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Prospective memory: Are preparatory attentional processes necessary for a single focal cue?

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The preparatory attentional and memory processes theory of prospective memory (PM) assumes that PM retrieval requires resource-demanding preparatory attentional processes, whereas the multiprocess theory assumes that retrieval can also occur spontaneously. On the basis of showing slowing on an ongoing task (i.e., task interference)—even when the PM cue was highly salient (i.e., the participant's own name)—Smith, Hunt, McVay, and McConnell (2007) concluded that preparatory attentional processes are always necessary for PM retrieval. We argue that the presence of preparatory attentional processes cannot be used to rule out the existence of spontaneous retrieval processes, and the goal of the present research was to examine whether PM retrieval can occur in the absence of preparatory attentional processes. We varied whether we emphasized the importance of the PM task or the ongoing task, and we assessed task interference across quarters of the ongoing task. Our results showed no evidence of task interference and, hence, no evidence of preparatory attentional processes in the periods proximal to the target event, and yet participants showed high PM performance. Thus, the results suggest the existence of spontaneous retrieval processes and support the multiprocess theory.

From remembering to buy groceries, to remembering to take medication, to remembering work and social obligations, *prospective memory* (PM; i.e., remembering to perform actions in the future) pervades our daily life. Currently, there are two major theories that seek to explain PM retrieval: the preparatory attentional and memory processes (PAM) theory and the multiprocess theory.

The PAM theory argues that resource-consuming attentional processes (i.e., preparatory attentional processes) must be engaged for successful PM performance (Smith, 2003; Smith & Bayen, 2004). Preparatory attentional processes are used to monitor the environment for a cue to perform a PM intention. These processes, which range from conscious strategic monitoring to attentional processes that occur outside of conscious awareness, are necessary for initiating a recognition check to determine whether the current stimulus is a cue for a PM intention. Within this view, PM failures occur because either the attentional processes associated with the PM intention have lapsed (see also Marsh & Hicks, 1998; West & Craik, 1999) or the recognition check has failed. Because our attentional resources are limited, the presence of preparatory attentional processes can be inferred by finding task interference or costs (e.g., slowing or impaired accuracy) in the ongoing task. Many studies are consistent with this theory, in that they have shown slowed response times (RTs) on the ongoing task when a PM task is added (Loft & Yeo, 2007; Smith, 2003; Smith & Bayen, 2004).

In contrast to the PAM theory, the multiprocess theory (McDaniel & Einstein, 2007) assumes that there are two broad categories of processes through which we retrieve PM intentions: monitoring processes (i.e., preparatory attentional processes) and spontaneous retrieval processes. By *spontaneous retrieval*, McDaniel and Einstein (2007) mean that a cue can trigger retrieval of a PM intention, even when preparatory attentional processes are not engaged. The idea is that, even when no cognitive resources are expended to monitor the environment, the occurrence of an external cue can trigger retrieval of a PM intention.

McDaniel and Einstein (2007) have explored two processes to account for spontaneous retrieval (see also McDaniel, Guynn, Einstein, & Breneiser, 2004). The reflexive associate process is based on Moscovitch's (1994) view of the hippocampal system and occurs when two concepts are associated and activation of one concept reflexively brings to mind the associated concept. For example, in a PM task, if the target *rake* and the intended action of pressing the "Q" key are closely associated in memory, the presentation of *rake* can spontaneously bring the intended action of pressing the "Q" key to mind via the reflexive associate process. The other mechanism is the discrepancy-plus-attribution process, which is based on Whittlesea and Williams's (2001) theory that we constantly evaluate the processing quality of the world around us. As a result of having thought about the target item during planning or encoding, we may notice a discrepancy in the processing quality or fluency of the target (relative to other items in that context) when we later encounter the item, and this may stimulate a search for the cause of this discrepancy. In a typical PM task, participants may be given the intention

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to press the "Q" key when the word *rake* appears in a lexical decision task. Because the target word was presented during encoding, it may be processed more fluently than the background items. This would lead to a search for the cause of the discrepancy in fluency (i.e., the enhanced fluency for the word *rake* relative to the background items), and the PM intention might be retrieved (see McDaniel & Einstein, 2007, chap. 3, for a more extensive description of both mechanisms, as well as for a description of other possible mechanisms). With both of these mechanisms, preparatory attentional processes are not necessary, and the occurrence of the target can initiate retrieval processes that bring the intention to mind.

