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Prospective Memory, Personality, and Working Memory: A Formal Modeling Approach

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Abstract

Prospective memory (PM) involves remembering to perform an action in the future. The current study applies a multinomial model to investigate the contribution of individual differences in personality, as well as individual differences in working memory span, to performance in an event-based PM task. The model includes a parameter *P* that measures the prospective component, or remembering *that* something is to be done. The model also includes a parameter *M* that measures the ability to discriminate between target and non-target events, part of the retrospective component of PM tasks. The model has been applied to investigate the effects of working memory variability in just one prior study, but has not been used in previous investigations of personality and PM. Working memory span and the personality dimension of conscientiousness showed differences between the higher and lower groups in PM performance. Modeling results showed that individuals higher in conscientiousness had higher estimated of *M* relative to individuals lower on the conscientiousness dimension. Conscientiousness did not affect the *P* parameter. In contrast, individuals with higher working memory span scores had higher estimates of *P* relative to individuals with lower span scores, but the two working memory groups did not differ in terms of parameter *M*.

Prospective Memory: Individual Differences in Personality and Working Memory

Prospective memory (PM), remembering to perform actions in the future, is important for maintaining our ability to function independently in our daily lives. For instance, the inability to remember to take medication or to turn off the stove translates into a need for daily assistance. Prospective memory is also important in our social interactions. For example, a person who routinely forgets to perform PM tasks in social contexts is likely to have problems maintaining positive professional and personal relationships. Why do people vary in their ability to perform PM tasks? Researchers have pointed to a role for both cognitive factors, such as individual differences in working memory, and non-cognitive factors, such as personality, in determining PM success. The aim of the present study was apply a multinomial process tree (MPT) model of PM to investigate how individual

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[2]Power analyses were conducted with GPower3 (Faul, Erdfelder, Lang, & Buchner, 2007) and Multitree (Moshagen, 2010).

differences in personality and working memory (WM) affect the underlying cognitive processes that contribute to successful PM performance. To this end, participants completed a lexical decision task in which they determined whether letter strings were words, with the embedded PM task of remembering to press the F1 key if either of two target syllables appeared during an ongoing lexical decision task. Participants also completed a personality questionnaire and a measure of WM.

The current experiment adopts the approach of the Five Factor Model and therefore focuses on the following dimensions of personality: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience (John & Srivastava, 1999). An individual high in extraversion has the characteristic of being energetic, sociable, talkative, assertive, and dominant. Altruism, trust, modesty, and a positive view of human nature characterize the dimension of agreeableness. An individual considered to be high on the dimension of conscientiousness is organized, thorough, efficient, and responsible. An individual who is anxious, tense, nervous, and fearful would score high on the dimension of neuroticism. Finally, the dimension of openness to experience describes an individual’s mental and experiential life with respect to its depth, creativity, and complexity.

Four previous studies have investigated the relationship between PM and dimensions of the Five Factor Model (Arana et al., 2008; Cuttler & Graf, 2007; Pearman & Storandt, 2005; Salthouse et al., 2004). Arana et al. (2008) found that the personality variable of rule-consciousness was positively correlated with PM performance. Similarly, Cuttler and Graf (2007) found that conscientiousness was a significant predictor of performance on two out of three PM tasks, while neuroticism predicted performance on one task. Pearman and Storandt (2005) found that subjects who remembered to do one or both of two PM tasks had higher scores on the conscientiousness characteristics of neuroticism and conscientiousness. In a study by Salthouse et al. (2004) involving adults ranging in age from 18 to 89, only agreeableness was related to PM performance. Interpretation of Salthouse et al.’s (2004) results is complicated by near ceiling levels of PM performance on the part of young adults and the use of a composite measure of PM (McDaniel & Einstein, 2007). In the studies by Cuttler and Graf (2007) and Pearman and Storandt (2005) reliability is a concern because there were very few observations in the PM tasks (Kelemen et al., 2006). Finally, in the study by Arana et al. (2008), there was no delay between the PM instructions and the start of the ongoing task and therefore this task could have functioned as more of a vigilance task (Uttl, 2008). Despite these possible limitations, the existing studies on the whole point to a role for conscientiousness in successful prospective remembering.

