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ORIGINAL ARTICLE

Let it go: the flexible engagement and disengagement of monitoring processes in a non-focal prospective memory task

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Abstract Remembering to perform a delayed intention is referred to as prospective memory (PM). In two studies, participants performed an Eriksen flanker task with an embedded PM task (they had to remember to press F1 if a pre-specified cue appeared). In study 1, participants performed a flanker task with either a concurrent PM task or a delayed PM task (instructed to carry out the intention in a *later* different task). In the delayed PM condition, the PM cues appeared unexpectedly early and we examined whether attention would be captured by the PM cue even though they were not relevant. Results revealed ongoing task costs solely in the concurrent PM condition but no significant task costs in the delayed PM condition showing that attention was not captured by the PM cue when it appeared in an irrelevant context. In study 2, we compared a concurrent PM condition (exactly as in Study 1) to a PM forget condition in which participants were told at a certain point during the flanker task that they no longer had to perform the PM task. Analyses revealed that participants were able to switch off attending to PM cues when instructed to forget the PM task. Results from both studies demonstrate the flexibility of monitoring as evidenced by the presence versus absence of costs in the ongoing flanker task implying that selective attention, like a lens, can be adjusted to attend or ignore, depending on intention relevance.

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Introduction

In everyday life, we must manage multiple goals and intentions such as returning emails, preparing for class, and meeting with students and colleagues. Very often, these intentions must be postponed until the appropriate moment arrives for their execution. Prospective memory (PM) refers to remembering to carry out delayed intentions (Einstein & McDaniel, 1990). Its importance is underscored by the fact that forgetting to take one's medication or keep an appointment with an employer can have serious negative consequences. Intention completion requires the cognitive system to be configured in such a way that the person is sensitive to intention-related information that facilitates a goal-relevant behavior (Cohen, 2013; Cox & Klinger, 2011). For example, a person may recognize an environmental event (seeing a mailbox) as a *cue* for a previously encoded action (e.g., the intention to mail a letter). In most laboratory studies of event-based prospective memory, participants receive instructions for an ongoing task (e.g., a lexical decision task). Then in an intention condition, participants are instructed to make a different response if a pre-specified target event occurs. For example, a participant may be given an intention to press the F1 computer key if an animal word is presented at any point during the pleasantness rating task. A critical aspect of PM is that the action must be retrieved while the person is involved in other ongoing activities and with no explicit prompt from the experimenter.

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Much research has focused on the degree of interference to ongoing task processing when people hold an intention in mind, as a way to investigate whether PM retrieval must rely on resource-demanding monitoring processes. According to the preparatory attention and memory (PAM) model, successful retrieval of a delayed intention can only occur in the context of resource-demanding processes called preparatory attentional processes (Smith, 2003; Smith & Bayen, 2004; Smith, Hunt, McVay, & McConnell, 2007). Thus, the PAM model argues that successful event-based prospective memory involves allocating resources to monitoring the environment to detect an intention-related cue. Previous findings (e.g., Cohen, Jaudas, & Gollwitzer, 2008; Einstein et al., 2005; Hicks, Marsh, & Cook, 2005; Smith, 2003) have supported this model by demonstrating longer latencies on a reaction time task that includes an intention compared to a condition without an intention. The multiprocess view (MPV) also acknowledges that retrieval of intentions often requires capacity consuming monitoring but it departs from the PAM model by suggesting that the presence of a target event can spontaneously initiate retrieval of the prospective memory intentions from memory, even when no preparatory attentional processes are engaged (see Einstein et al., 2005; McDaniel & Einstein, 2007).

Einstein and McDaniel (2005) argued that one factor influencing task interference is the *focality* of PM cues (Einstein & McDaniel, 2005). Prospective memory cues may be considered focal or non-focal depending on whether or not target properties associated with the intention are in the focus of attention during ongoing task performance. Focal and nonfocal cues differ in the extent to which the ongoing task directs attention to the prospective memory cue. For example, during a category decision task that involves deciding whether a presented word is a member of a given category, a focal cue would be the word *tornado,* whereas a non-focal cue would be the syllable *tor* (see Einstein & McDaniel, 2005, for additional examples of focal and non-focal cues). Because non-focal PM tasks require more effort to monitor for cues, they are more likely to exhibit task interference compared to focal tasks (e.g., Scullin, McDaniel, Shelton, & Lee, 2010). Scullin et al. (2010) concluded that qualitatively different retrieval processes support prospective memory for focal versus non-focal cues. That is, spontaneous retrieval may support focal prospective remembering but monitoring processes are critical for non-focal prospective remembering. When false PM responses to cues occur in a context where the intention is not relevant (Meiser & Rummel, 2012; Rummel & Meiser, 2015) or after the intention has been canceled (Bugg & Scullin, 2013; Scullin, Bugg, & McDaniel, 2012), this has been interpreted as evidence for a spontaneous process.

A prediction of the multi-process model would be that spontaneous processing of PM cues should not occur for non-focal PM cues; however, results from Knight et al. (2011) showed that lures experienced out of context did lead to spontaneous noticing. In this study, participants were given a non-focal PM task in which they had to press the "/" key if they encountered an animal word that started with a "C" (e.g., Cougar). Participants showed task interference when a lure appeared outside of the responding context. That is, participants performed a lexical decision task in which they were told in one phase that they did not need to make a PM response but when a lure (e.g., Cougar) appeared, participants exhibited interference relative to a condition in which no lures appeared. Their results indicate that, at least for lures experienced outside of the task context, focal processing is not always necessary for spontaneous noticing. In the current study, we build upon these findings and used an ongoing task that is used to measure selective attention with an embedded non-focal PM task. Our goal was to examine whether participants would spontaneously notice a PM cue when it appeared outside of the appropriate task context. Critically, PM cues were presented amidst distractors that are known to automatically interfere with the target response. The question is: Will such non-focal PM cues also (as in the Knight et al., study) trigger the PM intention, when the PM intention is not yet or no longer relevant.

