (Johnson & Raye, 1981).[7] Regardless of the explanation, overall our results indicate that a more complex motor task could be a useful mnemonic technique for older adults for effectively reducing repetition errors in a habitual prospective memory task.

It is worth noting that the above conclusion (and our findings) contrasts with the findings reported by Marsh et al. (2007). As mentioned in the introduction, these researchers reported that a complex motor task did not improve output monitoring for older adults in a prospective memory task and even tended to exacerbate such errors. Differences between the two studies regarding the ongoing activity, the number of prospective memory task repetitions, the relative uniqueness of the motor actions, or the prospective

[7]Of course, even the more complex task performance could become less effective when performed repeatedly. That is, with repeated execution in a habitual prospective memory task, a complex or novel motor action (e.g., placing a hand on one's head as in Experiment 1) could eventually be performed with little conscious awareness or attention, thereby undermining its usefulness in preventing habitual prospective memory errors. Therefore, for optimal effectiveness it might be necessary after some number of prospective memory trials to replace any particular complex motor action with another unique motor response.

memory task itself may be responsible for this discrepancy. For instance, perhaps the motor action in our experiment was more unusual or more distinctive (put one's hand on one's head) than Marsh et al.'s motor action (saying something to the experimenter). Another clear possibility noted by Marsh et al. is that their prospective memory task may have created high source confusion by presenting a number of semantically related target events, and subjects had to discriminate in output monitoring between responses among these related events. Further research will be needed to definitively identify the boundary conditions of positive effects of a complex motor task on older adults' output monitoring. In Experiment 2, however, we continued our focus on habitual prospective memory per se.

EXPERIMENT 2

In this experiment, we investigated a key issue that has not yet been addressed in the nascent aging and habitual prospective memory literature: the underlying processes exhibited by younger and older adults in performing the current (habitual) prospective memory task and possible differences therein. To gain leverage on these issues, we used a speeded category judgment task as the ongoing activity during each of the 10 blocks, and this enabled us to examine the resource demands of the prospective memory task across blocks. Past work has confirmed that prospective tasks that require attentional resources for their completion significantly increase response latencies to the category judgment task (Einstein et al., 2005). We reasoned that systematic changes in RTs to the category judgments within a prospective memory trial (that comprised a set of category-judgment items) would provide a footprint of whether and how participants deployed resources during the prospective memory task.

Specifically, to the extent that controlled attentional processes are recruited to consider initiation of a prospective memory response (including whether sufficient time had elapsed since the start of the trial block), these processes would be expected to peak just prior to the execution of the prospective memory action (see e.g., Einstein, McDaniel, Richardson, Guynn, & Cunfer, 1995). If so, then we should observe increased latencies to make a category judgment on items prior to the prospective memory action relative to latencies on the category judgment items at the outset of the block (and RT patterns in control blocks with no prospective memory task should not show this pattern).

Of additional theoretical interest is the dynamics associated with output monitoring processes. We reasoned that to the extent that participants reflected on and noted executing the prospective memory action (i.e., monitored their output), latencies on category judgment items subsequent to the prospective memory action should peak relative to the latencies at both the outset of the trial and at the conclusion of the trial. Especially important for present purposes, was the examination of possible age-related differences in the deployment of resources just subsequent to execution of the prospective memory action. Theoretically, two possibilities seemed most likely.

On the one hand, older adults could engage in little output monitoring throughout the prospective memory task, as suggested by Experiment 1 and the Einstein et al. (1998) findings of relatively high repetition errors for older adults. This view would predict that latencies for the older adults would not increase following execution of the prospective memory task. With little output monitoring, older adults would then be expected to be increasingly challenged on later trials by the source judgments of whether or not the prospective memory action was executed on a particular trial, and repetition errors should become more frequent (as in Experiment 1).