Following Marsh, Hicks, and Cook (2005; see also Hicks, Marsh, & Cook, 2005; Loft, Kearney, & Remington, 2008; Marsh, Cook, & Hicks, 2006), the multiprocess theory assumes that people develop an allocation policy that determines how they divide limited attentional resources between the PM and ongoing tasks. This policy is assumed to be fluid and is adjusted with experience with the task demands (e.g., Loft et al., 2008), as well as with natural variations in attention (e.g., momentary lapses in intention, West & Craik, 1999). On the basis of Bargh and Chartrand's (1999) view that conscious control of behavior is more of an exception than a rule and Baumeister, Bratslavsky, Muraven, and Tice's (1998) theory that self-regulation draws on a limited pool of resources that is quickly depleted, the multiprocess theory also assumes that there is a bias to rely on spontaneous retrieval (instead of resource-demanding monitoring). Beyond this bias, however, the multiprocess theory assumes that the general task demands—as well as aspects of the ongoing task, of the PM cue, and of the individual—influence how a person allocates resources and, thus, whether the person is likely to rely on monitoring processes or on spontaneous retrieval processes (McDaniel & Einstein, 2000). For example, with instructions that emphasize the importance of the PM task and multiple targets, participants are more likely to devote limited resources to monitoring for the target event (McDaniel & Einstein, 2007).

According to the multiprocess theory, another important factor that determines how participants allocate their resources (as well as the likelihood of spontaneous retrieval) is whether the ongoing task stimulates focal processing of the target event. Focal processing occurs when the ongoing task encourages processing of the same features that were processed at encoding. An example would be a case where the ongoing task encourages semantic processing (e.g., a lexical decision task) of a target that was semantically encoded during intention formation (see Einstein & McDaniel, 2005, for specific examples). With focal cues, the multiprocess theory assumes that spontaneous retrieval is likely and, moreover, that people are generally sensitive to this and therefore devote fewer, if any, resources to monitoring for the occurrence of the target event.

Both the PAM and multiprocess theories state that monitoring is necessary for high levels of PM performance under certain conditions, such as when there are many target items (Smith, 2003) or when there are nonfocal PM targets (Einstein et al., 2005). When there is only one focal target item, however, the multiprocess theory predicts that preparatory attentional processes are not necessary for high levels of PM performance, whereas the PAM theory predicts that they are. Smith, Hunt, McVay, and McConnell (2007) recently attempted to test the theories by presenting participants with a highly salient target (assumed by the multiprocess theory to encourage spontaneous retrieval) and examining task interference. Across all four experiments, Smith et al. found significant task interference and argued that that these results supported the PAM theory view that preparatory attentional processes are needed for successful PM retrieval.

In our view, finding significant levels of task interference on the ongoing task with a single salient target event (Smith et al., 2007) speaks to the allocation policies of participants in those particular contexts. The Smith et al. results are important in showing that participants tend to engage preparatory attentional processes in lab settings, even with a single focal target event (see also Einstein et al., 2005). These results do not, however, compel one to draw the conclusion that preparatory attentional processes are necessary for retrieval (see Einstein & McDaniel, 2010, for further development). Previous studies have indicated that levels of task interference do not always clearly relate to PM performance. For instance, McNerney and West (2007) reported an experiment in which lower task interference was associated with higher PM performance. Also, Scullin, McDaniel, and Einstein (2010) found that higher task interference before a target was functionally related to higher PM performance for a nonfocal cue, but not for a focal cue.

One problem in using the presence of significant levels of task interference to rule out the existence of spontaneous retrieval processes is that, although some participants may have relied on preparatory attentional processes (enough to produce significant task interference), others may have relied on spontaneous retrieval processes. Also, it may be that the task demands (e.g., instructions, frequency of occurrence of the target item, and duration of the ongoing task) encouraged the engagement of preparatory attentional processes, but these may not have been necessary for successful retrieval. Testing the theories is inconclusive in the presence of task interference, because both theories argue that preparatory attentional processes are helpful for retrieving PM intentions. Importantly, the theories make different predictions when there is no task interference, and the purpose of the present experiment was to examine PM performance under conditions that discouraged preparatory attentional processes.