Current study

To this end, we used an Eriksen flanker task (Eriksen & Eriksen, 1974) as ongoing task, which is typically used to measure selective attention. Selective attention is a property of the cognitive system allowing us to select relevant visual information for processing (Posner, 1980). James (1950) proposed that visual attention acts like a spotlight such that one can attend to only one region of space at a time. It seems likely that when an intention is active, then attention will be guided toward information that is meaningful and goal relevant (e.g., Dreisbach, 2012). To examine spatial distance effects of PM cues on task performance, we manipulated target-distracter distance (resulting in near, medium and far distance trials) to allow a more fine-grained analysis of attentional scope. In this task, a centrally located arrow points either left or right, surrounded by eight flanker arrows that point either in the same (congruent trial) or opposite (incongruent trial) direction. The participant was instructed to attend solely to the central arrow and to respond by pressing the left computer key if the central arrow points left and the right computer key if the central arrow points right. In the flanker task, conflict arises because of the competition between task-relevant and task-irrelevant information.

Although the flanking arrows are irrelevant to the central task, they nevertheless are processed and lead to interference when they point in the opposite direction to the central relevant arrow. The conflict between the two opposing directions for the central and flanker stimuli in the incongruent condition leads to increased reaction time (RT) and errors as compared to the congruent condition. The typical flanker effect is an example of how information, though irrelevant for the task at hand, is processed and, in the case of incongruent flankers, impairs reactions upon the central target. Most importantly, the non-focal prospective memory task was embedded within the Flanker task in that one of the flanking distractors was replaced by a PM cue. Since distractors in the flanker task are processed automatically, this provides an interesting test whether non-focal PM cues amidst such distractors will be noticed spontaneously. No such evidence for spontaneous noticing of the PM cues would speak to the idea that monitoring for non-focal PM cues can be flexibly switched on and off depending on the current task instructions. To foreshadow, we examined whether there would be spontaneous noticing of the cue when the intention was inactive (Experiment 1) or canceled (Experiment 2).

Experiment 1

In the current study, participants performed a flanker task in which a centrally located arrow pointed either left or right, surrounded by eight arrows that pointed either in the same or opposite direction. Participants were randomly assigned to either: (1) a control condition in which they performed two blocks of the flanker task, (2) a PM condition in which they had to remember to press F1 if a prespecified cue appeared in the flankers, and (3) a PM delayed condition in which the participant was given the PM intention but for a subsequent digit symbol task. We were interested in examining when PM cues appeared in the inappropriate context for those in the PM delayed condition whether the cues would capture attention even though the PM cue was not supposed to appear until a later digit symbol task. Building on results from Knight et al. (2011), one might predict spontaneous attention capture by the PM cue given its relevance for the upcoming digit symbol task. Such automatic retrieval should show up in increased task interference on trials with a PM cue distractor as compared to the control condition. Alternatively, if the monitoring process for the PM cue is flexible, one might predict reduced task interference on trials with a PM cue distractor as compared to the PM condition (and comparable to the control condition).

Method

Participants

A total of 60 participants were recruited to participate from both Yeshiva College and Stern College for Women of Yeshiva University. Four additional participants were tested but were not included in the final sample due to three participants misunderstanding the instructions and one involving an experimenter error. A power analysis revealed sufficient power (0.78) to detect a medium- to large-sized effect between conditions; therefore, we stopped testing at 20 participants per condition (Faul, Erdfelder, Lang, & Buchner, 2007). Participants received optional partial course credit as a part of their psychology course or $5.00.

