NIH Public Access

Author Manuscript

Conscious Cogn. Author manuscript; available in PMC 2015 July 01.

Published in final edited form as:

Conscious Cogn. 2014 July ; 27: 213–230. doi:10.1016/j.concog.2014.05.003.

Investigating How Implementation Intentions Improve Non-Focal Prospective Memory Tasks

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Abstract

Implementation intentions are a self-regulatory strategy broadly studied in the area of social cognition that can improve realization of one's goals and improve performance on prospective memory tasks. Three experiments, using a non-focal task for which the prospective memory targets were specified at the time of intention formation, investigated whether (and how) implementation intentions can improve non-focal prospective memory performance. An improvement in prospective memory performance was accompanied by an increase in the allocation of conscious resources to the prospective memory task, but not by an increase in perceived importance of the prospective memory task. The third experiment also investigated the effects of implementation intentions on recall of the appropriate action and found that accurate action recall was improved by implementation intentions. Finally, the effect of implementation intention instructions on cognitive processes that underlie non-focal prospective memory performance was investigated using a multinomial model.

Keywords

prospective memory; implementation intentions; conscious resources; multinomial modeling; importance

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1. Introduction

In our daily lives we often must remember to perform an action that cannot be carried out immediately, but that must be performed in the future. This type of memory task, called Prospective Memory (PM), is fundamentally important to our daily lives. For instance, failing to remember to perform a task after being asked to do so by a spouse or boss can, at the very least, lead to irritation and could lead to even more unpleasant outcomes. Thus, improving the ability to remember to perform these tasks could have important benefits in many situations and prior research has shown that PM can be improved through the application of a self-regulatory strategy known as *implementation intentions* (Brewer & Marsh, 2010; Brom, Schnitzspahn, Melzer, Franziska, & Kliegel, in press; Chasteen, Park, & Schwarz, 2001; Liu & Park, 2004; McDaniel, Howard, & Butler, 2008; McDaniel & Scullin, 2010; McFarland & Glisky, 2011, 2012; Meeks & Marsh, 2010; Schnitzspahn & Kliegel, 2009).

Implementation intentions, compared to standard PM instructions in full attention conditions, have been consistently shown to improve the PM of young adults in the laboratory when using *focal* PM tasks; where the ongoing task requires processing of the relevant characteristics of targets (McDaniel et al., 2008; McDaniel & Scullin, 2010; McFarland & Glisky, 2012; Schnitzspahn & Kliegel, 2009; see Table 1)[1]. In contrast, as shown in Table 2, under non-focal PM conditions, where targets are not highly integrated with ongoing task processing, findings have been more variable, with some studies showing a benefit of implementation intentions (Brewer & Marsh, 2010; Meeks & Marsh, 2010), and others not (Chasteen et al., 2001; Zimmermann & Meier, 2010). Many PM tasks in our everyday life and in work settings would be considered non-focal to ongoing task activities; therefore it is important to further examine the extent to which implementation intentions can facilitate non-focal PM.

Furthermore, when there has been improvement in non-focal PM with the use of implementation intentions, it has come at increased allocation of conscious resources to the PM task, at the expense of the ongoing task, when compared to standard PM encoding conditions (Meeks & Marsh, 2010). This increased allocation of conscious resources to the PM task might limit the applicability of implementation intention techniques to non-focal PM situations where errors or slowed performance on ongoing tasks could have dire consequences, such as the ongoing task demands performed by an air traffic controller (Loft & Remington, 2010; Loft, Smith, & Bhaskara, 2011; Loft, Smith, & Remington, 2013) or by medical professionals (Grundgeiger, Sanderson, MacDougall, & Venkatesh, 2010). Techniques that can improve non-focal PM without increasing the extent to which PM tasks draw on our limited span of consciousness, and therefore not having a negative effect on ongoing task performance, would be of particular interest in many situations where the ongoing task is demanding and important. Before applying implementation intentions to such applied situations in which ongoing task performance cannot be sacrificed, it is

[1]Effects of implementation intention instructions when combined with divided attention tasks are mixed, as can be seen in Table 1. This mixed pattern of findings is discussed in Section 5.5. Marsh and Meeks (2010) used a focal task in their third experiment, but PM performance was at ceiling.

important to understand the way in which implementation intentions lead to improved non-focal PM in the laboratory and in particular to understand how implementation intentions affect the engagement of conscious processing.

We used several approaches to investigate the effects of implementation intentions on non-focal PM. First, ongoing task performance served as an indicator of whether non-focal PM can be improved without increasing the conscious resource demands associated with the PM task. The second approach involved the application of a multinomial model to measure how implementation intentions affected the underlying cognitive processes involved in successful PM performance. The third approach involved measuring how implementation intentions affected participants' perceptions regarding the relative importance of the PM and ongoing tasks.

1.1 Implementation Intentions and Event-based Prospective Memory

Implementation intentions are special intentions that take the following form: "If Situation X is encountered, then I will perform Behavior Y!" (Brandstätter, Langfelder, & Gollwitzer, 2001, p.946). Brandstätter et al. argue that by forming an implementation intention a link is created between the action and target event that commits the individual to performing the action when the event occurs. This is in contrast to a goal intention in which the individual is committed to a goal outcome, but not to a specific action in a particular context. Implementation intentions have been shown to improve the likelihood of carrying out everyday goal related actions such as self-examination of breasts (Orbell, Hodgkins, & Sheeran, 1997), attendance at cancer screening appointments (Orbell & Sheeran, 2000) or taking vitamins (Sheeran & Orbell, 1999). Brandstätter et al. argued that forming implementation intentions "helps goal pursuit by automatizing the initiation of a distinct goal-directed response in the presence of a certain critical situation" (p. 958), which in turn increases the likelihood that the behavior will occur. In the PM literature, forming implementation intentions is argued to increase the salience of PM targets or to strengthen the relationship between the PM targets and intended actions, allowing PM actions to be spontaneously retrieved when targets are processed as part of ongoing tasks, with relatively little need for the allocation of conscious resources to the PM task (Gollwitzer, 1999; McDaniel & Scullin, 2010; Rummel, Einstein & Rampey, 2012).

PM tasks involve several components that may be influenced by implementation intentions: the retrospective recall of *what* is to be done (e.g., buy milk), the recognition of the event that signals *when* the action should be performed (e.g., when I see the grocery store) and remembering *that* you are supposed to do something (e.g., I need to interrupt my usual drive home to do something else). The "what" and the "when" make up the retrospective components of PM, while remembering "that" an action needs to be performed is the prospective component of PM. In the current study we use multinomial modeling to investigate how implementation intentions differentially impact these components of the PM task.

1.2 Implementation Intentions and Non-focal PM Tasks

As discussed in section 1.0, the effects of implementation intentions on non-focal PM have been mixed. Chasteen et al. (2001) found the implementation intention provided no benefit to participants required to make a PM response when a background border pattern changed during an ongoing computerized work recall task. However, because the background pattern was completely irrelevant to the ongoing recall task, it may not have been processed to the minimum level required to allow implementation intentions to facilitate target recognition. If implementation intentions improve PM by strengthening the association between the target and the action, thereby increasing the likelihood that processing of the target event will lead to retrieval of the intention, the target event must be processed for implementation intentions to improve PM.

Subsequent studies overcome this limitation by asking participants to make the PM response if they saw an animal word (Brewer & Marsh, 2010; Meeks & Marsh, 2010; Zimmermann & Meier, 2010), or in other experiments if they saw a word that contained the syllable “tor” presented in ongoing lexical decision task (Meeks & Marsh, 2010). The PM task of detecting exemplars of categories or syllables in words is non-focal because lexical decision does not require processing of the features of letter strings necessary to make a category determination or for detecting syllables. However, using word targets or syllable targets in an ongoing lexical decision task ensured that non-focal targets were at least minimally processed as part of ongoing task activity. Despite this, only two (Brewer & Marsh, 2010; Meeks & Marsh, 2010) of these three studies demonstrated a benefit to non-focal PM with implementation intentions. Zimmermann and Meier (2010) did not find a benefit from implementation intentions. In addition to differences in the effects of implementation intentions on non-focal PM, these studies differed with respect to the effects of implementation intention instructions on the allocation of conscious resources to the PM task as reflected by ongoing task performance.

Meeks and Marsh (2010) found that their benefit to PM with implementation intentions was accompanied by increased cost to the ongoing task. Cost to the ongoing task is investigated by comparing ongoing task performance for a condition in which the PM task is to be performed with ongoing task performance for a condition that performs only the ongoing task without a PM task. Cost is thought to reflect a reallocation of conscious capacity away from the ongoing task in service of processing related to the PM task. In Meeks and Marsh’s study, implementation intention produced a greater cost to the ongoing task when compared to standard PM encoding conditions (note that Brewer & Marsh, 2010, did not report ongoing task performance). This is interpreted as indicating that implementation intentions affect PM performance by increasing the allocation of conscious capacity to the PM task. Zimmermann and Meier (2010) did not find increased costs, but also did not report enhanced non-focal PM with implementation intentions. In summary, findings regarding whether implementation intentions can benefit non-focal PM are mixed, but when facilitation of PM has been found it has been accompanied by increased costs. This suggests that forming implementation intentions may increase the extent to which conscious resources are allocated to the PM task.

