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A Comparison of Transfer-Appropriate Processing and Multi-Process Frameworks for Prospective Memory Performance

Dawn M. McBride and Drew H. Abney

Department of Psychology, Illinois State University, Normal, IL, USA

Abstract. We examined multi-process (MP) and transfer-appropriate processing descriptions of prospective memory (PM). Three conditions were compared that varied the overlap in processing type (perceptual/conceptual) between the ongoing and PM tasks such that two conditions involved a match of perceptual processing and one condition involved a mismatch in processing (conceptual ongoing task/perceptual PM task). One of the matched processing conditions also created a focal PM task, whereas the other two conditions were considered non-focal (Einstein & McDaniel, 2005). PM task accuracy and ongoing task completion speed in baseline and PM task conditions were measured. Accuracy results indicated a higher PM task completion rate for the focal condition than the non-focal conditions, a finding that is consistent with predictions made by the MP view. However, reaction time (RT) analyses indicated that PM task cost did not differ across conditions when practice effects are considered. Thus, the PM accuracy results are consistent with a MP description of PM, but RT results did not support the MP view predictions regarding PM cost.

Keywords: prospective memory, transfer-appropriate processing, multi-process view

Prospective memory (PM) has been described as the ability to remember to perform an intended task (Einstein & McDaniel, 2005). PM generally involves remembering the task despite distraction from other tasks performed in daily life. In attempts to mirror these everyday situations involving PM in the laboratory, numerous studies have examined PM performance by embedding a PM task in an ongoing task that the participants are asked to perform throughout the study (Einstein & McDaniel, 2005). For example, participants may be asked to press a key when a certain word or type of word appears while they perform an ongoing cognitive task such as category judgments or lexical decisions.

Multi-Process View

One of the frameworks proposed to describe PM task performance, the multi-process (MP) view (McDaniel & Einstein, 2000), suggests that PM tasks can be performed with a spontaneous retrieval process that does not consume attentional resources, except in cases where the task is more difficult or important. Einstein and McDaniel (2005) suggest that spontaneous retrieval is likely to occur under certain conditions that should not require monitoring for PM cues. For example, when a PM cue is focal such that "the ongoing task encourages processing of the target and especially those

features that were processed at encoding" (Einstein & McDaniel, 2005, p. 287), participants can spontaneously notice the PM cue and retrieve the intention to perform the PM task prompted by this item. For example, when subjects are asked to count the vowels in words presented to them, a PM task of responding to words with repeated consecutive vowels will be focal because counting vowels will allow processing of the encoded feature of the PM cues: repeated consecutive vowels. However, when the PM task is non-focal (e.g., counting vowels with a PM task of responding to words that are animals) or is more important than the ongoing task, participants are more likely to monitor the task stimuli for the PM cues, consuming attentional resources and slowing them down in the ongoing task trials (Einstein et al., 2005).

Several studies have reported results that support the MP view. For example, Einstein et al. (2005) tested this view by manipulating the strength of association between the ongoing and PM tasks, the number of PM cues participants had to remember, and the importance of the PM task relative to the ongoing task. In different experiments, participants performed ongoing tasks of category judgments or sentence completion trials. The ongoing task was performed in two blocks, one with the PM task and one without the PM task (baseline), to determine the reduction in speed for the ongoing trials caused by the presence of the PM task relative to the non-PM task baseline. Einstein et al. found that ongoing

trial reaction times (RTs) were slowed relative to baseline (1) in the non-focal conditions, (2) when there were more PM cues for the participants to keep track of, and (3) when the PM task importance was emphasized. Ongoing trial RTs did not differ between baseline and PM task blocks (1) in the focal conditions, (2) when there were fewer PM cues for the participants to keep track of, and (3) when the PM task importance was not emphasized. These results support the MP view that spontaneous retrieval of the PM task can occur under some conditions.

Scullin, Einstein, and McDaniel (2009) further supported the suggestion that PM tasks can be performed with spontaneous retrieval using a modified PM methodology. Participants performed the ongoing and PM tasks and then, before completing a second ongoing task, were either told that they were finished with the PM task or that they would have to perform the PM task again later in the experiment. If participants believed that the PM task was finished (finished condition), they would have no reason to remember the task and no activation of the PM intention should occur when PM cues are presented in the ongoing task. However, if participants believed they would need to perform the PM task again later (suspended condition), presentation of the PM cues in the ongoing task might cause a spontaneous retrieval of the PM task intention and slow participants down in their responses to these items. Scullin et al. reported that even though they were not given the PM instruction for that block of trials, participants were slowed in responses to PM cue items when they were in the suspended condition, but not in the finished condition, indicating that spontaneous retrieval of the PM task does occur in support of the MP view.