Like Smith et al. (2007, Experiment 2), we engaged participants in an ongoing lexical decision task and also gave them the PM task of making a designated response whenever they encountered their own name. On the basis of previous research showing that instructional emphasis affects task interference (Einstein et al., 2005; Loft et al., 2008; Smith & Bayen, 2004), we emphasized either the ongoing task or the PM task.[1] Also, on the basis of several findings (Einstein et al., 2005; Loft et al., 2008; Scullin, McDaniel, Shelton, & Lee, 2010) showing that task interference generally declines over the course of the ongoing task, we divided the second block of lexical decision trials (the block in which the PM target occurred) into four quarters, in order to assess more specifically the costs throughout the ongoing task. To be clear, the goal of the present research was not to determine whether one finds costs with a single salient target event: As is developed above, this likely depends on a variety of factors. Our interest was in investigating the more theoretically revealing question of whether costs (and, presumably, preparatory attentional processes) are necessary for PM retrieval. To that end, we attempted to eliminate task interference with instructions, and we carefully measured task interference throughout the ongoing task. To the extent that preparatory attentional processes were discouraged, the PAM and multiprocess theories make different predictions. Specifically, the PAM theory predicts that, if there is no evidence of preparatory attentional processes (as inferred from task interference), PM performance should be at floor levels. By contrast, the multiprocess theory predicts high PM performance due to spontaneous retrieval.

METHOD

Participants and Design

Participants were 126 undergraduate students at Furman University who received either $7 or credit toward a requirement in an introductory psychology course. Participants were tested individually or in pairs. The experiment used a 3 × 5 mixed factorial design with the between-subjects variable of condition (control, ongoing task emphasis, and PM emphasis) and the within-subjects variable of segment of the ongoing task (Block 1 and Quarters 1–4 of Block 2).

Materials

For the lexical decision task in Blocks 1 and 2, we selected a pool of 133 medium-frequency words from the Kučera and Francis (1967) norms, with an average frequency of 132. Following Smith et al. (2007), we created the 133 nonwords by moving the first syllable of each word to the end of that word (Hunt & Toth, 1990). The words and nonwords were assigned randomly to the 100 trials of Block 1 and the 166 trials of Block 2. Half of the trials in Blocks 1 and 2 were words, and half were nonwords. The order of the words and nonwords was random, with the restriction that no more than 3 words or 3 nonwords could occur consecutively. Furthermore, in order to examine performance throughout the second block, Block 2 was composed of 166 trials that consisted of four quarters and 6 buffer trials at the beginning. Because task interference is known to decrease over trials when the initial PM cue is delayed (cf. Loft et al., 2008), to more accurately measure task interference, we split Block 2 into quarters. Each quarter consisted of 20 words and 20 nonwords, and we used a Latin square procedure, in order to present each set of words in each quarter to an equal number of participants. The participant's name occurred toward the end of Block 2 (the 163rd trial) for both PM conditions, whereas the control condition received a neutral word on the corresponding trial (in Smith et al.'s experiment, the target occurred on the 65th trial of Block 2). All strings were presented using lowercase letters. We used a desktop computer running the E-Prime 2.0 software to present instructions and stimuli and to collect all responses.

Procedure

Participants signed a consent form and then were seated at a computer. They were instructed to press a key labeled "Yes" (the "5" key on the number pad) if the letter string that appeared was a word and to press a key labeled "No" (the "6" key on the number pad) if the string did not form a word. Participants then completed 10 practice trials for which they received speed and accuracy feedback. The feedback was intended to encourage all groups to perform as quickly as possible. A screen then appeared that asked participants if they needed more practice; if so, the program repeated the 10 practice trials. Participants then completed the 100-trial Block 1.

Upon the conclusion of Block 1, participants in the control group received instructions to associate the slash (/) key with their name, and they were tested for this association at the end of the experiment. This was done to ensure that participants in the control and PM conditions had comparable retrospective memory loads (Smith, 2003), but that only the PM condition participants had a PM demand. In both the PM emphasis and ongoing task (OT) emphasis conditions, participants received the instructions to press the slash key when they saw their name. However, in the PM emphasis condition, this task was described as being the experiment's primary interest, and, in the OT emphasis condition, this task was described as being of secondary interest.