1.3 The Current Study

In the current experiments, we used an ongoing color matching task (Smith & Bayen, 2004, 2006) which required participants to decide whether a word was presented in a color that matched one of the four previously presented color rectangles. The PM task required participants to press the F1 key if the word presented was any one of six previously studied words. This PM task is non-focal because deciding whether a colored word matches previously presented colored rectangles does not require the actual word to be lexically processed. However, the classic Stroop effect shows that when the name of a color is printed in a color not denoted by the letter string, the naming of the color of the word takes longer and is more error prone than when the color of the ink matches the name of the color (MacCleod, 1991). Thus, unlike the Chasteen et al. (2001) study, it is highly likely that our non-focal targets will be processed to at least some minimal level.

Furthermore, the current experiments address an additional potential limitation of prior studies (Brewer & Marsh, 2010; Meeks & Marsh 2010; Zimmermann & Meier, 2010), in which the non-focal tasks were such that the particular target was not presented during encoding. Thus, the specific target words used "could not have been anticipated during intention formation" (Meeks & Marsh 2010, p. 87). If the benefits of implementation intentions result from the strengthening of the relationship between the specific target event and the intended action, the tasks used in previous research may have been less than ideal for extracting the full benefits of implementation intentions; thus, the increased cost, and in the case of the Zimmermann and Meier (2010) study, the lack of benefit to PM could be due to the type of non-focal task used. The current experiments examine the effects of implementation intentions on PM and the allocation of conscious resources when using a non-focal task in which the specific target events are present at the time of intention formation.

Finally, Meeks and Marsh (2010) suggested that implementation intention instructions could serve to emphasize the importance of the PM task. In the standard PM task, participants are asked to make a certain response if the target words appear. In the implementation intention conditions participants are also asked to say or write an If-then sentence regarding the PM task and in some cases also imagine seeing the targets and making the response. In other words, the instructions in the implementation intention condition are more extensive and require more involvement on the part of the participant and, although the instructions do not state that the PM task is more important than the ongoing task, participants may perceive this to be the case. This possibility has not been investigated empirically in previous research. Therefore, in our first experiment we directly compare implementation intention instructions with instructions that emphasize the importance of the PM task and in all three experiments we included a post-test question concerning the participants' perceptions of task importance.

1.4 Multinomial Model of Event-based Prospective Memory

While cost to the ongoing task can provide useful information about how techniques for improving PM affect conscious resource allocation, there are some limitations to this approach and employing multiple data analytic approaches can be advantageous (Smith, 2010), therefore, the current study uses a multinomial model that includes parameter *P* that measures the prospective component and parameter *M* that measures retrospective recognition memory processes needed for discriminating between target and non-target events.[2] The current ongoing task is a non-focal task and therefore the prospective component is thought to require resources according to the multiprocess view (Einstein & McDaniel, 2010). The preparatory attentional and memory processes (PAM) theory also predicts that the prospective component would require conscious resources (Smith, 2003, 2008, 2010). The PAM theory proposes that successful PM depends on the engagement of preparatory attentional processes that allow us to be prepared to make a response that is different from the responses required by the ongoing task. These processes can involve explicit monitoring for the target event, but can also occur on the periphery of consciousness (Smith, 2008; Smith et al., 2007). Because the prospective component in the current task is predicted to require conscious resources by both the multiprocess view and the PAM theory, the processes involved in the prospective component will be referred to as preparatory attentional processing.

Increases in preparatory attentional processing (parameter *P* in the multinomial model) can be accompanied by increases in the allocation of conscious resources to the PM task as reflected in the cost to the ongoing task (Smith & Bayen, 2004), and individuals with higher working memory capacity have higher estimates of P (Smith & Bayen, 2005). These types of findings indicate that parameter *P* is measuring processes that draw on conscious resources. If the increase in non-focal PM with implementation intentions is accompanied by an increase in the need for conscious processing, there will be an increase in estimates of *P* for the implementation condition compared to standard PM condition. If the formation of implementation intentions increases the likelihood that non-focal targets embedded in ongoing tasks can be recognized because of the strong connection between the target and the action, the action should more likely be retrieved when the target event occurs, but this should not increase the likelihood that the action is retrieved on non-target trials. Taken together, this should facilitate the ease with which target and non-target events can be discriminated from one another. This leads to a prediction that implementation intentions will increase, relative to standard instructions, parameter *M*, which reflects the retrospective recognition component in the multinomial model. Furthermore, this increase in target recognition might occur without a change in the extent to which conscious resources are allocated to the PM task; in this case PM performance would be improved while the estimates of *P* remain unaffected. Additional model details can be found in Appendix A.

2.0 Experiment 1

Experiment 1 included three PM conditions: a standard PM condition, a condition in which the importance of the PM task was emphasized, and an implementation intention condition. We also included a no-PM control condition. Based upon previous research we expected that emphasizing the importance of the PM task would increase PM performance, the

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[2]Although the model does not capture the processes for recall of the action, we used a single simple action, checked for recall of the action at the end of the PM task, and in Experiments 1 and 2 replaced participants who failed to recall the action. Finally, the third experiment includes a measure of action recall separate from the model, but one that occurs at the time that the PM task is to be performed, as opposed to evaluating action recall after the task is completed.

allocation of conscious resources as reflected by costs to ongoing tasks, and estimates of the *P* parameter, compared to the standard PM condition (e.g., Loft & Yeo, 2007; Smith & Bayen, 2004). As reviewed earlier, were we primarily interested in whether we would find benefit to non-focal PM with implementation intentions, and the extent to which increased conscious resources allocated to the PM task, or enhanced target recognition, drives this benefit.

2.1 Method

2.1.1 Participants and design—The 101 participants, who were native English speakers and received credit towards a course requirement as compensation, were randomly assigned to one of four conditions: no intention control, standard PM, emphasis on the importance of the PM task (PMI), and implementation intention (II). The control condition included 20 participants while the three PM conditions included 27 participants each.

2.1.2 Materials and procedures—The materials matched those used in Smith and Bayen (2006) and included two sets of 6 target words. Results did not differ as a function of list assignment, which was counterbalanced.

Participants began each trial of the color-matching task by pressing the space bar. Four different color rectangles (83 × 60 pixels) were shown in the center of a black screen for 500 ms each followed by a 250 ms blank screen, followed by a word (18 point font) either in a color that matched one of the four color rectangles (a match trial) or in a fifth color (a non-match trial). Participants pressed the Y or N key to indicate a color-match or non-match. Participants completed two practice trials followed by two blocks of 62 color-match trials. In the control condition participants completed the ongoing task alone in both blocks. In the three PM conditions the PM task was embedded in the second block of color-matching trials.

At the end of this first block of color-matching trials, participants in the three PM conditions read the following instructions: "After reading additional instructions you will complete a puzzle task. When the puzzle task is over you will finish the second part of the color-matching task. While completing the color-matching task, there will also be another task for you to remember to perform. In a moment you will learn some words. When you see one of these words during the color-matching task, please try to remember to press the "F1"."

Participants in the II condition received the following additional instructions: "In order to help you perform the F1 key task please do the following things while learning the special words. When each of the special words appears imagine yourself pressing the F1 key. Also silently say the following to yourself: When I see the word (insert the particular word here) I will press the F1 key." We followed the procedures used in studies that have reported benefits of implementation intentions for non-focal PM (Brewer & Marsh, 2010; Meeks & Marsh, 2010), which combined implementation intention and imagery instructions, in order to maximize the likelihood of finding an effect of implementation intentions. Forming implementation intentions by having participants say the statement to themselves has also been done previously (e.g., Brandstätter et al., 2001).

Participants in the PMI condition received the following additional instructions: "IT IS VERY IMPORTANT THAT YOU DO NOT MISS ANY OF THE SPECIAL WORDS. Please try hard to remember to press the F1 key if you see one of the words. This is the part of the task that we care the most about."

The six target words were displayed on the computer screen for 3 seconds each with a 5 second break after each word. After presentation of the target words, all participants worked on a non-verbal solitaire puzzle for four minutes. After the puzzle task participants completed the second block of the color-matching task, without further mention of the PM task. Target words appeared on trials 10, 20, 30, 40, 50, and 60 of the second block.

At the end of the second block, participants in the PM conditions recalled the targets and were asked which task they believed to be the more important task. Participants responded to the importance question by selecting one of three possible answers: the color-matching task was more important, the F1 key task was more important, or both were equally important. Due to an experimenter error, responses to target recall and the importance question were not saved for six participants in the standard condition and 3 participants in the II condition.