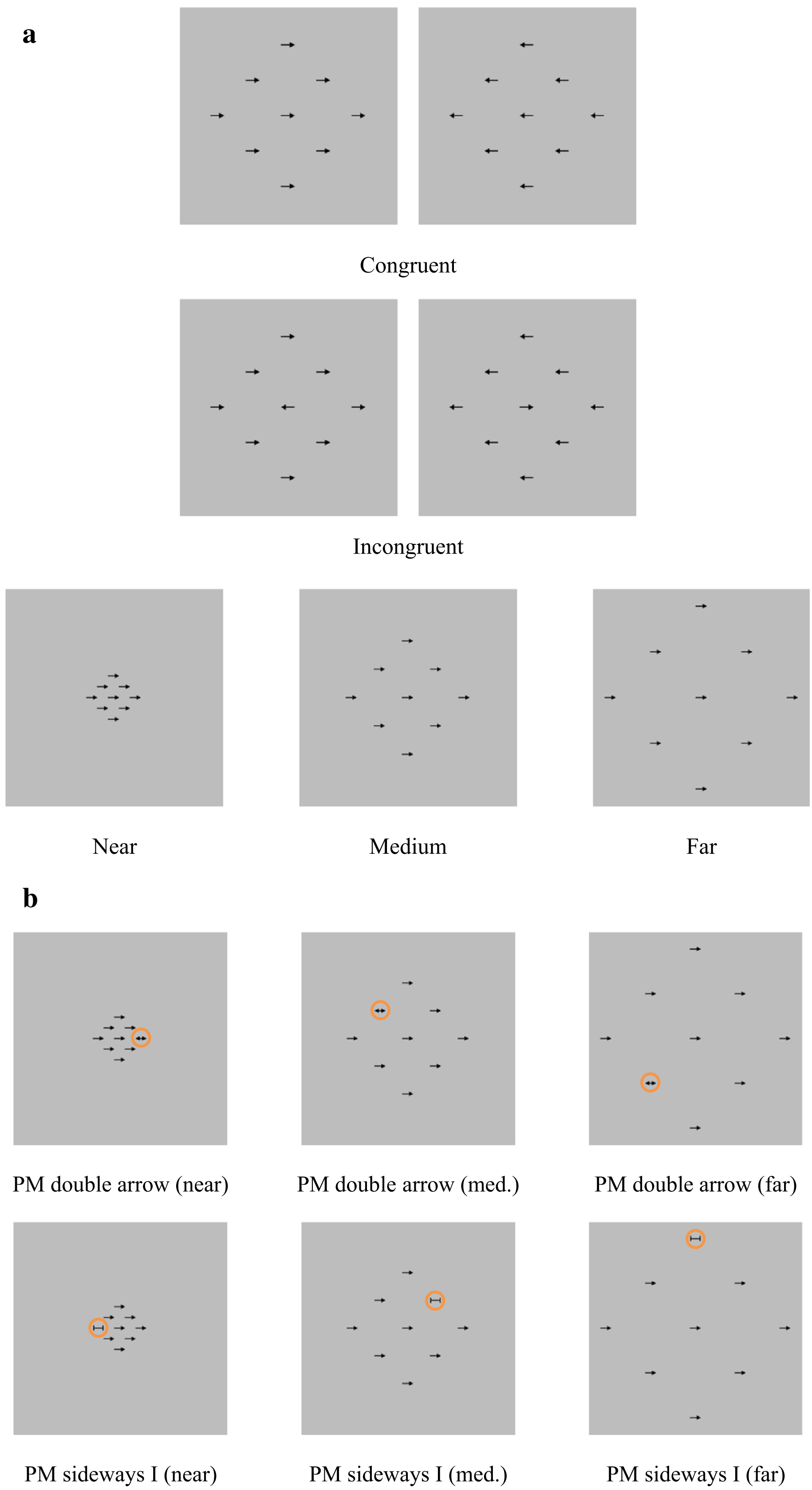
Materials

The experiment was administered using Presentation® (Neurobehavioral Systems, Inc., Albany CA). The stimuli were presented on a Dell Latitude E6410 Laptop with a screen resolution of 1280 × 800 pixels and the stimuli were black presented on a light gray background. In all three distances (near, medium, and far), the arrows and also the different PM targets were of the same width (0.73°) and height (0.30°). The horizontal and vertical distance between the arrows was 0.76° in the near condition, 1.96° in the medium condition, and 3.16° in the far condition. The viewing distance was approximately 45 cm. No chin rest was used.

In the flanker task, one of the manipulated variables was congruency; the flanking arrows either pointed in the same direction as the center arrow (congruent trials) or in the opposite direction (incongruent trials). We also manipulated distance of the flanking arrows from the center arrow (near, medium, far). See Fig. 1a, b. Each trial started with the presentation of a fixation point ("+") in the center of the screen. The target replaced the fixation point after 500 ms. The stimulus remained on the screen until a response was given. After the response, a slide was displayed saying "Press the space bar when you are ready for the next trial" therefore the trials were self paced.

Participants performed two blocks of flanker trials and each block consisted of 168 trials. Each flanker trial varied randomly according to: distance (near, medium, far), congruency (congruent, incongruent), and direction of the center arrow (pointing left or right). Crossing these levels of these independent variables resulted in 12 possible combinations (e.g., near, congruent, left; near, congruent, right; medium congruent, left, etc.) which appeared 14 times each in block 1 (e.g., 14 × 12 = 168 trials). In block 2, each of these 12 possible combinations occurred 10

Fig. 1 **a** Example of flanker trials: *Upper Panel* example of congruent/incongruent trials; *Lower Panel* example of near, medium, far trials. **b** Example of prospective memory cue trials when the cue is a double arrow or sideways "I"



times for a total of 120 trials with the remaining 48 trials including a prospective memory (PM) cue (24 times) or a deviant cue (24 times). A double arrow or a sideways "I" served as the PM cue or deviant cue which was counterbalanced across participants and these deviant or oddball cues were included to explore effects of rare deviants on reaction times. In each of the 24 flanker task trial types, this PM or deviant cue could replace one of the eight flanking arrows. The varying of distance in this paradigm was used to examine whether monitoring for the PM cue would be influenced by the distance in which case task interference should increase with increasing distance in the PM cue condition.

Procedure

After signing the consent form, participants were instructed to read the instructions for the experiment on the computer screen. The instructions described the flanker task in which they were asked to decide as quickly and as accurately as possible whether the central arrow in an array of arrows was pointing to the left or to the right, while ignoring the flanking arrows. If the arrow was pointing to the left they pressed the (spatially corresponding) "F" key and if it was pointing to the right they pressed the (spatially corresponding) "J" key with their index fingers. The experimenter reiterated the instructions and ensured that the participants did not have any questions. In block 1, all participants performed solely the flanker task and at the end of the block they were instructed that they could take a break. During this break, participants were given the instructions for the second block.

In the control condition, when participants were ready to resume, they were told that block 2 would be the same as block 1 and they should continue to perform the flanker task. Participants were not told that PM or Deviant cues would be appearing in the following block. In the PM condition, participants were told that they needed to remember to press a different key (e.g., the F1 key), if they saw a pre-specified cue (e.g., a double arrow or a sideways "I"). However, they were instructed that they should make their ongoing task response (F or J) to the central arrow first and then they should make their PM response, if appropriate. After the initial PM instructions, there were no further reminders from the experimenter and participants filled out the demographics questionnaire as a delay. In the Delayed PM condition, participants were told that they will perform a subsequent digit symbol task (Wechsler, 1997) after the flanker task and in *that* task they will have to remember to press F1 if they see the PM cue (e.g., a double arrow or a sideways "I"). Participants in the intention conditions were never warned that the deviant cues would be appearing in the next block. The instructions for the later digit symbol task were made convincing to the participants because experimenters showed participants the sheet that included the Digit Symbol Task stimuli. After participants showed understanding of the digit symbol task, they filled out the demographics questionnaire.

Design

The variables were Congruency (congruent, incongruent), Block (block 1, block 2), Distance (near, medium, far) and Instruction (control, PM, PM delayed). All factors were manipulated within participants except for instruction which was manipulated between participants. RT and error rates served as dependent measures.

Results

Performance on prospective memory trials

Prospective memory accuracy in the PM condition was on average quite good ($M = .71$). We conducted a paired samples t test to investigate whether PM accuracy varied as a function of congruency but congruency had no effect on PM accuracy ($p = .23$).