It is also important to consider the role of cognitive factors in explaining PM performance. One way of addressing this issue is to examine the relationship between PM performance and individual differences in the availability of resources for engaging controlled processing, as measured by tests of WM span. Previous studies have found a positive relationship between PM performance and WM span scores (e.g., Smith, 2003; Smith & Bayen, 2005). The current study investigated the relationships among WM, personality, and PM through the application of a MPT model of PM.

The MPT model used here, developed by Smith and Bayen (2004; see Erdfelder et al., 2009, for review of MPT models), allows researchers to determine independent estimates for two components of event-based PM tasks: the prospective component, which involves remembering that something must be done, and the retrospective component, specifically, recognition memory for target events. The model also includes parameters related to processes engaged by the ongoing task as well as guessing parameters. Prior research indicates that the prospective component can rely on non-automatic preparatory attentional processing (Smith & Bayen, 2004, 2005). Furthermore, various theories would agree that the

PM task in this experiment is likely to rely on non-automatic controlled processing to retrieve the delayed intention (e.g., Einstein & McDaniel, 2010; Smith, 2010). Therefore, the processes involved in the prospective component of the current PM task will be referred to as preparatory attentional processes.

The MPT model of PM can be applied when the PM task is embedded in an ongoing task with two response alternatives, such as word/non-word in the lexical decision task used in the current experiment. A second requirement is that the PM target events occur on both types of ongoing trials, which was true in this case, as the target syllables appeared on both word and non-word trials. While this is the first application of the MPT model to a study using the lexical decision ongoing task, the model has been applied successfully using both a color-matching task (e.g. Smith & Bayen, 2004, 2006; Smith, Bayen, & Martin, 2010) and a sentence verification task (Smith & Bayen, 2005).

There are four trial types in the current experiment, target syllables on word trials, target syllables on non-word trials, non-target word trials, and non-target-non-word trials, and three possible response outcomes: word, non-word, or PM target response (Figure 1). The full model includes seven free parameters: P = probability of engaging in preparatory attentional processing; M_1 = probability of recognizing that a letter string contains a target syllable; M_2 = probability of recognizing that letter string does not contain a target syllable; g = the probability of guessing that a target syllable is present; C_1 = probability that participants detect that the letter string is a word, C_2 = probability of correctly detecting that a string is not a word; c = probability of guessing that a string is a word.

Because the model with the seven free parameters is not identifiable, theoretically motivated restrictions are imposed (Smith & Bayen, 2004). Participants are assumed to calibrate their responses to the perceived ratio of items during an experiment, known as probability matching (cf. Spaniol & Bayen, 2002); thus, c is set to the proportion of match trials in the experiment and g is set to the proportion of target trials (c = .50 and g = .06 in this experiment).[1] A further assumption is made that target syllables and non-target syllables are equally well recognized (i.e., $M_1 = M_2$). The resulting model with four free parameters P, M, C_1, and C_2 is identifiable (see Smith & Bayen, 2004) and has been validated successfully (Horn, Bayen, Smith, & Boywitt, in press; Smith & Bayen, 2004).

One previous study has examined the effect of WM span on the parameter estimates in the MPT model (Smith & Bayen, 2005). In two experiments, participants completed an ongoing sentence verification task with the embedded PM task of responding to target words by pressing a specified key. Participants completed a WM task and a median split design was used to investigate the effects of WM. Relative to lower span participants, higher span individuals in both experiments were more likely to perform the PM task and model results showed that higher span individuals were more likely to engage in preparatory attentional processes.

The current experiment builds upon prior work in several ways. This is the first experiment to investigate the effects of personality on underlying cognitive processes through the application of the MPT model of PM. Second, unlike Smith and Bayen's (2005) use of a median split design, the current experiment uses an extreme groups design, which may be more advantageous (Conway et al., 2005) for investigating the effects of WM on the model parameters. Third, the current experiment also addresses the various methodological issues

[1]The model-based results are fairly robust against violations of the probability-matching assumption. When the two parameters deviate from c = .50 and g = .06 slightly, this has no substantial effect on the other parameters of the model (Smith & Bayen, 2004, p. 759).

noted above that could have contributed to failures in previous studies to find a relationship between PM and dimensions of personality other than conscientiousness. Finally, by simultaneously measuring the effects of personality and WM on PM, we can investigate the relative contribution of the two dimensions of individual difference.