2.2 Results and Discussion

2.2.1 Prospective memory performance and post-test target recall—The proportion of PM target trials for which the participant pressed the F1 key, shown in Figure 1, was significantly affected by instruction condition, $F(2,78) = 3.19$, $MSE = .08$, $p = .047$, $\eta_p^2 = .08$.[3] Planned comparison showed that participants in both the PMI condition, $t(52) = 2.05$, $p = .046$, $d = .62$, and the II condition, $t(52) = 2.26$, $p = .028$, $d = .55$, were more likely to perform the PM task than were participants in the standard condition. Experiment 1 adds to the two previous studies showing that implementation intentions can improve non-focal PM (Brewer & Marsh, 2010; Meeks & Marsh, 2010). The three PM conditions did not differ with respect to recall of the target words following the second block of color-matching trials, $F < 1$, $p > .54$, $M = .63$, $SEM = .02$.

2.2.2 Ongoing task accuracy—In keeping with previous research (e.g., Smith & Bayen, 2004) we excluded target trials and trials following each target from the analyses of ongoing task performance, including only the four trials immediately preceding each target trial. This allowed us to avoid finding a cost that was simply an artifact of carrying out the PM action or thinking about just having seen a target word. Prior to examining cost to the ongoing task, baseline accuracy was subjected to a 4×2 mixed ANOVA with the between subjects factor of condition and within-subjects measure of trial type (match and non-match). Neither the main effect of trial type, $F(1,97) = 1.54$, $p = .22$, nor the main effect of instruction condition, reached significance, $F < 1$, $p > .65$ and the variables did not interact, $F < 1$, $p > .87$. The mean proportion of accurate responses in the baseline block was .93, $SEM = .007$. Given that there were no significant effects on baseline accuracy, an accuracy difference score was

[3]Our initial analyses of PM performance included the within-subjects factor of trial type (match versus not match). In no case was the effect of trial type significant, across experiments all *F*s < 1, *p*s > .47. The variables of instruction condition and trial type did not interact in Experiment 1, $F(2,78) = 1.04$, $p > .35$, or Experiments 2 and 3, *F*s < 1, *p*s > .71.

computed for each participant by subtracting the participant's baseline accuracy from accuracy in Block 2. These accuracy difference scores did not vary as a function of condition, $M = -.03$, $SEM = .008$, $F < 1$, $p > .93$. Thus, as in previous experiments, a cost to ongoing color-matching task accuracy was not present (e.g. Smith & Bayen, 2004; Smith et al., 2007).

2.2.3 Ongoing task response times—In this and the following experiments, only accurate trials were included in the analysis of response times. Response times that were less than 300 ms or more than 3 standard deviations greater than the mean were excluded. In each experiment, trimming, which was based upon individual participant means and standard deviations calculated separately for each trial type and each block, resulted in the exclusion of less than 2% of trials. Baseline response times did not differ as a function of either trial type, $F < 1$, $p > .43$, or instruction condition, $F(3,97) = 1.36$, $p = .26$, and the two variables did not interact, $F < 1$, $p > .51$. The mean baseline response time was 1296 ms, $SEM = 31$.

Response time difference scores, shown in Figure 2, were calculated by subtracting each participant's mean response time for Block 1 from their mean response time in Block 2. The response time difference scores were significantly affected by instruction condition, $F(3,97) = 19.80$, $MSE = 169134$, $p < .001$, $\eta_p^2 = .38$. Planned comparisons demonstrated a cost in all three PM conditions. The standard condition, $t(45) = 6.19$, $p < .001$, $d = 1.92$, the II condition, $t(45) = 7.16$, $p < .001$, $d = 2.25$, and the PMI condition, $t(45) = 7.43$, $p < .001$, $d = 2.32$, all had larger difference scores relative to the control condition. This cost is expected given that the targets were non-focal. Planned comparisons showed that the standard condition had smaller difference scores than both the II condition, $t(52) = 2.28$, $p = .027$, $d = .62$, and PMI condition, $t(52) = 2.49$, $p = .016$, $d = .68$. The latter two conditions did not differ, $t < 1$, $p > .86$. Therefore, we replicated the finding of Meeks and Marsh (2010) that implementation intentions both facilitated PM and increased costs compared to the standard condition.

2.2.4 Modeling results—In all three PM conditions the model provided a good fit to the data: $G^2(4) = 3.88$, 2.03, 2.46, in the standard, II, and PMI conditions respectively, all of which are smaller than the critical value of 9.49, all *p*s > .42. The estimates for parameter *P*, which measures the likelihood of engaging in preparatory attentional processing, are shown in Figure 3. Both the II condition, $G^2(1) = 14.69$, $w = .07$, $p < .001$, and the PMI condition, $G^2(1) = 14.03$, $w = .06$, $p < .001$ differed from the standard group with respect to preparatory attentional processing, but the former two conditions did not differ from one another, $G^2(1) = .005$, $p = .95$. The estimates for parameter *M*, which measure the retrospective recognition processes involved in correctly discriminating between target and non-target events, are shown in Figure 4. The estimates of *M* did not differ between the II and the PMI conditions, $G^2(1) = 0.04$, or between either of these conditions and the standard condition, $G^2(1) = 1.90$ and 2.36, respectively, *p*s > .11. Thus, as with the PM performance and ongoing task response times, the II and PMI instructions had similar effects on the cognitive processes measured by the multinomial model, specifically, the improved PM performance was attributable to increased preparatory attentional processing in both cases.

2.2.5 Importance—Following completion of the second block of color-matching trials participants in the PM conditions were asked which task was more important, with the three response options of the PM task, the ongoing task, or the tasks were equal in importance. Response distributions are shown in Table 3 for each of the three PM conditions. Responses to this question were not normally distributed and arguably are measured on an ordinal rather than an interval scale; therefore Mann-Whitney tests were applied to determine if the groups differed from one another in the distribution of responses. The distribution of responses in the standard PM condition did not differ from the distributions for either the II group, $z = -1.29$, $p > .19$, or the PMI group, $z = -1.41$, $p > .15$, but the response distributions for the II and PMI groups were significantly different from one another, $z = -2.80$, $p = .005$. The response distribution for the PMI condition differed from what would be expected by chance with more participants selecting the PM task as important combined with fewer selecting the ongoing task or that the tasks were equal than would be expected if responses were random (chi-square test results for each condition are shown in Table 3; chance = 9 participants in a cell for the PMI condition). This was not the case for the II group, nor for the standard PM group, neither of which had distributions that were significantly different from random.

Although the PMI and II conditions mirrored each other on all previous measures, participants' responses to the importance question suggest that the two instructions have different effects on perceived importance. Of course, the increase in participants selecting the PM task as more important in the PMI condition could be a result of participants attempting to comply with experiment demands: participants in the importance condition may have selected the PM task as more important because they had been instructed that it was supposed to be more important. On the whole however, the results suggest that an increase in perceived importance is not driving the effects of implementation intentions.

3.0 Experiment 2

As described in Sections 1.0 and 1.2, the effects of implementation intentions on non-focal PM performance and on the allocation of conscious resources have been mixed in prior studies. Therefore it is important to replicate the finding from Experiment 1 that implementation intentions, relative to standard PM instructions, can improve PM performance and that this comes at a greater cost to the ongoing task. Thus, Experiment 2 included two PM conditions, a standard condition and an implementation intention condition, along with a no-PM control condition. In Experiment 1 implementation intention instructions did not affect the *M* parameter, perhaps because there was insufficient time provided for fully forming the strong if-then link between the target and action. In Experiment 1, each target was shown for 3 s followed by a 5 s interval during which time the participant was to imagine pressing the key and to silently say to themselves the if-then statement. This relatively short duration was selected in Experiment 1 in order to avoid ceiling effects on the *M* parameter (Smith & Bayen, 2004). However, it is possible that the encoding times were insufficient to fully realize the benefits of the implementation intention encoding procedure on the recognition of non-focal PM targets. Therefore, in Experiment 2, each target was shown for 10 seconds.

3.1 Method

3.1.1 Participants and design—The 120 native English speakers, who received course credit for participation, were randomly assigned to one of three conditions: standard, implementation intention (II), or no-PM control. The control condition included 30 participants, while each of the PM conditions included 45 participants.

3.1.2 Materials and procedures—The materials and procedures matched those of Experiment 1 with the following exceptions. The PM instructions in Experiment 1 referred to the target words as “special” words. In order to counter any possibility that this created an unnecessary emphasis in the standard PM conditions, which could mask any differential effect of implementation intentions on perceived task importance, we did not refer to the target words as special words in Experiment 2. Second, the time to encode the target words was increased. As noted in section 3.0, the presentation duration for encoding the target words was extended to 10 s. Third, the occurrence of the target events was changed to vary the interval between target events. In Experiment 2 the number of trials between target events varied between 8 and 13. Finally, because the model parameter *M* measures retrospective target recognition, we switched from the recall test used in Experiment 1 after the second block of color-matching trials to a recognition test that included the six target words and six words that had appeared on non-target trials in Block 2.