On the other hand, unlike the conditions of Experiment 1 (as well as those of Einstein et al., 1998), in the present experiment, the ongoing task did not change for each prospective memory trial (this change was made in Experiment 2 in order to obtain sensitive RT measures). Arguably this would ease the demands of the ongoing task from trial to trial. Based on the Einstein et al. (1998) finding that older adults did not show exaggerated repetition errors when the ongoing task was not overly demanding, it might be that in these circumstances, older adults are able to engage in output monitoring. If so, older adults would be expected to display significant RT increases for category judgment items just subsequent to executing the prospective memory action. Further, if such output monitoring is successful, then the older adults should not show repetition errors. This pattern, if obtained, would be of great theoretical (and practical) importance, because it would provide insights into the processes that preclude repetition errors in older adults' habitual prospective memory.

Finally, the pattern for younger adults was uncertain. Increased latencies subsequent to the prospective memory action would reveal that younger adults are engaging in output monitoring in the current prospective memory context. However, younger adults may not need to engage in extensive output monitoring in the present task. If so, then their latencies on category judgment items immediately following the execution of the prospective memory action would not increase, at least not more so than in control blocks with no prospective task.

Method

Participants and Design

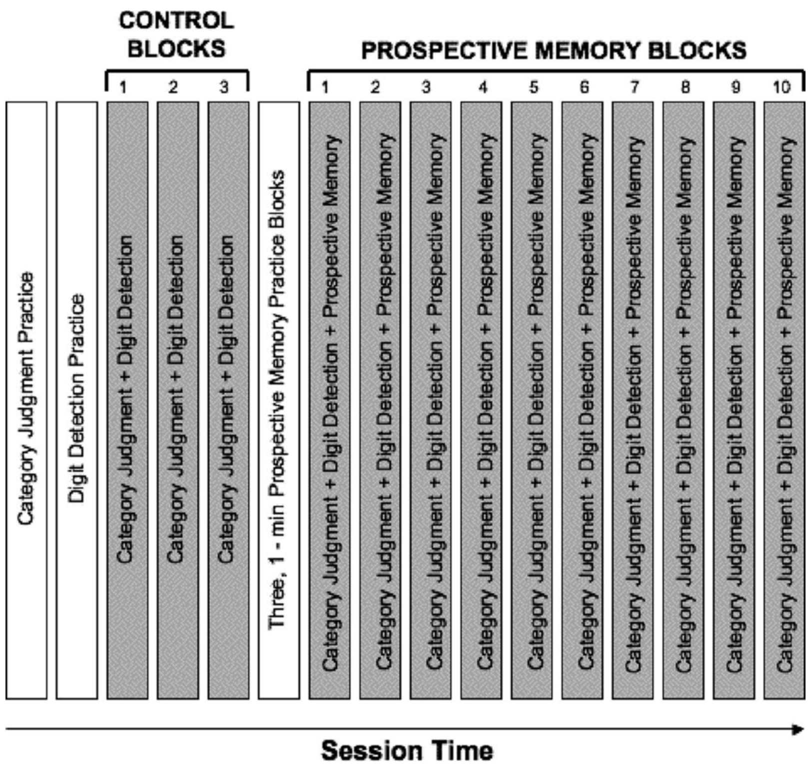
Sixteen younger adults and 22 older adults participated in the experiment. The young participants were undergraduate psychology students at Washington University who participated to fulfill a course requirement; they ranged in age from 18 to 23 with a mean age of 20 (*SD* = 1.7). The older participants were recruited from the Washington University older-adult subject pool, and they ranged in age from 60 to 80 years, with a mean age of 69 (*SD* = 5.6). The subject pool consists of healthy older adults who have not been diagnosed with dementia or a neurological illness (e.g., Parkinson's disease). The older participants in our study were living independently and transported themselves to campus to be tested. Using a Likert scale ranging from 1 (Poor) to 5 (Excellent), participants rated their health (*M* = 3.95, *SD* = 1.05) as good and indicated that health problems do not greatly limit daily activities (*M* = 3.41, *SD* = 0.96 on a 4-point Likert scale ranging from 1 (A lot) to 4 (None)). They were paid US $10 per hour for participating. Younger (*M* = 29.6, *SD* = 3.4) and older adults (*M* = 30.0, *SD* = 3.8) did not differ in Shipley Vocabulary scores, $t(36) = .32$, $p = .75$. Older adults (*M* = 15.7, *SD* = 2.3) did, however, complete more years of formal education than their younger counterparts (*M* = 13.9, *SD* = 1.6), $t(36) = 2.60$, $p < .05$.

