Performance predictions affect attentional processes of event-based prospective memory.

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Rummel, J.. *Kuhlmann, B. G., & Touron, D. R. (2013). Performance predictions affect attentional processes of event-based prospective memory. *Consciousness and Cognition, 22(3)*, 729-741.

Abstract:

To investigate whether making performance predictions affects prospective memory (PM) processing, we asked one group of participants to predict their performance in a PM task embedded in an ongoing task and compared their performance with a control group that made no predictions. A third group gave not only PM predictions but also ongoing-task predictions. Exclusive PM predictions resulted in slower ongoing-task responding both in a nonfocal (Experiment 1) and in a focal (Experiment 2) PM task. Only in the nonfocal task was the additional slowing accompanied by improved PM performance. Even in the nonfocal task, however, was the correlation between ongoing-task speed and PM performance reduced after predictions, suggesting that the slowing was not completely functional for PM. Prediction-induced changes could be avoided by asking participants to additionally predict their performance in the ongoing task. In sum, the present findings substantiate a role of metamemory for attention-allocation strategies of PM.

Keywords: prospective memory | metamemory | performance predictions | reactive effects | cognition | memory | psychology

Article:

1. Introduction

Event-based prospective memory (PM) refers to the ability to remember to perform an intended action in response to a target event such as remembering to buy medicine on the way home (Einstein & McDaniel, 1990). Current theorizing suggests two different cognitive routes to successful intention fulfillment: resource-demanding attentional monitoring for the appropriate moment of intention fulfillment and rather automatic (i.e., spontaneous) retrieval of the intention (Einstein and McDaniel, 2010 and McDaniel and Einstein, 2007). Research has yielded mixed findings regarding people's engagement of attentional resources for PM intentions (Einstein and McDaniel, 2010 and Smith, 2010). In the present research, we examined metamemory influences on attentional monitoring by examining how making performance predictions within PM task settings may alter the allocation of attention to a PM intention as well as its functionality for intention fulfillment.

1.1. Assessing attentional monitoring of prospective memory

In the Einstein–McDaniel paradigm of PM (1990), participants have to perform an ongoing experimental task and, additionally, to prospectively remember to respond to specific PM-target stimuli within the ongoing task with a special key. This task setting mimics the common PM situation of remembering to do something at a future moment while performing other ongoing activities. To the extent that PM performance (i.e., pressing the special key in response to the PM targets) relies on attentional monitoring and thus requires cognitive resources, the PM intention should interfere with the ongoing task (Smith, 2003 and Smith, 2010). Indeed, the addition of a PM intention has been shown to slow ongoing task performance (Hicks et al., 2005, Marsh et al., 2003, Scullin et al., 2010a and Smith, 2003). Furthermore, PM performance has been shown to vary with the demands of the ongoing task (Marsh, Hancock, & Hicks, 2002), demonstrating that both tasks draw on the same limited attentional resources. The interrelation between the PM task and the ongoing task is quite strong for nonfocal PM targets, whose processing imposes attentional demands in addition to the ongoing task demands. The interrelation is weaker, however, for focal PM targets, which require little attentional monitoring (Scullin, McDaniel, Shelton, & Lee, 2010; see also Einstein & McDaniel, 2005, for a review of focality effects). A target can be considered focal when the processing of the ongoing task encourages processing (1) of the PM target, usually referred to as task- or transfer-appropriate processing (cf. Marsh et al., 2000, Maylor, 1996, Meier and Graf, 2000 and Meiser and Schult, 2008), and, especially, (2) of those features of the PM target that were encoded as relevant for the PM intention during intention formation (McDaniel & Einstein, 2007; see also McBride & Abney, 2012, for a comparison of task-appropriate and focal processing of PM). To illustrate, when driving home, the pharmacy sign we encounter on our usual way home can serve as a focal target because the sign has probably been encoded as relevant to the intention to buy medicine at the pharmacy. Further, there is a processing overlap between the ongoing activity of driving the car and encountering the sign, because while driving we must attend to road signs anyways. If the pharmacy requires a detour or is inside a mall, however, one would not spontaneously encounter the intention-relevant sign. Thus, attention has to be devoted to not miss the correct turn (i.e., a nonfocal cue; see Einstein & McDaniel, 2008, for similar everyday examples).

Although it is well demonstrated that the engagement in monitoring for PM targets depends on the PM task demands, like the cues’ focality for example, there is evidence that other factors can also influence attention allocation. If the importance of the PM intention relative to the ongoing task is stressed/de-stressed, for instance, monitoring increases/decreases (Marsh et al., 2005 and Smith and Bayen, 2004). On the other hand, if participants imagine themselves performing the

PM task during intention formation (i.e., mental simulation of the PM-task, Brewer & Marsh, 2010), PM performance increases while attentional monitoring remains unaffected or even decreases (Brewer et al., 2011, McFarland and Glisky, 2012, Meiser and Rummel, 2012 and Rummel et al., 2012).

1.2. Prospective memory predictions and attentional monitoring

Recently, PM researchers have started to investigate people's insight into their own PM abilities by asking them to predict their PM performance (e.g., Meeks, Hicks, & Marsh, 2007). Performance predictions have been used in various memory domains to assess people's metamemory (Hertzog & Hultsch, 2000). Memory-performance predictions allow direct investigation of how accurately individuals anticipate their memory performance (e.g., Nelson & Dunlosky, 1991) and have been found to relate to memory strategies (cf. Hertzog et al., 2007 and Kuhlmann and Touron, 2011). More globally, making performance predictions improves retrospective memory performance (Kelemen and Weaver, 1997 and Spellman and Bjork, 1992).

Regarding the accuracy of PM predictions, people generally underestimate their PM performance (Knight et al., 2005, Meeks et al., 2007 and Schnitzspahn et al., 2011; but see Devolder, Brigham, & Pressley, 1990). Meeks et al. (2007), however, found moderate but significant correlations between PM predictions and actual PM performance, implying that participants had at least some insight in their own PM performance (see also Schnitzspahn et al., 2011). Surprisingly, Meeks et al. (2007) did not find significant correlations between ongoing-task response speed and PM performance, although PM performance in this study should have depended on attentional monitoring as the PM targets were nonfocal.1 That is, requiring participants to make PM performance predictions appears to have altered attentional monitoring processes, which are usually related to nonfocal PM performance in studies not assessing predictions.

Despite its repeated use, prior research has not sufficiently considered global effects of making PM predictions on the allocation of attention to a PM task by comparing a condition making PM predictions to an appropriate no-prediction control condition. Given that performance predictions have reactive effects on RM performance, we argue that making PM predictions can also reactively affect PM performance and the processes engaged in favor of the PM task (see Meier, von Wartburg, Matter, Rothen, & Reber, 2011, for a similar argument). Such reactive effects from PM predictions would not only complicate the interpretation of PM prediction accuracy but also imply that metamemory plays a critical role for attention allocation strategies in PM (cf. Einstein & McDaniel, 2008).