Transfer-Appropriate Processing View

Another perspective on PM tasks applies a popular memory view, transfer-appropriate processing (TAP), to describe performance on PM tasks. The TAP view proposes that memory is enhanced when similar processing occurs at study and test (Morris, Bransford, & Franks, 1977). For example, if participants study words with either a conceptual task (e.g., making pleasantness ratings) or a perceptual task (e.g., counting the number of vowels) and then are given a conceptual memory test (e.g., category cued recall), memory performance should be higher for words processed similarly from study to test. Numerous studies have documented such results (e.g., Blaxton, 1989; Weldon & Roediger, 1987, Weldon, Roediger, & Challis, 1989).

The same logic can be applied to the overlap in processing between ongoing and PM tasks: Using the TAP view, one can predict better performance for PM tasks that overlap in type of processing with the ongoing task in which they are embedded (Maylor, 1996). The TAP view differs from the focal/non-focal distinction in the MP view in defining the overlap between the ongoing and PM tasks. Morris et al. (1977), for example, discussed overlap in processing in terms of categories of processing types such as semantic and non-semantic processing. In the TAP view, similar processing (e.g., processing meaning or processing surface features) in the two tasks is sufficient to create a PM advantage, whereas, the

MP view defines focal tasks such that the ongoing task encourages processing of the defining features of the PM cues. For example, Einstein and McDaniel (2005) define a lexical decision task as focal if particular target words are the PM cues (e.g., "tortoise"), but the same task is classified as non-focal with animal words as PM cues. In lexical decision tasks, one must process what a word is to decide if it is a word, making it likely one would notice that the word is a target they are to respond to. But making word/nonword judgments does not require processing of its categorical aspects so one is not as likely to automatically recognize the targets as PM cues in this case. Thus, by definition, focal tasks involve a match in processing (in order to focus on the relevant aspects of the PM cues, the processing in the two tasks must be similar), but tasks that involve a match in processing are not necessarily focal (e.g., rating pleasantness of words and responding to animal words as the PM task). The TAP view predicts a PM advantage for ongoing and PM tasks that involve similar types of processing (e.g., conceptual, perceptual), whereas, the MP view predicts a PM advantage for ongoing and PM tasks that are defined as focal.

Several studies have tested the prediction of the TAP view using various combinations of ongoing and PM tasks. In one such application, Meier and Graf (2000) compared performance for conditions that varied the overlap in processing between ongoing tasks and PM tasks. Conditions where the type of processing matched between the ongoing and PM tasks were compared with conditions where the type of processing differed across the ongoing and PM tasks. Consistent with the TAP view predictions, Meier and Graf's results showed that matches in processing resulted in higher PM task performance than mismatches in processing, regardless of the type of processing involved. McGann, Ellis, and Milne (2003) also reported similar results supporting the TAP view.

West and Craik (2001, Experiment 2), however, only found partial support for TAP view predictions when they compared PM task performance in conditions that included either a match in processing or a mismatch in processing. Conceptual PM task performance was higher for a match with ongoing task processing than for a mismatch with ongoing task processing. However, no perceptual PM task performance difference was found for a match and mismatch with ongoing task performance. Marsh, Hicks, and Hancock (2000) also reported partial support for the TAP view in their first two experiments with better PM performance with a perceptual match in processing for the ongoing and PM tasks, but no significant difference in PM task conditions matched with a conceptual ongoing task.

Other studies have also shown mixed support for the TAP view of PM task performance. Maylor, Darby, Logie, Della Sala, and Smith (2002) described a PM study in which older adults produced lower PM performance than college students, but this effect was larger when there was a mismatch in ongoing and PM task processing than when the processing of the tasks matched. However, in contrast to predictions of the TAP view, no overall processing match advantage was found in this study. Marsh, Hicks, and Cook (2005) also found a processing match advantage in their three experiments, but only when the task involved low

effort. No processing match advantage was found when subjects were instructed to complete the ongoing task as quickly and accurately as possible and to put in as much effort as they could to the task, suggesting that when subjects place more importance on and put more effort into an ongoing task that requires similar processing as the PM task, a processing match hinders PM performance.

Similar to the Marsh et al. (2005) study, Meiser and Schult (2008) also examined processing match effects on PM performance for low and high effort instructions for speed and accuracy on the ongoing task. They found a processing match advantage for conceptual ongoing and PM tasks when instructions asked subjects to manipulate effort on the ongoing task according to speed, but no advantage when instructions manipulated effort on accuracy. They concluded that when subjects focused on accuracy, they were able to monitor more for PM cues and increase PM performance even when the tasks involved different types of processing, thus reducing the processing match advantage. Their analysis of the correlations between PM performance and speed on the ongoing task supported this conclusion with ongoing task speed and PM performance positively correlated only under accuracy emphasis instructions and mismatched processing conditions.