We manipulated within-subjects whether a prospective memory task was present or not during the ongoing activity (for purposes of exposition, the trials without the prospective memory task are labeled *control* blocks). The sequence in which the control and prospective memory blocks were presented was counterbalanced across participants. With regard to the prospective memory task, for 11 of the older adults, as in Experiment 1 the prospective memory action was pressing the F1 key. Having tested these participants, however, we realized that the sensitivity of the response latency measures (proximal to performing the prospective memory action) might be compromised by degree of hand movement necessary to relocate the finger from the keypad (on which the responses were made in the Experiment 2 ongoing activity) to the F1 key. Accordingly, for the remainder of the older adults (11) and all of the younger adults, the prospective memory action was to press the '*' key (adjacent to the keypad). Because the particular prospective memory action turned out to have no effect on the results, all presented analyses are collapsed across this feature.

Procedure

The procedure is depicted in Figure 2 and was similar to that of Experiment 1, with two key exceptions. A category judgment task adopted from Einstein et al. (2005) served as the ongoing task for the entire experiment. For this task, word pairs were presented, with the word representing the category label presented in capital letters on the left side of the computer monitor. A total of 316 word pairs were used, all from Einstein et al. Participants had to decide as quickly as possible if the lower-case word presented on the right side of the monitor belonged to the indicated category. To make a response, participants pressed keys labeled Y ('5') or N ('6') on the numeric keypad of the keyboard. The word-pair stayed on the

FIGURE 2. Experimental procedure used in Experiment 2. The order of the control blocks and prospective memory blocks was counterbalanced across participants.



screen until the participant responded; the response initiated presentation of the next word-pair.

A second new feature implemented in this experiment was that, in addition to ten 3-min blocks of the category judgment task being performed along with the prospective memory task, we included three 3-min control blocks in which only the category judgment task was performed. We limited the control trials to 3 blocks because we believed that additional blocks would be overly taxing or boring for the participants (as it was, the entire experiment lasted approximately 1–1.5 h). The 3 control blocks were presented either before or after the prospective memory trial blocks (counterbalanced across participants). The word-pair presentations were randomly ordered from the pool of 316 pairs for both the control and prospective memory blocks. On average, younger adults completed 108 word pairs per block, and older adults completed 79 word pairs per block.

To begin the experiment, participants were instructed on the category judgment task and given 6 trials of practice on that task alone. Ten additional trials of practice were then given during which participants were instructed to make their responses as quickly as possible without sacrificing accuracy, as would be expected throughout the task. Feedback on reaction time and accuracy was provided after these trials.

Those performing the control blocks first were then introduced to the digit detection task used in Experiment 1. A 60-s practice trial involving just this task was administered. Following, participants engaged in three 3-min blocks of control trials, involving the category judgment and digit detection tasks. A green 'go' screen signaled the beginning of a 3-min block and a red 'stop' screen signaled its end. Following completion of these blocks, the prospective memory task (i.e., pressing either the 'F1' or '*' key once after waiting at least 30 s) was introduced (using the instruction to repeat the action if unsure whether it was completed; see Experiment 1), and participants engaged in three 1-min practice blocks involving just this task. Participants were given feedback after each block regarding how long they waited before pressing the designated key. Participants who did not wait 30 s were asked to delay their responses in subsequent blocks. Once the experimenter was satisfied that participants understood the prospective memory task, the participants proceeded to the 10 prospective memory blocks. Each prospective memory block lasted 3 min and was followed by administration of the post-trial questionnaire used in Experiment 1.