All participants had to press the slash (/) key to ensure that they could locate the key. After they pressed the "/" key, the PM emphasis conditions received these instructions: "PLEASE KEEP IN MIND THAT YOUR MOST IMPORTANT GOAL IS TO REMEMBER TO PRESS THE (/) KEY WHEN YOUR NAME APPEARS. IT IS IMPERATIVE THAT YOU GIVE THIS TASK YOUR FULL ATTENTION." Both the OT emphasis condition and the control condition received these instructions: "PLEASE KEEP IN MIND THAT YOUR MOST IMPORTANT GOAL IS TO PERFORM THE WORD IDENTIFICATION TASK AS QUICKLY AS POSSIBLE. IT IS IMPERATIVE THAT YOU GIVE THIS TASK YOUR FULL ATTENTION." Participants were asked to repeat the instructions to the experimenter in order to make sure that they understood the task demands; they were also asked to indicate their most important task. While testing the first 80 participants (27, 28, and 25 participants in the control, PM emphasis, and OT emphasis conditions, respectively), we discovered that some participants thought that they could press the slash key only on the trial on which their name occurred. Thereafter, we adjusted the instructions slightly and explicitly told participants in the OT emphasis and PM emphasis conditions that they could press the slash key when the target item occurred or within several trials of the target item.

Next, in order to draw their attention away from the PM task, participants performed filler tasks: a vocabulary quiz followed by Kuhl's (1994) action-control scale, which consists of 35 questions that assess individual differences in maintaining goal-related behavior. Combined, both tasks lasted approximately 10 min. Next, participants were informed that they would begin another block of the lexical decision task and were told to make responses as quickly as they could. After finishing the 166-trial Block 2, participants completed a postexperimental questionnaire.

RESULTS

An alpha level of .05 was used for all statistical tests. We report effect sizes for significant effects and for all comparisons examining differential task interference between the control and PM conditions.

Ongoing Task Performance

To determine whether performing the PM task exacted costs on the accuracy of performing the ongoing task, we first examined the proportion of lexical decision trials that participants identified correctly on the ongoing task. The first three words and three nonwords in Block 1 were eliminated from statistical analyses along with the final four trials (two words and two nonwords) of each quarter in Block 2. We eliminated 6 participants (1 from the control group, 2 from the PM emphasis group, and 3 from the OT emphasis group) from the analyses for being less than 85% accurate in Quarter 4 of Block 2. This left 40 participants in each condition. We then computed the proportion of strings correctly identified and subjected them to a 3 × 5 mixed ANOVA with the between-subjects variable of condition (control, OT emphasis, and PM emphasis) and the within-subjects variable of segment (Block 1 and Quarters 1–4 of Block 2). Consistent with previous experiments (Einstein et al., 2005; Smith et al., 2007), there was no effect of performing the PM task on the accuracy of performing the lexical decision task (*M*s = .97, *SD*s = .003 in the OT emphasis and PM emphasis conditions, and *M* = .96, *SD* = .003 in the control condition; $F < 1$ for the main effect of condition). The main effect of segment also was not significant [$F(4,468) = 1.07$, $MS_e = .001$]. Critically, there was no evidence of an interaction between condition and segment [$F(8,468) = 1.14$, $MS_e = .001$, $\eta^2 = .020$], indicating that performing a PM task did not compromise accuracy on the ongoing task.

We next examined RTs for the lexical decision task. Following Smith et al. (2007), we tabulated RTs for correct words for each participant (without using a trimming procedure) and included these in a 3 × 5 mixed ANOVA like the one described earlier. As can be seen in Table 1, neither the main effect of condition [$F(2,117) = 2.27$, $MS_e = 37{,}165.26$] nor the main effect of segment [$F(4,468) = 2.05$, $MS_e = 2{,}964.05$] was significant; the interaction was significant [$F(8,468) = 1.96$, $MS_e = 2{,}964.05$, $\eta^2 = .032$]. To determine the source of this interaction, we conducted two additional ANOVAs comparing the PM emphasis and OT emphasis groups individually with the control group.