Next, we analyzed reaction time performance on flanker trials in which a prospective memory target or a deviant target was present. We conducted a 2 (Trial Type: PM Cue, deviant cue) $\times$ 3 (Instruction: control, PM, PM delayed) repeated measures ANOVA with Trial Type as a within-subjects factor and Instruction as a between-subjects factor. There was a significant main effect of Trial Type, $F\ (1, 57) = 24.15$, $p < .001$, $\eta^2 = .30$, revealing that reaction time was slower on PM versus deviant cue trials. There was a significant effect of Instruction, $F\ (1, 57) = 67.08$, $p < .001$, $\eta^2 = .70$ showing that performance was slowest in the PM condition relative

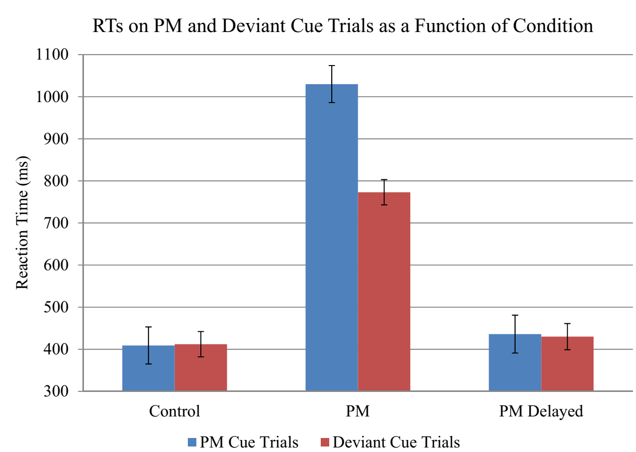


Fig. 2 Reaction time on flanker trials when a prospective memory cue or deviant cue was present as a function of instruction in Experiment 1. *Bars* represent standard error

to both control and PM delayed condition which did not differ significantly from each other ($p = .67$). Finally, there was a significant interaction between Trial Type and Instruction, $F\ (2, 57) = 22.46$, $p < .001$, $\eta^2 = .44$. Inspection of Fig. 2 shows that performance was significantly slower in the PM cue relative to the deviant cue trials but only for those assigned to the PM condition.[1]

Performance on ongoing flanker task trials

Data trimming was done separately for each block and each trial type for each participant. Several trials were excluded: (a) the initial 3 trials of block 1 and the first 3 trials of block 2 after the break; (b) trials that contained PM targets; (c) each trial that following a PM trial; (d) trials where the response time was <250 or >3000 ms; and (e) trials containing incorrect decisions. Data trimming resulted in 5 % of trials being eliminated.

To analyze performance in the ongoing flanker task, we conducted a 2 (Congruency: congruent, incongruent) × 2 (Block: block 1, block 2) × 3 (Distance: near, medium, far) × 3 (Instruction: control, PM, PM Delayed) mixed factorial ANOVA. All main effects and interactions are displayed in Table 1. Below we discuss the results that were most relevant to our hypotheses.

Results revealed a main effect of Congruency, $F\ (1, 56) = 210.11$, $p < .001$, $\eta^2 = .79$ showing faster RTs on congruent compared to incongruent trials. There was a main effect of Distance, $F\ (2, 112) = 6.64$, $p < .01$, $\eta^2 = .11$. Pairwise comparisons showed that performance was significantly faster for medium trials compared to both near and distant trials. There was a significant main effect of Block, $F\ (1, 56) = 22.50$, $p < .001$, $\eta^2 = .29$ showing faster RTs in block 1 compared to block 2. Finally, there was a main effect of Instruction, $F\ (2, 56) = 22.18$, $p < .001$, $\eta^2 = .44$ revealing significantly slower RTs in the PM condition compared to the control and PM Delayed conditions. There were two significant 3-way interactions. Analyses revealed a significant Distance × Block × Instruction interaction, $F\ (4, 112) = 21.10$, $p < .001$, $\eta^2 = .43$ revealing that in block 2, there was an effect of Distance solely for those in the PM condition with RTs increasing from near to far trials. See Fig. 3. There was also a significant Distance × Block × Congruency interaction, $F\ (2, 112) = 4.02$, $p < .05$, $\eta^2 = .07$ showing that there were no significant differences between near, medium, and far flanker trials in block 1 for congruent trials but there were significant effects of Distance on block 2 of congruent trials and blocks 1 and 2 for incongruent trials. See Fig. 4.

Table 1 Ongoing flanker task performance for Experiment 1: Full table of results of the 3 (Instruction: Control, PM, PM delayed) × 2 (Block: block 1, block 2) × 2 (Congruency: congruent, incongruent) × 3 (Distance: near, medium, far) mixed factorial ANOVA

Effect	*df*	F	*p*	η_p^2
Error rate				
1 (Instruction)	2	.96	.39	.03
2 (Block)	1	14.15	**.001**	.20
1 × 2	2	1.96	.15	.07
3 (Congruency)	1	40.31	**.001**	.42
1 × 3	2	1.08	.35	.04
4 (Distance)	2	29.10	**.001**	.34
1 × 4	4	3.52	**.01**	.11
2 × 3	1	7.99	**.007**	.13
1 × 2 × 3	2	.57	.57	.02
2 × 4	2	8.50	**.001**	.13
1 × 2 × 4	4	.85	.50	.03
3 × 4	2	33.03	**.001**	.37
1 × 3 × 4	4	1.70	.16	.06
2 × 3 × 4	2	11.12	**.001**	.17
1 × 2 × 3 × 4	4	1.37	.25	.05
RT data for experiment 1				
1 (Instruction)	2	22.18	**.001**	.44
2 (Block)	1	22.50	**.001**	.29
1 × 2	2	31.34	**.001**	.53
3 (Congruency)	1	210.12	**.001**	.79
1 × 3	2	.72	.49	.03
4 (Distance)	2	6.64	**.002**	.11
1 × 4	4	20.54	**.001**	.42
2 × 3	1	.44	.51	.01
1 × 2 × 3	2	1.73	.19	.06
2 × 4	2	24.43	**.001**	.30
1 × 2 × 4	4	21.10	**.001**	.43
3 × 4	2	69.50	**.001**	.55
1 × 3 × 4	4	1.38	.25	.05
2 × 3 × 4	2	4.02	**.02**	.07
1 × 2 × 3 × 4	4	1.37	.25	.05