Those participants performing the prospective memory trials first were given the prospective memory instructions immediately following the 10 trials in which they practiced responding quickly and accurately on the category judgment task. The three 1-min practice trials with feedback on how long they waited before pressing the designated key followed. Participants were then introduced to the digit detection task and were given practice on just this task for 60 s. The 10 prospective memory blocks followed. Upon completion, participants were given the 3 control blocks.

After completing all of the category-judgment trial blocks, participants were given the Shipley Vocabulary test (Shipley, 1946). Participants were given 10 min to complete this test. At the end of the experiment, participants were debriefed.

Results and Discussion

For all statistical tests, the significance level was set at .05.

Prospective Memory Performance

Of primary interest were the repetition errors and the omission errors. As in Experiment 1, a repetition error was recorded if a participant pressed the prospective memory response key twice in a particular 3-min trial block. Table 2 shows the proportion of repetition errors for early blocks (2–4), middle blocks (5–7) and late blocks (8–10). As can be seen, repetition errors

TABLE 2. Experiment 2: Mean Proportion and Standard Deviation of Repetition Errors and Omission Errors for Younger and Older Adults across Blocks

	Blocks 2–4	Blocks 5–7	Blocks 8–10
Repetition errors			
Younger	.06 (.25)	.06 (.13)	.06 (.13)
Older	.08 (.14)	.05 (.12)	.11 (.16)
Omission errors (source memory failures)			
Younger	.02 (.08)	.02 (.08)	.00 (.00)
Older	.03 (.10)	.00 (.00)	.00 (.00)
Prospective memory failures			
Younger	.13 (.24)	.02 (.08)	.13 (.24)
Older	.06 (.13)	.09 (.23)	.08 (.18)

were relatively infrequent and of similar magnitude across blocks and age group. A mixed ANOVA, with age group as the between-subjects factor and blocks (early, middle, late) as the within-subjects variable, confirmed these impressions. There were no significant effects of age group, block, or an interaction (all Fs < 1).

One interpretation of the low repetitions errors for older adults is that using the relatively simple category judgment task throughout the experiment reduced the cognitive demands of the ongoing activity (relative to Experiment 1, wherein different ongoing tasks were used across the experiment) (cf. Einstein et al., 1998). Repeatedly performing the same ongoing task might itself reduce cognitive demands. However, another potentially important feature is that the time-estimation component embedded in the prospective memory task could well have become somewhat unitized with the ongoing activity (see Healy, Wohldmann, Parker, & Bourne, 2005, for evidence that well-trained estimations of temporal intervals are disrupted when the ongoing activity is changed after training, even when the ongoing activity is changed to an easier task). These features of the ongoing activity may have allowed older adults the opportunity to engage in effective output monitoring (cf. Skladzien, 2007), thereby precluding extensive repetition errors. Below we report an analysis of ongoing task activity to evaluate the evidence for this interpretation.