In a 2 × 5 mixed ANOVA, with the between-subjects variable of condition (PM emphasis, control) and the within-subjects variable of segment, there was neither a significant main effect of condition [$F(1,78) = 1.65$, $MS_e = 39{,}082.52$] nor a main effect of segment [$F(4,312) = 1.34$, $MS_e = 3{,}107.75$]. Importantly, there was a significant interaction between these two variables [$F(4,312) = 3.55$, $MS_e = 3{,}107.75$, $\eta^2 = .043$], indicating that participants in the control condition sped up on the lexical decision task from Block 1 to Block 2, whereas participants in the PM emphasis condition did not (see Table 1). Thus, as was the case in Smith et al. (2007), the significant interaction indicates that the addition of a PM task induced participants to engage preparatory attentional processes. To localize the source of this interaction, we performed comparisons examining whether the speedup from the initial block to each of the subsequent quarters was different for the control and PM emphasis conditions. These comparisons revealed a significant or marginally significant interaction ($p < .10$; we report marginally significant effects in an attempt to be conservative about the presence or absence of interference effects) in a comparison of Block 1 with Quarters 1–3 [$F(1,78) = 8.32$, $MS_e = 3{,}289.22$, $\eta^2 = .096$; $F(1,78) = 3.97$, $MS_e = 2{,}298.02$, $\eta^2 = .046$; and $F(1,78) = 8.90$, $MS_e = 3{,}737.50$, $\eta^2 = .101$, respectively]. Consistent with previous findings showing that task interference declines over the course of the ongoing task (Einstein et al., 2005; Loft et al., 2008), the interaction was not significant in a comparison of Block 1 with Quarter 4 of Block 2 [$F(1,78) = 1.49$, $MS_e = 3{,}089.28$, $\eta^2 = .018$].

We also conducted a corresponding 2 × 5 ANOVA comparing the RTs of the control and OT emphasis conditions across segments. Whereas the main effect of condition was not significant ($F < 1$), the main effect of segment was significant [$F(4,312) = 3.73$, $MS_e = 2{,}465.47$, $\eta^2 = .045$], indicating that participants in both conditions showed a practice effect by generally speeding up from Block 1 to Block 2 (as Table 1 shows). However, there was no evidence for an interaction between condition and segment ($F < 1$, $\eta^2 = .012$). As can be seen in Table 1, this finding indicates that the speedup from Block 1 to Block 2 was similar in the control and OT emphasis conditions. On the basis of Smith et al.'s (2007) findings of medium-to-large effect sizes (their task interference effect in the experiment corresponding to the present one was large: $\eta_p^2 = .20$), we report that our power for detecting a medium size effect ($\eta^2 = .06$) of the condition × segment interaction effect using G*Power 3.1.0 (Faul, Erdfelder, Lang, & Buchner, 2007) was greater than .99.

Despite our failure to find any evidence of monitoring in the OT emphasis condition, it is possible that statistical averaging effects over the four degrees of freedom associated with the interaction effect could have obscured the detection of monitoring. Thus, we performed comparisons like those described above examining whether the speedup from the initial block to each of the subsequent quarters was different for the control and OT emphasis conditions. These comparisons revealed a marginally significant ($p < .10$) interaction when Block 1 was compared with Quarter 1 [$F(1,78) = 3.12$, $MS_e = 2{,}681.87$, $\eta^2 = .037$], which is consistent with the idea that participants in the OT condition engaged some preparatory attentional processes at the start of the ongoing trials after they had received PM instructions. There was

Table 1
Mean Response Times (RTs, in Milliseconds) on the Ongoing Task As a Function of Condition and Segment

	Segment									
			Block 2							
	Block 1		Quarter 1		Quarter 2		Quarter 3		Quarter 4	
Condition	RT	*SD*	RT	*SD*	RT	*SD*	RT	*SD*	RT	*SD*
Control	575	14	546	18	544	14	535	13	549	18
Ongoing task emphasis	543	14	543	14	532	15	525	13	531	17
Prospective memory emphasis	568	15	591	17	567	13	585	22	564	14

no statistical evidence of task interference when Block 1 was compared with Quarters 2–4 of Block 2 [$F(1,78) = 2.14$, $MS_e = 2{,}022.45$, $\eta^2 = .024$; $F(1,78) = 2.19$, $MS_e = 2{,}296.38$, $\eta^2 = .023$; and $F < 1$, $\eta^2 = .007$, respectively]. For all of these analyses, our power was greater than .99 to detect a medium effect.

Proximal Ongoing Task Performance

Several researchers have argued that measuring costs just before the target event occurs should be the most sensitive measure of whether participants are engaging in preparatory attentional processes at a favorable time for producing PM retrieval (Loft & Yeo, 2007; Scullin, McDaniel, & Einstein, 2010; West, Krompinger, & Bowry, 2005). Thus, we conducted a 3 × 2 mixed ANOVA in which we compared, for all three conditions, the average Block 1 RT for correct words with the average RT for the last six correct word trials occurring most proximal to the target event (in the control condition, we used the six items preceding the corresponding target event position in the PM conditions). The latter means are listed in Table 2.[2] This analysis revealed no significant main effect of condition [$F(2,116) = 2.01$, $MS_e = 13{,}319.86$]. On average, there was a 5-msec speedup from Block 1 to the most proximal items; however, the main effect of block was not significant ($F < 1$). Most important, and as is evident in Table 2, there was no interaction between condition and block ($F < 1$, $\eta^2 = .010$), despite excellent power to detect a medium-sized effect (>.99).