Discussion

In sum, Experiment 1 yielded three main findings. First of all, RTs on flanker trials including a PM or deviant cue amidst the surrounding flanker stimuli incurred costs only in the PM condition but not in the control and PM delayed condition (s. Fig. 2). Second, RTs in the ongoing flanker task increased with increasing distance of the flanker distractors only in the PM condition but not in the control and PM Delayed condition (see Fig. 3, Block 2). That is, PM task interference increased with increasing distance of the possible PM cue. Third, we also found a typical effect of

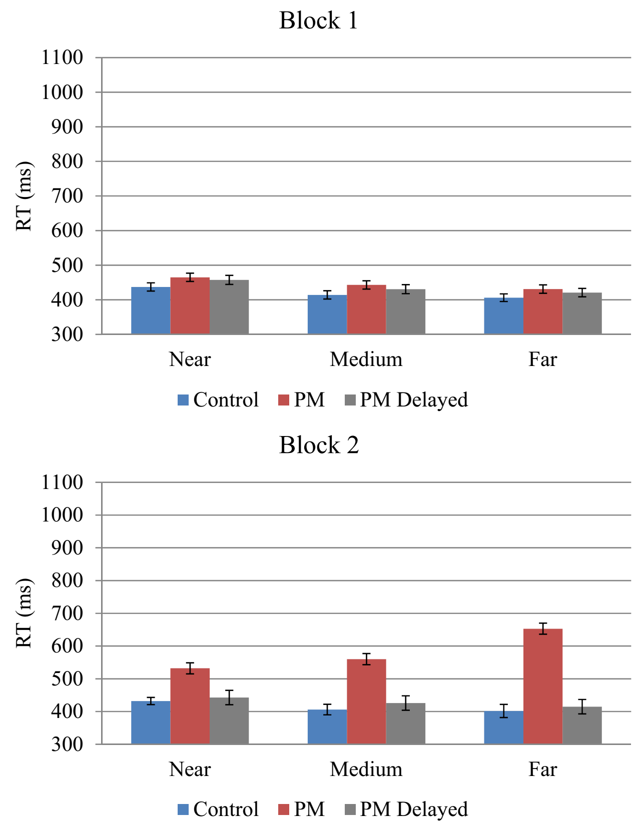


Fig. 3 Reaction time on flanker trials as a function of distance, instruction, and block in Experiment 1. *Bars* represent standard error

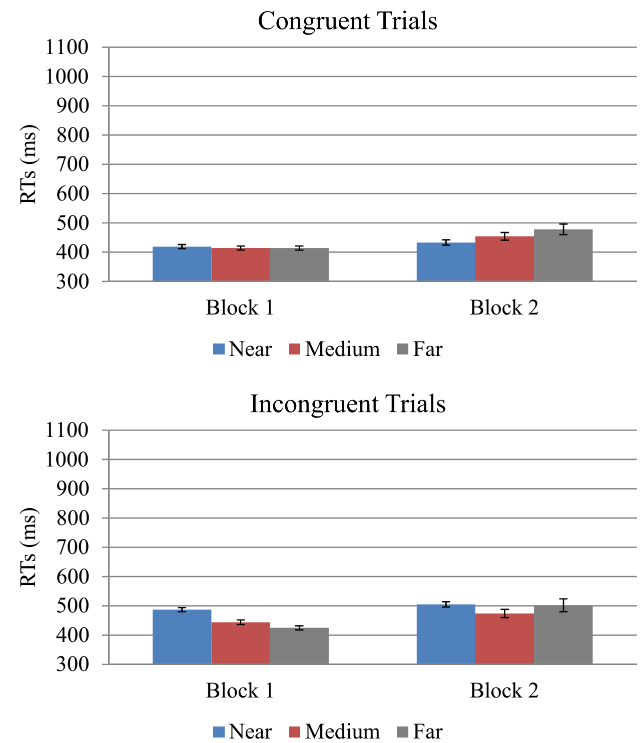


Fig. 4 Reaction time on flanker trials as a function of distance, congruency, and block in Experiment 1. *Bars* represent standard error

increasing flanker interference with *decreasing* distance in Block 1 when no PM cue intention was given yet (see Fig. 4). Flanker interference is assumed to be the result of automatic response activation; however, in the PM condition, we found increasing response latencies with increasing flanker distance which shows that this effect cannot be due to automatic retrieval. By the contrary, it must be the result of strategic monitoring for PM cues, a process that takes longer with increasing search space. And this monitoring process can be flexibly adjusted to the given instructions (as evidence by the difference between the PM and PM Delayed condition) and, from trial to trial, to the task space (as evidenced by the Distance effect in the PM condition).

One might have expected that PM cues would lead to spontaneous retrieval of the prospective memory intention when they appeared as flanker stimuli especially when flankers were near to the central arrow. In the standard flanker task, flankers in incongruent trials are processed resulting in longer RTs (hence the flanker effect) despite the fact that it is in the best interest of participants to ignore flankers and pay attention to the center arrow. Similarly, one might have anticipated that the PM cue would be noticed in the Delayed PM condition even though participants were supposed to be attending to the center stimulus. Our results suggest that participants are very adept at tuning attention to monitoring for PM cues when appropriate, and deactivating the monitoring process when the context is deemed inappropriate. Interference costs increased as a function of distance for participants assigned to the PM condition such that RT costs increased from near to far distance trials when prospective memory cues were present. Considering the "spotlight" metaphor of selective attention, our results suggest that when the intention was active, attention was broadened to process flankers as distance between them increased.

In the next experiment, we aimed to further investigate the flexibility of the monitoring process. An even stricter test of the assumed flexibility would be to show that an already performed prospective intention can be "switched off" again when participants are told to forget about the intention. In Experiment 1, it may be that the idea that participants would have to perform a later digit symbol task was only theoretical because they had no tangible experience with it; therefore, it was easier to put it out of mind. In contrast, in Experiment 2, participants had experience with actually performing the intention allowing them to establish a habit. Previous research (e.g., Stone, Dismukes, & Remington, 2001) showed that giving up a habit takes considerable control because one of the most common errors is habit intrusion in which a person reverts to a habitual sequence of actions instead of the intended sequence. Therefore, in Experiment 2 participants performed a PM intention for a block of trials and in the subsequent block they were told that they no longer had to respond to the PM cues. However, the PM cues continued to appear as flankers and we were interested in examining whether participants would again be able to successfully cease monitoring for intention-related cues or whether they would continue to monitor for PM cues.