The present study thus aims first to demonstrate that making PM predictions can reactively affect attentional PM processing. Additionally, we suggest a design-based modification of prediction assessment that controls for attentional changes and thus for at least some of the reactive effects of PM predictions. Finally, we argue that examining reactive effects may help to clarify the puzzling null-correlations between PM and ongoing-task performances after predictions (cf. Meeks et al., 2007), as reactive additional monitoring may not be completely functional for PM performance and as such predictions may incite a strategic approach which is not maximally efficient.

To our knowledge, the only previous investigation of reactive effects from PM predictions is a study by Meier et al. (2011). These authors argued that making PM predictions might facilitate processing of the PM target. In particular, they suggested that performance predictions might encourage participants to mentally simulate (cf. Brewer & Marsh, 2010) the PM task in order to anticipate their performance, which would cause the PM targets to pop-up in the ongoing-task environment and thus allow participants to rely more on spontaneous retrieval and less on attentional monitoring for their PM performance. Accordingly, Meier and colleagues found performance improvements after making PM predictions with a nonfocal PM task. In addition, they asked those participants who performed the PM task correctly whether they remembered the intention (a) because they were searching for the target or (b) because the target popped into their mind. Results showed that participants who fulfilled the PM task and had made a PM prediction did not report more PM target pop-up experiences but rather more searching for the PM targets than participants who fulfilled the PM task but had not made predictions. Thus, according to the self-reports, participants seemed to consciously engage more strategic processing after PM predictions rather than relying more on a pop-up experience. Notably, self-reports in the study by Meier et al. were conditional on the successful performance of the PM task and assessed after PM response execution. Thus, successful performance of the PM task might have affected self-reports. Furthermore, Meier and colleagues did not use a speeded ongoing task. Therefore, it is unclear whether the PM prediction-induced changes in retrospectively reported searching translate into attentional monitoring as it is commonly measured, by objective performance assessed online (i.e., slowed responding in an ongoing task). Further, in Meier et al.’s study, participants in one condition completed six questions anticipating PM performance after intention formation and PM performance in this condition was compared to a control condition that did not complete any questions regarding the PM task. Thus, the participants in the PM-prediction condition had several additional opportunities to rehearse the intention. This manipulation is likely to encourage monitoring by stressing the importance of the PM task over the ongoing task as well as to facilitate spontaneous retrieval by allowing participants to rehearse (and potentially to mentally simulate, cf. Meier et al., 2011), the intention. Therefore, their manipulation does not allow for differentiating between PM-performance benefits from increased attentional monitoring versus from facilitated spontaneous retrieval or a combination of both.

1.3. The present study

To better understand the reactive effects of PM predictions, we used a standard PM paradigm with a speeded ongoing task (OT) that has been used to assess attentional monitoring in terms of PM-induced slowing to the OT (Einstein et al., 2005, Hicks et al., 2005, Marsh et al., 2003, Meeks et al., 2007, Scullin et al., 2009 and Smith, 2003). One group of participants predicted their PM performance and another (control) group made no predictions. Comparing these two groups should result in replication of the previous finding regarding reactive effects of PM predictions on PM performance (Meier et al., 2011). Extending previous research, the use of a speeded OT allows for an investigation of whether and how PM predictions change attentional PM processing. For better comparability with previous findings by Meeks et al. (2007), participants in the present study predicted their PM-performance only once.

Importantly, we added a third condition of participants who predicted their PM performance but also predicted their OT performance. Importantly, this PM/OT-prediction condition had identical opportunities to rehearse the intention during encoding as participants in the PM-prediction condition, who only predicted their PM performance. Thus, both prediction groups should have encoded the PM intention equally well, leading to similar levels of spontaneous retrieval. Notably, unlike in the PM-prediction condition, the importance of the PM task (relative to the OT) was not particularly stressed in the PM/OT-prediction condition. This manipulation therefore allows to disentangle whether reactive effects from predictions on PM performance are due to monitoring effects (occurring in the PM-prediction condition only resulting from stressing the PM task over the OT) versus spontaneous retrieval effects (occurring in both the PM-prediction and PM/OT-prediction conditions resulting from better PM encoding due to additional intention rehearsal).

As focality of PM-target events influences the engagement of spontaneous retrieval processes, PM predictions may affect processing in nonfocal and focal PM tasks differently. Thus, we investigated the effects of PM predictions on PM processing under nonfocal (Experiment 1) and focal (Experiment 2) PM task conditions.

To more clearly interpret the expected prediction-induced effects, in the present study we applied the drift diffusion model (e.g., Ratcliff, 1978) to the OT data. Generally, this model estimates specific cognitive processes contributing to performance, based on accuracy and response speed data from two-choice decision tasks (Ratcliff, Gomez, & McKoon, 2004). Therefore, the model integrates two behavioral measures which are usually in a compensatory relationship (i.e., accuracy and response speed) into psychologically meaningful process parameters (Ratcliff et al., 2004). For the present analyses, we focused on the three core parameters of the drift diffusion model, namely the drift rate (parameter v), the response criterion (parameter a), and a non-decisional component (parameter t0) which have been shown to underlie lexical-decision performance. The drift rate characterizes how efficiently information about the stimulus regarding the required decision (e.g., word or nonword) is processed and is selectively influenced by manipulations of factual task demands in a lexical decision task (e.g., using high versus low frequency words; Ratcliff et al., 2004). The response criterion, on the other hand, characterizes how conservative participants are in making their decision with conservative participants requiring more evidence before making a response; this process is influenced by manipulating response tendencies in a lexical decision task (e.g., via speed versus accuracy instructions; Wagenmakers, Ratcliff, Gomez, & McKoon, 2008). Last, the non-decisional component captures time spent for processing unrelated to the decision such as perception of the target stimulus or execution of the response but also stimulus encoding time (Voss, Voss, & Klauer, 2010). Past applications of the drift diffusion model to PM data with a lexical-decision task as OT have found variations of factual PM task demands to be reflected by changes in the drift rate (i.e., the parameter v) and sometimes in the non-decisional (t0) component (Boywitt and Rummel, 2012 and Horn et al., 2011). This implies that these parameters represent the (dis)engagement in additional resource-demanding PM processing (e.g., monitoring of a different quality, cf. Albinski, Sedek, & Kliegel, 2012). Providing bogus information that the PM target is unlikely to occur (while holding factual task demands constant), on the other hand, has been shown to result in less cautious OT responding as reflected by a less conservative response criterion (i.e., the parameter a) of the drift diffusion model (Boywitt & Rummel, 2012, Experiment 1). Boywitt and Rummel conclude that subjective expectations about PM-task demands are selectively reflected by the parameter a. Therefore, to the extent that making PM predictions increases the perceived importance of the PM task relative to the OT, we would expect response speed decrements to be mirrored by a more conservative response criterion. To the extent that the factual processing demands of the PM task are comparable with and without PM predictions, the other drift diffusion parameters should remain largely unaffected by the present manipulation.