3.2 Results and Discussion

3.2.1 Prospective memory performance and target recognition—As can be seen in Figure 1, participants in the II condition were significantly more likely to perform the PM task relative to participants in the standard PM condition, $F(1,88) = 5.82$, $MSE = .13$, $p = .02$, $\eta_p^2 = .06$. PM is somewhat reduced relative to performance in the first experiment which could be due to dropping the term “special words” in the PM instructions; however, this difference of 6%–8% across experiments amounts to a difference of less than one half of a target event between experiments. As in the recall test of Experiment 1, accuracy on the post-test target recognition test was not affected by instruction condition, $F(1,88) = 2.05$, $p > .15$, $M = .91$, $SEM = .01$.

3.2.2 Ongoing task accuracy—Baseline accuracy was subjected to a 3×2 mixed ANOVA with the between subjects factor of instruction condition (the two PM conditions plus the control condition) and trial type (match and non-match). The main effect of trial type $F(1,117) = 24.74$, $MSE = .01$, $p < .001$, $\eta_p^2 = .18$, was significant, but neither the effect of instruction condition, $F<1$, $p = .76$, nor the interaction, $F(2,117) = 1.07$, $p =.35$, reached significance. Baseline accuracy was greater for non-match trials, $M = .96$, $SEM = .01$, than for match trials, $M = .92$, $SEM = .01$, consistent with previous findings (e.g. Smith & Bayen, 2004, Experiments 1 and 2). Given the differences in baseline accuracy, separate difference scores were computed for each item type. Accuracy differences scores were not significantly affected by instruction condition for either the match trials, $M = -.03$, $SEM = .01$, $F(2,117) = 2.13$, $p = .12$, or the non-match trials, $M = -.02$, $SEM = .01$, $F < 1$, $p = .59$. As in Experiment 1, there was no evidence of a cost to ongoing task accuracy.

3.2.3 Ongoing task response times—Baseline response times, M = 1289 ms, SEM = 34, were not affected by trial type, F<1, p = .64, or by instruction condition, $F(2,117)$ = 1.70, p = .19, and the two variables did not interact, $F(2,117)$ = 1.33, p = .27. Response time difference scores, shown in Figure 2, were significantly affected by instruction condition, $F(2,117)$ = 21.75, MSE = 284363, p < .001, η_p^2 = .27. The difference scores for the control condition were significantly smaller than in the standard PM condition, $t(73)$ = 4.70, p < . 001, d = 1.19, and smaller than in the II condition, $t(73)$ = 7.93, p < .001, d = 1.99. The comparison of the standard and II conditions showed a trend towards larger differences scores in the latter condition, $t(88)$ = 1.79, p =.077, d = .38. In short, a significant cost was found in both PM conditions relative to the control condition, which was not accompanied by a difference in ongoing task accuracy, therefore the cost in the PM was not reflective of a speed/accuracy trade-off. While the difference between the II and standard conditions only approached significance, the effect was in the same direction as in Experiment 1 and in the Meeks and Marsh (2010) study, with increased costs for the II condition compared to the standard PM condition.

3.2.4 Modeling results—The model provided a good fit to the data in both the standard PM condition, $G^2(4)$ = 2.39, and the implementation intention condition, $G^2(4)$ = 2.69, ps > . 60. The estimates for parameters P and M can be found in Figures 3 and 4, respectively. As in the previous experiment the II condition was more likely to engage in preparatory attentional processing relative to the standard PM condition, $G^2(1)$ = 23.81, w = .07, p < . 001, but the two conditions did not differ in the discrimination of target and non-target events, $G^2(1)$ = 1.10, p = .29. In short, the improvement in observable PM performance seen with the application of implementation intention instructions was achieved solely through an increase in the likelihood of engaging in preparatory attentional processing.

3.2.5 Importance—As shown in Table 3, the response distributions for both PM groups differed from what would be expected by chance. In the case of the standard PM condition, participants were less likely to select either the ongoing task or PM task as important, but more likely to respond that the tasks were equal than would expected by chance (chance = 15 participants in each cell in both conditions). In the II condition, fewer participants selected the ongoing task and more selected the tasks as equal than would be expected by chance. Crucially, neither group showed an increase in the selection of the PM task as the more important task and the distribution of responses to the importance question did not differ between the two PM conditions, z = −.46, p > .64. As in Experiment 1, there is no evidence from the post-test question on importance that the effects of implementation intentions are associated with increased perceived importance.

4.0 Experiment 3

Implementation intentions increased non-focal PM performance in the first two experiments, replicating prior studies by Brewer and Marsh (2010) and Meeks and Marsh (2010). In addition, this increase in non-focal PM performance was accompanied by increased allocation of conscious resources to the PM task as reflect by the increased cost to the ongoing task and increased preparatory attentional processing as measured by the P parameter, with no benefit to the retrospective component of the PM task as measured by parameter *M*. The third experiment was conducted to determine whether a different mode of forming the implementation intentions would lead to improved PM without increasing the allocation of conscious resources for preparatory attentional processing, and perhaps along with an increase in the retrospective memory component. In the first two experiments participants in the implementation intention condition said the if-then sentence to themselves, and while this has been done in previous studies (e.g. Meeks & Marsh, 2010), it is possible that this is not the most effective method for forming implementation intentions. In Experiment 3, participants wrote the if-then sentence on paper. Another factor could have interfered with the formation of a strong if-then link in the first two experiments, namely, the pairing of six target events with the same action. This may not be the optimal approach for seeing the full benefits of implementation intentions. In Experiment 3 the number of target events was reduced from six to two and each target was paired with a different action. In addition, the time to encode the target action pairs was increased.

The changes noted in the previous paragraph were instigated in the hopes of forming a better if-then connection between the target and the action. We also made two other modifications designed to decrease the role of preparatory attentional processing and thus decrease the allocation of conscious resources to the PM task, which may in turn facilitate the detection of effects of implementation intentions on the retrospective components of the PM task. The first concerned the length of the delay following the PM instructions and prior to the start of the second block of ongoing task trials. The 4 minute delay used in the first two experiments is the same as the delay length used by Meeks and Marsh (2010). In contrast, Zimmermann and Meier (2010) used a delay length of 10 minutes. It is possible that the contribution of preparatory attentional processes will decrease, and the contribution of recognition memory processes will increase, with this longer delay. On the other hand, Zimmermann and Meier (2010) did not report a benefit of implementation intentions on non-focal PM to begin with, so at a more basic level it will be crucial to show that implementation intentions can facilitate non-focal PM with longer (10 minute) delays.

A change was also made to the instructions for the implementation intention condition. In the first two experiments, participants were given imagery instructions along with silently repeating the if-then sentence. Imagery instructions are often included with the implementation intention instructions (e.g., Brewer & Marsh, 2010; Meeks and Marsh, 2010), but this is not always the case (e.g. McDaniel & Scullin, 2010, Experiment 2). Thus, in the third experiment we investigated the effects of implementation intentions without using additional imagery instructions to determine if our effects would replicate in this case.

4.1 Method

4.1.1 Participants and design—The 100 participants, all native English speakers, received course credit in exchange for their participation and were randomly assigned to one of three conditions: standard PM, implementation intentions (II), and no-PM control. The number of participants in each PM condition was 40. The control condition included 20 participants.

4.1.2 Materials and procedure—The materials and procedures differed from those in the previous experiment in the following ways. First, the length of the first block of color-matching trials was reduced to compensate for the additional time needed for the increased delay and increased number of trials in Block 2 of the color-matching task. Following the instructions and practice trials used in the previous experiments, participants completed a block of sixteen color-matching trials, half of which were match trials and half of which were non-match trials. At the end of the first block, participants were informed that they had completed the first part of the color-matching task and that they would be performing other tasks before resuming the color-matching task.

Participants in the PM conditions were instructed that when they completed the color-matching task that there was also another task to perform. Participants in both PM conditions read the following instructions "In a moment you will learn word-number pairs. When you see one of these words during the color-matching task, please try to remember to press the key corresponding to the number that is paired with that word." Participants were also instructed that if they did not remember the particular number that it was okay to guess and press any number when the word appeared. Prior to target encoding, each participant was asked to tell the experimenter what they were supposed to do in the number-word task. The experimenter made sure that the participants understood that they could press any number key if they could not remember the correct number.

During target encoding the word-number pairs were shown simultaneously, one above the other, on the computer screen for 30 seconds. The target words "record" and "maybe" were each paired with a different one-digit number ranging from 1 to 9. The assignment of numbers to words was determined randomly for each participant, as was the order in which the word-number pairs appeared on the screen. After target encoding, participants in the II condition were asked to write down two sentences on a piece of paper. Each sentence took the form of 'If I see the word "Target Word", then I will press the "Number" key!' Where "Target Word" was one of the two prospective memory targets and "Number" was the digit assigned to that target word.

All participants completed a health and demographics questionnaire, followed by the same solitaire puzzle used in the previous experiments. Following the filler tasks, which lasted for a total of 10 minutes, participants began the second block of the color-matching task, which included 112 trials. The target words appeared twice each, once each on a match trial and once each on a non-match trial. The order of occurrence was randomly determined for each participant. The target words appeared on trials 20, 52, 85, and 111. After the second block of color-matching trials, participants completed the target recognition test and answered the question about importance.