Method

Participants

The 413 participants (239 females), who were native English speakers between 17 and 30 years of age, received either monetary compensation or credit towards a course requirement.

Materials

Lexical decision task—Letter strings included 62 two-syllable words with a mean frequency of 136 (Kucera & Francis, 1967) and 62 non-words, which were created by moving the first syllable to the end of each word. Strings appeared once in Block 1 and were repeated twice in Block 2, each time in a different random order.

Prospective memory task—Participants were asked to press the ‘F1’ key if target syllables (*low* and *per*) appeared during lexical decision task. Target syllables occurred as the 1st syllable of a word, 2nd syllable in a word, 1st syllable of a non-word, and 2nd syllable in a non-word, resulting in eight different target strings. Word strings had a mean frequency of 136. Target strings were presented in a random order and then repeated in a different random order for a total of 16 target events occurring on Trials 16, 30, 45, 63, 79, 96, 110, 125, 139, 155, 168, 183, 196, 210, 225, and 242 of Block 2. This number of target events was selected to increase reliability (Kelemen et al., 2006) and while remaining consistent with previous studies (see Smith, 2003 for discussion).

Big Five Inventory (BFI)—For the BFI (John, Donahue, & Kentle, 1991) personality questionnaire, participants self-reported the extent they agreed or disagreed with each of 44 phrases as a description of themselves. The internal consistency and reliability of the BFI instrument has been established (Cronbach’s alpha of .83 and test-retest reliability of .85), and evidence of validity includes substantial convergent and divergent relations with other widely used Big Five instruments (John & Srivastava, 1999).

Working memory span task—The automated symmetry span task provides an efficient test of WM capacity and has been shown to have good internal consistency (alphas range from .80 to .99) and test-retest reliability (.77; Unsworth, Heitz, Schrock, & Engle, 2005; Unsworth et al., 2009). Furthermore, the storage and processing components of this task correlate well with other measures of WM and measures of general fluid intelligence (Unsworth et al., 2009). In this task, participants remember the location of red squares on a grid, while also judging whether black and white geometrical figures are symmetrical about the horizontal axis. Participants practiced each task individually and together before starting the primary task. The primary task consisted of trials with between two and five locations to recall, with three trials of each length. The span score was the total number of correctly recalled locations. Participants whose accuracy on the symmetry judgments was below 85% were excluded and replaced (see Unsworth et al., 2009).

Procedure

Participants read the instructions for the lexical decision task, which stated that they would see strings of letters and that they should decide as quickly and accurately as possible whether each letter string is a word by pressing the ‘Y’ key for yes or the ‘N’ key for no. Each trial of the lexical decision task began with a display screen instructing the participant to press the space-bar to begin the next trial. Next, a focal point was displayed on the screen for a randomly selected time between 250 ms and 750 ms. Finally, a letter string appeared on the screen until the participant made a response. Participants completed four practice trials followed by 124 trials in Block 1 of the lexical decision task. After completing Block 1, participants were given the PM instructions, which asked participants to try to remember to press the 'F1' key if a target syllable appeared anywhere in a letter string during the second part of the experiment. Participants were then shown the target syllables for 5 s each and were given the opportunity to ask questions before continuing to the 4 min filled delay, during which participants worked on a number puzzle, followed by the start of Block 2 of lexical decision trials. Participants were not reminded of the PM task. Upon completion of Block 2, participants recalled the PM action. Because the multinomial model does not include a separate parameter for retrospective recall of the action, 11 participants who failed to make any PM responses and who also failed to recall the action on the post-task questionnaire, were excluded and replaced (see Smith & Bayen, 2004). Participants completed a recognition test for the target syllables that included the two target syllables plus six distractor syllables presented in a random order. Participants next completed the BFI questionnaire and WM task.