To directly compare the control condition with each of the PM conditions, we performed two additional 2 × 2 mixed ANOVAs. A comparison of the control condition with the PM emphasis condition showed that neither of the main effects (Fs < 1) nor the interaction ($F < 1$, $\eta^2 = .007$) approached significance. A comparison of the control condition with the OT condition showed no effect of block [$F(1,77) = 1.41$], no effect of condition [$F(1,77) = 2.14$], and, importantly, no hint of an interaction between these variables ($F < 1$, $\eta^2 = .0007$). Indeed, the speedup from Block 1 to the proximal six items was nominally greater in the OT emphasis condition. Our power to detect a medium-sized effect for the interaction was greater than .99 in both of these analyses. The fact that there was no differential slowing in the PM conditions relative to the control condition (and, in fact, nominally less in the OT emphasis condition) is strong evidence that, in all conditions, participants were not engaging preparatory attentional processes immediately before the occurrence of the target event.

Table 2
Mean Response Times (RTs, in Milliseconds) on Block 1 and the Six Items Most Proximal to the Target As a Function of Condition

	Block 1		Proximal Six Items	
Condition	RT	*SE*	RT	*SE*
Control	566	11	557	15
Ongoing task emphasis	543	14	530	14
Prospective memory emphasis	568	15	575	18

PM Task Performance

PM responses were counted as correct if participants pressed the slash key on the trial when their name appeared or within the two trials afterward. Consistent with the multiprocess theory, PM performance was well above floor for both the OT emphasis and the PM emphasis conditions (75% and 85%, respectively).[3] The difference between the two conditions was not significant [$\chi^2(1) = 1.25$, $p = .26$].

Additional Individual-Difference Analyses

To further examine whether preparatory attentional processes are necessary for PM retrieval, we identified participants in the two PM conditions who showed a speedup or practice effect from Block 1 to Quarter 4 of Block 2. We reasoned that those who showed a practice effect were the least likely to have engaged preparatory attentional processes, and we assumed that the fourth quarter was the most relevant period in which to examine ongoing task processing speed, because it was the one within which the target event occurred. Twenty-two participants in the OT emphasis condition and 19 participants in the PM emphasis condition showed a speedup (this compares with 28 participants in the control condition). Using only those participants who showed a speedup, a 3 × 2 (condition × block) mixed ANOVA of the RTs revealed no significant main effect of condition [$F(2,66) = 1.84$, $MS_e = 9{,}816.76$] and, naturally, a large speedup over blocks [$F(2,66) = 110.13$, $MS_e = 1{,}307.22$, $\eta^2 = .622$]. Importantly, there was no evidence of an interaction between these two variables ($F < 1$, $\eta^2 = .006$), indicating that the average speedup (62, 58, and 65 msec in the control, OT emphasis, and PM emphasis conditions, respectively) was similar across the three conditions.

By the typical assumptions (e.g., Smith et al., 2007), those who did not show a practice effect were the most likely to be engaging preparatory attentional processes, and those who showed a practice effect were the least likely. There was no evidence that PM differed for those who did and did not speed up in the OT emphasis condition [$\chi^2(1) = 1.21$, $p = .27$] or in the PM emphasis condition [$\chi^2(1) = 1.04$, $p = .31$]. Consistent with the multiprocess theory view that PM retrieval can occur in the absence of preparatory attentional processes, PM performance was high, regardless of whether participants exhibited a practice effect (in the OT emphasis condition, 82% of the participants who showed a practice effect and 67% of those who did not show a practice effect remembered to make the PM response; in the PM emphasis condition, 79% of the participants who showed a practice effect and 90% of those who did not show a practice effect remembered to make the PM response).