2. Experiment 1

In Experiment 1, we tested whether making PM predictions changes processing in a nonfocal PM task by asking one group of participants to predict their PM performance (i.e., PM-prediction condition) and comparing their performance to a no-prediction control condition. A third group (i.e., PM/OT-prediction condition) made OT performance predictions in addition to the PM predictions to test whether additional OT predictions counteract attentional changes expected with exclusive PM predictions. Importantly, participants in the PM/OT-prediction and the PM-prediction conditions had identical opportunities to rehearse the PM intention when making the PM prediction, thus PM-performance differences between these two conditions should only reflect differences in the engagement of attentional monitoring.

2.1. Method

2.1.1. Participants and design

A total of 145 undergraduates at the University of North Carolina at Greensboro who all indicated English as their first language participated for course credit. Six participants who did not recall the PM task at the end of the experiment were excluded from the analyses. As PM has been show to decline with age (Kliegel, Jäger, & Phillips, 2008), we a priori confined our sample to young adults (aged 18–35). Consequently, one tested participant who was 52-year old was also excluded from the analyses, even though including this participant would not have changed the pattern of results. The final sample consisted of 138 participants (18–33 years, M = 18.95). Participants were randomly assigned to the three experimental conditions (i.e., PM-prediction, PM/OT-prediction, and no-prediction control) with n = 46 in each condition. As we expected a null effect in terms of identical OT performance in the PM/OT-prediction and the no-prediction control condition, the sample-size was chosen on the basis of an a priori power analysis using the software G∗Power (Faul, Erdfelder, Lang, & Buchner, 2007). The achieved power to reveal at least a medium-sized $(\eta_p^2 \geqslant .06)$ difference between the two conditions in a planned-comparison analysis was $1 - \beta = .82$.

2.1.2. Procedure and materials

After signing a consent form, participants received instructions for the lexical-decision task (i.e., classifying letter strings as words or nonwords). This task was introduced as a word judgment task. Participants were instructed to respond by pressing the keys “F” for nonwords and “J” for words (labeled “N” and “Y,” respectively). Participants were ask to use their index fingers for the lexical decisions and were encouraged to be fast and accurate. After completing 20 practice trials (10 words, 10 nonwords), participants received the additional PM instruction to press the “/” key (no finger specified) instead of the “Y” key whenever they saw a member of the animal category in the lexical decision task. To ensure that they understood the instructions, participants repeated them in their own words to the experimenter.

Participants in the two prediction conditions (but not in the control condition) then predicted their task performance. In the PM-prediction condition, participants answered the question “What percentage of the animal words do you think you will detect during the word judgment task?” using a scale from 0% to 100% (Meeks et al., 2007). In the PM/OT-prediction condition, participants answered two additional questions, that is, “What percentage of the strings of letters do you think you will correctly judge as words or nonwords?” (again, using a scale from 0% to 100%) and “How fast do you think you can perform the word judgment task?” (using a scale from 0 = much slower than other participants to 100 = much faster than other participants).2

Next, all participants completed a figural reasoning task for 5 min to prevent rehearsing the PM intention. Then, participants performed 300 lexical-decision trials for which 146 words of medium frequency and 146 nonwords were derived from an online database controlling for length (Balota et al., 2007). For the additional PM task, eight animal names (i.e., “sheep,” “moose,” “zebra,” “rabbit,” “squirrel,” “giraffe,” “elephant,” and “goat,”) were selected as PM targets and presented at trials 60, 90, 130, 160, 200, 230, 260, and 295. These target words were matched to the OT words in frequency and length. On each trial, participants saw a fixation cross in the center of the screen of a random duration between 250 and 750 ms followed by a probe stimulus. The fixation-cross duration was varied to prevent participants from using the inter-stimulus interval for an attentional break (cf. Smith, Hunt, McVay, & McConnell, 2007). After participants responded to the probe stimulus, a new fixation cross was presented after a blank screen of 500 ms.

Upon completion of the lexical-decision task, participants indicated what special words they were supposed to respond to with which special key. As noted, only participants who could recall these instructions were included in the analyses. Finally, participants answered demographic questions and were debriefed.

2.2. Results and discussion

We set an alpha level of .05 for all analyses.

2.2.1. Reactive effects of making predictions on OT performance

Error rates and response times (RTs) in the ongoing lexical-decision task were both submitted to a one-way ANOVA with the between-subjects variable prediction condition (PM-prediction, PM/OT-prediction, No-prediction control) to assess whether making PM predictions affected OT performance (cf. Table 1). Error rates in the lexical-decision task were small (<.08, in all three conditions) and did not vary with conditions, F(2, 135) = 1.19, p = .305, $\eta_p^2 = .02$

Table 1.

Means (standard errors) for performance and metacognitive measures in Experiment 1.

	PM prediction	PM/OT prediction	No prediction
OT error rate	.07 (.01)	.08 (.01)	.07 (.01)
OT response times (ms)	780 (16)	708 (15)	742 (16)
Response criterion (*a*)	1.47 (0.05)	1.32 (0.04)	1.38 (0.05)
Drift rate (*v*)	2.26 (0.07)	2.53 (0.10)	2.41(0.09)
Non-decisional component (*t*0)	0.50 (0.05)	0.50 (0.05)	0.50 (0.05)
PM accuracy rate	.50 (.04)	.45 (.04)	.38 (.04)
PM prediction	.74 (.03)	.73 (.03)	–

Note: PM = prospective memory; OT = ongoing task.

RT-analyses were confined to words in the lexical-decision task, because PM targets were words only and thus word RTs will better reflect any additional PM processing (cf. Hicks et al., 2005). The first four trials of the task as well as any trials including a PM target and the four trials following a PM target were excluded from the RT analyses to control for switch costs associated with these trials (cf. Smith & Bayen, 2004). RTs were trimmed such that values below 300 ms or 2 standard deviations above the individual mean were excluded (cf. Einstein et al., 2005). The ANOVA for RTs revealed a significant main effect of prediction condition, F(2, 135) = 5.18, p = .007, $\eta_p^2 = .04$. 3 We used two orthogonal planned contrasts rather than post hoc comparisons to follow up on the significant main effect, because they allow a more focused test of our hypotheses that attentional PM processing increased after exclusive PM predictions but not after combined PM and OT predictions. Additionally, planned contrasts achieve a higher statistical power (Rosenthal & Rosnow, 1985), and as we expected a null-effect regarding the comparison between the PM/OT-prediction and the control condition a powerful test was warranted. The first contrast compared the PM-prediction condition with the control condition and the PM/OT-prediction condition to test whether attentional monitoring increased after making exclusive PM predictions. In line with our hypothesis, this contrast revealed that RTs were significantly higher in the PM-prediction condition as compared to the other two conditions, t(135) = 2.83, p = .005, d = .50. The second contrast compared the control condition and the PM/OT condition to test for monitoring differences between these two conditions. With good statistical power, the second contrast did not yield significance, t(135) = 1.57, p = .119, d = .30. Thus, in line with our hypothesis, the OT slowing from exclusive PM predictions was significantly reduced to the level of a no-prediction control group by asking participants to additionally predict their OT performance. Notably, RTs in the PM/OT-prediction condition were numerically even faster than in the control condition. Thus, while the significant first contrast implies that exclusive PM predictions caused an additional allocation of attention to the PM intention, the non-significant second contrast demonstrates that there was no such additional allocation of attention when both PM and OT predictions were made. These results demonstrate that the additional OT predictions were effective in avoiding reactive effects of making PM predictions in terms of an additional allocation of attention to the PM intention.