Results

Prospective Memory

Descriptive statistics are provided in Table 1. Reliability of the PM task was evaluated using a split-half comparison that revealed a significant positive correlation between the two sets of items ($r = .84$, $p < .001$). As shown in Table 1, PM was positively correlated with conscientiousness and WM span, and WM span was positively correlated with openness. Conscientiousness and WM were not correlated with one another. When controlling for differences in WM span, the correlation between PM and conscientiousness remained significant (Table 1); similarly, when controlling for variability in conscientiousness, the relationship between PM and WM remained significant as well, $r = .12$, $p = .02$. Thus, both WM and conscientiousness appear to make independent contributions to PM performance. No other correlations between personality and PM or personality and WM reached significance.

We created higher and lower groups for each personality dimension and WM span by selecting scores as cut points that created groups that were as close as possible to containing the top and bottom 25% for each measure. Conscientiousness was the only personality dimension to produce a significant difference in the PM performance between the higher, $M = .62$, $SEM = .03$, and lower groups, $M = .52$, $SEM = .03$, $F(1,181) = 4.73$, $p = .03$, $\eta_p^2 = .03$ (all other Fs < 1.07, and ps > .30). Higher, $M = .60$, $SEM = .03$ and lower WM span groups, $M = .51$, $SEM = .03$, also differed from one another, $F(1,200) = 4.27$, $p = .04$, $\eta_p^2 = .02$.

Modeling Results

The MPT model of PM was applied to investigate how the dimension of conscientiousness and WM affected preparatory attentional processing as measured by parameter *P* and retrospective recognition of the target events as measured by parameter *M*. The parameters were estimated from response frequency data (Appendix) using maximum-likelihood parameter estimation. Parameter estimates and goodness-of-fit statistic $G^2(4)$ were calculated for each group using current software (Moshagen, 2010; Stahl & Klauer, 2007). With a sample size of $N = 22{,}320$ (90 participants × 248 trials) and a conventional alpha level of .05, the power for the goodness-of-fit tests was 1.00 for detecting small effects, $w = .10$. In order to avoid rejecting the model due to minute differences between the data and model predictions, we adopted an alpha level of .001 for the goodness-of-fit tests, and still retained a power of .99 for detecting very small effects, $w < .10$ In all eight cases, the model provided a good fit to the data (Table 2).

Comparisons were conducted to determine if the parameter values differed significantly between groups. This is accomplished by combining trees for each group into a single joint model with 8 degrees of freedom. The model is then constrained by setting the parameter values of *P* to be equal across groups. The value of $G^2(8)$ for the full model is subtracted from the value of $G^2(9)$ for the constrained model, resulting in the test statistic $\Delta G^2(1)$. This is done in turn for each parameter. With an alpha level of .05, the power of the comparison tests to detect small differences, $w = .10$, in the parameter estimates was 1.00. Thus, we also adopted an alpha level of .001 for the tests of parameter differences, retaining a power of .95 to detect very small effects, $w < .10$

As can be seen in Table 2, individuals with higher WM scores were more likely to engage in preparatory attentional processing than were participants with lower WM span scores. The two WM groups did not differ in the estimates of *M*. Conscientiousness showed the opposite pattern, with no difference in *P*, but a significant difference in *M*. The only effect on the ongoing task parameters was that higher WM was associated with an increase in the ability to detect non-word strings as non-words.

Cost to the Ongoing Task

As is typically done in prospective memory research (e.g., Loft, Pearcy, & Remington, 2011; Smith et al., 2007), the PM target trials, and the two trials following each PM target trial were excluded from the analysis of ongoing task performance, in order to avoid finding a cost due to having just performed the PM task. The first nine trials in each block were also excluded. In the conscientiousness groups, Block 1 baseline accuracy was higher for word trials, $M = .98$, $SEM = .002$, than for non-word trials, $M = .97$, $SEM = .003$, $F(1,181) = 8.67$, $p = .004$, $\eta_p^2 = .05$, but did not differ between the groups and the variables did not interact, *F*s < 1, *p*s > .47. Difference scores, which were calculated by subtracting baseline accuracy from Block 2 accuracy for each trial type, did not differ between the two conscientiousness groups for either words or non-words, *F*s < 1, *p*s > .73. Difference scores for words, $M = -.01$, $SEM = .003$, was significantly different from zero, indicating a decline in accuracy on words trials $t(182) = 4.27$, $p < .001$, $d = .32$, but no decline was seen for non-word trials, $t(182) = 1.34$, $p = .18$. Thus, a cost was found on accuracy that did not vary as a function of conscientiousness.