One issue with applications of the TAP view is that some of the conditions described above showing better PM task performance also fit the description of focal tasks as defined by Einstein and McDaniel (2005) – the ongoing task focuses attention on the relevant aspects of the PM cues. For example, in the Meier and Graf (2000) study, counting the number of enclosed spaces in the letters of the words presented for the perceptual ongoing task may have allowed subjects to easily notice the words that had three e's, as this is a letter with an enclosed space. This would be considered a focal task according to Einstein and McDaniel's (2005) definition of such tasks, as the ongoing task likely encouraged processing of the PM cue, which may have allowed the PM task to be retrieved automatically. According to the MP view, these are the conditions under which PM task performance is at an advantage. Thus, the MP and TAP views can both explain the processing match advantage when the PM task is also considered focal. The MP view may also provide an explanation for the mixed findings reported by Marsh et al. (2000). They only found a processing advantage for their perceptual match condition, which involved identifying repeated letters as the ongoing task and responding to palindromes as the PM task. This task could be classified as focal, as palindromes involve repeated letters in the words. However, their conceptual match condition involved pleasantness ratings as the ongoing task and responding to animal words as the PM task, making the task non-focal. Thus, Marsh et al. may have failed to find a processing match in this condition due to the non-focal nature of the task. A similar argument could be made for the West and Craik (2001) results.

To further investigate this issue, the current study tested predictions of the MP and TAP frameworks using conditions that varied both the match in type of processing across the ongoing and PM tasks and the focal/non-focal nature of the PM tasks. Another issue with support for the TAP view is that the use of attentional resources for the PM task has rarely been measured to determine if PM task cost aided completion of the PM tasks. According to the MP view, focal tasks can rely on spontaneous retrieval of the PM cues more often than non-focal tasks. Thus, non-focal tasks should result in a slowing of ongoing task performance relative to focal tasks (Einstein et al., 2005). Meiser and Schult (2008) supported this notion with their correlational analysis between ongoing task speed and PM accuracy described above. Their subjects slowed down in the ongoing task when processing type was different for the two tasks and accuracy was emphasized. However, according to Einstein and McDaniel's (2005) definition, Meiser and Schult's matched processing condition was also non-focal (lexical decision ongoing task with animal words as PM cues) and no slowing in the ongoing task was evident for this condition, despite high PM accuracy, a result that is not consistent with the MP view of focal versus non-focal tasks. Thus, in the current study, we further tested the MP view prediction that faster ongoing task performance should be seen on focal relative to non-focal tasks, regardless of processing match.

The Current Study

Ongoing task was manipulated between-subjects in an experiment involving a perceptual PM task (respond to items with repeated consecutive vowels, such as *moose* and *deer*). In the experiment there were two conditions that involved a match in processing between the ongoing and PM tasks, one that was considered focal and one that was considered non-focal, and one condition that involved a mismatch in processing for these tasks, which by definition was non-focal.

The TAP view predicts higher PM performance for the matched processing conditions than for the mismatched processing condition, regardless of the focality of the PM task. This result would be consistent with past studies showing a processing match advantage for tasks that are also considered non-focal (e.g., Marsh et al., 2005; Meiser & Schult, 2008). The MP view predicts higher PM performance for focal than for non-focal conditions. Further, the MP view also predicts more reliance on spontaneous retrieval of the PM intention in the focal condition as compared to the non-focal conditions. Thus, the MP view predicts that the focal task will show a lower cost of the PM task than the non-focal tasks.

Method

Participants

Participants included 141 undergraduate students from Illinois State University. Table 1 includes the cell sizes by condition. All subjects were native English speakers and received course credit for participation. Five subjects were deleted from the study for failure to follow task instructions and one subject was replaced for failure to recall the PM task at the end of the experiment.

Table 1. Mean ongoing task accuracy and standard errors (in parentheses) by task condition, PM condition, and block

	Block 1	Block 2
PM task subjects		
Vowel (match/focal)	.91 (.02)	.64 (.01)
Syllable (match/non-focal)	.89 (.02)	.68 (.01)
Living (mismatch/non-focal)	.86 (.02)	.52 (.01)
Control subjects		
Vowel task	.89 (.02)	.68 (.01)
Syllable task	.85 (.02)	.62 (.01)
Living task	.89 (.02)	.55 (.01)

Design

Ongoing task was manipulated between-subjects. Subjects were randomly assigned to complete two blocks of the number of vowels tasks (i.e., match/focal), the number of syllables tasks (i.e., match/non-focal), or the living/non-living tasks (i.e., mismatch/non-focal). Further, approximately half of the participants were randomly assigned to either a control or experimental group regarding the PM task instruction in Block 2. Block 1 was considered a baseline block, where all participants completed their assigned ongoing task without the PM task. Subjects assigned to the PM task conditions were asked to complete the PM task (respond to words containing repeated consecutive vowels) prior to beginning Block 2. Control subjects were simply asked to complete another block of the ongoing task. Accuracy of PM task responses and RT to complete ongoing task trials was recorded for each subject.

Materials

Items for the ongoing tasks were chosen from exemplars in the Battig and Montague (1969) category norms. Two random lists of 96 items were created for use in the ongoing tasks. Items were chosen in an attempt to balance the number of yes/no responses for each ongoing task as much as possible. However, due to the nature of the categorical items – many of the items are living and are shorter words – the number of "yes" responses was not equal for the three ongoing tasks. The list presented in Block 2 contained the six PM cue items containing consecutive repeated vowels: moose, deer, sheep, raccoon, reindeer, and cheetah. No other words presented in the experiment contained consecutive repeated vowels. The same items were presented in all ongoing tasks.