To more clearly interpret the prediction-induced slowing to the OT, we applied the drift diffusion model to the present data. As indicated when modeling lexical decisions with the drift diffusion model (Ratcliff et al., 2004 and Wagenmakers et al., 2008), we first controlled for aberrant RTs using the same trimming procedure and exclusion criteria for post-cue trials as before. Then, trimmed RTs and accuracy rates for words that were not PM targets were submitted to the drift diffusion model (cf. Boywitt & Rummel, 2012) using the software Fast-dm (Voss & Voss, 2007). The upper threshold of the model was associated with a correct word classification, whereas the lower threshold was associated with an incorrect word classification (i.e., classifying a word as a nonword). The parameter z (i.e., the starting point of the diffusion process) was set to a/2 (cf. Boywitt & Rummel, 2012). Individual Kolmogorov–Smirnov goodness-of-fit tests were all non-significant, indicating that the drift diffusion model fit the present data (Voss & Voss, 2008). Next, the three core parameters of the model as well as their inter-trial variability parameters were estimated. As these core parameters have been shown to reflect different attentional processes of PM (Boywitt and Rummel, 2012 and Horn et al., 2011) we computed separate one-way ANOVAs with the between-subjects variable prediction condition (PM-prediction, PM/OT-prediction, No-prediction control) for all three parameters (see Table 1). The ANOVAs did not yield significance for the non-decisional t0 parameter, F < 1, or the processing parameter v, F(2, 135) = 2.31, p = .103, $\eta_p^2 = .03$. However, we found a marginally significant overall effect for the response-criterion parameter a, F(2, 135) = 2.53, p = .084, $\eta_p^2 = .04$. As we aimed to further investigate the OT RT pattern described above with the drift diffusion modeling, we followed up on the marginal effect on the a parameter by computing the same two planned contrasts as for the OT RT analyses. Reflecting the RT results, the first contrast revealed that the a parameter was significantly higher in the PM-prediction condition as compared to the control condition and the PM/OT-prediction condition, t(135) = 2.07, p = .037, d = .36. With good statistical power, the second contrast comparing the control condition and the PM/OT condition did not yield significance, |t| < 1. This pattern of results suggests that the RT results reported above are due to individuals becoming more cautious in their response decisions for a given stimulus after making exclusive PM predictions. In line with previous interpretations of the a parameter as reflecting strategies of how a PM setting is approached (cf. Boywitt & Rummel, 2012), this finding speaks in favor of an additional allocation of attention to the PM task after making exclusive PM predictions and further corroborates the interpretation that PM predictions changed attention allocation within the PM setting.

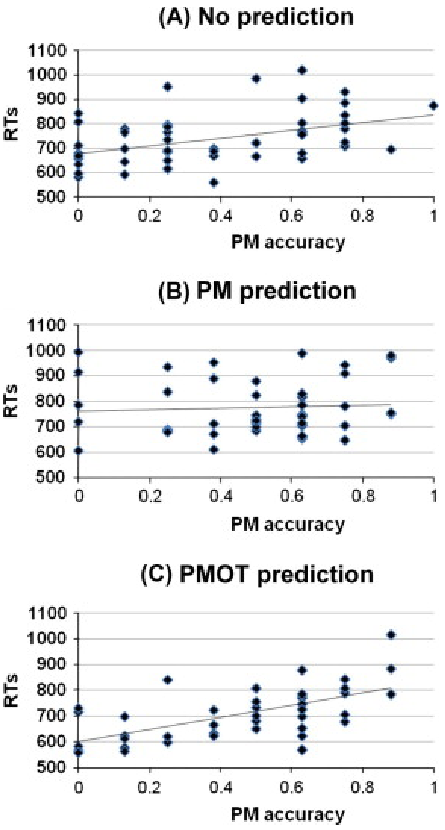
2.2.2. Reactive effects of making predictions on PM performance

Proportions of correct PM responses (i.e., pressing the “/” key to PM-target words) were used to assess PM performance. When applying a strict criterion by counting only immediate (but not late) “/”-key presses as correct PM responses, we found a marginally significant overall effect in a one-way ANOVA with the between-subjects variable prediction condition (PM-prediction, PM/OT-prediction, no-prediction control), $F(2, 135) = 2.57$, $p = .080$, $\eta_p^2 = .04$. [4]LSD comparisons showed that the proportion of immediate PM responses was significantly higher in the PM-prediction condition as compared to the no-prediction control condition, $p = .025$, which replicates previous findings by Meier et al. (2011). The PM/OT prediction did not differ significantly from either the PM-prediction or the control condition, both ps $\geqslant .213$.

A central aim of Experiment 1 was to consider whether PM-performance improvements after PM predictions were due to increased attentional monitoring, facilitated spontaneous retrieval of the PM intention upon encountering a PM cue, or both. Despite their equal additional opportunities to rehearse the PM intention (and perhaps to engage in PM simulation), which should facilitate spontaneous retrieval, only the PM-prediction condition but not the PM/OT-prediction condition achieved a significantly higher PM performance than the no-prediction control condition. Given that the two prediction conditions differed significantly in the level of attentional monitoring but not in PM-performance level, it seems that increased attentional monitoring or the combination of increased monitoring and additional PM rehearsal was effective in improving PM performance. However, PM performance in the PM/OT-prediction condition was numerically higher than in the control condition and the statistical power of this comparison to reveal a small effect was only moderate, so we cannot rule out the possibility of an undetected (small) improvement due to additional PM rehearsal after making both PM and OT predictions.