Experiment 2

In Experiment 1, we established that cues that were encountered in an unexpected context could be ignored and had no negative impact on ongoing task performance. An interesting follow-up question was whether the cue will be more difficult to ignore when it has become part of a well-established habit or routine (see also, Dreisbach & Bäuml, 2014). In Experiment 2, we explored whether attention would be captured by the PM cue when it continued to appear even though the intention had been canceled.

Method

Participants

A total of 40 participants were tested at the University of Regensburg who received course credit for participating. Four participants were excluded and replaced because they responded to both the Deviant *and* PM cue. A power analysis revealed sufficient power (0.80) to detect a medium- to large-sized effect between conditions; therefore, we stopped testing at 20 participants per condition (Faul et al., 2007).

Materials

We used a Dell desktop and a 17-inch CRT display (display resolution at 1024 $\times$ 768 pixels). The experiment was programmed in E-Prime 2.0 (Psychology Software Tools, Sharpsburg, PA, USA). All details regarding the stimuli were kept consistent with Experiment 1. An exception was that there were three blocks of flanker trials in this experiment as opposed to two. Block 1 consisted of 84 trials with no PM cue. Block 2 had 168 trials in total with 24 PM cues and 24 deviant cues. Block 3 was the same as block 2 with 168 trials in total with 24 PM and 24 deviant cues. Each flanker trial varied randomly according to Distance (near, medium, far), Congruency (congruent, incongruent), and whether the center arrow pointed left or right.

Design

The variables were Congruency (congruent, incongruent), Block (block 1, block 2, block 3), Distance (near, medium, far) and Instruction (PM continue, PM forget). All factors were manipulated within participants except for instruction which was manipulated between participants. RT and error rates served as dependent measures.

Procedure

After signing the consent form, participants were instructed to read the instructions for the experiment on the computer screen. The instructions describing the flanker task were identical to Experiment 1. After participants finished reading the instructions, they were asked if they had any questions and after they were answered, participants began the flanker task. In block 1, all participants performed solely the flanker task and at the end of the block they were instructed that they could take a break. During this break, participants were given the instructions for the second block.

In block 2, for both the PM continue and PM forget conditions, participants were told that they needed to remember to press a different key (i.e., the F1 key), if they see a pre-specified cue (e.g., a double arrow or a sideways "I") in the flanker stimuli. As in Experiment 1, they were instructed that they should make their ongoing task response (F or J) to the central arrow first and then they should make their PM response, if appropriate. After the initial PM instructions, there were no further reminders from the experimenter. After participants finished block 2, they were given another break. At this point, instructions differed by condition. Those participants, in the PM continue condition, were told that they could take a break and then they would resume the flanker task with the embedded PM task. Participants in the PM forget condition were instructed that they no longer should respond to the PM cue and they only need to perform the flanker task.

Results

Performance on prospective memory trials

We conducted an independent samples t test on prospective memory accuracy in block 2 before the two groups received instructions that differed by condition. PM performance was high and there was no reliable difference between performance in the PM continue ($M = .95$) versus PM forget ($M = .93$) conditions, $p = .74$. Prospective memory accuracy was similarly high for the PM continue condition ($M = .93$) in block 3 and those in the PM forget condition made no false alarms or commission errors when the PM stimuli continued to appear. We examined whether PM performance varied as a function of congruency but results were not reliable (*ps* > .09).

In the next analysis, we examined reaction time performance on flanker trials in which a prospective memory target or a deviant target was present. We conducted a 2 (Trial Type: PM cue, deviant cue) × 2 (Block: block 2, block 3) × 3 (Instruction: control, PM, PM Delayed) repeated measures ANOVA with Trial Type and Block as within-subject factors and Instruction as a between-subjects factor. Results yielded a significant main effect of Trial Type, F (1, 38) = 24.41, $p < .001$, $\eta^2 = .41$, revealing that reaction time was slower on PM ($M = 795$ ms) versus deviant ($M = 734$ ms) cue trials. There was a significant effect of Block, F (1, 38) = 143.63, $p < .001$, $\eta^2 = .79$ showing that performance was much slower in block 2($M = 916$ ms) compared to block 3 ($M = 614$ ms). The effect of Instruction was significant, F (1, 38) = 14.07, $p < .001$, $\eta^2 = .27$ with RTs being slower in the PM continue ($M = 847$ ms) versus PM forget ($M = 682$ ms) condition. Results yielded a significant interaction between Block and Instruction, F (2, 57) = 22.46, $p < .001$, $\eta^2 = .44$. Inspection of the means shows that RTs for participants in the PM forget ($M = 894$ ms) and PM continue ($M = 948$ ms) conditions in block 2 were more equivalent compared to means in block 3 for each condition (PM forget: $M = 481$ ms; PM continue: $M = 747$ ms). All of these effects were qualified by a significant 3-way interaction between Trial Type × Block × Instruction, F (1, 38) = 13.22, $p < .001$, $\eta^2 = .26$. As Fig. 5 shows, RTs did not differ between PM and deviant cue trials for those in the PM forget condition (who were instructed to forget the PM task in block 3).[1]

Performance on ongoing flanker task trials

Data trimming was conducted similar to Experiment 1 and resulted in 3.35 % of trials excluded. To analyze performance on the ongoing flanker task, we conducted a 2