Procedure

Participants were randomly assigned to one of the ongoing task conditions and to one of the PM task instruction conditions (PM task or control). In Block 1, participants assigned to the number of vowels task were asked to determine if the word had three or more vowels (yes response) or not (no response). Participants assigned to the number of syllables task were asked to determine if the word had three or more syllables (yes response) or not (no response). Participants assigned to the living/non-living task were asked to determine if the item was living (yes response) or not (no response). Participants endorsed a yes or no response by pressing either the "y" or "n" key, respectively.

After completing Block 1, Block 2 instructions were presented to each participant specific to their assigned PM task instruction condition. Participants assigned to the experimental conditions were instructed to press the space bar whenever they saw a word that contained repeated consecutive vowels while completing more trials of the ongoing task performed in Block 1. An example of such an item (door) was given in the instructions. Participants assigned to the control conditions were instructed to complete another block of ongoing task trials according to the instructions given to them for Block 1.

On each trial, a single word appeared in the center of the screen. Items were presented in white on a black background in lower-case lettering. Each item was presented in 48-point Geneva font type. Item presentation was self-paced; thus, items remained on the screen until subjects made a keypress response. The next item was then presented on the screen after the keypress. In Block 1, items were presented in a new random order for each participant. In Block 2, order of items was identical for each participant. The PM cues appeared in the same position within Block 2 for each participant (trials 10, 26, 36, 58, 67, and 82).

At the end of Block 2, all PM task subjects were asked to recall to the experimenter the PM task they were asked to complete. One subject who could not recall the task was replaced.

Results

PM Task Accuracy

PM task responses were considered correct if subjects pressed the space bar on the trial on which a PM cue was presented or the trial immediately following the cue (4.2% of all PM cue trials). A one-way ANOVA on proportion PM accuracy data for ongoing task conditions (vowels/match/focal, syllables/match/non-focal, living/mismatch/non-focal) indicated a significant difference between conditions, $F(2, 67) = 4.54$, $p = .014$, $\eta_p^2 = .119$. Post hoc tests with a Bonferroni correction indicated that the vowels/match/focal condition ($M = .93$, $SD = .13$) had higher accuracy than the syllables/match/non-focal condition, $M = .72$, $SD = .32$; $t(43) = 2.81$, $p = .02$, and the living/mismatch/non-focal condition, $M = .76$, $SD = .25$, $t(45) = 2.92$, $p = .02$. The two non-focal conditions did not significantly differ, $t(46) = 0.43$, $p = .69$. Power estimated by the GPOWER program (Erdfelder, Faul, & Buchner, 1996) was .17 for a small effect size, .52 for a medium effect size, and .86 for a large effect size.

Table 2. Mean RT (in ms) and standard errors (in parentheses) for ongoing task by PM task instruction conditions for each block

	n	Block 1	Block 2	Difference
PM task subjects				
Vowel (match/focal)	22	1513 (136)	1343 (111)	−171
Syllable (match/non-focal)	23	1286 (66)	1146 (45)	−40
Living (mismatch/non-focal)	25	1014 (43)	1139 (47)	124
Control subjects				
Vowel task	25	1653 (144)	1237 (91)	−416
Syllable task	23	1235 (99)	1046 (56)	−189
Living task	23	1029 (44)	912 (43)	−117

Ongoing Task Performance

The first five trials of each block were considered practice trials and were excluded from the ongoing task analyses. For all other trials, the ongoing task accuracy was calculated for the ongoing tasks. Mean proportion accuracy on the ongoing task is presented in Table 1. It is clear from these means that ongoing task accuracy declined from Block 1 to Block 2 for all subjects, including the control subjects who did not complete the PM task in Block 2. This was confirmed in an ANOVA with task type and PM instruction between-subject factors and a block within-subject factor. The main effect of block was significant, $F(1, 135) = 1083.15$, $p < .001$, with lower performance in Block 2 than in Block 1. Further, the Block × Task Type interaction was significant, $F(2, 135) = 20.83$, $p < .001$, but simple effects tests confirmed that performance significantly declined from Block 1 to Block 2 for all task types, all *p*'s < .001. The decline in ongoing task accuracy from Block 1 to Block 2 could indicate a change in task focus across the block, but there was no interaction between block and PM instruction, $F(1, 135) < 1.0$, $p = .47$. There was also no three-way interaction, $F(2, 135) = 1.94$, $p = .15$. Thus, the change in ongoing task performance across blocks is not due to focus on the PM task, as the control subjects who did not complete the PM task also showed this decline. In addition, there was no correlation found between ongoing task accuracy and PM task accuracy for any of the task conditions, all *p*'s > .34.