To investigate whether variations in OT response speed were related to PM performance, we correlated the proportion of correct PM responses with OT RTs separately for each condition. Scatter-plots for these correlations are provided in Fig. 1. These analyses revealed significant correlations in the control condition, $r(46) = .44$, $p = .002$, and in the PM/OT-prediction condition, $r(46) = .49$, $p < .001$, but not in the PM-prediction condition, $r(46) = .10$, $p = .520$. One could assume that attentional PM processing was at ceiling after making exclusive PM predictions, and the reduced correlation reflects experimentally reduced variability of RTs in this group. The Levene test for equality of variances showed, however, that RT variances in all three groups were comparable, F < 1. The variance in the PM-prediction condition was numerically even higher (12404.85) than in the PM/OT-prediction (9920.86) and the control condition (11622.61). Thus, the reduced correlation in the PM-prediction condition is unlikely to be a statistical artifact and rather indicates a dissociation of the OT response speed and PM performance after exclusive PM predictions. Hicks, Marsh and colleagues (Hicks et al., 2005 and Marsh et al., 2003) have reported such a dissociation for PM tasks of various difficulties. The present finding further suggests that even within the same PM task, the relation between OT RTs and PM performance is likely to vary as a function of intention instructions. Specifically, this pattern of results implies that the observed slowing in the PM-prediction condition (as compared to the PM/OT-prediction condition) did not completely translate into functional PM processing, and that this reactivity thereby did not incite an efficient strategic approach. This might explain why Meeks et al. (2007) did not find correlations between OT RTs and nonfocal PM performance in their study where all participants made exclusive PM predictions.

Fig. 1. Scatter-plots reflect the relationship between PM-accuracy rates (ranging from 0 to 1) and response times (RTs) to words (in ms) of Experiment 1. Separate plots are provided for (A) the control conditions where no predictions were made, (B) the PM-prediction condition where the performance in the PM task was predicted only, and (C) the PM/OT-prediction condition where both performances in the PM task and in the ongoing task were predicted.



2.2.3. Accuracy of PM predictions

To evaluate the absolute accuracy of PM predictions, we subtracted the factual proportion of correct PM responses from the predicted proportions and compared these differences against 0 in one-sample t-tests separately for the two prediction conditions. Results showed that participants expected their PM performance to be significantly higher than it actually was in both the PM-prediction condition (M = .23, SE = .05), t(45) = 4.67, p < .001, and the PM/OT-prediction condition (M = .28, SE = .05), t(45) = 6.02, p < .001. As expected, the level of overestimation was comparable in both prediction groups, |t| < 1. Finding a general overestimation of the actual PM performance was unexpected as most other studies reported a PM-performance underestimation (Knight et al., 2005, Meeks et al., 2007 and Schnitzspahn et al., 2011; but see also Devolder et al., 1990) and might stem from procedural differences between the tasks. We will discuss this finding further in Section 4.

Furthermore, we did not find significant correlations between PM predictions and PM performance in the PM-prediction condition, r(46) = .19, p = .202, or the PM/OT-prediction condition, r(46) = .05, p = .768, suggesting that participants had little insight into their own PM performance before the task.

3. Experiment 2

Results of Experiment 1 provided original evidence that making PM predictions reactively changes attentional monitoring in a PM setting with nonfocal targets and that these reactive effects can be partly avoided by additionally asking participants to predict their OT performance. It remains an open question, however, whether attention allocation is similarly affected by making PM predictions in the case of focal targets. With focal PM targets, PM performance should rely more on spontaneous retrieval processes (Einstein & McDaniel, 2005). Although there is an ongoing debate of whether PM can succeed in the complete absence of attentional monitoring (Einstein and McDaniel, 2010 and Smith, 2010), all current theories of PM would agree that less monitoring is necessary to accomplish a PM task when the PM targets become more focal. Indeed, there is empirical evidence that a PM task with a single focal cue results in very high PM performance (i.e., 92% correct responses) while attentional monitoring is reduced as compared to nonfocal targets (Marsh et al., 2003). Given that focal PM performance is very high, one cannot necessarily expect that making PM predictions can further improve PM performance by either increased attentional monitoring or facilitated spontaneous retrieval (cf. Uttl, 2005). It is possible, however, that making PM predictions changes PM processing in a focal PM task, even if the generally high PM performance leaves no room for these processing changes to translate into a PM benefit. To test this assumption, we compared the same three experimental conditions (PM-prediction, PM/OT-prediction, and no-prediction condition) as in Experiment 1 but with a focal PM task.

As the precise and reliable assessment of attentional monitoring in the case of focal targets is a critical issue in PM research (Einstein and McDaniel, 2010 and Smith, 2010), we followed Smith's suggestion to control for inter-individual differences in response latencies by measuring lexical-decision response times in a baseline block where participants did not yet hold an intention. At the same time, we shortened the lexical-decision block with the embedded PM task accordingly to keep the length of Experiments 1 and 2 comparable. Importantly, we also kept the ratio of PM trials to OT trials constant between Experiments 1 and 2, because increasing the proportion of PM trials is likely to increase monitoring (Loft & Yeo, 2007, Experiment 3). Thus, four (instead of eight) PM trials were included in the experimental block of the lexical-decision task in Experiment 2.

3.1. Method

3.1.1. Participants and design

A total of 138 undergraduates of the University of Mannheim, Germany (18–29 years, M = 20.54) who all indicated German as their first language participated for course credit or monetary incentives. All participants correctly recalled the PM instructions at the end of the experiment. Participants were randomly assigned to a PM-prediction condition, a PM/OT-prediction condition, and a no-prediction control condition. Sample-size (n = 46 in each condition) was chosen in accordance with Experiment 1 to achieve comparable power.

3.1.2. Procedure and materials

The procedure was identical to Experiment 1 with the following exceptions. After receiving OT instructions and performing the practice trials, participants first performed 140 lexical-decisions trials before they received PM-task instructions to allow for a baseline measurement of lexical-decision performance. The PM instruction was to press the "/" key instead of the "Y" key whenever they saw a specific word, which was randomly selected for each participant from a body of seven PM-target words. A single PM-target word should be rather focal in the context of a lexical-decision task as the exact word is encoded as intention-relevant and performing the OT already requires word processing (cf. Einstein & McDaniel, 2005). The German translations of the PM-target words from Experiment 1 were used in Experiment 2 as the focal targets. Only the word "squirrel" was dismissed because the German equivalent "Eichhörnchen" would have stood out from the OT stimuli due to its length. After receiving PM instructions and eventually making performance predictions (worded as in Experiment 1), participants performed another 164 lexical-decision trials. The randomly selected PM-target word was presented at Trials 60, 90, 130, and 160.

Instructions from Experiment 1 and PM-target words were translated into German by a native speaker. For the lexical-decision task, 300 words were chosen from a German word-norm database (Hager & Hasselhorn, 1993) to serve as probes with the same selection criteria as in Experiment 1. Nonwords were created by swapping two syllables in half of the words.

3.2. Results and discussion

3.2.1. Reactive effects of making predictions on OT performance

Error rates and RTs in the ongoing lexical decision task were both submitted to a 3 × 2 mixed ANOVA with the between-subjects variable of prediction condition (PM-prediction, PM/OT-prediction, no-prediction control) and the within-subjects variable of block (PM-intention absent, PM-intention present) to assess whether making performance predictions affected OT performance (cf. Table 2). Error rates in the lexical decision task were small (<.07 in all conditions) and did not vary between conditions or blocks, all Fs < 1.5, all ps > .22.

Table 2.

Means (standard errors) for performance and metacognitive measures in Experiment 2.