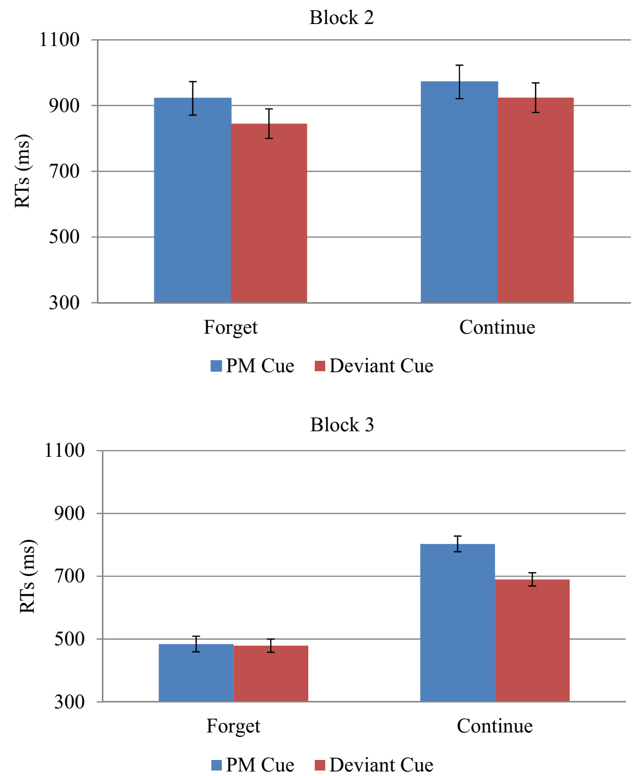


Fig. 5 Reaction time on flanker trials when a prospective memory cue or deviant cue was present as a function of block and instruction in Experiment 2. *Bars* represent standard error

(Congruency: congruent, incongruent) × 2 (Block: block 2, block 3) × 3 (Distance: near, medium, far) × 2 (Instruction: PM forget, PM continue) mixed factorial ANOVA with all factors being manipulated within subjects except for instruction which was a between-subjects factor. All main effects and interactions are depicted in Table 2.

Results revealed a main effect of Congruency, F (1, 38) = 69.21, $p < .001$, $\eta^2 = .65$ showing faster RTs on congruent ($M = 623$ ms) compared to incongruent ($M = 677$ ms) trials. There was a main effect of Distance, F (2, 76) = 52.07, $p < .001$, $\eta^2 = .58$. Pairwise comparisons showed that RTs increased from near ($M = 605$ ms) to medium ($M = 639$ ms) to far ($M = 706$ ms) trials with all comparisons significantly different from each other. Results yielded a significant main effect of Block, F (1, 38) = 78.00, $p < .001$, $\eta^2 = .67$ showing faster RTs in block 3 ($M = 541$ ms) compared to block 2 ($M = 760$ ms). Finally, there was a main effect of Instruction, F (1, 38) = 5.22, $p < .05$, $\eta^2 = .12$ revealing significantly slower RTs in the PM continue ($M = 693$ ms) compared to the PM forget ($M = 608$ ms) condition. Results revealed a significant Instruction × Distance interaction, F (2, 76) = 10.24, $p < .001$, $\eta^2 = .21$, showing that for those assigned to the PM continue condition, RTs increased much more dramatically from near to

[1] To check whether reaction times to PM cues initially started off slow in early trials and then eventually sped up, we divided the PM and Deviant trials into mini-blocks (of 4 trials each) for the PM Delayed condition in Experiment 1 and in the PM Forget condition in Experiment 2. We conducted Trial type (PM Cue vs. Deviant) × - Miniblock (Miniblock 1 vs. 2) ANOVAs for both experiments. Results revealed that the interaction was far from significant in Experiment 1 ($p = .89$) and in Experiment 2 ($p = .70$). Furthermore, we computed contrasts between PM and deviant trials for the first mini block of trials and there was no significant difference for Experiment 1 ($p = .30$) or Experiment 2 ($p = .40$). These analyses confirm that even in the very first mini-block trials, reaction times to PM trials did not differ significantly from deviant trials when the intention was not active.

Table 2 Ongoing flanker task performance for Experiment 2: Full table of results of the 2 (Instruction: PM forget, PM continue) × 2 (Block: block 2, block 3) × 2 (Congruency: congruent, incongruent) × 3 (Distance: near, medium, far) mixed factorial ANOVA

Effect	*df*	F	*p*	η_p^2
Error rate				
1 (Instruction)	1	1.02	.32	.03
2 (Block)	1	4.60	**.04**	.11
1 × 2	1	1.45	.24	.04
3 (Congruency)	1	17.46	**.001**	.32
1 × 3	1	.40	.53	.01
4 (Distance)	2	3.44	**.04**	.08
1 × 4	2	1.09	.34	.03
2 × 3	1	1.88	.18	.05
1 × 2 × 3	1	3.67	.06	.09
2 × 4	2	6.21	.003	.14
1 × 2 × 4	2	1.20	.31	.03
3 × 4	2	7.12	**.001**	.16
1 × 3 × 4	2	.93	.40	.02
2 × 3 × 4	2	8.86	**.001**	.19
1 × 2 × 3 × 4	2	2.86	.06	.07
RT data for experiment 2				
1 (Instruction)	1	5.22	**.03**	.12
2 (Block)	1	78.01	**.001**	.67
1 × 2	1	2.74	.11	.07
3 (Congruency)	1	69.21	**.001**	.65
1 × 3	1	.60	.44	.02
4 (Distance)	2	52.07	**.001**	.58
1 × 4	2	10.24	**.001**	.21
2 × 3	1	8.42	**.01**	.18
1 × 2 × 3	1	.15	.7	.004
2 × 4	2	56.82	**.001**	.6
1 × 2 × 4	2	1.29	.28	.03
3 × 4	2	4.16	**.02**	.1
1 × 3 × 4	2	1.80	.17	.05
2 × 3 × 4	2	.36	.7	.01
1 × 2 × 3 × 4	2	2.58	.08	.06

medium to far trials compared to those in the PM forget condition (see Fig. 6).

Discussion

Overall, our results from Experiment 2 demonstrated that participants assigned to the PM forget condition were able to flexibly update their monitoring policy and were not influenced when confronted with stimuli that were associated with an intention in the previous block. Participants were able to switch off the monitoring process when instructed to discontinue performing the PM task. These results are in contrast to findings reported by Walser et al.