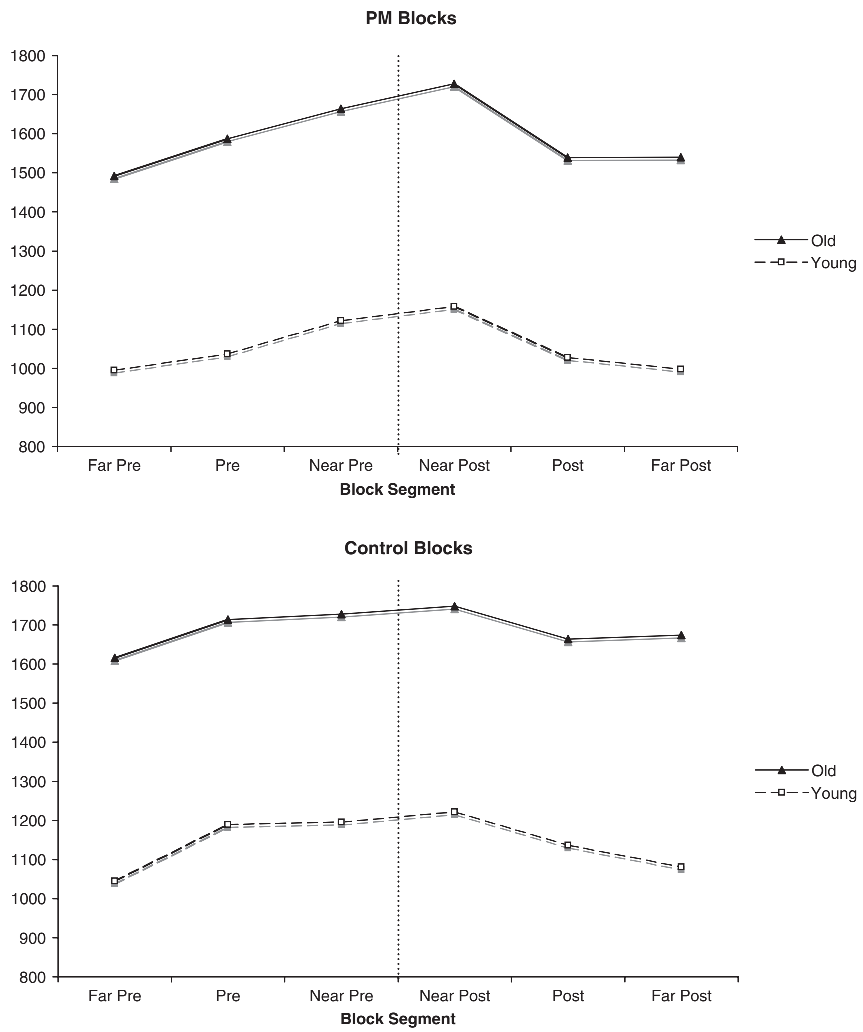
Two types of omission errors were possible, as in Experiment 1. First, we analyzed the mean proportion of omission errors attributable to source-memory failure (i.e., participants incorrectly said they pressed the designated prospective memory key on the response-monitoring questionnaire). Overall, these omission errors were low (M = 0.01), and there were no differences across age groups or trial blocks, and there was no interaction between age and trial block (F < 2.2, p > .10; see Table 2 for means). Next, we analyzed the mean proportion of omissions attributable to prospective memory failure (i.e., participants correctly said they failed to press the designated prospective memory key). These prospective memory failures were more common (M = 0.08). Again, however, there were no age or trial block differences, and no interaction between age and trial block (F < 1.75, p > .10; see Table 2).

Ongoing Task Performance

The primary goal of these analyses was to chart the resource-allocation dynamics throughout the prospective memory trial blocks. Following the theoretical possibilities outlined in the introduction to this experiment, we identified the critical segments of each block according to when each participant executed the prospective memory task during each block. (Blocks on which a prospective memory response was omitted or a repetition error occurred were excluded from the following analyses, thereby resulting in two younger adults and two older adults not having complete data for the omnibus ANOVA reported below.) For each block, the category judgment trials prior to the prospective memory response were divided into three segments: the five trials immediately preceding the prospective memory response (*NearPre),* the next five trials preceding the response (i.e., 6–10 trials preceding the response; *Pre*), and the remainder of the trials preceding the response (*FarPre)*. Similarly, the trials subsequent to the response were divided into three segments: the five trials immediately succeeding the prospective memory response (*NearPost*), the next five trials succeeding the response (i.e., 6–10 trials succeeding the response; *Post*), and the remainder of the trials succeeding the response (*FarPost)*. Participants' median RTs on correct trials for each of these six segments were calculated after trimming response times to omit those less than or equal to 200 ms and greater than or equal to 8000 ms. As in Experiment 1, to provide a relatively stable index of performance, we averaged values across blocks of three, omitting the first block as a warm-up block. We submitted these data to a 2 × 6 × 3 mixed ANOVA that included the between-subjects variable of age (younger, older) and the within-subjects variables of block segment (6 segments) and block group (blocks 2–4, blocks 5–7, and blocks 8–10).