For the WM span groups, the significant effects of trial type, $F(1,200) = 13.62$, $p < .001$, $\eta_p^2 = .06$, and span group, $F(1,200) = 5.46$, $p = .02$, $\eta_p^2 = .03$, were qualified by a significant interaction, $F(1,200) = 4.19$, $p = .04$, $\eta_p^2 = .02$. Baseline accuracy on word trials, $M = .98$, $SEM = .002$, did not differ between the two groups, $F < 1$, $p = .63$, nor did difference scores for word trials, $M = -.01$, $SEM = .002$, $F < 1$, $p > .56$, which were significantly different from zero, $t(201) = 4.96$, $p < .001$, $d = .35$. In contrast, baseline non-word accuracy was higher for the higher span group, $M = .98$, $SEM = .004$, than for the lower span group, $M = .96$, $SEM = .004$, $F(1,200) = 6.78$, $p = .01$, $\eta_p^2 = .03$, but in neither group were the non-word difference scores significantly different from zero, *t*s < 1.45, *p*s > .15. As with conscientiousness a cost was found on accuracy, but this did not vary as a function of span group.

Response times (RT) for inaccurate trials, less than 200 ms, or more than three standard deviations from the individual's mean for each item type and block were excluded. Baseline RT did not differ as a function of conscientiousness group, $F < 1$, $p > .41$, but were significantly longer for non-word trials, $M = 808$, $SEM = 16$, than for word trials, $M = 674$, $SEM = 9$, $F(1,181) = 159.69$, $p < .001$, $\eta_p^2 = .47$. The variables did not interact, $F < 1$, $p >$.

87. The difference scores were equivalent in the two groups, *Fs* < 1, *p*s > .41, and were significantly greater than zero for both words, *M* = 359, *SEM* = 18, *t*(182) = 20.50, *p* < .001, *d* = 1.51, and non-words, *M* = 277, *SEM* = 18, *t*(182) = 15.21, *p* < .001, *d* = 1.90. In other words, both higher and lower conscientiousness groups showed a cost on response times.

The analysis for the WM span groups produced significant effects of trial type, *F*(1,200) = 163.27, *p* < .001, η_p^2 = .45, and span group, *F*(1,200) = 10.34, *p* = .002, η_p^2 = .05, which were qualified by a significant interaction, *F*(1,200) = 4.48, *p* = .04, η_p^2 = .02. Baseline word trial RT were faster for the higher span group, *M* = 654, *SEM* = 10, than for the lower span group, *M* = 698, *SEM* = 12, *F*(1,200) = 7.80, *p* = .006, η_p^2 = .04. Similarly, the higher span group, *M* = 768, *SEM* = 18, was faster to respond to baseline non-word trials than was the lower span group, *M* = 858, *SEM* = 23, *F*(1,200) = 9.48, *p* = .002, η_p^2 = .05. The difference scores were significantly greater than zero for the lower span group for words, *M* = 331, *SEM* = 25, *t*(99) = 13.48, *p* < .001, *d* = .94, and non-words, *M* = 251, *SEM* = 27, *t*(99) = 9.40, *p* < .001, *d* = 1.35, and for the higher span group for words, *M* = 356, *SEM* = 24, *t*(101) = 15.33, *p* < .001, *d* = 1.52, and non-words, *M* = 287, *SEM* = 23, *t*(101) = 12.37, *p* < .001, *d* = 1.23. Direct comparisons of difference scores for the two working memory groups were not conducted because of baseline differences. Meaningful interpretation of potential group differences in the difference scores is not possible when the groups differ in terms of baseline performance. Thus, although cost measures can provide an indirect measure of preparatory attentional processing, the usefulness of the RT analysis is limited in this case. Moreover, RT are only an indirect indicator of preparatory attentional processing and can be affected by other factors such as target rehearsal or recognition (Smith, 2010). In contrast, the MPT model analysis provided clear information about the effect of working memory on preparatory attentional processing.[3]

Prospective Memory Target Recognition

There was a trend for the higher, *M* = .94, *SEM* = .01, and lower, *M* = .91, *SEM* = .01, conscientiousness groups to differ on the post-task recognition test, *F*(1,181) = 2.82, *p* < .10, η_p^2 = .02. This comparison provides another illustration of the advantage of using the multinomial model: higher conscientiousness participants responded correctly to more target events during the test block, which could serve as rehearsals of the targets, leading to better post-task recognition. In contrast, the model provides unambiguous data concerning the ability to discriminate between target and non-target events during the interval in which the PM task is to be performed. No other group comparisons were significant: all *F*s < 2.48, *p* > .11.