4.2 Results

4.2.1 Prospective memory performance and target recognition—PM performance was initially examined using lenient scoring, in which the press of any number key in response to a PM target event was considered a hit. This measure of performance is reported in Figure 1. This analysis provides information on whether the general intention of pressing a number was retrieved, apart from accuracy of action recall. Overall, performance

is noticeably lower than in the previous two experiments and this is likely due to the longer delay interval, which was more 2.5 times as long as the delay in the previous experiments. Despite the relatively low levels of performance, the likelihood of pressing a number key when a target word appeared was significantly greater in the II condition than in the standard PM condition, $F(1,78) = 9.07$, $MSE = .12$, $p = .003$, $\eta_p^2 = .10$. This finding provides the first evidence using a non-focal PM task that imagery instructions are not required in order for implementation intentions to increase PM performance.

It is also possible that if the implementation intention instructions lead to the formation of a particularly strong link between the target and the specific action that this will benefit the accuracy of the PM responses. This possibility was examined in a conditional analysis of PM performance. A conditional probability was computed by dividing the number of exact PM responses by the total number of PM responses. The mean probability of making the correct number press, given that a number was pressed when a target event occurred, was 1.00, $SEM = 0$, in the II condition, and .88, $SEM = .09$, in the standard PM condition. The effect of condition approached significance, $F(1,31) = 3.52$, $MSE = .03$, $p = .07$, $\eta_p^2 = .10$. The failure to find a significant effect in this conditional analysis could be due in part to ceiling levels of performance and a small number of observations, as only participants who made at least one PM response could be included in the conditional analysis. Overall, the results for PM performance suggest that implementation intentions increase the likelihood of remembering not just that something needs to be done, but also remembering what needs to be done. This is consistent with the argument that the link between the target and action and strengthened by the use of implementation intentions. To our knowledge this is the first such demonstration showing benefits of implementation intentions when each target is associated with different actions.

As in the previous experiments, accuracy on the post-test target recognition test did not differ between the standard condition and the II condition, $F < 1$, $p > .58$, $M = .90$, $SEM = .02$.

4.2.2 Ongoing task accuracy—All trials in Block 1 and the ten trials preceding each target event in Block 2 were included in the analysis of ongoing task performance. As in the previous experiment, baseline accuracy was greater for non-match trials, $M = .96$, $SEM = .01$, than for match trials, $M = .94$, $SEM = .01$, $F(1,97) = 4.23$, $MSE = .005$, $p = .04$, $\eta_p^2 = .04$. The effect of condition was not significant and the two variables did not interact, Fs < 1, ps > .76. Difference scores, which were computed separately for match, $M = -.04$, $SEM = .01$, and non-match trials, $M = .002$, $SEM = .01$, were not significantly affected by condition, $Fs < 1$, ps > .77. In other words, there was no cost to ongoing task accuracy.

4.2.3 Ongoing task response times—Baseline response times did not differ as a function of condition, $F < 1$, $p > .86$, or trial type, $F(1,97) = 1.09$, $p > .29$, and the variables did not interact, $F < 1$, $p > .48$. Because baseline response times, $M = 1384$, $SEM = 26$, did not differ as a function of trial type, a single difference score was calculated for each participant collapsing over trial type. Difference scores, shown in Figure 2, were significantly affected by condition, $F(2,97) = 4.08$, $MSE = 105837$, $p = .02$, $\eta_p^2 = .08$. The difference scores for the control condition were significantly smaller than those in the II condition, $t(58) = 2.76$, $p = .008$, $d = .78$, but the difference between control and the standard PM condition was not significant, $t(58) = 1.06$, $p = .29$. As in Experiment 2, the difference between the II and standard PM conditions approached significance, $t(78) = 1.94$, $p = .057$, $d = .43$. Thus, the pattern seen across the three experiments suggests that implementation intentions improve PM performance, but at a greater cost to the ongoing task.

In contrast to the first two experiments, a significant cost was not found in the comparison of the standard PM and control conditions, but this is not surprising given that many of the participants did not perform the PM task. When including only participants in the standard PM condition who made at least one PM response, difference scores were significantly smaller in the control condition than in the standard PM condition, $M = 293$, $SEM = 93$, $t(29) = 3.88$, $p = .001$, $d = 1.44$. Thus, for participants who did perform the PM task a cost to ongoing task response times was demonstrated in both the standard and II conditions.

4.2.4 Modeling results—The model provided a good fit to the data in both the standard PM condition, $G^2(4) = 1.04$, and the II condition, $G^2(4) = 0.76$, *p*s > .90. As in the previous two experiments, we evaluated the effects of instructions on the underlying cognitive processes. The significant increase in preparatory attentional processing (Figure 3) associated with implementation intentions relative to standard PM instructions that was seen in the two previous experiments was replicated in the current experiment, $G^2(1) = 20.85$, $w = .05$, $p < .001$. The two conditions did not differ with respect to parameter *M*, $G^2(1) = 1.17$, $p = .28$, as shown in Figure 4.

4.2.5 Importance—In contrast to the first two experiments, the difference between the standard and II groups in the response distributions to the importance question (Table 3) was significant, $z = -1.97$, $p = .049$. Furthermore, the distribution of responses differed from chance in the standard condition, with fewer participants selecting either the ongoing task or the PM task as more important and more participants selecting the tasks as equal than would be expected by chance. There was also a trend towards a non-random distribution of responses for the II group, with fewer participants selecting the ongoing task and more selecting either the PM task or the tasks were equal than would be expected by chance (chance = 13.33 in both conditions). Although the II condition responses indicate greater perceived importance relative to the standard condition in this experiment, the distribution of responses in the II condition in this experiment is similar to that found in the II conditions of the previous experiments.

5.0 General Discussion

The effect of implementation intentions, which are formed by creating an if-then link between a target event and an intended action, on non-focal event-based PM tasks have been mixed, with two studies reporting a benefit (Brewer & Marsh, 2010; Meeks & Marsh, 2010) and two showing no benefit (Chasteen et al., 2001; Zimmermann & Meier, 2010). We found a benefit of forming implementation intentions for non-focal PM tasks in all three of our experiments. In addition, the current experiments provide four new pieces of information regarding the way in which implementation intentions increase non-focal PM performance.

5.1 Increased Allocation of Conscious Resources to the PM Task

While implementation intentions improved non-focal PM performance in all three experiments, implementation intentions also increased the cost to the ongoing task, consistent with the findings of Meeks & Marsh (2010). That is, in all three experiments, the cost to the ongoing task, as measured by response time differences scores, was as great as or greater in the implementation intention condition relative to the standard condition. This increased cost indicates that implementation intentions resulted in an increase in the allocation of conscious resources to the PM task at the expense of the ongoing task. We found this despite the fact that, unlike previous studies, our choice of paradigm ensured that targets were processed at least minimally as part of ongoing ask activity, and we had participants form implementation intentions about specific targets. Furthermore, across the three experiments we made several further design modifications designed to decrease the role of consciousness demanding preparatory attentional processing and to increase the benefits of implementation intention encoding on non-focal target recognition. These modifications included increasing the target study time (Experiment 2), changing the modality by which participants formed implementation intentions (Experiment 3), reducing the number of target events (Experiment 3), and increasing the delay interval (Experiment 3). Overall, the current results provide clear evidence that implementation intentions do not increase the likelihood that non-focal targets can be recognized, but rather benefit non-focal PM tasks though stimulating an increase in cognitive processing that draws on our limited span of consciousness.

5.2 Increased Preparatory Attentional Processing

While measures of cost to the ongoing task have played an important role in determining the resources demands of PM performance, these measures do have limitations (Smith, 2010). A cost to the ongoing task does indicate that conscious resources are being allocated to the PM task even when the target event is not present, but this does not always mean that the costs are due solely to preparatory attentional processing. For instance, the increased cost could be due to increased rehearsal of the targets and/or action. Greater clarity can be achieved by combining the cost analysis with other approaches, such as mathematical modeling. The current study is the first to apply a multinomial model to investigate the question of how implementation intentions improve PM. Across all three experiments, implementation intentions increased the estimates of P, which is thought to reflect the likelihood of engaging in preparatory attentional processing, but had no effect on retrospective recognition of the target events as measured by M. The model results indicate that the increased cost to the ongoing task seen in the implementation intention conditions in these experiments are perhaps not due to rehearsal of the target events, as the estimates of M were unchanged. It is through the combination of the cost measure and application of the multinomial model that we can determine that the increased cost to the ongoing task seen in the implementation intention conditions is associated with increased preparatory attentional processing. The model results have implications, discussed in section 5.5, for when it would be most useful to employ implementation intentions for improving non-focal PM.

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5.3 Improved Action Recall

The combined use of the cost analysis and modeling approach were further enhanced in Experiment 3 in which each of two different targets was associated with a different intended action. The results of the final experiment indicate that while target recognition was not improved by implementation intentions, recall of the action was. The overall picture is that implementation intentions lead to improved non-focal PM through an increase in preparatory attentional processing and an increase in the accuracy of action recall. The simultaneous use of cost analysis, modeling, and multiple actions provides a fuller description of the way in which implementation intentions increase non-focal PM than can be determined using any one approach in isolation.