As expected, younger adults responded more quickly than older adults, $F(1, 32) = 32.52$, $p < .001$, MSE = 1,430,433.96. Response times did not change significantly across blocks, $F = 1.69$, $p = .20$, and this factor did not interact with age group or with the block segment ($F < 1$). Most importantly, there were significant variations in response time across the block segments, $F(5, 160) = 15.36$, $p < .001$, MSE = 207,031.95. The top panel of Figure 3 provides the averaged RT medians for younger and older adults for the six segments across all blocks combined (because there were no interactions with block group and no three-way interaction, $F < 1$). As can be seen in this figure, both younger and older adults showed increased RTs to the category judgment task immediately preceding (*NearPre*) and immediately succeeding

FIGURE 3. Top panel: Mean reaction time medians collapsed across prospective memory blocks as a function of trial segments in the block and age group in Experiment 2. Checked vertical line represents moment of a prospective memory response. Bottom panel: Mean control reaction time medians collapsed across blocks. Note that the checked vertical line represents the anticipated moment of a prospective memory response (calculated for each participant), based on each participants' performance in the prospective memory block.



the prospective memory response (*NearPost*) relative to trials more distal to performance of the prospective memory task (thereby producing a quadratic shape to the RT patterns).

These impressions were confirmed by separate ANOVAs for each age group that included the within-subjects variable of block segment (collapsed across blocks). Specifically, the pattern of RT differences across block segment was primarily a consequence of a significant quadratic component for younger adults, $F(1, 15) = 28.60$, $p < .001$, $MSE = 9865.12$, and for older adults, $F(1, 21) = 34.72$, $p < .001$, $MSE = 17{,}764.40$.[8] Planned comparisons based on these ANOVAs across pre-prospective memory block segments and across post-prospective memory block segments were conducted to specify the fine-grained patterns. These analyses showed that RT increased just prior to executing the prospective memory action (*NearPre*) relative to RT at the beginning of the block (*FarPre*) and relative to RTs between 6 and 10 trials prior to executing the action (*Pre*); for younger adults, $p < .05$ and .01, respectively and for older adults, $p < .001$ and .13 (nonsignificant), respectively. Perhaps more importantly, the RT observed immediately after performing the prospective memory action (*NearPost*) were substantially slower than RTs for the trials at the end of the block (*FarPost*) and for the 6–10 trials after performing the prospective memory action (*Post*); for younger adults $p < .005$ and for older adults, $p < .001$.

To explore whether the above patterns were associated with the prospective memory task per se, we next analyzed control blocks (which did not include a prospective memory task). For these analyses, we collapsed across the second and third control blocks (as for the analyses of the prospective memory blocks, we eliminated the first block as a warm-up for participants who received control blocks first and as a buffer for carry-over effects from the prospective memory blocks for participants who received control blocks second). For each participant we identified the average moment in the prospective memory blocks at which the prospective memory response had been executed. Using this average moment, for each participant, we then created six segments of trials for each control block using the approach that we utilized in analyzing the prospective memory blocks. Specifically, these segments paralleled the segments used in analyzing the blocks containing the prospective memory task: the five trials immediately preceding (or succeeding) the (expected) prospective memory response, the next five trials preceding (or succeeding) the response (i.e., 6–10 trials preceding [succeeding] the response), and the remainder of the trials preceding (or succeeding) the response. For each age group we conducted a within-subjects ANOVA of these data with block segment as the independent variable and planned comparisons paralleling those reported for the prospective memory blocks (see the bottom panel of Figure 3 for means).