Discussion

We investigated the effects of personality and WM on performance in an event-based PM task. Small, but significant, positive relationships were found between PM performance and both the personality dimension of conscientiousness and WM. The personality dimension of openness also correlated with WM. Thus, the current results replicate previous studies showing a relationship between PM and conscientiousness (e.g., Arana et. al, 2008; Cuttler & Graf, 2007; Pearman & Storandt, 2005), between PM and WM (e.g., Smith, 2003), and between openness and measures of executive functioning (Salthouse et al., 2004). Significant partial correlations indicated that the relationship of WM and conscientiousness to PM were independent of one another. The inclusion of the WM measure allowed us to address an additional question, specifically, could variability in cognitive ability be masking the effects of the other personality dimensions on PM? The answer appears to be no. Even

[3]See Brewer (2011) and Horn, Smith, & Bayen (in press) for alternative approaches to RT analysis.

when controlling for individual differences in WM in the current study, only the correlation between PM and conscientiousness was significant (Table 1). Similarly, in a stepwise regression analysis, Cuttler and Graf (2007) found that the pattern of personality predictors for PM performance remained the same, regardless of whether personality was entered into the model before or after measures of cognitive functioning.

The next step in our investigation was to apply the MPT model of event-based PM (Smith & Bayen, 2004) to investigate how conscientiousness and WM affect the cognitive processes that underlie successful PM performance. In the case of conscientiousness, individuals scoring higher on this dimension showed an increased ability to discriminate between target and non-target events, as measured by parameter M. Working memory on the other hand, affected parameter P with higher span individuals being more likely to engage in preparatory attentional processing. This is the first experiment to provide information regarding how conscientiousness leads to improved PM performance through the application of the MPT model of PM, and the outcome was somewhat surprising for the following reasons. One might expect that participants high in conscientiousness may be more motivated to perform the assigned tasks successfully due to being more responsible and thorough. Motivation in the form of task importance has been shown to improve PM through an increase in preparatory attentional processing (Smith & Bayen, 2004). Thus, because individuals high on the dimension of conscientiousness may be motivated to perform the tasks as instructed, one might have expected that more conscientious participants would be more likely to engage in preparatory attentional processing. There are two possible explanations for the null effect of conscientiousness on preparatory attentional processing.

As noted earlier, the MPT model of PM has not previously been applied when using lexical decision as the ongoing task or when using syllables as the PM targets. Taken in isolation, the lack of an effect of conscientiousness on the P parameter might lead one to wonder whether the particular PM task used discourages participants from changing the allocation in resources away from the ongoing task for engaging in preparatory attentional processing. If this were the case, it may be that conscientiousness had no effect on preparatory attentional processing simply because of the task used. However, WM did affect preparatory attentional processing, and so it does not appear that the outcome of the current experiment is attributable solely to the use of a lexical decision task. While it may be the case that conscientiousness could affect P in different task contexts, the null effect of conscientiousness on P in the current experiment is not attributable to the use of the lexical decision ongoing task.

The model results, combined with the ongoing task results, point to a different interpretation for the effects of conscientiousness. Preparatory attentional processing requires resources and this is reflected in the cost to the ongoing task found in this experiment. The fact that there is a cost to the ongoing task also demonstrates that the ongoing task itself requires resources. Considering that individuals who are conscientious are likely to make an effort to perform both the ongoing task and the PM task as instructed, individuals high on the dimension of conscientiousness may not spontaneously shift additional resources from the ongoing task to the preparatory attentional processes. Although participants higher in conscientiousness in the current experiment did not show a significant increase in preparatory attentional processing, we may be able to detect differences in preparatory attentional processing as a function of conscientiousness using different manipulations. For instance, instructions that emphasize the importance of either the ongoing task or the PM task may have a differential impact as a function of conscientiousness. Participants higher in conscientiousness may be more responsive to such instructional manipulations and may therefore show greater effects of this and similar manipulations.