Trials on which a PM cue was presented were also excluded from RT analyses. RT data were trimmed to three standard deviations for each subject, resulting in a deletion of 0.93% trials across all subjects. In addition, only trials on which a correct response to the ongoing task was presented were included in the analyses (see ongoing task accuracy rates above). Mean RTs by condition and block are displayed in Table 2. Mean RTs for Blocks 1 and 2 were first analyzed for subjects who completed the PM task in Block 2 to consider differences in PM cost that might exist for the different conditions. The two-way ANOVA with Block as

a repeated measures factor and Ongoing Task as a between-subjects factor indicated a main effect of Task, $F(2, 67) = 5.55$, $p = .006$, $\eta_p^2 = .142$, and no main effect of Block, $F(1, 67) < 1.0$, $p = .46$, $\eta_p^2 = .008$. There was an interaction between the two factors, $F(2, 67) = 4.94$, $p = .01$, $\eta_p^2 = .129$, such that Block 2 was completed significantly faster than Block 1 by the vowel task subjects, $F(1, 67) = 6.15$, $p = .016$, with a similar speed to Block 1 by the syllable task subjects, $F(1, 67) < 1.0$, $p = .55$, and marginally slower than Block 1 by the living task subjects, $F(1, 67) = 3.71$, $p = .058$. These results suggest that the PM task cost differed across the conditions, such that ongoing task speed was slowed by the PM task most for the non-focal/mismatch (living task) condition and least for the focal/match (vowel task) condition.

An examination of the means in Table 2 for Block 1 shows differences across the task conditions. Therefore, an analysis that includes the control subjects was conducted to consider practice effects as suggested by Smith, Hunt, McVay, and McConnell (2007). Thus, a 3 × 2 × 2 mixed ANOVA was next conducted that included the control subjects who did not complete the PM task in Block 2. In this analysis, the main effects of Block, $F(1, 135) = 26.73$, $p < .001$, $\eta_p^2 = .165$, and Task Condition, $F(2, 135) = 13.52$, $p < .001$, $\eta_p^2 = .167$, were significant. The two-way interactions between Block and Task Condition, $F(2, 135) = 11.10$, $p < .001$, $\eta_p^2 = .141$, and between Block and PM condition, $F(2, 135) = 16.51$, $p < .001$, $\eta_p^2 = .109$, were also significant. The Block × PM Condition interaction suggests that the subjects who completed the PM task in Block 2 did show a PM task cost overall. The Block × Task Condition suggests overall differences in the Block 1 versus Block 2 difference across tasks conditions, however, the three-way interaction was not significant, $F(1, 135) < 1.0$, $p = .695$, $\eta_p^2 = .005$. The power to detect the three-way interaction was estimated using the GPOWER program (Erdfelder et al., 1996). Power was estimated at .39 for a small effect size, but > .99 for medium and large effect sizes.[1] Thus, this analysis provided no evidence that the Block 1 versus Block 2 RT differences across task condition varied according to

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[1] Medium-sized effects were reported by Einstein et al. (2005) for the mean RT comparison across focal and non-focal tasks in their first experiment ($\eta^2 = .20$) and by Smith et al. (2007) in a comparison of mean RTs across task blocks for control subjects (average $d = .49$) for all experiments.

whether subjects completed the PM task in Block 2. In other words, differences in PM task cost were not detected in this analysis for the different ongoing task conditions. The lack of a three-way interaction combined with the Block × Task Condition interaction found indicates that the magnitude of the Block 1 to Block 2 RT changes reflects the differences in baseline (Block 1) RTs across tasks for both groups of subjects. The Block 1 RTs were slowest for the vowel task and this task showed the largest change in speed across blocks. No other effects were found to be significant in this ANOVA, all F's < 1.3, p's > .27.

Correlational analyses for ongoing task RT differences across Block 1 and Block 2 and PM accuracy indicated no significant relationship for the living task (mismatch, non-focal), $r(23) = .04$, $p = .87$, but a significantly positive relationship for the syllables task (match, non-focal), $r(21) = .56$, $p = .005$, and a marginally significant effect for the vowels task (match, focal), and $r(20) = .39$, $p = .076$. The significant correlations are positive, indicating that as PM accuracy increased, ongoing task RT also increased. Thus, the correlational analyses suggest that monitoring may have contributed to the high PM performance in the vowels task that involved both a match in processing and a focal PM task.

RT Distribution Analyses

Because ANOVA and correlational analyses on the mean RT analyses resulted in different findings regarding differences in PM task cost across the ongoing task conditions, we further analyzed the RT distributions for ongoing task, as suggested by Brewer (2011). Ex-Gaussian functions were fit separately to trimmed RT data for each subject for Block 1 and Block 2 of the ongoing task. The ex-Gaussian function was chosen as it has provided good fits to RT distributions in past studies (Heathcote, Popiel, & Mewhort, 1991; Luce, 1986), as these functions are typically skewed. Function fits were performed using the Quantile Maximum Probability Estimation program (Cousineau, Brown, & Heathcote, 2004). The fits produced three parameters for each subject's Block 1 and Block 2 data: μ, σ, and the exponential parameter τ. The μ parameter provides an estimate of the mean of the RT distribution for each subject by block. The τ parameter provides information about the shape of the distribution in terms of skew. Thus, these two parameters provide information regarding attentional cost due to the PM task. Brewer (2011) found that although μ did not differ across blocks (baseline and PM blocks) in a PM task, τ was larger for the PM task block, indicating that the PM task resulted in more skewing in the RT distributions with more responses in the slow tail.