	PM prediction		PM/OT prediction		No prediction	
	PM intention absent	PM intention present	PM intention absent	PM intention present	PM intention absent	PM intention present
OT error rate	.06 (.01)	.05 (.01)	.06 (.01)	.06 (.01)	.06 (.01)	.07 (.01)
OT response times (ms)	668 (16)	740 (16)	653 (15)	695 (16)	647 (16)	690 (16)
Response criterion (*a*)	1.28 (0.04)	1.31 (0.04)	1.22 (0.04)	1.19 (0.04)	1.20 (0.04)	1.17 (0.04)
Drift rate (*v*)	2.63 (0.09)	2.37 (0.08)	2.77 (0.09)	2.42 (0.08)	2.68 (0.09)	2.36 (0.08)
Non-decisional component (*t*0)	0.46 (0.01)	0.50 (0.01)	0.46 (0.01)	0.50 (0.01)	0.45 (0.01)	0.50 (0.01)

	PM prediction		PM/OT prediction		No prediction	
	PM intention absent	PM intention present	PM intention absent	PM intention present	PM intention absent	PM intention present
PM accuracy rate	.87 (.03)		.85 (.03)		.88 (.03)	
PM prediction	.66 (.03)		.69 (.03)		–	

Note: PM = prospective memory; OT = ongoing task.

RT-analyses were confined to words and trimmed as in Experiment 1. The ANOVA for RTs did not yield a main effect of prediction condition, F < 1.6, but a significant main effect of block, F(1, 135) = 138.75, p < .001, $\eta_p^2 = .51$, with faster RTs in the absence of a PM intention (M = 656 ms, SE = 9) than in the presence of a PM intention (M = 709 ms, SE = 9). Importantly, this main effect was qualified by a significant interaction with prediction condition, F(1, 135) = 4.91, p = .009, $\eta_p^2 = .07$. RTs in the block without the PM-task did not vary with conditions, F < 1. Next, we computed difference scores by subtracting the mean RTs in the block without the PM-task from the RTs in the block with the PM-task. These difference scores reflect PM-induced slowing controlling for a priori response-speed differences between participants. Thus this RT cost measure should be a more sensitive measure of attentional monitoring (cf. Smith, 2010). The ANOVA for RT-difference scores with the between-subjects factor condition became significant, F(2, 135) = 4.91, p = .009, $\eta_p^2 = .07$. We followed up on this main effect using the same two planned contrasts as in Experiment 1 to test our hypothesis that attentional monitoring increases with exclusive PM predictions but not with PM and OT predictions with high statistical power (Rosenthal & Rosnow, 1985). The planned contrast showed that RT-difference scores were significantly higher in the PM-prediction condition (M = 72 ms, SE = 8) as compared to the control condition (M = 43 ms, SE = 8) and the PM/OT-prediction condition (M = 42 ms, SE = 8), t(135) = 3.13, p = .002, d = .51. At the same time, with good statistical power (1 − β = .84) to reveal a medium-sized effect, the PM/OT-prediction condition did not differ from the control condition, |t| < 1. These results match the finding from Experiment 1 that attentional monitoring is increased after making exclusive PM predictions. Furthermore, the results show that, as in Experiment 1, the prediction-induced slowing to the OT is avoided by asking participants to also predict their OT performance.

Again, we applied the drift diffusion model to the trimmed word RT and accuracy data (see Table 2) to follow up on the significant RT results. Individual Kolmogorov–Smirnov goodness-of-fit tests were all non-significant, indicating that the drift diffusion model fit the data. Next, we submitted each core parameter to an ANOVA with prediction condition (PM-prediction, PM/OT-prediction, No-prediction control) and block (PM-intention absent, PM-intention present). The drift rate parameter v decreased with blocks, F(1, 135) = 47.45, p < .001, $\eta_p^2 = .26$, demonstrating that OT processing was less efficient in the presence of a PM intention (M = 2.38, SE = 0.05) than in its absence (M = 2.70, SE = 0.05). The non-decisional t0 component increased with blocks, F(1, 135) = 142.40, p < .001, $\eta_p^2 = .51$, implying that OT responding was slowed by a constant additive factor in the presence of a PM intention (M = 0.50, SE = 0.004) as compared to when the PM intention was absent (M = 0.46, SE = 0.004). This constant factor might reflect some additional checking for PM targets on each trial (Boywitt & Rummel, 2012). No other main effects or interactions reached significance for these two parameters, all Fs < 1. These results suggest that the presence of a PM intention resulted in the engagement of additional processing while performing the OT replicating Horn et al. (2011). As the main purpose of the block without a PM intention was to reduce error variance in terms of a priori differences in response speed, however, we did not counterbalance the order of blocks. Thus, the processing changes from the first to the second block could also reflect a fatigue effect and should be interpreted with caution.

For the a parameter, only the interaction of prediction condition and block yielded significance, F(2, 135) = 3.427, p = .035, $\eta_p^2 = .05$, with all other Fs < 2.10, ps ⩾ .126. To further investigate this interaction, we computed block-difference scores (PM-intention present – PM-intention absent) for the a parameter in each condition. The one-way ANOVA with the between-subjects variable prediction condition (PM-prediction, PM/OT-prediction, No-prediction control) for the a-parameter difference scores was significant, F(2, 135) = 3.427, p = .035, $\eta_p^2 = .05$. Next, we applied the same two planned-contrasts as for the RT analyses. The first contrast revealed that the a-parameter difference score was significantly higher in the PM-prediction condition (M = 0.04, SE = .02) as compared to the control condition (M = −0.03, SE = .02) and the PM/OT-prediction condition (M = −0.03, SE = .02), t(135) = 2.61, p = .010, d = .45. With good statistical power, the second contrast comparing the PM/OT and the control condition did not yield significance, |t| < 1. This pattern of results again implies that making exclusive PM predictions resulted in more cautious responding, likely reflecting an additional allocation of attention to the fulfillment of the intention.

3.2.2. Reactive effects of making predictions on PM performance

Proportions of correct PM responses (i.e., pressing the “/” key to PM-target words) were used to assess PM performance. Again, we applied a strict criterion of only counting immediate PM responses as accurate. Including late PM responses, however, would not have changed the present pattern of results. We did not find reactive effects of making PM predictions on PM performance, F < 1. Notably, PM performance assessment in Experiment 2 was based on four observations only, which might have negatively affected the reliability of this measure. At the same time, the fairly large sample-size should have counteracted caveats from reduced reliability of the PM performance measure. As in other studies with focal PM targets (Einstein et al., 2005 and Marsh et al., 2003), PM-performance was very high in all three conditions, even with only four occurrences of the PM target (see Table 2). Therefore, as argued earlier, the non-significant results might be due to the near ceiling PM performance. Most critically, that does not alter the important result that despite the easiness of the present focal PM task, individuals allocated additional attention to the fulfillment of the PM task after having made exclusive PM predictions.