Although we used a reliable PM task and included 413 participants, we failed to detect significant relationships between PM performance and other personality dimensions, including agreeableness. In contrast, Salthouse et al. (2004) did find a relationship between PM and agreeableness. Cuttler and Graf (2007) conducted the only other study to investigate agreeableness and PM, and they did not find a significant relationship between the two. Cuttler and Graf proposed that an important difference between their study and the Salthouse et al. study was that Salthouse et al. (2004) used primarily computer based tasks, while Cuttler and Graf used more naturalistic tasks, which Cuttler and Graf suggested “seem to have more “degrees of freedom” and permit influences from a greater variety of sources” (p. 227). However, the current experiment used a computer based PM task and our findings are more similar to those of Cuttler and Graf than to those reported by Salthouse et al. Our findings also match those of Pearman and Storandt (2005), who used naturalistic tasks, and the findings reported by Arana et al. (2008) who used non-computer based, but traditional laboratory PM tasks. Thus, the laboratory versus naturalistic PM task distinction cannot explain the different outcomes.

The studies differ in other ways as well, including the age range of participants, with two studies including participants from across the adult age range (Cuttler & Graf, 2007; Salthouse et al., 2004), while two include only young adults (the current study; Arana et al., 2008) and one included only older adults (Pearman & Storandt, 2005). Another possible factor in the different findings across studies is that the various studies have used different measures of personality and not all have considered the same specific personality dimensions. Nonetheless, a fairly consistent picture emerges when considering all of the studies together. As noted above, three studies have included a measure of agreeableness (this study; Cuttler & Graf, 2007; Salthouse et al., 2004) and only one has found that agreeableness predicts PM performance (Salthouse et al.). Four studies have investigated neuroticism and PM (this study; Cuttler & Graf; Pearman & Storandt, 2005; Salthouse et al.), but only one has found a relationship between the two (Cuttler & Graf). In contrast, all five studies included measures of conscientiousness and all but one (Salthouse et al.), have detected a positive relationship between conscientiousness and PM. Thus, the overall picture is that conscientiousness plays at least a small role in determining PM performance on both laboratory and naturalistic tasks.

There are potential limitations to the current study. First, with the exception of neuroticism, our sample did not include individuals scoring at the very lowest end of each personality dimension, for instance, in the case of agreeableness the lowest observed score was 16 while the lowest possible score is 9, similarly, the lowest observed score for openness was 17 while the lowest possible score is 10. This may have impacted our ability to detect significant correlations. Second, while it is the case that some previous studies may have been limited by the use of composite measures (McDaniel & Einstein, 2007), one could also argue that the use of a single measure of PM does not fully capture all of the relevant aspects of PM tasks, and personality may play a greater role in different kinds of tasks, such as in activity-based or time-based tasks (e.g., Margrett, Reese-Melancon, & Rendell, 2011; Voigt, Aberle, Schönfeld, & Kliegel, 2011). An additional limitation is that we used a single measure of WM, which increases the possibility that measurement error might reduce the ability to detect significant findings, and the WM measure and personality questionnaire were administered after the PM task, which could possibly affect the outcome. Concerns about the WM measure are countered by the fact that the results are consistent with a number of prior investigations of WM and PM (e.g., Smith & Bayen, 2005). Given that personality traits are by definition considered to be stable, the order of tasks should not be a factor for the personality measure.

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Conclusions

The current findings provide new information through the application of the MPT model of PM. If we have examined only observable PM performance, we would simply have seen that both WM and conscientiousness can be related to PM performance. Without the model results, we could not have determined that conscientiousness and WM affect PM performance through different cognitive processes. The current findings also point to avenues for future research. As noted above, it may be that conscientiousness affects the way that participants respond to different instructional manipulations, such as importance of the PM task, and future research should move beyond simply looking for a relationship between personality and PM to consider more complex interactions of personality, PM, and different instructional manipulations. It is also possible that more substantial effects of conscientiousness, as well as effects of other aspects of personality such as agreeableness, would emerge in tasks that have greater social importance (Cuttler & Graf, 2007). In the future, researchers should also strive to determine, not just whether personality influences observed PM performance, but also why the relationship exists. Not all changes in PM can be attributed to the same underlying processes, as illustrated by the current results showing that cognitive and non-cognitive factors can affect PM through different mechanisms.