5.4 No Increase in Perceived Task Importance

Finally, although the pattern of non-focal PM performance, cost to the ongoing task, and model estimates was equivalent between the implementation intention condition and the condition in which the importance of the PM task is emphasized in Experiment 1, the two conditions differed on one dimension. Namely, the importance manipulation was associated with an increase in perceived importance of the PM task, but this was not the case for the implementation intention condition. On the whole, the results indicate that implementation intentions did not increase the perceived importance of the PM task. These results to do not support the proposal made by Meeks and Marsh (2010) that the mechanism by which implementation intentions improve non-focal PM is through an increase in the importance of the PM task.

5.5 Implementation Intentions: Multiple Mechanisms?

The current findings, in conjunction with those of Meeks and Marsh (2010), indicate that when implementation intentions improve non-focal PM this is accompanied by an increase in cost to the ongoing task, i.e., an increase in the extent to which conscious resources are allocated to the non-focal PM task. How does this compare to research using focal PM tasks? Examination of Table 1 shows that when using a focal PM task, implementation intentions do not increase cost to the ongoing task. Does this mean that implementation intentions improve focal and non-focal PM performance through different mechanisms? Specifically, does this indicate that focal PM tasks are improved through an increase in reliance on automatic processing (Gollwitzer, 1999)? Closer consideration of studies demonstrating a beneficial effect of implementation intentions in focal PM tasks suggests that implementation intentions are not necessarily increasing performance through increased automatic processing.

The clearest such indication comes from a study by McDaniel and Scullin (2010) showing that a divided attention task of random number generation decreased PM performance in both standard and implementation intention conditions. More importantly, when attention was divided, implementation intentions did not improve performance relative to standard PM instructions. If implementation intentions were improving performance through an increase in automatic processing, divided attention should not have these effects.

The McDaniel and Scullin (2010) findings appear to contradict results reported by McDaniel et al. (2008), who, in their first experiment, found that divided attention had no effect on PM performance for the implementation intention condition, but this was also the case for the standard PM condition, suggesting that the secondary digit detection task was not sufficiently demanding to produce divided attention effects. Using a more demanding random number generation task in their second experiment, McDaniel et al. did find a reduction in PM performance for the standard PM condition, but not for implementation intention condition. This was interpreted by McDaniel et al. as indicating that implementation intentions function through increased automaticity. However, as pointed out by McDaniel and Scullin, the particular ongoing task used by McDaniel et al. may have limited the full potential for the DA task to impair PM under implementation conditions. Specifically, McDaniel and Scullin note that the response times for making an ongoing task word rating response in the McDaniel et al. experiment ranged from 2.24 to 2.61 sec, much less than the 5 sec for which each word was shown on the screen. Participants may have made the ongoing task response and then devoted conscious resources to the PM task and secondary task (see Loft and Remington, 2013). Participants may have used this additional time to engage in extra processing for the PM task in order to compensate for the divided attention demands, but there would be no way to detect the effects of this reallocation of resources because the words remained displayed considerably longer than the time needed to make the ongoing task response (Loft and Remington, 2013; see McDaniel and Scullin for discussion of additional limitations to the McDaniel et al. study). This methodological approach would also complicate any attempts to interpret the lack of an effect on ongoing task performance in focal PM conditions with implementation intentions.

A similar methodological approach also limits our ability to interpret the lack of an increase in cost the McFarland and Glisky (2011, 2012) focal PM studies, as items remained on the screen after the response was made. Neither of the McFarland and Glisky articles reported mean response times for the ongoing task as this was not the focus of either of the McFarland and Glisky studies. Finally, the Schnitzspahn and Kliegel (2009) and Chasteen et al. (2001) studies did not include a measure of ongoing task performance.

In summary, the majority of studies using focal PM tasks either do not report ongoing task performance or use methods that were not well suited for investigating cost, which in turn limits our ability to interpret any lack of a cost. The one study that used appropriate methods did not find an increase in cost, but did find an effect of divided attention that eliminated the benefits of implementation intentions on focal PM performance. While additional research is needed to draw definitive conclusions, the overall evidence that implementation intentions improve performance focal tasks through an increase in automatic processing is currently quite weak and is countered with clear evidence to the contrary (McDaniel & Scullin, 2010). Therefore, it seems likely that a single explanation can potentially apply to how implementation intentions improve PM performance in both focal and non-focal tasks.

5.6 Summary and Implications

Implementation intentions increased preparatory attentional processes, while having no effect on retrospective recognition of the non-focal target events. These experiments are the first, as far as we know, to investigate the effect of implementation intentions on participants' perceptions regarding the relative importance of the PM and ongoing tasks, showing no increase in perceived importance. Finally, in Experiment 3, non-focal PM target events were each associated with a different action and the results indicate that implementation intentions have a beneficial effect on recall of which action is to be performed.

These findings have implications for determining when to use implementation intentions to improve non-focal PM. Given that implementation intentions did not affect retrospective recognition of the target events, as measured by parameter *M*, the formation of implementation intentions would perhaps not be the best compensatory technique for individuals who are having difficulty remembering *when* an intended action should be performed, such as individuals who have suffered a traumatic brain injury (Pavawalla, Schmitter-Edgecombe, & Smith, 2012). In addition, the current findings suggest that in cases where it is important to improve non-focal PM performance without increasing the allocation of conscious resources to the PM task at the expense of the ongoing task, for instance in safety-critical work contexts such as air traffic control (Loft et al., 2011, 2013), the use of implementation intentions may not provide the best technique for improvement of PM. Another problem here is that after conscious resources have been allocated to a PM task, they might be difficult to disengage, even during non-PM relevant task contexts (see Smith & Loft, in press). However, there are also likely many cases in which the increased cost to the ongoing task would be inconsequential and therefore, in those cases, the benefit of implementation intentions in terms of improved non-focal PM is likely to outweigh the increase in cost to the ongoing task. For example, the boost to non-focal PM from implementation intentions may be accompanied by inconsequential cost to understanding the content of a TV show or novel. Furthermore, in cases in which there is a need to increase preparatory attentional processing or recall of the correct action, implementation intentions would be a good selection for improving non-focal PM.

The findings regarding action recall are consistent with the argument that implementation intentions improve retrieval of the intended action (Brandstätter et al., 2001). Further investigation is needed to determine if there are cases in which this improved action recall can facilitate the recognition of targets in a non-focal PM task. Regardless of the eventual outcome of the issue of implementation intentions and the allocation of conscious resources, the current results add to the growing evidence that implementation intentions are an effective way of increasing non-focal PM performance and point to factors to consider in determining the types of tasks and the types of individuals for whom implementation intentions would be most beneficial.

Acknowledgments

Support for this project was provided in part by grant AG034965 from the National Institute on Aging to RES, and by Grant DP12010311 from the Australian Research Council to SL and RES. We are grateful to Marisa Aragon, Andrew Bolisay, Ross DeForrest, Kathryn Dunlap, Christopher Harris, Sadaf Kazi, Robert Lara, Cameron Lindsay, Sheila Meldrum, Brittany Nifong, Amy Nurnberger, Deborah Persyn, Cathy Prazak, Laura Randol, Matt Thompson, Joe Tidwell, Maria Villasenior, and Jarryd Willis for assistance with data collection.

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Appendix A. Additional Details of the Multinomial Process Tree Model

The model is shown in Figure A1. With probability *P* participants will engage in preparatory attentional processing and will make the PM response if they recognize the word as a PM target (*M*) or guess the word is a target (*g*). If a PM response is not made, participants will respond “Yes” if they detect that the color matches (C_1), or “No” if the detect that the color does not match (C_2), or the participant may guess that the color matches (*c*), resulting in a “Yes” response, or they may not guess that the color matches ($1-c$), resulting in a “No” response.

Participants are assumed to engage in probability matching, thus *g* is set equal to the ratio of target trials to total trials (g = .10 in Experiments 1 and 2 and .035 in Experiment 3 of the current study) and *c* equal to the ratio of match trials to total trials (c = .50). The resulting model is identifiable with four free parameters, *P*, *M*, C_1, and C_2, and has provided a good fit to the data in at least 18 experiments (Horn, Bayen, Smith, & Boywitt, 2011; Smith & Bayen, 2004, 2005, 2006; Smith, Bayen, & Martin, 2010; Smith, Horn, & Bayen, 2012; Smith & Hunt, in press; Smith, Persyn, & Butler, 2011; Wesslein, Rummel, & Boywitt, 2014).

The model estimates and goodness of fit index $G^2(4)$ were obtained for each PM condition by applying the model to the raw data shown in Appendix B using Multitree and HMM Tree (Moshagen, 2010; Stahl & Klauer, 2007). GPower software (Erdfelder, Faul, & Buchner, 1996) was used to conduct power analyses for each experiment. In each case power reported is for detecting small effects in the goodness of fit tests with four degrees of freedom and alpha set to .05. In Experiment 1with N = 1674 (27 participants × 62 trials) power was .9. In Experiment 2 with N = 2790 (45 participants × 62 trials) power was .99. Finally, in Experiment 3 with N = 4480 (40 participants × 112 trials) power was .99.