For younger adults, the pattern in the control blocks was not dramatically different from that seen in the prospective memory blocks. There was a

[8]The order four component was also significant for younger, $F(1, 15) = 9.68$, and older adults, $F(1, 21) = 7.92$.

significant difference across block segments, $F(5, 75) = 4.32$, $p < .002$, $MSE = 18{,}205.20$, and the quadratic component was significant, $F(1, 15) = 15.39$, $p < .002$, $MSE = 23{,}033{,}71$. The planned comparisons showed that *NearPre* RTs were significantly slower than *FarPre* RTs ($p < .01$) but not *Pre* RTs ($p > .93$), and *NearPost* RTs were significantly slower than *Post* and *FarPost* RTs ($p < .05$). By contrast, older adults showed a pattern that diverged decidedly from the prospective memory blocks. Specifically, the RTs across trial segments did not differ significantly ($F < 1$), there was no significant quadratric component ($F = 1.25$), and none of the planned comparisons was significant (smallest $p = .18$).

Considering the results from the prospective memory and control blocks in concert, these patterns imply that sometime after the initiation of a prospective memory block, older adults' attention to the ongoing activity was somewhat redirected to demands associated with the prospective memory task. Just prior to the execution of the task, theoretically these additional cognitive demands may have included consideration of whether enough time had elapsed to perform the prospective memory response and decision processes to initiate the prospective memory response. Another notable aspect of these patterns is that for the older adults, there was a robust increase in RTs on category judgment trials subsequent to execution of the prospective memory action (that was not also found in the control blocks). Apparently, older adults were especially engaged in noting and encoding their output of the prospective memory action. Further support for the idea that older adults were engaged in output monitoring related to execution of the prospective memory response is that the slower reaction times were not sustained (as they might have been if the latency pattern were driven by some other non-prospective memory related component of the ongoing activity). On the other hand, the evidence did not conclusively suggest that younger adults were deploying significant attentional resources toward preparing and monitoring the prospective memory response (because the quadratic RT patterns were somewhat mimicked in the control blocks).

These patterns link remarkably well with the novel age-related prospective memory results from this experiment (relative to Experiment 1 and Einstein et al., 1998). In accordance with the reaction time patterns suggesting that older adults were engaged in preparatory processes to support appropriate execution of the prospective memory intention, older adults displayed relatively few prospective memory failures. Most importantly for present purposes, older adults' reaction times (to the ongoing task) were slowed for several trials after executing the prospective memory response, suggesting that older participants were still considering their prospective memory response, thereby contributing to effective output monitoring. This pattern was consistent as it did not interact with blocks, thus paralleling the low repetition errors for older adults for all trial blocks.

The implication is that, unlike Experiment 1 in which at least some of the ongoing activities were relatively challenging and these activities changed every block, in this experiment the relatively simple nature of the ongoing activity allowed older participants to allocate resources to preparing and monitoring their prospective memory actions. (In addition, perhaps the focus on response latencies in the ongoing task, cued or prompted older adults to be more attentive to the temporal parameters of the prospective memory task.[9]) As a consequence prospective memory performance was quite similar to that displayed by younger adults. Younger adults presumably had sufficient resources to prepare and monitor the current habitual prospective memory activity without disrupting the ongoing activity (as seen in good performance in Experiment 1 and in the resource allocation dynamic profiles in the current experiment).

GENERAL DISCUSSION

In this study we used a laboratory prospective memory paradigm that attempted to capture features of a habitual prospective memory task, in particular the opportunity for participants to erroneously repeat the execution of an already performed intended action (most typical prospective memory paradigms are not designed to reveal such errors; see McDaniel & Einstein, 2007, for an overview). The results replicate an initial key finding related to habitual prospective memory and aging and also provide a number of important new findings. As in Einstein et al. (1998), when the ongoing activity was demanding (the present Experiment 1; the ongoing tasks were changing and were performed in the presence of a secondary task), older adults but not younger adults began displaying significant levels of repetition errors as the prospective memory task became more practiced (or habitual). Extending Einstein et al., this age-related increase in repetition errors was observed even when the instructions explicitly encouraged participants to avoid making a repetition error; i.e., in one condition the instructions encouraged participants to omit a response if unsure about whether the intention had been executed.