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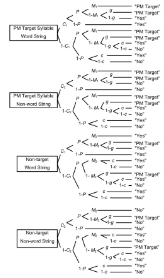

Figure 1.

Multinomial model of event-based prospective memory. PM = prospective memory; C_1 = probability of detecting words; C_2 = probability of detecting non-words; P = probability of engaging preparatory attentional processes; M = probability of discriminating between targets and non-targets (i.e. remembering *when*, the retrospective recognition component); g = probability of guessing that a string contains a target syllable; c = probability of guessing that a string is a word. Adapted from “A multinomial model of event-based prospective memory” by R. E. Smith and U. J. Bayen, 2004, *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *30*, p. 758.

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Table 1

Descriptive statistics and correlation coefficients.

				PM		WM		partial	
Measure	***M***	***SEM***	***Range***	***r***	***p***	***r***	***p***	***r***	***p***
Prospective Memory	.55	.02	0 to 1.0	-	-				
Working Memory	28.67	.36	4 to 42	.11	.02	-	-	-	-
Conscientiousness	31.96	.27	14 to 45	.10	.04	−.03	.61	.10	.04
Openness	36.92	.29	17 to 50	.04	.45	.12	.02	.02	.62
Agreeableness	35.34	.26	16 to 45	.08	.12	−.07	.13	.09	.08
Extroversion	27.29	.33	10 to 40	.001	.98	−.07	.14	.01	.85
Neuroticism	22.42	.30	8 to 39	−.01	.78	−.06	.21	−.01	.90

Note: PM = zero-order correlation with prospective memory; WM = zero-order correlation with working memory. Partial = correlation with prospective memory when controlling for working memory

Table 2

Parameter estimates and statistics for model fits and tests of parameter differences.

			Parameter			
Group	**N**	$G^2(4)$	P	M	C_1	C_2
Higher Conscientiousness	93	8.49 (.08)	.71 [.68, .74]	.85 [.83, .88]	.95 [.95, .96]	.95 [.95, .96]
Lower Conscientiousness	90	9.12 (.06)	.67 [.64, .71]	.75 [.72, .78]	.93 [.92, .94]	.95 [.94, .95]
		$\Delta G^2(1) = 2.75$ (.10)		34.26 (<.001)	8.07 (.005)	1.36 (.24)
Higher Working Memory	102	8.12 (.09)	.72 [.69, .75]	.81 [.78, .83]	.95 [.94, .95]	.96 [.95, .96]
Lower Working Memory	100	12.84 (.01)	.60 [.57, .63]	.84 [.81, .86]	.94 [.94, .95]	.94 [.93, .94]
		$\Delta G^2(1) = 35.74$ (<.001)		2.13 (.14)	0.07 (.80)	27.11 (<.001)

Note: Alpha was set to .001 for all goodness-of-fit tests and tests of parameter differences. The upper and lower bounds of the 95% confidence intervals for each parameter estimate are shown in brackets. The *p*-values for the goodness-of-fit tests and tests of parameter differences are shown in parentheses.

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Appendix

Response category frequencies

Group	Trial type	Response type		
		"PM"	"Word"	"Non-word"
Conscientiousness: Higher	Target, word	450	285	9
	Target, non-word	465	14	265
	Non-target, word	62	10432	294
	Non-target, non-word	72	241	10475
Conscientiousness: Lower	Target, word	348	357	15
	Target, non-word	395	8	317
	Non-target, word	94	9995	351
	Non-target, non-word	117	265	10058
Working Memory Span: Higher	Target, word	472	337	7
	Target, non-word	500	13	303
	Non-target, word	93	11416	323
	Non-target, non-word	102	241	11489
Working Memory Span: Lower	Target, word	379	408	13
	Target, non-word	429	21	350
	Non-target, word	66	11214	320
	Non-target, non-word	71	358	11171