To investigate whether the variations in the OT response speed were functionally related to the PM-performance level, we correlated the proportion of correct PM responses with the RT-difference scores separately for each condition. Scatter-plots are presented in Fig. 2. These analyses revealed no significant correlations in the control condition, r(46) = .16, p = .294, in the PM-prediction condition, r(46) = −.03, p = .865, or in the PM/OT-prediction condition, r(46) = .11, p = .463. This is in line with previous research showing that PM performance in the case of focal cues requires few attentional resources (Einstein et al., 2005). Thus, the prediction-induced slowing of OT performance was not functional for focal PM performance.

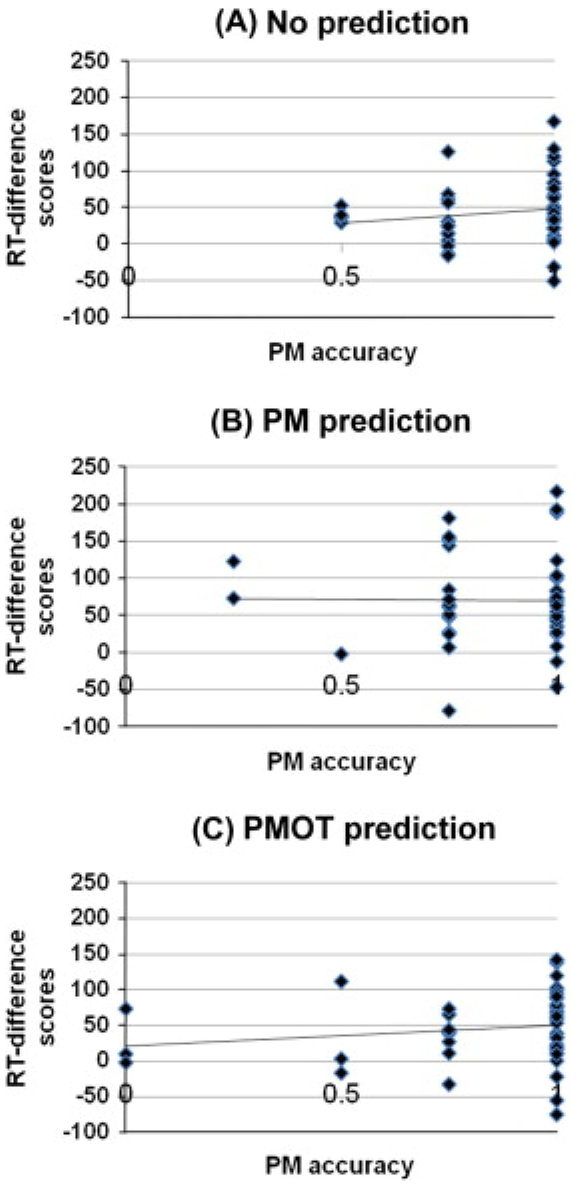


Fig. 2.

Scatter-plots reflect the relationship between PM-accuracy rates (ranging from 0 to 1) and response-time differences (RTs to words in the lexical-decision block where the intention was present minus RTs to words in the block where the intention was absent) (in ms) of Experiment 2. Separate plots are provided for (A) the control conditions where no predictions were made, (B) the PM-prediction condition where the performance in the PM task was predicted only, and (C) the PM/OT-prediction condition where both performances in the PM task and in the ongoing task were predicted.

3.2.3. Accuracy of PM predictions

To evaluate the absolute accuracy of predictions we again subtracted the actual proportion of correct PM responses from the predicted proportion and compared these differences against 0 in one-sample t-tests, separately for the two prediction conditions. Participants in the PM-prediction condition ($M = -.21$, $SE = .04$), $t(45) = -5.95$, $p < .001$, and in the PM/OT-prediction condition ($M = -.17$, $SE = .05$), $t(45) = -3.35$, $p = .002$, expected their PM performance to be significantly lower than it actually was. As expected, the two groups did not differ in the magnitude of underestimation, $|t| < 1$. An underestimation of the actual PM performance is in line with most previous research on this topic (Knight et al., 2005, Meeks et al., 2007 and Schnitzspahn et al., 2011) but it is noteworthy that we found an overestimation of the actual PM performance in the nonfocal PM task in Experiment 1. We will discuss these findings further in Section 4. The correlation between PM performance and PM predictions again did not reach significance in the PM-prediction condition, $r(46) = .11$, $p = .457$, or in the PM/OT-prediction condition, $r(46) = -.09$, $p = .561$, suggesting that PM predictions were insensitive to relative performance level.

4. General discussion

In two experiments, we demonstrated that predicting one's own performance in a PM task reactively changes PM processing. In Experiment 1, replicating previous findings from Meier et al. (2011), we found that nonfocal PM performance increased after making exclusive PM predictions as compared to a control condition without predictions. Importantly, these PM improvements were accompanied by slowed OT responding, which indicates that, after making exclusive PM predictions, participants allocated additional attention to the detection of the PM targets. These results are original evidence that making PM predictions reactively affects attentional PM processes as reflected by an objective processing measure. Furthermore, we showed that making OT predictions in addition to PM predictions counteracted such reactive effects of exclusive PM predictions, with attentional monitoring staying at the level of a no-prediction control condition. Similarly, results of Experiment 2 demonstrated that attentional monitoring in a focal PM task was increased after making exclusive PM predictions. Again, when making PM predictions and additional OT predictions, attentional monitoring was equivalent to the level in a control condition without predictions. These results demonstrate that asking participants to predict their OT performance in addition to their PM performance prevents them from engaging in additional attentional PM processing over and above the level of attention devoted to the PM task when no predictions are made.

In sum, the present findings provide direct evidence that making performance predictions influences the engagement in attentional PM processing. However, our results did not support Meier et al.'s (2011) assumption that asking participants to predict their own PM performance is an efficient strategy to improve (nonfocal) PM performance. Exclusive PM predictions were effective in as much as they resulted in a significant PM performance increase as compared to when no-predictions were made, at least, when late PM responses were not considered as accurate. However, while OT response speed was positively correlated with PM performance in our Experiment 1 with nonfocal cues when no predictions were made or when PM and OT predictions were made, making exclusive PM predictions rendered this correlation non-significant. This correlational pattern suggests that the increase in attentional monitoring after exclusive PM predictions did not completely translate into PM performance improvements, suggesting that these attentional changes were a somewhat inefficient strategic response. Furthermore, when PM predictions and OT predictions were made, individuals achieved comparable PM performance as after exclusive PM predictions despite becoming significantly faster in their OT responding. Similarly, with the focal PM task in Experiment 2, the prediction-induced slowing was unnecessary to achieve a high level of PM performance and OT performance. On the one hand, these findings are further evidence that small changes to the task procedure can affect attention-allocation policies. On the other hand, these findings suggest that one should carefully consider how much consideration is devoted to unfulfilled intentions, because exclusive rumination on unfulfilled intentions (or on their likelihood of being fulfilled) may come with a cost to other ongoing activities that is not completely functional for intention fulfillment.