The Experiment 1 and Einstein et al. (1998) results taken together converge on the conclusion that in situations where older adults are challenged by the ongoing activity (e.g., switching ongoing activities in the presence of other secondary task demands), they do not or cannot engage in effective output monitoring so as to accurately assess whether a habitual intended action (e.g., taking medication every day) has been performed in any given time period (for related results using other indices of output monitoring in older adults see also Marsh et al, 2007; Skladzien, 2007). Moreover, when

[9]We thank an anonymous reviewer for pointing out this possibility.

older adults are uncertain about having performed the prospective memory task (in the present case in later trial blocks), they appear biased toward executing the intention rather than omitting it (i.e., omission errors were relatively low). This basic finding implies that age-related difficulties in output monitoring in habitual prospective memory tasks will more likely result in older adults repeating rather than omitting a prospective memory response (i.e., over medicating rather than under medicating). It is worth mentioning that extension of the present findings to real-world habitual prospective memory may be limited by aspects of our laboratory paradigm. In particular, the short questionnaires administered after each trial-block that prompted participants to consider their prospective memory performance in the previous trial-block may have affected performance in unforeseen ways.

A second key novel finding is that older adults' repetition errors were significantly reduced to levels displayed by younger adults when the older adults were required to perform a distinct motor activity (Experiment 1). Theoretical interpretations of this finding were discussed following Experiment 1. For applied purposes, using a distinct motor activity to minimize repetition errors in older adults' prospective memory tasks would seem to have great potential. For instance, in extended medication-taking situations, remembering to take medications may be minimally problematic for older adults (see McDaniel & Einstein, 2007), but the habitual nature of the task may make it difficult for older adults to remember whether or not they took the medication on a particular day (especially if pill boxes are not used). To remedy this potential problem, older adults could be instructed to take their medication by placing one hand on their head (as in Experiment 1) or in some other unusual or silly way, like crossing their arms (however, if more than one medication is being taken across the day, using a single unusual activity may not be effective; see Marsh et al., 2007).

A third key finding is that when the ongoing task was not overly demanding, older adults' repetition errors were relatively low and not different from those displayed by younger adults (Experiment 2). Though this kind of finding had been previously reported by Einstein et al. (1998) using different ongoing tasks, it has remained unclear whether the resource allocation policies used to support prospective memory performance in these experimental contexts are similar or dissimilar across younger and older adults. It seemed possible that similar prospective memory performances across age groups could be supported by different allocation strategies. For instance for non-habitual prospective memory tasks, older adults can maintain relatively high prospective memory performance but with greater sacrifice to the ongoing activity than displayed by younger adults (McDaniel, Einstein, & Rendell, 2008a). The present study (Experiment 2) was the first to examine younger and older adults' resource allocation policies for a more habitual type of prospective memory task. The important finding was that older adults' resource allocation profiles were more pronounced than those exhibited by younger adults, particularly when considered relative to the control blocks in which no prospective task was presented.

Finally, the specific resource allocation topography suggested that older adults (and perhaps also younger adults) were attending to two aspects of the prospective memory task. First, resources were engaged just prior to execution of the prospective memory intention. One reasonable interpretation of this finding is that older participants were briefly considering whether the time was appropriate for executing a prospective memory response. Second, older participants engaged additional resources for a handful of trials subsequent to the execution of the prospective memory intention. This finding possibly suggests that older participants were attending to or fully encoding the fact that they had performed the task within the current trial block. Such an interpretation is bolstered by the low incidence of repetition and omission errors for older adults in the experiment (Experiment 2). In light of these findings, it seems reasonable to conclude that, at least in a context like that of Experiment 2 in which the ongoing activity is not overly demanding, older adults can implement strategies that are effective for supporting execution and output monitoring of habitual prospective memory tasks. Subsequent research could reinforce this conclusion by demonstrating a link between the resource allocation topographies like those from Experiment 2 and particular strategic processes (either preparation for a response or output monitoring) presumed to underlie the resource allocation profiles.

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