The model fits were successful for all sets of subject data. Mean parameter estimates are provided in Table 3. Each set of parameter estimates (μ, σ, and τ) was analyzed in a three-way ANOVA with block, task condition, and PM condition factors. Results for the μ parameters were similar to those of the analysis presented above for mean RTs. Block, $F(1, 135) = 17.21$, $p < .001$, $\eta_p^2 = .113$, and task

Table 3. Mean μ, σ, and τ parameter estimates (in ms) and standard errors (in parentheses) for ongoing task by PM task instruction conditions for each block

	Block 1	Block 2
μ Estimates		
PM task subjects		
Vowel (match/focal)	924 (90)	874 (76)
Syllable (match/non-focal)	791 (37)	759 (42)
Living (mismatch/non-focal)	683 (22)	715 (24)
Control subjects		
Vowel task	984 (85)	763 (49)
Syllable task	815 (46)	655 (41)
Living task	712 (33)	649 (26)
σ Estimates		
PM task subjects		
Vowel (match/focal)	333 (59)	268 (52)
Syllable (match/non-focal)	198 (34)	231 (42)
Living (mismatch/non-focal)	86 (18)	121 (22)
Control subjects		
Vowel task	271 (48)	224 (36)
Syllable task	195 (26)	150 (24)
Living task	86 (21)	65 (12)
τ Estimates		
PM task subjects		
Vowel (match/focal)	524 (75)	372 (36)
Syllable (match/non-focal)	432 (38)	231 (42)
Living (mismatch/non-focal)	270 (33)	121 (22)
Control subjects		
Vowel task	545 (80)	394 (41)
Syllable task	401 (54)	150 (24)
Living task	303 (29)	65 (12)

condition, $F(2, 135) = 9.24$, $p < .001$, $\eta_p^2 = .12$, main effects were significant. In addition, block by task condition, $F(2, 135) = 3.13$, $p = .047$, $\eta_p^2 = .044$, and block by PM condition, $F(1, 135) = 10.87$, $p = .001$, $\eta_p^2 = .075$, interactions were significant, indicating that the differences across blocks varied by task condition and PM condition. However, no other effects, including the three-way interaction, were significant, all Fs < 1. In the ANOVA of σ parameters, only the task condition main effect was significant, $F(2, 135) = 21.03$, $p < .001$, $\eta_p^2 = .238$. The PM condition main effect was marginally significant, $F(1, 135) = 3.14$, $p = .079$, $\eta_p^2 = .023$. No other effects were significant for σ, all $ps > .27$. The results of the τ analysis were similar to those of the μ analysis: The main effects of Block, $F(1, 135) = 8.29$, $p = .005$, $\eta_p^2 = .058$, and task condition, $F(2, 135) = 8.69$, $p < .001$, $\eta_p^2 = .114$, were significant, as was the Block × Task Condition, $F(2, 135) = 5.71$, $p = .004$, $\eta_p^2 = .078$, interaction. The Block × PM Condition interaction was marginally significant, $F(1, 135) = 3.14$, $p = .079$, $\eta_p^2 = .023$. No other effects were significant, all $ps > .17$. Thus, the RT distribution analyses are consistent with the mean RT analyses: PM task costs seem to be present for subjects who completed the PM task in Block 2 and there is no evidence

that the costs differ by ongoing task condition when practice effects are considered.

Discussion

The accuracy results of the current experiment are consistent with predictions made by the MP view, not the TAP view. An accuracy advantage was found for the focal condition as compared with both of the non-focal conditions, regardless of processing match, but no difference in accuracy was found for the non-focal conditions. We also found that subjects who completed the PM task in Block 2 were faster to complete ongoing task trials in Block 2 than Block 1 with the vowels task (focal/match condition), but either showed no difference between Blocks 1 and 2 or slower Block 2 than Block 1 performance in the non-focal conditions. This result on its own is consistent with the MP view. However, when the control subjects were included in the analysis to account for practice effects across the blocks (cf. Smith et al., 2007), no three-way interaction was evident, indicating that the same Block 1 versus Block 2 RT differences occurred for the PM and control subjects across the three ongoing task conditions. This result is inconsistent with the conclusion that PM task cost differed across the ongoing tasks. In fact, examination of the mean RT differences in Table 1 indicates more slowing for the PM task subjects than for the control subjects. These mean differences show that the vowels task was the only task that resulted in faster performance for Block 2 than for Block 1, but this result was seen for both PM task and control subjects. The smaller negative difference (170 ms vs. 416 ms for PM task and control subjects, respectively) for the PM task subjects indicates that some slowing did occur for the vowels (i.e., focal) task. This result is not consistent with the MP view or past studies (e.g., Einstein et al., 2005; Harrison & Einstein, 2010) showing reduced PM task cost for focal tasks. Further, correlational analyses for RT differences and PM accuracy showed a significant positive relationship for the vowels task, indicating that ongoing task cost increased as PM accuracy increased. Thus, the results of the current study were only consistent with accuracy predictions of the MP view. However, as the TAP view only made predictions regarding the accuracy data, and these predictions were not supported, the current study does not provide support for the TAP view.