Significance tests were conducted to evaluate the effects of instructions on each of the parameter estimates. Values of $G^2(1)$ greater than 3.84 indicate a difference across conditions. Effect sizes (*w*) are reported for significant effects. The values parameters C_1 and C_2were not significantly affected by the instruction manipulation in any of the experiments (see Appendix C).

Appendix B. Response Frequencies as a Function of Item Type and Instruction Condition

		Experiment								
		1			2			3		
		Response Type			Response Type			Response Type		
Condition	Item Type	Yes	No	PM	Yes	No	PM	Yes	No	PM
Standard										
	Target, Match	32	8	41	66	10	59	63	5	12
	Target, Non-Match	4	35	42	6	71	58	4	63	13
	Non-target, Match	649	101	6	1072	183	5	1949	211	0
	Non-target, Non-Match	53	701	2	71	1179	10	104	2059	2
II										
	Target, Match	20	2	59	43	8	84	44	6	30
	Target, Non-Match	2	27	52	1	51	83	2	45	33
	Non-target, Match	659	86	11	1094	149	17	1940	218	2
	Non-target, Non-Match	49	699	8	67	1180	13	95	2064	1
PMI										
	Target, Match	24	4	53						
	Target, Non-Match	0	24	57						
	Non-target, Match	640	103	13						
	Non-target, Non-Match	49	700	7						

Note: The empty cell was replaced by 1 when modeling the data. Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized.

Appendix C. Model results for ongoing task parameters

		Condition			Standard v II		Standard v PMI		II v PMI	
Exp.		Standard	II	PMI	$G^2(1)$	p	$G^2(1)$	p	$G^2(1)$	p
1	C_1	.72 [.68, .77]	.77 [.73, .82]	72 [.67, .77]	1.91	.16	.002	.96	2.01	.16
	C_2	.86 [.82, .89]	.87 [.83, .90]	.87[.84, .91]	0.24	.63	0.33	.57	0.007	.93
2	C_1	.71 [.67, .75]	.76 [.72, .79]	-	3.19	.07	-		-	
	C_2	.88 [.86, .91]	.90 [.87, .92]	-	0.41	.52	-		-	
3	C_1	.81 [.78, .83]	.80 [.77, .82]	-	0.25	.61	-		-	
	C_2	.90 [.89, .92]	.91 [.89, .93]	-	0.50	.48	-		-	

Note: Standard = standard PM instructions. II = Implementation intention instructions. PMI = importance of PM task is emphasized. Numbers in brackets indicate bounds of 95% confidence intervals.

Highlights

- Implementation intentions improved non-focal prospective memory (PM) accuracy
- Implementation intentions increased conscious resources directed to the PM task
- Implementation intentions did not affect recognition of the non-focal target event
- Implementation intentions improved recall of the appropriate PM action

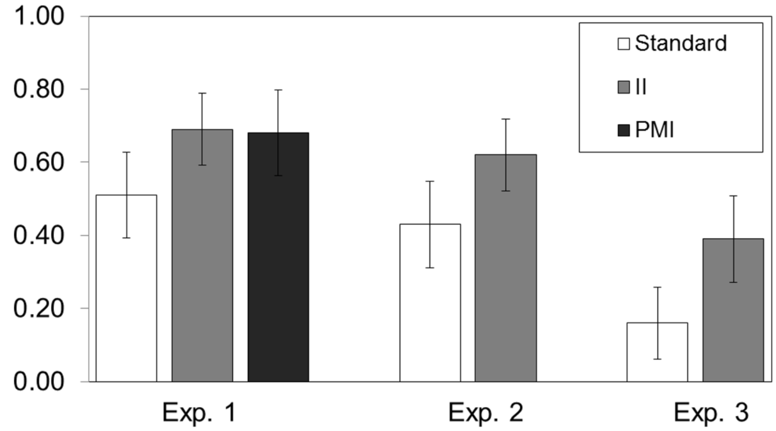

Figure 1.

The mean proportion of PM target trials on which the PM response was made. Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized. Error bars represent 95% confidence intervals.

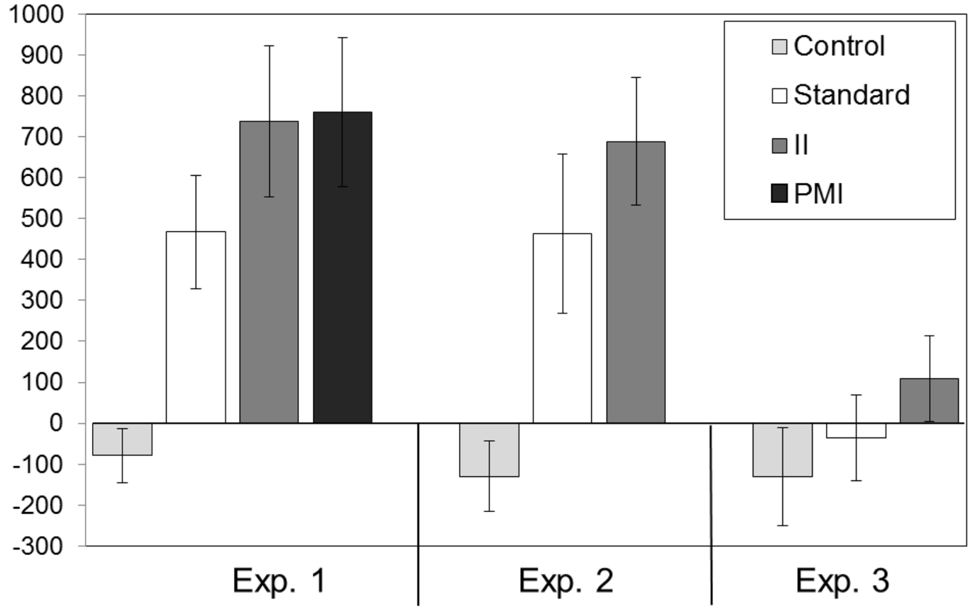

Figure 2.

Response time difference scores (Block 2 RT - Block 1RT) as a function of condition. Control = Ongoing task only control condition. Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized. Error bars represent 95% confidence intervals.

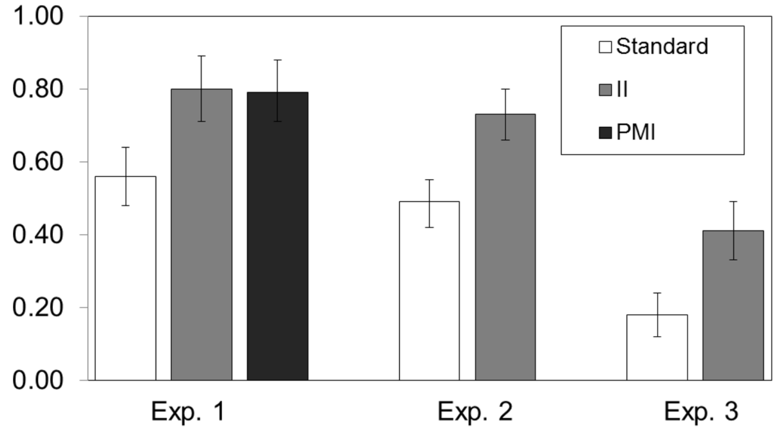

Figure 3.

Estimates of parameter *P* (preparatory attentional processing). Error bars represent 95% confidence intervals. Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized.

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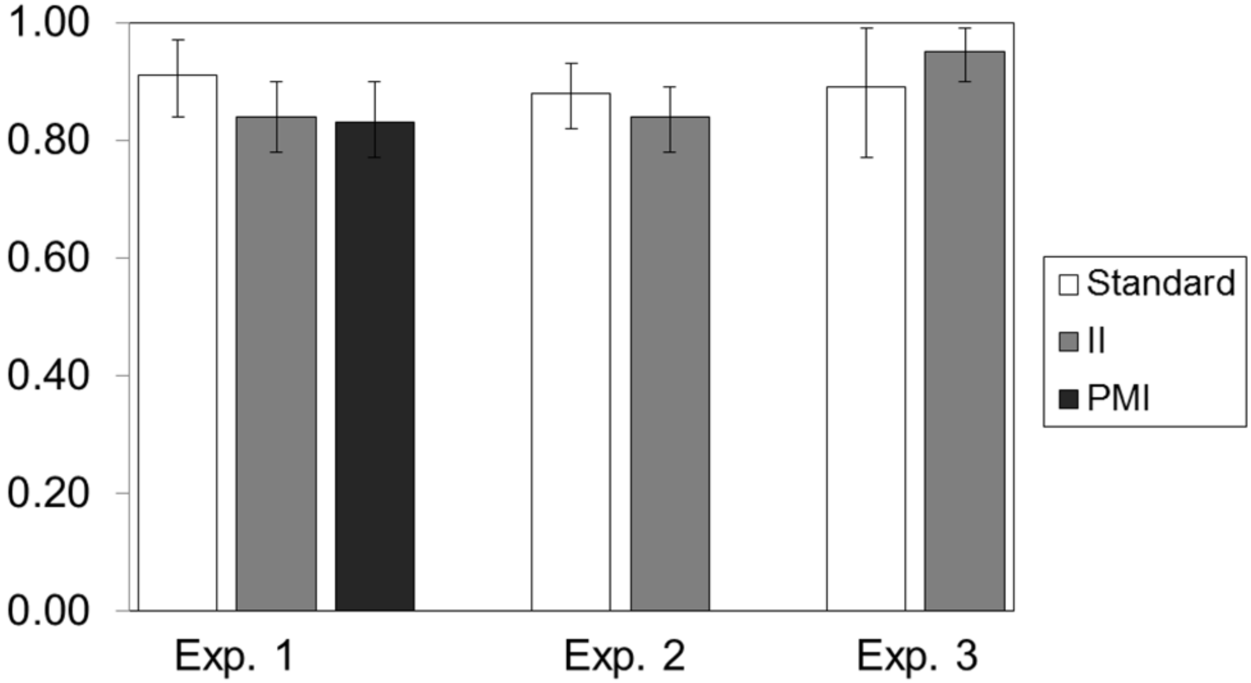

Figure 4.
Estimates of parameter *M* (retrospective recognition of target events). Error bars represent 95% confidence intervals. Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized.