The finding of reactive effects of PM predictions also has general implications for investigating metamemory in the domain of PM. That is, the present demonstration that making PM predictions increases attentional monitoring for PM-target cues in both nonfocal and focal PM tasks highlights the importance of taking reactive effects of PM predictions into account when interpreting their accuracy. However, the present findings also suggest a simple (design-based) way of counteracting some of these reactive effects. When participants were not only asked to predict their PM performance but also to predict their OT performance, attentional monitoring was comparable to and nominally even lower than when no performance predictions were made. This finding indicates that the additional OT-prediction resulted in a de-allocation of attentional resources from the PM task as compared to the group that made PM predictions only. Alternatively, one could argue that predicting both the PM and the OT performance increased the overall level of attention devoted to the task setting consisting of the PM task and the OT.5 This alternative interpretation of the present results would imply that lexical-decision performance should have been more efficient in the PM/OT-prediction condition as compared to the PM-prediction condition and the No-prediction control condition. We cannot completely rule out this alternative interpretation, but the additional drift–diffusion model analyses provide some contradictory evidence. Changes in the parameter a of the drift–diffusion model are associated with a more or less cautious responding in a lexical-decision task while changes in the parameter v are associated with variations in the processing efficiency (Ratcliff et al., 2004 and Wagenmakers et al., 2008). In both Experiments 1 and 2, only parameter a but not parameter v varied with conditions, implying that participants in the PM/OT-prediction condition were not overly efficient in their processing as compared to the other groups. Therefore, results of the drift diffusion analyses are more in line with the interpretation that the exclusive PM prediction resulted in an allocation of attention from the OT to the PM task and that the additional OT prediction counteracted this attentional shift.

Even after the readjustment of attentional monitoring via additional OT predictions, however, absolute PM predictions were rather inaccurate. In Experiment 2, participants underestimated their PM performance, independent of whether additional OT predictions were made or not. This is in line with most previous research on the accuracy of PM performance predictions (Knight et al., 2005, Meeks et al., 2007 and Schnitzspahn et al., 2011; but see also Devolder et al., 1990). In Experiment 1, PM predictions with and without additional OT predictions were also inaccurate, but participants significantly over-estimated their PM performance. Based on this findings, one could simply argue that PM predictions, just as some ever-day PM questionnaires (Uttl & Kibreab, 2011), are not overly valid, because they are not in line with the objective criterion (i.e., PM performance).6 However, in the present study, participants were ask to predict their performance in a task and then actually had to perform the task they made predictions for. Thus, PM predictions have a high face-validity. Nevertheless, criterion-validity was low, that is, PM predictions and actual PM performance data did not converge, and the question is why this was not the case. One could speculate that cultural differences play a role for the different estimation tendencies in Experiments 1 and 2, but the specific pattern of results indicate that these play a minor role at most.7 A more compelling explanation for these inconsistent findings might be that, especially in laboratory settings, individuals have no prior task experience to rely on in their PM predictions and thus they might anchor their predictions on information provided in the instructions (Rummel & Meiser, submitted for publication), follow general expectations about their own competence (cf. Hertzog & Hultsch, 2000), or follow a self-serving bias by expecting themselves to be above-average (cf. Chambers & Windschitl, 2004), as indicated by the middle-point of the scale. If the objective difficulty of the PM task is then quite high and thus the PM performance rather low, as in our first experiment, these ill-calibrated performance-predictions are likely to result in an overestimation of the actual PM-performance. If the actual PM performance is quite high as in our second experiment, however, they are likely to result in an underestimation of the actual performance.

While the present research suggests a design-based attenuation of reactive effects of PM predictions on attentional PM processes, future research is necessary to develop methods of better calibrating PM predictions. In line with findings that delayed retrospective memory predictions tend to be more accurate (Nelson & Dunlosky, 1991), Schnitzspahn et al. (2011) recently demonstrated that delayed PM predictions are more accurate than immediate ones, probably because individuals experience how likely they are to remember the intention. Future research should also consider that absolute predictions are likely to be contaminated by biases such as those described above.

Despite the caveats for assessing expectancies about PM performance via performance predictions, we believe that PM predictions are a useful tool to better understand the cognitive strategies individuals engage to remember intentions. The finding that performance predictions reactively change the processing in a PM task is further evidence that metamemory can affect attention allocation strategies in PM (cf. Einstein & McDaniel, 2008). This finding also demonstrates, however, that such direct questioning can have some pitfalls, which researchers using PM predictions should take into account when interpreting their results.

Acknowledgments

We thank Donna Lee, Verena Glöckler, Jonathan Heckeroth, Elana McHenry, and Franka Vontz for help with data collection.

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Notes

1 Meeks et al. (2007) examined two different kinds of PM-target conditions. That is, participants were asked to respond to members of the animal category or to the syllable “tor” with the PM key. Both making category inferences and engaging a perceptual search for a syllable should not

rely on the same processes as making lexical decisions. Thus both kinds of PM-targets can be considered as nonfocal (cf. Einstein & McDaniel, 2005).

2 As previous research has shown that a speed versus accuracy focus in the ongoing task affects monitoring processes (Meiser & Schult, 2008), we decided to ask participants to predict both the accuracy and the speed in the ongoing task to avoid inducing a reactive speed or accuracy bias.

3 To rule out that the condition main effect was driven by a priori response-speed differences between experimental groups, we also analyzed the word RTs of the practice block. The ANOVA of prediction condition for practice-block RTs suggested that a priori response speed was comparable between the PM-prediction ($M = 782$; $SE = 30$), the PM/OT-prediction ($M = 771$; $SE = 30$), and no-prediction control condition ($M = 797$; $SE = 30$), $F < 1$.

4 When applying a more lenient criterion by counting both immediate PM responses as well as late PM responses (i.e., pressing the “/” key within the inter-stimulus interval after having pressed the “Yes” or “No” key in response to a PM target) as correct PM responses, we did not find evidence for reactive effects of making PM predictions on PM performance, $F(2, 135) = 1.61$, $p = .204$, View the MathML source. This outcome suggests that allowing late PM responses can reduce the sensitivity to subtle manipulations of PM processing strategies (see also Boywitt & Rummel, 2012, Experiment 1). The data in Table 1 refers to the application of a strict criterion and, if not indicated otherwise, we will apply the strict criterion for the following analyses.

5 We thank an anonymous reviewer for pointing out this possibility.

6 We thank an anonymous reviewer for bringing up this issue.

7 The German participants of our Experiment 2 tended to underestimate their PM performance just as the American participants in the study from Meeks et al. (2007). Additionally, we also found an underestimation of PM performance in a focal task in a sample of American (UNCG) students in another unpublished experiment. The UNCG students of our Experiment 1, on the other hand, tended to overestimate their performance in a PM task, which was largely comparable to the one Meeks et al. reported an underestimation with. The other studies on PM predictions, which included samples from Germany, Switzerland, New Zealand, and the US did not show a consistent pattern of culture-dependent PM over- and under-estimation.