We also included an additional analysis using RT distribution function fits (see Brewer, 2011) to further test the predictions. This analysis fit ex-Gaussian functions to the distributions of RT data for subjects in the current study, estimating model parameters by block for each subject. The parameters for Blocks 1 and 2 were compared for each of the ongoing tasks by PM task instruction conditions. The results of this analysis for the μ and τ parameters were similar to those of the mean RT ANOVA: No significant three-way interaction was seen in any of the analyses, indicating that PM task cost did not differ across ongoing task conditions when practice effects are considered. These results are consistent with the results of studies conducted by Smith and colleagues (Smith, 2003; Smith et al., 2007) that

showed similar PM task costs for focal tasks. Thus, the results of the current study support the MP view prediction that focal tasks result in higher PM accuracy, but do not support the MP view prediction that focal tasks do not require a PM task cost.

The accuracy results of the current study do not support the TAP view (Maylor, 1996) that a categorical (e.g., perceptual) match in processing type between the ongoing and PM tasks will result in better PM task performance, despite findings in previous studies consistent with this view. As described earlier, the discrepancy with many of the past results indicating processing match advantages may be due to use of focal tasks in these conditions. This issue may explain the mixed findings reported by Marsh et al. (2000) and West and Craik (2001). However, the conceptual matching conditions used by Meier and Graf (2000) and by Meiser and Schult (2008) would be classified as non-focal and a PM task advantage was still found for these tasks. Thus, the focality of the conditions used in these studies cannot fully account for the PM advantages found.

It should be noted that there is considerable conceptual overlap between the concepts of focality and processing match. In fact, the definition of a focal task can be viewed as a stricter form of categorical processing overlap. For focal tasks, match in processing is necessary but not always sufficient to provide a PM performance advantage. One might also consider the concepts of focality and processing match as continuous, rather than discrete, classifications. In this view, one might classify the three tasks in the current study as high match/focal (vowels), intermediate match/focal (syllables), and low match/focal (living). However, such a view would predict a difference in PM accuracy across all three tasks, with the vowels tasks showing the highest performance and the living task showing the lowest performance. No such difference was found between the syllables and living tasks in the current study, but estimated power was only high for a large effect size. The mean PM accuracy difference between the non-focal conditions was only 4% and the syllables task resulted in the lower mean of these two conditions. Thus, there is no evidence in the current results to support the graded match in processing view, but this may be an avenue to pursue in future PM studies.

Some limitations of the current study should be considered. One such limitation is the use of different ongoing tasks across conditions. This choice was made to allow us to hold constant the PM task and cues across conditions to provide a stronger test of the accuracy predictions, while manipulating the focality and match in processing between the ongoing and PM tasks. However, this manipulation resulted in some differences across the ongoing tasks, such as differences in ongoing task accuracy and speed. However, the exclusion of incorrect ongoing task responses from the RT data analyses and the inclusion of the block factor in the analyses should help offset the effects of these differences in the results. Researchers have suggested that differences in ongoing task accuracy may provide a secondary measure of PM task cost. Thus, the differences in ongoing task accuracy in the current study may reflect differing costs that are consistent with the MP view (the vowels task

showed the highest level of accuracy). Another interpretation of the ongoing task accuracy difference is that the tasks simply differed in their level of difficulty. However, if ongoing task difficulty affected PM task performance, one would expect to see a correlation between ongoing task accuracy and PM task accuracy overall. No such correlation was found in the current study either for task conditions separately (see results above) or for all task conditions combined, $r(68) = .072$, $p = .555$.

The manipulation of ongoing task also created different correct ongoing task responses to the PM cues across tasks (e.g., all "yes" for the living task, all "no" for the syllables task). However, if this difference in responses had an effect on the PM task accuracy, we should have seen a difference between the living and syllables task, as these tasks had the largest discrepancy in correct responses. It is also unlikely that this difference across tasks affected the RT data, as trials on which a PM cue was presented were not included in the analyses.

In summary, when tested with conditions that dissociate match in processing between ongoing and PM tasks from the focality of the PM task, the PM accuracy results of the current experiment were supportive of predictions made by the MP view instead of predictions made by the TAP view. However, PM task cost results indicated monitoring for all task conditions and a positive correlation between ongoing task RT and PM accuracy in the focal vowels task. These results stand in contrast to predictions made by the MP view that focal tasks can support high PM task performance without a cost to the ongoing task. Future studies should further explore the possibility that degree of processing match is linearly related to PM accuracy. Other future directions include use of multinomial models (see Horn, Bayen, Smith, & Boywitt, 2011) to examine differences in PM processes across processing match conditions and other possible conditions under which spontaneous retrieval may operate in PM tasks (see Cohen, Kantner, Dixon, & Lindsay, 2011).