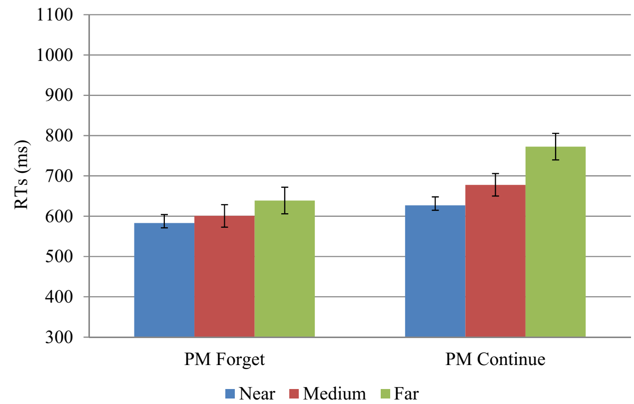


Fig. 6 Reaction time on flanker trials as a function of distance and instruction in Experiment 2. *Bars* represent standard error

(2012) who showed that participants were unable to suppress intention-related thoughts when cues related to a previously completed intention appeared. Of course, this is likely due to their use of a focal PM cue which would make the lure more difficult to ignore. In line with Experiment 1, our manipulation of distance in this experiment showed that participants experienced increasing PM task interference from near to medium to far trials on a trial-by-trial basis suggesting that the monitoring process can be flexibly adapted from trial to trial.

General discussion

Results from two experiments produced a consistent pattern of results showing flexible engagement and disengagement of monitoring processes. We purposely used the flanker task and presented PM cues amidst distractors that are known to automatically interfere with the target response. These experiments yielded two main findings. First, ongoing task interference occurred only in PM conditions but not in the PM delayed condition (Experiment 1) or when the PM task was canceled (Experiment 2). Second, in both experiments, latencies in the ongoing flanker task increased with increasing distance of the flanker distractors but only when the PM task was active. The fact that differential patterns of interference costs were found in a non-focal task suggests that strategic monitoring for cues can be flexibly adjusted according to task instructions and on a trial-by-trial basis (as evidenced by the Distance effect in PM conditions). It seems adaptive that the cognitive system is configured in such a way that monitoring can be flexibly attuned depending on the task environment.

Our results are in contrast to those of Knight et al. (2011) who demonstrated lure interference outside of the appropriate responding context with a non-focal PM task.

An explanation for these different outcomes may be due to the nature of the non-focal PM tasks used in each study. Knight et al. (2011) used categorical PM cues which are considered non-focal but may be more likely to trigger intention-related thoughts compared to the non-focal cues employed in the current task. In fact, Knight et al. state that their PM instructions to respond to a C-animal may have been more focal because they restricted the category size compared to the typical general categorical cue instructions that require one to respond to any animal word.

In both Experiments 1 and 2, distance of flankers (near, medium, far) interacted with instruction and block showing that the distance of flankers from the center stimulus had an effect but only when participants were monitoring for PM cues. That is, reaction times increased linearly from near to far trials when participants were aware that they needed to detect PM cues that might be appearing in the flanker stimuli. When participants had to broaden their attention "spotlight", then there was a corresponding increase in reaction time costs. These effects of distance clearly show that attention was prioritized according to specific goals associated with the prospective memory task. As distance of flankers increased, so too did the time it took to scan for PM stimuli.

Previous studies also support the notion that attention allocation strategies can change flexibly. For example, Marsh et al. (2006) explored whether task costs are more pronounced when the class of stimulus in the ongoing task matches the class of stimulus relevant to the intention. Results showed that task interference could be reduced when participants could reliably predict the material about to be processed in the ongoing task. That is, task interference was reduced on word trials with an intention about pictures and on picture trials with an intention about words. In addition, Cohen et al. (2012) showed that task interference could change on a trial-by-trial basis under task conditions where participants could not predict the nature of the upcoming stimulus (see also Cohen et al., 2008). Furthermore, Lourenço and Maylor (2014) contributed to the above findings by showing that trial-by-trial modulations in task interference can be observed not only with focal PM tasks but also with non-focal PM tasks. The results of these studies along with the present findings provide further support for a view of monitoring as a flexible mechanism.

The data presented here nicely fit with a related research domain focusing on the influence of instructed vs. implemented/practiced stimulus–response (SR) rules (e.g. Wenke, Gaschler & Nattkemper, 2007). The basic finding there is that the mere instruction to press a certain key in response to a certain stimulus leads to interference when this stimulus occurs as a distractor later on, even when this stimulus had never occurred as target before. This is taken as evidence that instructed SR rules are automatically activated by the respective stimulus even without prior practice (see also Cohen-Kdoshay & Meiran, 2007, 2009; but see Waszak, Wenke & Brass, 2008). This effect, however, crucially depends on the *intention* to apply the instructed SR rule (e.g. Hommel, 2000). When participants were simply told to remember the rule for later recognition, automatic response activation was no longer found (Liefooghe, Wenke & De Houwer, 2012). Here, we complement this latter finding by showing that the automatic activation of instructed task rules also depends on the task appropriate context as described in the instructions (Experiment 1: delayed intention condition). Moreover, it has been shown that the influence of instructed SR rules can be reduced by specific no-go instructions (Wenke, Gaschler, Nattkemper, & Frensch, 2009). In Experiment 2 of the present study, we showed that the monitoring for PM cue intentions can be entirely switched off by instructions, as evidenced by the total lack of monitoring costs in the ongoing task and the absence of commission errors. Taken together, the effect of instructed rules (be it frequent SR rules or rare pm cues) not only depends on the intention to carry out the rule but also on the appropriate task context.

In sum, our results are in line with both the MPV and PAM theory. The fact that there was no slowing to non-focal PM cues in an inappropriate context suggests that the engagement of preparatory attention was not present. As well, one of the assumptions of the MPV regarding spontaneous processing is that it is most likely to occur for focal cues; therefore, our results are in line with this account, too. Findings by Knight et al. (2011) did yield spontaneous processing of lures in a non-focal event-based PM task; however, the fact that lures in our ongoing task were spatially separated from the central target stimulus appears to have helped participants ignore their influence. Our study offers new insight into the ease with which participants can adjust attention allocation policies according to properties of the stimuli (e.g., distance manipulation) and the task instructions. Results from two studies demonstrate the flexibility of monitoring as evidenced by the presence versus absence of costs in the ongoing flanker task implying that attention, like a lens, can be adjusted to attend or ignore, depending on intention relevance.

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