DISCUSSION

The purpose of the present research was to test the PAM and multiprocess explanations regarding the processes underlying PM retrieval. According to the PAM theory, preparatory attentional processes, which are inferred from task interference or costs occurring prior to the target event, are necessary for PM retrieval (Smith, 2003; Smith et al., 2007). Having found significant levels of task interference across four experiments with a single salient target event, Smith et al. concluded that preparatory attentional processes are required for PM retrieval. As Einstein and McDaniel (2010) pointed out, it is not possible to rule out the existence of spontaneous retrieval processes by simply demonstrating the existence of task interference, and the theories make different predictions concerning levels of PM performance only in the absence of task interference. Thus, we attempted to create opportunities for observing whether PM retrieval occurs in the absence of preparatory attentional processes. We did so by strongly emphasizing the ongoing task in one condition and by examining task interference through different periods of the ongoing task. We turn now to evaluating our success in discouraging task interference.

Smith et al. (2007) found robust levels of task interference with a single salient target event in all four of their experiments, including a large effect size in the one experiment that we used as a model (e.g., a lexical decision ongoing task and the person's name as the target). Averaging over all of the trials before the target event in Block 2, their control group sped up 63 msec from Block 1 to Block 2, whereas their PM group slowed down by 27 msec (a relative slowing or task interference of 90 msec). Consistent with research showing that task interference tends to decline over the course of an ongoing task (Einstein et al., 2005; Loft et al., 2008; Scullin, McDaniel, Shelton, & Lee, 2010), we found more modest and more localized levels of task interference. In the PM emphasis condition, we found significant or marginally significant levels of task interference in Quarters 1–3 of Block 2. In the OT emphasis condition, there was marginally significant evidence of task interference only in Quarter 1. In the periods most proximal to the target event, there was no statistical evidence for task interference in the PM emphasis condition (a relative slowing or task interference of 21 msec from Block 1 to Quarter 4 and 16 msec from Block 1 to the proximal six words). On the basis of nominal differences, one might be tempted to argue that even these small, nonsignificant task interference levels are sufficient to account for the high PM retrieval (note that the PAM theory does not specify the processing costs of preparatory attentional processes). This argument cannot be made, however, in the OT emphasis condition, in which the task interference was 14 msec for Quarter 4 and −4 msec for the most proximal six words.

Comparing our effect sizes with those of Smith et al. (2007) also suggests that preparatory attentional processes were greatly reduced, if not eliminated, in the periods proximal to the occurrence of the target event. In comparison with Smith et al.'s large task interference effect ($\eta_p^2 = .20$) in the experiment corresponding to ours, our task interference effect sizes for the PM emphasis condition were .018 (when Block 1 was compared with Quarter 4 of Block 2) and .007 (when Block 1 was compared with the proximal six items). The corresponding effect sizes in the OT emphasis condition were .007 (when Block 1 was compared with Quarter 4 of Block 2) and .0007 (when Block 1 was compared with the proximal six items).

Thus, it is unlikely that participants—especially those in the OT emphasis condition—were engaging much, if any, resource-demanding preparatory attentional processes when the PM target occurred. According to the PAM theory, these processes are necessary for PM retrieval, and, thus, PM performance should have been at or near floor. Smith et al. (2007) reported 85% PM performance in their corresponding experiment, and given our minimal effect sizes relative to theirs, PM should have been affected. Clearly, this was not the case, because PM performance averaged 80% in our experiment, thereby indicating that spontaneous retrieval processes can be quite powerful in producing PM retrieval. Our finding of conditions of no task interference and yet good levels of PM performance is in line with other research when a single focal target event has been used (Cohen, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; Marsh, Hicks, Cook, Hansen, & Pallos, 2003; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, & Lee, 2010). Moreover, individual-difference analyses indicated that the PM performance of participants who sped up from Block 1 to Quarter 4 of Block 2 (and, thus, were least likely to be engaging preparatory attentional processes) was very similar to (and nominally higher than) that of participants who slowed down (and were most likely to be monitoring).

Both our group and individual-difference results add to the growing number of results showing that levels of task interference are not always related to PM performance (Einstein et al., 2005; Foster, McDaniel, Repovš, & Hershey, 2009; Loft & Yeo, 2007; McNerney & West, 2007; Scullin, McDaniel, & Einstein, 2010; Scullin, McDaniel, Shelton, & Lee, 2010). The results strongly support the multiprocess theory that spontaneous retrieval processes (i.e., processes that are initiated by the presentation of cues) can accomplish successful PM retrieval in the absence of preparatory attentional processes. By comparing our results with those of Smith et al. (2007), an important implication of this research is that simply demonstrating the existence of significant levels of task interference cannot be used to rule out the existence of other retrieval processes (cf. Einstein & McDaniel, 2010; Scullin, McDaniel, & Einstein, 2010).