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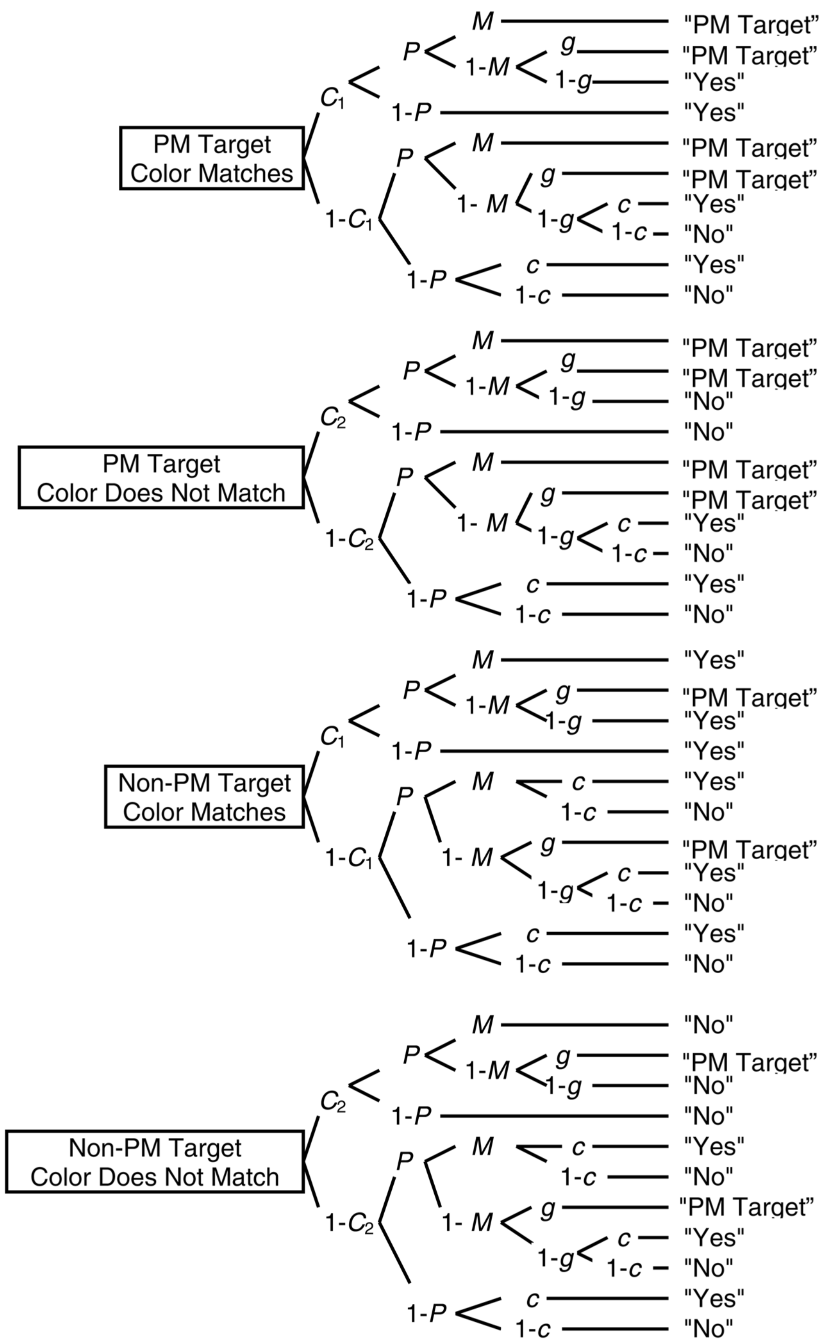

Figure A1.

Multinomial model of event-based PM. C_1 = probability of detecting a color match; C_2 = probability of detecting that a color does not match; 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 word is a target; c = probability of guessing that a color matches. 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

Laboratory studies of the effects of implementation intentions using focal PM tasks.

Experiment		Task Descriptions		Did II Improve PM?	Cost Increase?	Notes
		Ongoing	PM			
Chasteen et al. (2001)	1	Complete pencil and paper tasks.	Write day of week on top of each piece of paper.	Yes	N/A	Same experiment included a non-focal PM task described in Table 2.
McDaniel, Howard, & Butler (2008)	1	Word rating	Press Q if see spaghetti or doll	Yes	Not reported.	DA task: detect two odd digits in a row. DA did not affect PM performance.
	2			Yes	No	DA task: RNG. DA decreased PM in standard, but not in the II condition. Items remained on screen for 5 seconds even if response made before this time limit.
McDaniel & Scullin (2010)	1	Category verification	Press Z if see either of two specific target words.	Yes, in FA condition. No, in DA conditions.	No	DA task: RNG. DA decreased performance in both standard PM and II conditions.
	2		Press Enter if see word "history"		No	
	3		Press Enter if see the target word.[1]	No, compared to practice.	No	Practice condition[2] out performed II in DA condition. No difference in FA.
Meeks & Marsh (2010)	3	Lexical decision	Press / if see either of two target words	No	No	Ceiling effects prohibit interpretation.
McFarland & Glisky (2011)		Trivia Questions	See Notes	Yes	No	Standard PM Instructions: "If you see questions pertaining to 'states,' you should press the '6' key." II Instructions: "When I see the word 'state,' I will press the '6' key." Questions shown for 12 seconds, even if response made more quickly.
McFarland & Glisky (2012)			See Notes	Yes	No	
Schnitzspahn & Kliegel (2009)		Complete pencil and paper tasks.	Write day of week on top of each piece of paper.	Yes	N/A	Benefit for II occurred for young-old, but not older-old. Same pattern for a time-based task.

PM = Prospective memory. II = Implementation intention. DA = Divided attention. FA = Full attention. RNG = Random number generation.

[1] The target word varied.

[2] The practice condition had standard PM instructions, but practiced the PM task.

Table 2

Laboratory studies of implementation intentions using non-focal PM tasks.

Experiment		Tasks		Did II Improve PM?	Cost Increase?	Notes
		Ongoing	PM			
Current Study	1	Color-matching	Press F1 if see any of six target words.	Yes	Yes	
	2		Press F1 if see any of six target words.	Yes	Yes	
	3		Press a specific number for each of two target words.	Yes	Yes	Each target word associated with a different number.
Brewer & Marsh (2010)	1	Lexical decision	Press/when see animal word.	Yes	Not reported.	
Chasteen et al. (2001)	1	STM task	Press 0 if see target background pattern	No	No	Same experiment included focal PM task described in Table 1.
Meeks & Marsh (2010)	1	Lexical decision	Press / if see an animal word	Yes	Yes	
	2		Press / if see word with syllable “tor”	Yes	Yes	
Zimmerman & Meier (2010)		Lexical decision	Lift left index finger off shift key and use left index finger to press 1 key when see an animal word.	No for young adults. Yes for older adults.	No, for young. Trend, $p < .10$, for older.	Participants had to continuously press shift key with left index finger in order to progress through ongoing task.

PM = prospective memory. II = implementation intention. STM = Short term memory.

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Table 3

Number of participants selecting each response option on the post-test importance question.

		Which task was more important?				
Experiment	**Condition**	**Ongoing**	**Equal**	**PM Task**	$\chi^2(2)$	***p***
1	Standard	5	6	10	2.00	.37
	II	9	8	7	0.25	.88
	PMI	3	6	18	14.00	.001
2	Standard	9	23	13	6.93	.03
	II	8	22	15	6.53	.04
3	Standard	10	24	6	13.40	.001
	II	7	18	15	4.85	.09

Note: Standard = standard PM instructions. II = implementation intention instructions. PMI = importance of PM task is emphasized. Chi-square test statistics are for the comparison of response distribution to random distribution for each condition.