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References

Battig, W. F., & Montague, W. E. (1969). Category norms for verbal items in 56 categories: A replication and extension of the Connecticut category norms. *Journal of Experimental Psychology Monographs, 80* (3, Pt. 2).

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer-appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15*, 657–668.

Brewer, G. A. (2011). Analyzing response time distributions: Methodological and theoretical suggestions for prospective memory researchers. *Journal of Psychology, 219*, 117–124.

Cohen, A.-L., Kantner, J., Dixon, R. A., & Lindsay, D. S. (2011). The intention interference effect: The difficulty of ignoring what you intend to do. *Experimental Psychology, 58*, 425–433.

Cousineau, D., Brown, S., & Heathcote, A. (2004). Fitting distributions using maximum likelihood: Methods and packages. *Behavior Research Methods, Instruments, & Computers, 36*, 742–756.

Einstein, G. O., & McDaniel, M. A. (2005). Prospective memory: Multiple retrieval processes. *Current Directions in Psychological Science, 14*, 286–290.

Einstein, G. O., McDaniel, M. A., Thomas, R., Mayfield, S., Shank, H., Morrisette, N., & Breneiser, J. (2005). Multiple processes in prospective memory retrieval: Factors determining monitoring versus spontaneous retrieval. *Journal of Experimental Psychology: General, 134*, 327–342.

Erdfelder, E., Faul, F., & Buchner, A. (1996). GPOWER: A general power analysis program. *Behavior Research Methods, Instruments, & Computers, 28*, 1–11.

Harrison, T. L., & Einstein, G. O. (2010). Prospective memory: Are preparatory attentional processes necessary for a single focal cue? *Memory & Cognition, 38*, 860–867.

Heathcote, A., Popiel, S. J., & Mewhort, D. J. K. (1991). Analysis of response time distributions: An example using the Stroop task. *Psychological Bulletin, 109*, 340–347.

Horn, S. S., Bayen, U. J., Smith, R. E., & Boywitt, C. D. (2011). The multinomial model of prospective memory: Validity of ongoing-task parameters. *Experimental Psychology, 58*, 247–255.

Luce, R. D. (1986). *Response times*. New York, NY: Oxford University Press.

Marsh, R. L., Hicks, J. L., & Cook, G. I. (2005). On the relationship between effort toward an ongoing task and cue detection in event-based prospective memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 68–75.

Marsh, R. L., Hicks, J. L., & Hancock, T. W. (2000). On the interaction of ongoing cognitive activity and the nature of an event-based intention. *Applied Cognitive Psychology, 14*, S29–S41.

Maylor, E. A. (1996). Age-related impairment in an event-based prospective-memory task. *Psychology and Aging, 11*, 74–78.

Maylor, E. A., Darby, R. J., Logie, R. H., Della Sala, S., & Smith, G. (2002). Prospective memory across the lifespan. In P. Graf & N. Ohta (Eds.), *Lifespan development of human memory* (pp. 253–256). Cambridge, MA: MIT Press.

McDaniel, M. A., & Einstein, G. O. (2000). Strategic and automatic processes in prospective memory retrieval: A multiprocess framework. *Applied Cognitive Psychology, 14*, S127–S144.

McGann, D., Ellis, J., & Milne, A. (2003). Conceptual and perceptual processing in prospective remembering. *European Journal of Cognitive Psychology, 15*, 19–41.

Meier, B., & Graf, P. (2000). Transfer appropriate processing for prospective memory tests. *Applied Cognitive Psychology, 14*, S11–S27.

Meiser, T., & Schult, J. C. (2008). On the automatic nature of the task-appropriate processing effect in event-based prospective memory. *European Journal of Cognitive Psychology, 20*, 290–311.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior, 16*, 519–533.

Scullin, M. K., Einstein, G. O., & McDaniel, M. A. (2009). Evidence for spontaneous retrieval of suspended but not finished prospective memories. *Memory & Cognition, 37*, 425–433.

Smith, R. E. (2003). The cost of remembering to remember in event-based prospective memory: Investigating the capacity demands of delayed intention performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29,* 347–361.

Smith, R. E., Hunt, R. R., McVay, J. C., & McConnell, M. D. (2007). The cost of event-based prospective memory: Salient target events. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 33,* 734–746.

Weldon, M. S., & Roediger, H. L. III. (1987). Altering retrieval demands reverses the picture superiority effect. *Memory & Cognition, 15,* 269–280.

Weldon, M. S., Roediger, H. L. III, & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition, 17,* 95–105.

West, R., & Craik, F. I. M. (2001). Influences on the efficiency of prospective memory in younger and older adults. *Psychology and Aging, 16,* 682–696.

Dawn M. McBride

Department of Psychology
Campus Box 4620
Illinois State University
Normal
IL 61790-4620
USA
E-mail dmcbride@ilstu.edu