Although there has been little research on people's metamemory for intended actions (see Einstein & McDaniel, 2008, along with Marsh et al., 2005, and others—e.g., Loft et al., 2008), the multiprocess theory assumes that participants develop an allocation policy based on a variety of contextual factors, including the perceived task demands, an individual's natural inclinations (e.g., Goschke & Kuhl, 1993), and the nature of the ongoing and PM tasks. The multiprocess theory also assumes that there is a bias for the participant to rely on spontaneous retrieval processes rather than on capacity-consuming monitoring processes, and increasingly so as the length of the ongoing task increases (McDaniel & Einstein, 2007). The idea here is that it is difficult to sustain capacity-consuming preparatory attentional processes (Baumeister et al., 1998). In light of using a single highly salient target event—a condition that the multiprocess theory assumes is likely to produce spontaneous retrieval—Smith et al.'s (2007) results have been important in demonstrating that it is difficult to discourage monitoring processes in laboratory settings.

In the interest of testing the theories and exploring the conditions under which the spontaneous retrieval processes are effective in producing PM retrieval, however, it is important to understand how to discourage monitoring in laboratory experiments. Along with the research of Scullin, McDaniel, Shelton, and Lee (2010; see also Loft et al., 2008; Scullin, McDaniel, & Einstein, 2010), our results suggest that task interference declines over the course of the ongoing task. Thus, it appears critical to have ongoing tasks of sufficient duration and to measure task interference precisely at different periods, especially on those trials proximal to the target event (see Scullin, McDaniel, & Einstein, 2010). In this light, it is interesting to note that the target event in the corresponding Smith et al. (2007) experiment always occurred relatively early (task interference in all four of their experiments was measured within the first 64 trials). Had we presented our target early on, we also would have found evidence for task interference. It also seems important to emphasize performance on the ongoing task (Einstein et al., 2005; Loft et al., 2008; Smith & Bayen, 2004) and, more generally, to present demand characteristics that focus interest on the ongoing task (e.g., the title of our experiment was "Speed of Word Processing"). Given the significance of the expectations that we transmit to our participants, we agree with McDaniel and Einstein (2007, chap. 10) that PM researchers should clearly describe the exact instructions used in their experiments.

In conclusion, the present research revealed high levels of PM retrieval in the absence of preparatory attentional processes, and this result supports the multiprocess theory's core assumption that spontaneous retrieval processes can accomplish PM retrieval. It should be recognized, however, that we used a highly salient target event in the present research and that further research is necessary to determine the extent to which spontaneous retrieval occurs for less distinctive targets and to explore encoding conditions that encourage spontaneous retrieval (Gilbert, Gollwitzer, Cohen, Oettingen, & Burgess, 2009). More generally, consideration of our pattern of results showing high PM with no evidence of preparatory attentional processing, in combination with the Smith et al. (2007) results showing high PM with high levels of preparatory attentional processing, suggests that an important challenge for PM researchers will be to continue to develop and refine techniques for determining the actual processes that underlie PM retrieval in a given situation.

AUTHOR NOTE

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NOTES

1. Smith et al. (2007) did not describe the extent to which they emphasized the PM task for Experiment 2, the one on which our experiment was modeled. Smith et al. did indicate that they deemphasized the PM task in their Experiments 3 and 4. However, other aspects of these experiments could have encouraged monitoring (e.g., six PM targets occurred within 60 trials; see Loft et al., 2008, for evidence that cue presentation enhances the engagement of preparatory attentional processing).

2. In an effort to provide the strongest and most sensitive test of task interference for the proximal six items, we eliminated 1 participant from the control group for this analysis. Thus, the means for the control condition are based on 39 participants. The eliminated participant had a mean RT of 1,752 msec for the proximal six items (12.5 *SD*s above the mean) and was the only participant to have a mean RT above 935 msec. The statistical conclusions were identical, regardless of whether we eliminated this participant.

3. These numbers probably underestimate actual retrieval, because some of our initial 80 participants were under the impression that they could press the slash key only on the trial in which they saw their name. After the switch in instructions, the percentages of PM responses to the target were 87% and 77% in the OT emphasis and the PM emphasis conditions, respectively.

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